A QUANTITATIVE STUDY OF THE LARGER AQUATIC PLANTS OF GREEN LAKE, WISCONSIN[1]

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Notes from the Biological Laboratory of the Wisconsin Geological and Natural History Survey. XXII.

INTRODUCTION

In the summer of 1921 a survey was made of Green Lake, Wisconsin, with a view to the estimation of the amount of large aquatic plants produced by this body of water. This report embodies the results of the investigation. Besides the gross quantitative data, the study also furnished information on the distribution of various plants, their depth relations, and the vegetation of different parts of the lake.

A similar report has already been made (3) on Lake Mendota. The methods used and the nature of the information obtained in the study presently to be described were in general the same as those in the previous case.

The work was done for the Wisconsin Geological and Natural History Survey, under the supervision of Professor Chancey Juday. For assistance in identifying several of the plants collected, I am indebted to Dr. E. A. Baird, Dr. R. H. Denniston, Dr. G. M. Smith, and Dr. G. E. Nichols. For much assistance in collecting, I wish to thank Professor Juday and Mr. L. E. Noland.

DESCRIPTION OF LAKE

Green Lake is a roughly oval body of water, seven and one-half miles in length and from one to two miles broad. It is 66 meters deep at its west end,—by far the greatest depth recorded for any Wisconsin lake. The east end is somewhat shallower. Its waters are cool, clear (compared, for instance, with those of Mendota), and of the bright tint which gives the lake its name. The color of

[1] This investigation was made in cooperation with the U. S. Bureau of Fisheries, and the results are published with the permission of the Commissioner of Fisheries.

the water is best seen on cloudy days; but even at other times, when most lakes reflect the blue of the sky, the surface of this lake is often a bright green. The same color is very noticeable when one is beneath the surface. The lake floor is in most places covered with a fine marl.

These conditions afford an interesting comparison with those in Lake Mendota. The waters of the latter are less transparent and warmer than those of Green Lake, and the bottom is of mud. There are striking differences in the underwater vegetation of the two lakes, which may be correlated to some extent with these environmental differences.

Various types of shore are found in different parts of Green Lake. Along most of the north side of the lake the land ends in smooth boulders of considerable size, behind which the shore slopes steeply upward for a short distance (fig. 1). A beach of smaller stones runs out a considerable distance beneath the water. Towards the northwest corner of the lake rises the hill known as Sugar Loaf (see the accompanying map), whose steep sides descend below the surface of the water at almost the same pitch, broken only by a narrow rocky beach at the water's edge. The opposite shore of Norwegian Bay, and a long stretch of the south shore of the lake (fig. 2), descend even more steeply into the water, and consist largely of more or less sheer rock walls. At both ends of the lake are wide sandy beaches, backed by gently rising meadows. Finally, at the mouths of the various streams that enter the lake, and around the outlet in Dartford Bay, there are extensive swamps and marshes (fig. 3). At the head of Norwegian Bay is found a muddy bog.

In general the shore line is very similar to that of Mendota, with the difference that the sandy beaches of the latter are much more extensive.

As in Mendota, the shore line is paralleled by a belt of submerged attached plants, extending in an unbroken line all around the lake. In Green Lake, however, this flora differs widely in nature and distribution from that of Mendota. The wide sandy beaches are not nearly so well covered. The rocks of the shore are nearly destitute of the tufts of Cladophora that are so characteristic of Mendota. The main axis of the lake lies parallel to the southwest winds that prevail in summer, and the consequent vigorous action of the waves is perhaps partly responsible for these

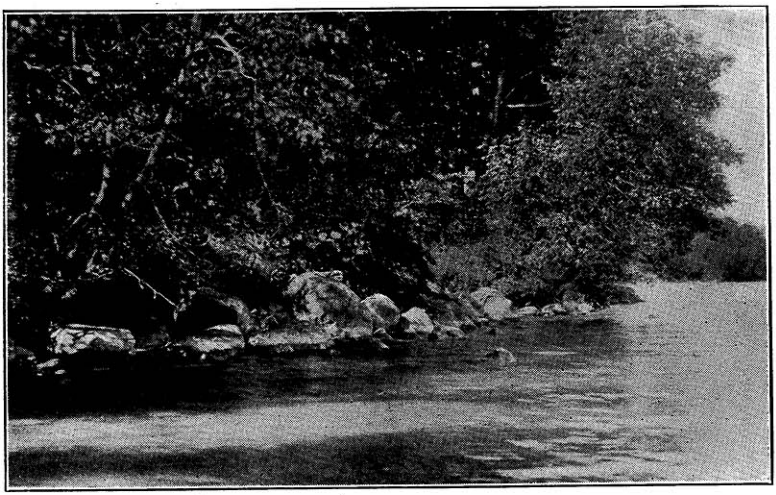

FIG. 1. A boulder-covered shore. Malcolm Bay.

FIG. 2. Precipitous shore. Near Dickinson Bay.

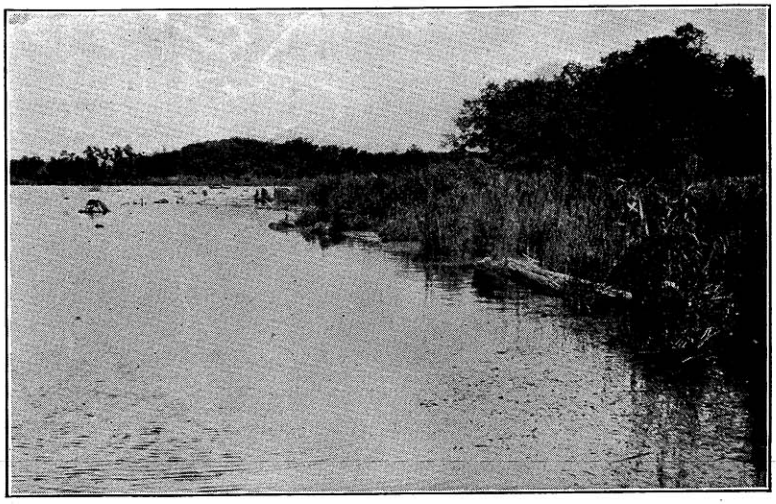

FIG. 3. Marshy shore, covered with Typha and Sagittaria. Near Silver Creek.

facts. On the other hand, vegetation is very abundant in the deeper waters, and descends to a greater depth than in Mendota.

Besides the main plant belt, consisting entirely of submerged plants, there are near the marshy shores regions well populated with emersed and floating forms, which merge gradually into the flora of the swamps themselves.

Methods

The apparatus was the same as that used on Mendota. The various stations for collecting were reached by means of a rowboat equipped with a detachable motor. An iron frame, half a meter on a side, was let down to the bottom, and all plants falling within the area thus limited were gathered. Depths up to 3 meters were reached by ordinary diving. Collections in deeper water (up to 10 meters) were made by means of a diving hood, supplied with air by a hand pump in the boat. This device permitted almost as intimate an acquaintance with submerged plants in their habitat as can be enjoyed with land plants in theirs. It was found possible to stay down from 15 to 20 minutes, and to explore a considerable portion of the lake floor. The water of Green Lake being comparatively clear and admitting a fairly bright light to these depths, this method of survey furnished an accurate idea of the kinds of plants present, the uniformity of their distribution, and the downward extent of the plant belt. It is interesting to note that the decrease in illumination is very rapid in water deeper than 8 or 9 meters. At 7 meters there is what seems to be fairly bright sunlight; at 10 meters one is almost in darkness.

A section of shore of uniform general characteristics usually has opposite to it a section of the plant belt of fairly uniform nature throughout. Stations were therefore chosen on the basis of the character of the beach, and of the shallow water flora. The number of stations that can be made in this way of course depends largely upon convenience, since in many places the flora varies greatly within a small area (for instance, in the densely populated Stations 1 and 2). The plant belt was divided into 38 stations, with 3 additional stations representing the marshy bays. This was about the smallest number which would fairly represent every type of vegetation and at the same time include the whole circumference of the lake; it would not have been possible to collect thoroughly from a larger number. The stations used are shown by number on the map (fig. 4).

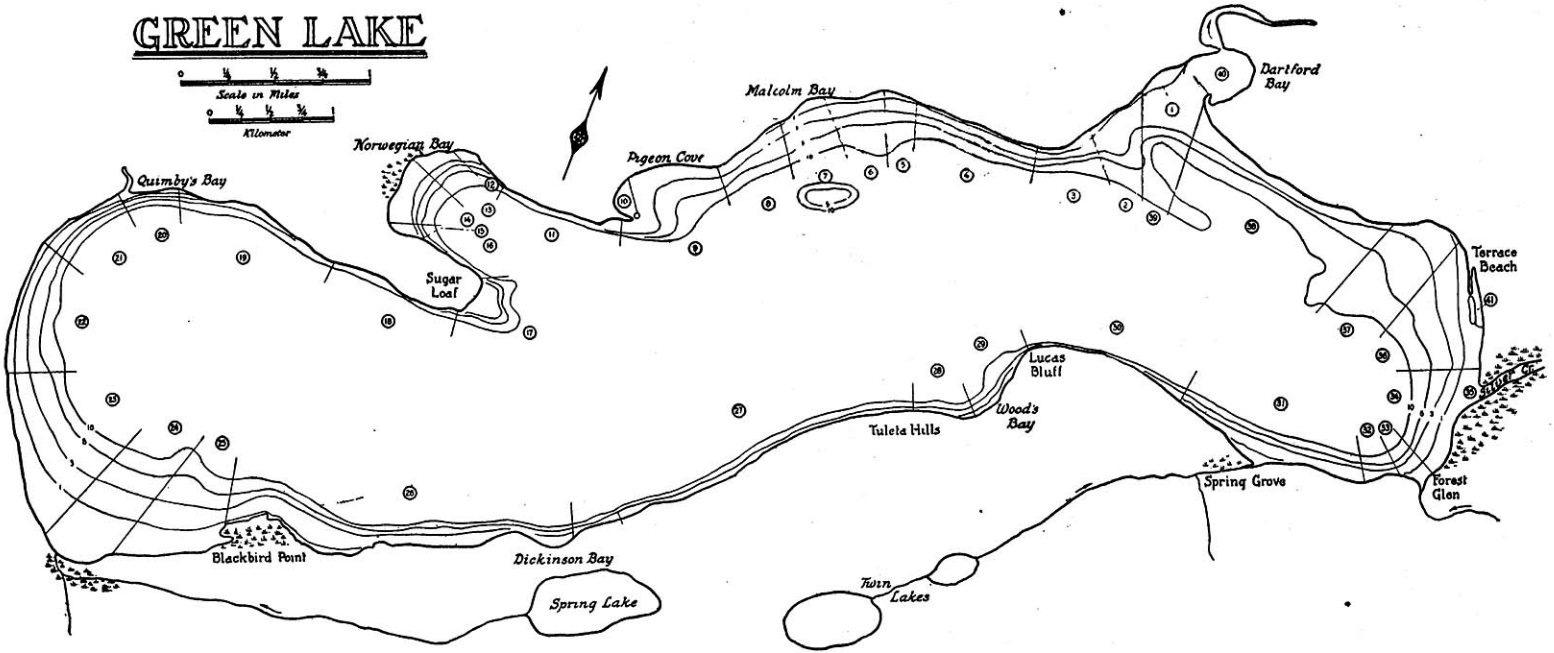

FIG. 4. Map of Green Lake showing 1, 3, 5, and 10 meter contour lines and the 41 stations from which plants were collected.

Experience with Lake Mendota profited to make the collection more systematic and more evenly distributed. An effort was made to collect from every region at the time of flowering, thus obtaining nearly the greatest weight attained by the plants, and making quantitative comparisons between different species and different localities more valuable. Plants in shallow water flower first; the time of flowering varies directly with the depth of the water. The early summer was therefore spent in collecting samples from the shallow water of the lake; then collections were made in water of medium depth; finally the deepest flora was sampled, using the diving hood. In the latter case it was not possible in the time remaining to visit all the stations; but this does not seriously impair the accuracy of the results, for the flora is more uniform in deeper water and the plant belt might here be divided into fewer stations. One station was therefore taken as representative of a group of several adjacent ones.

Because of the previous experience in this method of collecting it was possible, in spite of much stormy weather, to collect a larger number of samples than in Mendota—309 as against 221.

It soon became evident that the character of the flora varied at different depths. For convenience in handling the data, the plant belt was divided, as in Mendota, into three zones, within each of which the flora may be taken as fairly uniform, but between which there are great differences. The limits of the zones were the same as those used in Mendota, namely: Zone 1, 0–1 meter; Zone 2, 1–3 meters; Zone 3, 3 meters to the deepest limit of plant growth.

Samples were brought back to the lakeside laboratory (improvised from a boathouse), and there each was separated into its component species, the latter being numbered as sub-samples. These were weighed and spread out to dry. When air-dry, the smaller ones were dried in an oven at 60°C. for 48 hours. A few trials served to show that loss of water beyond this point was negligible.

From the wet and dry weights of a number of samples was obtained the percentage of moisture of each species. About twelve determinations were made for each species and averaged. In many cases, differences between the averages of different species were not significant, as shown by their probable errors; such species were therefore averaged together and considered as having the same percentage of moisture. Between some species, however, there were marked differences. The values for all species are shown

in table 2. It is curious that the plants of Green Lake show in all cases a slightly higher percentage of water than those of Mendota, although the method of determination was as nearly as possible the same in both cases.

The Flora

A list of the species collected is given in table 1.

Most of the genera are the same as those found in Mendota. There are more species of Potamogeton in Green Lake and a few genera not reported in Mendota. The list given does not pretend to include all of the species present in the lake; it shows only the predominating ones. Identification of rare forms was not thought to be of value in a quantitative study. Some other species may therefore be included in the quantitative data, among the ones named, with those they resemble most closely.

The dominant plant is Chara,—which in Mendota forms only a small fraction of the total vegetation. Chara grows almost everywhere in Green Lake, sometimes mixed with other plants, often forming great masses in which no other form can get a foothold.

Radicula aquatica deserves special mention. This plant was found only in two places (see table 4). It is usually described as having two kinds of leaves, the immersed ones pinnately dissected into capillary divisions, the emersed entire, serrate, or pinnatifid. In Green Lake the plant seems never to reach the surface and flowers were not observed; yet there are these two sorts of leaves, both under water (it was collected at a depth of two or three meters). The shape of the leaves would seem, therefore, not to be determined directly by the medium in which it grows. It may be conditioned by the intensity of the light.

Drepanocladus pseudo-fluitans, a moss, not collected in Mendota, grows in deep water at low temperatures, and in a few places forms immense mats or beds of close-growing stems and leaves, into which one may sink to the knees. Apparently it does not fruit in the lake, but depends wholly upon vegetative methods of reproduction.

Castalia is found in large quantities in Dartford Bay and the outlet and in the little bay behind Terrace Beach (Station 41). Nymphaea occurs at the other end of the lake, behind Blackbird Point; but in the open water of the marshes through which runs

the small stream that enters the lake here, Castalia is abundant, and there is less Nymphaea.

The marshes at the southwest corner of the lake have a rich and varied flora. Here one finds *Bidens Beckii,* various species of Typha, Sagittaria, and many others. *Sagittaria latifolia* is found mostly on land or at the water's edge; *S. heterophylla,* with its long lance-shaped leaves easily mistaken for those of a Carex, grows half submerged in shallow water. There is a Carex growing in a similar situation, both here and in several other places; in its young stages it may be mistaken for Vallisneria.

All the swampy or boggy parts of the shore are fronted by bars some distance out from shore. These bars have the usual shallow water flora and in addition large patches of Scirpus, of which several species were observed.

The attached algae form a smaller percentage of the total yield of the lake than they do in Mendota, owing chiefly to the comparatively small quantity of Cladophora. This plant, when present, is found on rocks at the water's edge, or only a few inches beneath the surface. In many places it is replaced by a thin fringe of Oedogonium. In some of the muddier stations (for example, Stations 32 and 33), there are quantities of Spirogyra, attached both to the mud and to rocks. The blue-greens, of which Nostoc and Rivularia were collected, are attached to the rocks near the shore and to the stems and leaves of many of the other plants, especially to the species of Potamogeton. *Vaucheria tuberosa* was found in one place (Station 37) in fairly deep water,—6.5 meters, averaging as high as 200 grams per square meter (wet weight) over a small area. It has been described as growing in a similar location in Lake George, N. Y., by Miss E. Moore (1).

As already indicated, the plant belt extends down to 8 meters beneath the surface, much deeper than that of Mendota. This is probably due largely to the greater transparency of the water. At the water's edge, there is, in all except the marshy places, a zone of rocks almost barren of plants. In Mendota, where a similar rocky beach exists, it is almost always densely covered with Cladophora. In Green Lake there are occasional patches of Cladophora, frequently a thin strip of Oedogonium, and here and there isolated plants of Myriophyllum arising from between the rocks. Outside of the border of rocks there is sometimes a thin strip of mud or sand bearing small, scattered plants, usually Chara, Naias, and Hetheranthera. Here the water is about 1 meter in depth and this

is the limit of Zone 1. From this point the bottom falls away more or less gently to about 6 meters, the flora passing from that included in Zone 2 to that characteristic of deeper water. At about 6 meters the slope usually becomes much steeper and the outer strip of vegetation hangs, as it were, to the brow of a hill. The plants often cease quite sharply at 8 meters, as if an invisible boundary were holding them in check; on one side they rise two or three meters high, and packed closely together; on the other side there is nothing but the smooth mud sloping away towards the bottom of the lake.

In many places, however, the slope continues gentle to a much greater depth; in these cases the vegetation does not come to a sudden end, but thins out gradually down an imperceptible slope. In one such station (25) plants were found growing at a depth of 10 meters, though small and stunted in growth. Such gently sloping places are found around the entire west end of the lake, opposite Woods Bay, at Forest Glen, and thence up to Dartford Bay. In the west end of the lake and in parts of the east end, this gentle slope occurs in connection with wide sandy beaches. Figures 5 and 6 show the difference between these two sorts of stations.

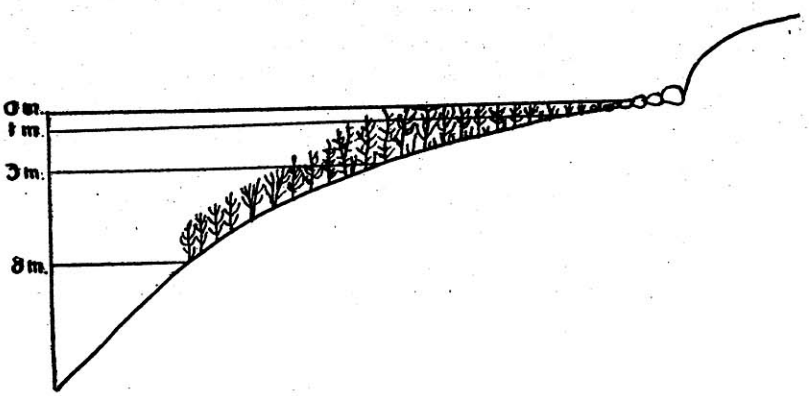

FIG. 5. Diagram of portion of lake floor bearing attached plants. Medium slope.

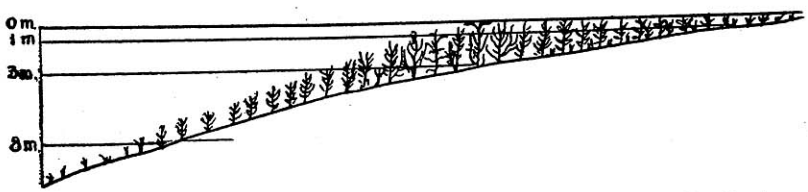

FIG 6. Diagram of portion of lake floor bearing attached plants. Gentle slope.

In a few stations there is no flattening out from 1 to 6 meters, but the bottom drops steeply beneath the water (Stations 16 and 30). In these cases the vegetation extends only to 4 or 5 meters beneath the surface. This condition is represented in figure 7.

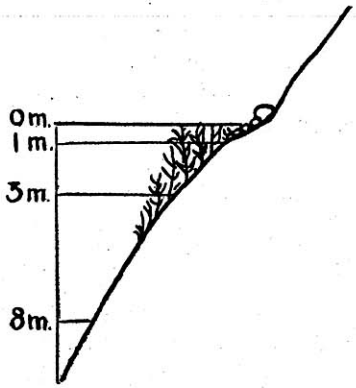

FIG. 7. Diagram of portion of lake floor bearing attached plants. Steep slope.

There is a certain degree of correspondence between the type of shore, the slope of the lake floor, and the vegetation. The type of slope represented in figure 5 is the most common, and is found opposite rocky shores of all sorts, such as those shown in figures 1 and 2. The steeper the shore, the steeper the slope of the bottom. The second kind of slope (figure 6) corresponds to low shores, either marshy or sandy (figure 3). The last type (figure 7) is found only opposite high land, such as Lucas Bluff and Sugar Loaf.

In Mendota it was found that there are well-defined patches of sand in various places, running into fairly deep water; and that some species were more or less limited to a sandy substrate, others to a muddy one. No such differentiation exists in Green Lake. The type of bottom is fairly uniform; it consists of a fine mud mixed with marl in deep water and with a small amount of sand in shallow water. The most important difference between stations is the presence or absence of rocks. Yet there is great regional variation in the vegetation, and although this cannot be correlated with any visible soil difference, it is probable that chemical analysis of soil from different places would tell a different story. In the few places where there are distinct sandy beaches, such as are more common in Mendota, these are not nearly so well covered with

plants as in the latter lake, nor, indeed, so well as are the muddier parts of Green Lake; nor do they display any species which do better there than on mud. The comparative scantiness of their vegetation may perhaps be explained by the violence of the waves in this lake; but it is interesting that species, such as *Potamogeton Richardsonii* and *P. pectinatus,* which grow decidedly better on sand in Mendota, attain their greatest development in Green Lake elsewhere than on these few sandy places.

Calculations

The data obtained by weighing the plants were treated in much the same way as in the case of Lake Mendota. The original weights obtained were reduced to common terms—grams per square meter —for each sample and all the samples in each zone of each station averaged together. The results are shown in tables 3, 4, and 5. The values for all the stations of each zone were then averaged, to give the weight per square meter of each species for each zone. Since the stations were of greatly differing sizes, it was judged best not to give them all the same weight in the average. One of the smallest stations was selected as a unit, and the other stations expressed in terms of this. The average weights in each station were multiplied by a factor for the station, its area in terms of the unit station, and the resulting figures averaged together, using the sum of all the factors as a divisor. The dimensions of the stations were obtained by measurement on the map. In Zone 1, for instance, the area of Station 23 was found to be 9, that of Station 36 was 6, Station 1 being the unit. The results of these calculations are given in table 6.

There were several plants that did not form part of the main plant belt, being found in scattered patches, and yet were present in considerable quantities. Such were Scirpus, Carex, Castalia, Nymphaea, and Cladophora. Of the first four of these, samples were collected in the usual way; the area of the particular spot sampled was estimated, in most cases by rowing around it and expressing it in terms of boat-lengths. From these data total weights were obtained directly. The same method was used for Cladophora in some cases, where there were large patches. In most cases, the fringe of Cladophora being thin, all of the growth for a certain distance was cleaned off, and measurement made of the length (instead of the area) of the strip or station from which

the sample came. The sample was converted to grams per meter, and this value multiplied by the length of the strip to give the total weight. The details of the data on these scattered plants are presented in table 7.

The areas of the different zones were measured on the map by means of a planimeter; these figures being checked up with data obtained by the Survey at other times. By multiplying the average weights of species (table 6) by the appropriate area, the total weight of each species in each zone was determined. These figures, together with those for the scattered plants (table 7) are shown in tables 8, 9, and 10. Total weights of the species for the whole lake flora were obtained by adding together the values for the three zones. These are given in table 11. In each case the total weight of a species is expressed also as a percentage of the total weight of all plants in the zone under consideration.

From tables 8, 9, and 10, table 12 was prepared. It shows the relative amounts of each species found at each depth, expressed as a percentage of the total weight of the species.

Table 13 summarizes the results shown in tables 6 and 11 and shows the average yield for each zone and for the lake as a whole, expressed in various units. The averages for the separate zones are the same as those in table 6, and hence disregard the weights of the scattered plants. The latter, however, are included in the average for the lake as a whole.

Quantitative Results

The 309 samples, when divided into their species, gave 1,380 subsamples. This is an average of 4.5 species per sample,—which is nearly equivalent to 4.5 species per square meter. The corresponding value in Lake Mendota is only 3.5. Samples containing as many as twelve species were not uncommon in Green Lake, but a large number consisted of only one or two species.

The average yield of Green Lake is much smaller than that found for Mendota. Whether this would hold all seasons is, of course, unknown. The area of the plant zone is also less than that of Mendota, the total yield being, therefore, very much smaller in Green Lake.

The greatest difference between the two lakes is in the shallow water flora. In Green Lake Zone 1 is only a little more than one-third the area of that in Mendota. Its yield per unit area is less than one-third. The total yield is, therefore, very much less.

Zone 2 is of approximately the same size in both lakes, but has a considerably higher yield in Mendota. Zone 3, on the other hand, is slightly larger in Green Lake, and considerably more productive. Putting the facts in a different way, in Green Lake, about 9 per cent of the vegetation is in water less than 1 meter deep, about 40 per cent between 1 and 3 meters, and more than 50 per cent between 3 and 8 meters (table 12); whereas in Mendota 30 per cent is found in the shallowest water, 45 per cent between 1 and 3 meters, and only 25 per cent in water deeper than 3 meters.

About one-half of the entire vegetation (dry weight) is composed of Chara (table 11). In shallow water (table 3), this is everywhere fairly abundant except at the east end of the lake where the bottom is muddy (in the other swampy places there seems to be more sand mixed with the mud). It is most frequently associated with *Potamogeton heterophyllus* and small amounts of Naias; often it is mixed also with *P. pectinatus,* Heteranthera, and Vallisneria. In Zones 2 and 3 (tables 4 and 5), the distribution of Chara is about the same as in Zone 1, but it is usually mixed with most of the other species. Where it occurs unmixed, it is present in very great abundance. One sample of Chara, gathered from 0.25 square meter, weighed 2,700 grams (wet).

The various species of Potamogeton form about 20 per cent of the total flora. Potamogeton occurs abundantly in shallow water only in a few stations of different characteristics. In Zone 2, however, it thrives everywhere except for a few stations along the north and west shores. Restriction of Potamogeton in these places may be due to greater wave action. The shores here are of the type shown in fig. 1. In the northwest corner of the lake, Potamogeton is for some reason almost entirely replaced by Drepanocladus, here present in great quantity. In the deepest zone, species of Potamogeton are not abundant, except *P. zosterifolius.*

Ceratophyllum and Myriophyllum rank next in importance, each forming about 10 per cent of the vegetation. The former is found in abundance only in Zone 3, and is there universal. The distribution of Myriophyllum is similar, but its range is slightly shallower; it is found more commonly than Ceratophyllum in Zone 2 and does not extend down quite so far as the latter plant (table 12). A visit to the bottom 7 or 8 meters below the surface reveals a forest of almost pure Ceratophyllum; whereas at 5 or 6 meters, while the general appearance of things is the same, the vegetation is about half Myriophyllum.

Potamogeton pectinatus also forms about 10 per cent of the total weight of plants. It is distributed unevenly, but is locally very abundant. Elodea, Vallisneria, Drepanocladus, Scirpus, and *Potamogeton zosterifolius* each form between 2 and 10 per cent and all other species less than 2 per cent each.

In Mendota the situation is entirely different. Chara forms a negligible fraction of the vegetation. Vallisneria almost takes its place, composing about one-third of all the plants. Several species of Potamogeton bulk large,—*P. amplifolius* about 25 per cent, *P. Richardsonii* 10 per cent, *P. pectinatus* 8 per cent. Taken together the species of Potamogeton total about 50 per cent. Myriophyllum forms only 4 per cent of the total and Ceratophyllum still less.

It has been remarked already that both Myriophyllum and Ceratophyllum are deep water plants, as far as Green Lake is concerned; this may explain their relative scarcity in Mendota, where the whole deep flora is so much less luxuriant. The other differences, however, must be attributed to various factors. Temperature may perhaps hold down the Vallisneria in Green Lake, wave action the shallow water Potamogetons, and soil differences perhaps account for the immense development of Chara.

The distribution of species according to depth is well marked in some cases, in others less so. The cases of Ceratophyllum and Myriophyllum have been dealt with already. In Mendota the greater part of these plants is found in Zone 2. Vallisneria reaches its greatest abundance in Zone 2 in both lakes, but is hardly found in Zone 3 in Green Lake, while in Mendota about 25 per cent of it is found in deep water. Ranunculus reaches deeper water in Green Lake, half of it being found in Zone 2, and one-fourth in Zone 3; in Mendota it is confined to Zone 1. The same is true of Chara, which is nearly evenly distributed between Zones 2 and 3 in Green Lake, and between Zones 1 and 2 in Mendota. *Potamogeton amplifolius* and *P. zosterifolius* are similarly distributed in both lakes; but *P. Richardsonii* and *P. pectinatus* are found mostly in deeper water in Green Lake, while in Mendota their greatest growth occurs in Zone 1.

The final averages and totals of course conceal a great deal of regional variation. The varying characters of different stations may be seen in tables 3, 4, and 5, which present the stations separately. Two general kinds of stations may be distinguished. In one the vegetation is not very rich and is composed mostly of

Chara, with small amounts of *Potamogeton heterophyllus,* Naias, and Vallisneria; the other contains great quantities of the larger Potamogetons, often in addition to large amounts of Chara. The shallow water is most often of the first type. The deeper water is of the latter sort, grading out into almost pure Ceratophyllum and Myriophyllum. The medium depths vary the most. The species of Potamogeton often grow in great abundance mixed with Chara, Ranunculus, and others. Chara, as already mentioned, frequently grows alone in large patches. Drepanocladus also, in the few places where it attains abundance, grows in large patches almost unmixed with other plants, except that scattered stems of Myriophyllum are often found arising from it. There are in several stations absolutely barren patches irregularly distributed amidst luxuriant vegetation.

In some places samples of great weight were obtained. The largest came from Station 21, and yielded 2,700 grams (wet) from 0.25 square meter. There were several others almost as big. They were composed for the most part of Chara. There is, as far as I know, no single spot in Lake Mendota which yields as much as this. The smallest sample collected weighed 30 grams (wet) from 0.5 square meter. Most of the samples weighed about 200 to 300 grams (wet) from 0.25 square meter. In Mendota the general average was somewhat higher.

General Discussion

Aside from its presentation of the quantitative data, this paper cannot do much more than suggest the ecological problems that await the botanist in this field. Pearsall (2) has attacked similar questions in the English lakes and in an excellent paper presents important evidence on the nature of the environmental factors that affect submerged vegetation. He considers that light is important only insofar as it limits the downward extension of the flora and that temperature has little effect in determining the kind of vegetation, at least within the limits found in one lake. Most of the variation in the kind of vegetation proves to be connected with soil differences, which often correspond to differences in their physical characteristics.

Nothing has as yet been done on Wisconsin lakes which is comparable to Pearsalls correlation of soil composition and type of vegetation. With regard to the other factors, light and tempera-

ture, there are abundant records from many Wisconsin lakes, which have been made available to me by Professor Juday. A brief comparison of Green Lake and Lake Mendota serves to bring out several interesting points.

The degree of transparency of the water was measured by means of a white disc, 10 centimeters in diameter, which was lowered into the water until it disappeared from view; the depth at which this occurred being recorded. This depth in Green Lake varied from 2.75 to 6.25 meters, the average being about 4.25 meters, during June, July and August. In Mendota, the range during the same months of the same year was from 1.75 to 3.8 meters, the average about 2.25 meters. When these figures are compared with the downward limits of the plants in the two lakes, it is evident that they confirm Pearsall's statement that light is a limiting factor in this respect; and, further, make it probable that it is the chief limiting factor.

Pearsall also showed, by an iodine method of measuring the light intensity, that plants grew in as little as 2 per cent of the light of the surface, but not in less. According to some figures kindly supplied me by Dr. E. A. Birge, the light intensity in Green Lake is reduced to 1 per cent of that at the surface at a depth of about 8 meters. The same light intensity in Mendota is found at a depth of about 4 meters. These depths correspond approximately with the limits of the plant zone in each case. Birge's determinations were made in an entirely different way from those of Pearsall, which may partially account for the discrepancy between the two sets of results.

With regard to temperature, table 14 shows the differences between Green Lake and Lake Mendota. The figures are averages of readings taken through June, July, and August. These differences in temperature evidently are not large enough to limit the plant zone, since plants grow in Green Lake in water 6°C. cooler than that at which they cease in Mendota; the temperatures at corresponding depths are also lower in Green Lake. It seems that the lower temperatures of Green Lake may partly account for the smaller productivity of its bottom by retarding the growth of plants to a slight extent.

The effect of low temperatures and low light intensity in retarding growth is illustrated by the reduced stature of plants in deep water. Most submerged plants flower at or near the surface. This is especially true of such plants as Potamogeton, Vallisneria, and

Ranunculus. Teleologically speaking, the plants in the deepest water should grow the tallest so as to obtain more light for the manufacture of food and for the formation of flowers and fruits. An "adaptation" to this effect has, however, not been provided by Nature. Plants growing 7 or 8 meters below the surface reach heights of 1 or 2 meters, those in deeper water still less; while those which are but 3 or 4 meters deep frequently reach the surface. These conditions are illustrated in figures 5 and 6.

Another interesting point in this connection is that in Green Lake many instances were observed of plants flowering before they reached the surface, even when they were growing in fairly shallow water. In Mendota this was not noticed, and indeed some of the larger plants grew 5 or 6 meters to the surface before they flowered. These facts suggest that there is a minimal light intensity for the production of flowers, which is of course realized further beneath the surface in Green Lake than in Mendota; so that in the latter lake some plants remain vegetatively active for a longer period and finally grow to reach the surface, in spite of the retarding effects of low temperature and low light intensity. Different plants probably vary in this respect. The whole argument does not, of course, concern such plants as Ceratophyllum, which regularly produces flowers under water.

LITERATURE CITED

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3. **Rickett, H. W.** A quantitative study of the larger aquatic plants of Lake Mendota. Trans. Wis. Acad. Sci., Arts, and Let. **20**: 501–527. 1922.

TABLE 1. *List of plants collected.*

Submerged plants, forming main plant belt.

1. Ceratophyllum demersum L.
2. Chara sp.
3. Drepanocladus.
4. Elodea canadensis Michx.
5. Myriophyllum verticillatum L. var. pectinatum Wallbr.
6. Naias flexilis (Willd.) Rostk. & Schmidt.
7. Potamogeton amplifolius Tuckerm.
8. " foliosus Raf.
9. " heterophyllus Schreb.

10. " natans L.
11. " pectinatus L.
12. " Richardsonii (Benn.) Rydb.
13. " zosterifolius Schumacher.
14. Radicula aquatica (Eat.) Robinson.
15. Ranunculus aquatilis L. var. capillaceus DC.
16. Vallisneria spiralis L.
17. Heteranthera dubia (Jacq.) MacM.

Emersed or floating plants, growing in scattered patches.

18. Bidens Beckii Torr.
19. Carex sp.
20. Castalia odorata (Ait.) Woodville & Wood.
21. Lemna trisulca L.
22. Nymphaea advena Ait.
23. Sagittaria heterophylla Pursh.
24. " latifolia Willd.
25. Scirpus spp.
26. Typha sp.
27. Zizania aquatica L.

Attached algae.

28. Cladophora sp.
29. Nostoc sp.
30. Oedogonium sp.
31. Rivularia sp.
32. Spirogyra sp.
33. Vaucheria tuberosa.

TABLE 2. *Percentage of water in plants.*

Species	Per Cent of Water
Ceratophyllum	92.9
Chara	84.9
Drepanocladus	81.1
Elodea	92.9
Myriophyllum	90.2
Naias	90.2
Potamogeton (all spp.)	88.1
Ranunculus	88.6
Vallisneria	92.9
Heteranthera	90.2
Scirpus	88.6
Cladophora	89.2
Average	89.2

TABLE 3. *Yield by stations, Zone 1, stated in grams per square meter.*

Species are designated by number according to their places in table 1. The upper line opposite each species show wet weights, the lower one dry weights; X indicates a trace.

	STATIONS										
Species:	1	3	5	7	9	12	13	14	15	18	20
1	55.0 3.8	.....	.....	.....	.....	.....	.....	x	.....	.....	.....
2	167.0 25.3	228.0 31.0	40.0 6.0	220.0 33.2	407.0 61.3	1240.0 187.2	15.0 2.3	704.0 106.3	105.0 15.8	....	80.0 12.0
4	....	.....	.....	x	.....	.....	.....	.....	.....	.....	.....
5	13.0 1.2	x	.....	.....	.....	.....	.....	.....	.....	9.0 0.9	.....
6	x	x	.....	x	25.0 2.8	x	.....	10.0 1.2	5.0 0.5	24.0 2.4	.....
7	383.0 46.7	13.0 2.5	.....	.....	.....	.....	.....	120.0 15.7	.....	.....	.....
8	x	.....	.....	.....	.....	.....	.....	.....	.....	120.0 12.6	.....
9	5.0 0.6	227.0 26.9	.....	160.0 19.2	93.0 11.1	60.0 7.2	.....	18.0 2.1	x	.....	95.0 10.4
10	23.0 3.4	.....	.....	.....	.....	.....	.....	20.0 2.1	170.0 22.4	.....	.....
11	120.0 14.3	53.0 6.3	.....	20.0 2.4	.....	.....	300.0 35.6	220.0 26.2	x	.....	10.0 1.2
12	8.0 0.9	267.0 31.7	.....	.....	.....	.....	.....	48.0 5.8	.....	.....	.....
13	13.0 1.5	7.0 0.8	.....	.....	.....	.....	.....	12.0 1.4	.....	.....	.....
15	390.0 47.0	.....	.....	.....	.....	.....	.....	x	.....	.....	.....
16	58.0 4.1	.....	.....	100.0 7.2	6.0 0.4	.....	.....	28.0 2.0	.....	.....	95.0 6.7
17	75.0 12.8	.....	160.0 19.2	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3—Continued

Species	Stations											
	22	23	24	25	28	30	31	33	35	36	39	41
1									50.0			987.0
									3.6			70.0
2	200.0	358.0	153.0	54.0	315.0	x				160.0	260.0	
	20.9	54.0	23.1	7.8	48.4					34.0	39.2	
	60.1											
4												x
5			23.0									193.0
			2.0									18.9
6	x	x	3.0	x	10.0	20.0			14.0		x	x
		x	0.3		1.0	2.0			1.4			
7												240.0
												28.5
8					x				x			
9	20.0	131.0	123.0	18.0	150.0						370.0	
	2.4	15.6	17.2	2.1	17.8						48.4	
10			53.0		35.0							293.0
			6.4		2.8							34.7
11	13.0	49.0	37.0		70.0				400.0	80.0		133.0
	1.5	5.8	4.4		8.4				67.2	9.6		15.9
12		26.0			10.0							
		3.6			1.2							
13												493.0
												61.6
15			50.0									x
			4.7									
16		28.0	237.0		65.0				310.0			
		2.0	16.8		4.5				28.2			
17			30.0		245.0	220.0	100.0	200.0	20.0			
			2.9		24.6	16.0	9.0	18.1	2.0			

TABLE 4. *Yield by stations, Zone 2, stated in grams per square meter. For explanation see heading of table 3.*

	Stations										
Species:	2	3	4	5	6	7	8	9	10	11	12
1.....	625.0 44.4	20.0 1.5	10.0 0.7	100.0 6.6	....	493.0 35.0	....	....	....	x	20.0 1.5
2.....	50.0 8.6	193.0 29.2	330.0 49.8	140.0 21.2	3980.0 601.0	107.0 18.6	1800.0 274.8	4100.0 619.0	310.0 44.7	540.0 81.6	4387.0 662.3
3.....	....	....	....	20.0 3.8	....	....	....	....	....	....	....
4.....	85.0 5.9	x	x	20.0 1.4	100.0 7.0	x	....	....	....	....	200.0 23.9
5.....	800.0 78.4	100.0 9.5	....	....	....	93.0 9.1	....	....	....	....	x .....
6.....	10.0 1.0	280.0 30.0	60.0 5.8	120.0 11.6	90.0 8.8	40.0 3.8	x	6.0 0.6	5.0 0.5	60.0 6.0	x .....
7.....	280.0 29.3	....	....	250.0 22.4	....	170.0 29.2	....	....	20.0 2.4	....	....
8.....	40.0 4.8	x	....	x	....	x	....	....	x	x	....
9.....	x	233.0 18.0	145.0 17.3	x	10.0 1.2	3.0 0.4	....	20.0 2.4	80.0 9.5	....	7.0 0.7
10.....	70.0 10.2	....	....	170.0 20.2	....	17.0 2.0	....	....	175.0 20.8	....	40.0 5.1
11.....	55.0 6.6	37.0 4.5	....	700.0 83.2	70.0 8.4	150.0 17.8	....	....	5.0 0.5	60.0 7.2	133.0 16.5
12.....	150.0 16.6	67.0 8.0	....	....	....	153.0 18.1	....	....	55.0 8.0	....	....
13.....	120.0 15.8	x	x	150.0 16.4	....	247.0 29.4	....	....	....	x	167.0 19.9
14.....	180.0 18.0	....	....	....	....	....	....	....	....	....	....
15.....	x	7.0 0.8	....	20.0 2.2	x	100.0 9.0	....	....	10.0 1.1	....	100.0 10.5
16.....	250.0 17.7	7.30 7.1	60.0 5.7	190.0 13.4	....	40.0 2.8	....	....	x	....	....
17.....	....	....	....	....	120.0 11.8	3.0 0.3	....	....	75.0 7.3	....	....

TABLE 4—Continued

Species:	Stations										
	13	14	15	16	17	18	19	20	21	22	23
1.....	7.0 0.5	23.0 1.7	.....	.....	23.0 1.7	.....	.....	.....	.....	.....	x .....
2.....	83.0 12.6	2175.0 326.5	.....	980.0 148.0	1066.0 209.2	520.0 78.4	967.0 145.9	890.0 134.2	1564.0 235.0	1107.0 167.2	400.0 60.4
3.....	27.0 5.1	x	.....	.....	x	.....	x	1400.0 260.2	460.0 89.4	547.0 89.6	....
4.....	....	9.0 0.7	.....	.....	....	.....	.....	.....	x	.....	13.0 0.9
5.....	23.0 2.3	884.0 78.1	x	x	44.0 4.4	.....	.....	650.0 63.8	20.0 2.0	x	x .....
6.....	13.0 1.3	2.0 0.2	150.0 12.2	8.0 0.8	13.0 1.3	.....	60.0 5.9	.....	72.0 7.2	x	4.0 0.4
7.....	137.0 16.3	.....	.....	.....	60.0 7.1	.....	.....	.....	.....	.....	....
8.....	x	x	80.0 4.6	.....	3.0 0.4	.....	.....	.....	20.0 3.3	.....	x .....
9.....	5.0 0.5	90.0 8.7	.....	.....	x	.....	53.0 6.1	.....	60.0 8.2	x	87.0 8.4
10.....	13.0 1.6	20.0 2.7	.....	.....	17.0 2.0	.....	.....	.....	.....	.....	13.0 1.6
11.....	1433.0 170.5	250.0 29.7	650.0 77.4	.....	417.0 49.6	.....	53.0 6.4	.....	12.0 1.4	.....	733.0 87.2
12.....	30.0 6.3	30.0 6.6	200.0 22.4	.....	47.0 5.5	.....	53.0 6.4	.....	x	.....	....
13. ...	33.0 4.0	58.0 7.8	150.0 15.8	.....	198.0 23.5	.....	.....	.....	4.0 0.5	.....	7.0 0.8
14.....	....	.....	.....	.....	....	.....	.....	.....	.....	.....	....
15.....	x	x	.....	.....	x	.....	40.0 4.8	.....	12.0 1.8	.....	....
16.....	110.0 7.7	.....	1160.0 58.8	.....	467.0 32.9	.....	7.0 0.4	.....	20.0 1.4	.....	13.0 0.9
17.....	....	.....	.....	.....	....	20.0 2.0	.....	.....	.....	.....	....

TABLE 4—Continued

Species:	Stations										
	24	25	26	27	28	29	30	31	32	33	34
1.....	2.0 0.2	4.0 0.2	180.0 12.7	5.0 0.3	73.0 5.2	....	63.0 4.4	380.0 27.4	240.0 17.2	117.0 9.4	....
2.....	163.0 24.5	844.0 127.4	205.0 31.0	183.0 27.5	673.0 130.4	840.0 126.8	420.0 63.2	20.0 3.1	320.0 48.4	29.0 4.3	37.0 5.5
3.....	....	....	....	....	....	....	....	....	....	....	....
4.....	....	....	25.0 3.3	....	....	....	....	....	....	x	....
5.....	8.0 0.8	x	950.0 93.1	....	13.0 1.3	....	90.0 8.9	x	80.0 8.0	29.0 2.8	....
8.....	5.0 0.5	6.0 0.6	15.0 1.5	38.0 3.7	27.0 2.7	20.0 2.0	83.0 7.9	20.0 2.0	20.0 2.0	23.0 2.2	x .....
7.....	....	4.0 0.5	40.0 4.8	....	40.0 5.6	....	20.0 2.3	x	....	26.0 2.5	....
8.....	....	....	x	x	67.0 8.0	....	115.0 14.1	187.0 22.3	x	14.0 1.7	....
9.....	125.0 15.3	8.0 0.9	....	30.0 4.6	100.0 14.8	100.0 12.0	70.0 9.8	....	....	60.0 7.1	12.0 1.4
10.....	13.0 1.5	36.0 4.2	....	....	380.0 55.3	....	70.0 8.4	27.0 2.8	....	11.0 1.3	....
11.....	98.0 11.2	4.0 0.5	160.0 19.0	55.0 6.5	407.0 48.4	....	20.0 2.4	20.0 2.4	x	220.0 15.2	....
12.....	70.0 8.4	....	....	300.0 35.7	80.0 9.6	....	33.0 4.5	247.0 29.3	....	6.0 0.7	....
13.....	3.0 0.3	....	8.0 1.0	....	134.0 14.9	....	95.0 11.3	67.0 11.3	....	94.0 11.2	....
14.....	....	....	....	....	....	....	....	....	....	....	....
15.....	....	26.0 3.0	....	8.0 0.9	13.0 1.5	....	75.0 7.8	100.0 8.9	x	31.0 3.6	....
16.....	85.0 3.6	88.0 6.2	....	13.0 0.9	60.0 4.3	....	80.0 5.7	247.0 17.2	....	66.0 4.1	x .....
17.....	....	....	....	90.0 8.8	27.0 2.7	....	183.0 17.9	287.0 30.1	220.0 21.6	283.0 24.2	....

TABLE 4—Continued

Species:	Stations				
	36	37	38	39	40
1	10.0 0.7	76.0 5.3	....	724.0 50.9	270.0 18.4
2	298.0 44.9	140.0 21.1	237.0 35.7	1844.0 322.9	x .....
3	....	....	....	....	....
4	....	8.0 0.5	....	118.0 9.3	....
5	5.0 0.5	260.0 23.7	....	311.0 30.4	117.0 11.4
6	x	60.0 5.9	5.0 0.5	9.0 0.6	3.3 0.3
7	....	40.0 4.8	....	16.0 1.9	430.0 51.2
8	....	120.0 14.3	....	9.0 1.1	7.0 0.8
9	15.8 1.8	12.0 1.4	12.0 1.5	49.0 6.0	....
10	....	12.0 1.4	....	44.0 5.3	203.0 21.0
11	8.0 0.9	x	....	138.0 16.7	387.0 46.9
12	....	8.0 1.0	....	33.0 5.0	23.0 2.8
13	....	300.0 35.7	....	209.0 24.9	230.0 27.7
14	....	....	....	....	....
15	....	....	....	27.0 3.0	x .....
16	3.0 0.2	468.0 33.2	....	49.0 3.5	2083.0 145.0
17	x	24.0 2.4	....	x	143.0 14.1

TABLE 5. *Yield by stations, Zone 3, stated in grams per square meter. For explanation see heading of table 3.*

	Stations									
Species:	2	4	7	9	11	13	14	17	18	21
1.....	1067.0 62.7	215.0 15.2	1749.0 124.1	647.0 46.0	1120.0 79.5	2933.0 208.3	2743.0 186.1	353.0 29.8	4.0 0.3	333.0 23.6
2.....	7.0 0.9	1372.0 198.1	1163.0 175.5	1400.0 211.9	160.0 24.2	....	....	1585.0 248.4	253.0 38.1	3600.0 543.6
3.....	....	....	....	....	....	....	....	141.0 20.8	13.0 2.5	....
4.....	347.0 24.7	233.0 16.5	240.0 18.4	107.0 5.3	275.0 21.1	x	....	220.0 15.6	40.0 2.8	353.0 22.5
5.....	253.0 18.8	7.0 0.7	183.0 17.9	197.0 18.7	990.0 97.1	1600.0 156.8	1318.0 128.7	13.0 1.3	27.0 2.7	447.0 43.7
6.....	....	x	6.0 0.6	17.0 1.6	x	....	....	....	x	....
7.....	....	....	....	....	....	....	....	....	87.0 8.0	....
8.....	x	x	63.0 7.5	....	x	....	....	....	....	....
9.....	....	....	....	....	....	....	....	....	....	....
10.....	....	....	....	....	....	....	....	....	....	....
11.....	....	....	....	x	x	....	....	140.0 15.4	....	....
12.....	....	....	....	....	....	....	....	....	....	....
13.	46.0 5.6	53.0 5.2	x	500.0 52.3	x	67.0 8.5	53.0 6.4	....	x	40.0 4.4
15.....	....	....	....	....	20.0 2.2	....	x	....	9.0 1.1	x .....
16.....	....	....	....	....	....	....	....	....	....	....
17.	....	....	....	....	....	....	....	....	....	....

TABLE 5—Continued

	Stations									
Species:	23	25	26	27	28	29	31	33	34	36
1.....	188.0 13.5	16.0 1.1	180.0 12.7	313.0 22.3	35.0 2.5	193.0 13.7	1490.0 105.7	1093.0 77.6	460.0 32.8	113.0 7.9
2.....	792.0 119.5	995.0 151.2	205.0 31.0	13.0 2.0	x	47.0 7.2	....	....	....	160.0 23.8
3.....	64.0 14.6	....	....	....	....	....	....	....	....	....
4.....	44.0 3.1	115.0 10.5	25.0 3.3	607.0 43.2	x	....	55.0 3.9	....	....	18.0 1.3
5.....	156.0 17.7	....	950.0 93.1	47.0 5.3	484.0 57.1	220.0 31.6	1380.0 134.7	x	....	18.0 1.7
6.....	....	10.0 1.0	15.0 1.5	7.0 0.7	71.0 6.9	27.0 2.7	x	....	....	x .....
7.....	....	....	40.0 4.8	73.0 7.9	60.0 7.1	....	10.0 1.2	45.0 7.9	340.0 40.4	....
8.....	x	....	x	x	65.0 7.3	4.0 0.5	x	....	....	20.0 2.4
9.....	....	....	....	60.0 5.6	....	....	....	....	....	....
10.....	....	....	....	....	....	....	70.0 8.3	....	....	....
11.....	616.0 73.3	....	160.0 19.0	333.0 29.7	145.0 17.2	....	236.0 26.2	x	....	288.0 34.2
12.....	....	....	....	27.0 2.4	15.0 1.3	....	....	....	....	....
13.....	12.0 1.4	20.0 2.4	8.0 1.0	47.0 5.6	74.0 8.9	354.0 44.4	103.0 12.3	1000.0 118.8	60.0 7.2	5.0 0.6
15.....	4.0 0.5	....	....	40.0 4.5	140.0 15.3	....	x	....	....	....
16.....	....	....	....	....	10.0 0.7	x	....	....	....	....
17.....	....	....	....	x	465.0 45.8	53.0 4.7	....	....	....	....

TABLE 5—Continued

	Stations		
Species:	37	38	39
1	20.0 1.5	x	2460.0 174.7
2	67.0 10.0	10.0 1.2	....
3	53.0 10.4	....	....
4	7.0 0.4	....	513.0 34.8
5	x	....	587.0 56.8
6	40.0 3.9	20.0 2.0	....
7	....	....	....
8	153.0 14.9	x	x .....
9	....	x	....
10	....	....	....
11	53.0 6.4	370.0 48.8	....
12	....	....	....
13	40.0 5.7	....	60.0 8.5
15	7.0 0.8	....	47.0 5.3
16	....	....	....
17	....	....	....

TABLE 6. *Average weights of species, stated in grams per square meter. (From tables 3, 4, and 5.)*

Species	Zone 1		Zone 2		Zone 3	
	Wet	Dry	Wet	Dry	Wet	Dry
Chara	202	33.8	832	129.3	518	78.0
Ceratophyllum	28	2.0	114	8.1	429	29.7
Drepanocladus	.....	.....	35	6.1	15	3.0
Elodea	.....	.....	20	1.8	113	8.2
Myriophyllum	8	0.8	184	17.9	239	23.5
Naias	4	0.4	22	2.1	11	1.1
Potamogeton amplifolius	15	1.8	41	4.6	14	1.6
Potamogeton foliosus	4	0.4	12	1.4	21	2.2
Potamogeton heterophyllus	62	7.8	35	3.9	2	0.2
Potamogeton natans	18	2.2	26	3.1	1	0.1
Potamogeton pectinatus	52	6.8	158	18.3	171	20.5
Potamogeton Richardsonii	10	1.2	41	5.0	1	0.1
Potamogeton zosterifolius	13	1.6	48	5.8	69	7.9
Ranunculus	13	1.4	11	1.2	5	0.5
Vallisneria	52	3.9	125	8.4	.....	.....
Heteranthera	29	2.7	27	2.6	3	0.3
Total	510	66.8	1,731	219.6	1,612	176.8

TABLE 7. *Weight of scattered plants.*

Species	Station	Area in Square Meters	Average Weight, Grams per Square Meter		Total Weight in Kilograms	
			Wet	Dry	Wet	Dry
Scirpus.....M	24	150,000	393	44.7	58,950	6,705
	25	255,000	867	102.9	221,085	26,265
	24 and 25	4,800	1,000	115.2	4,800	553
	34	3,685	2,000	228.0	7,370	840
	39	3,500	5,400	615.6	18,900	2,155
Carex.....	3	5,000	283	28.3	1,698	170
	24	25,000	23	1.2	575	30
	25	25,500	76	7.6	1,938	194
Castalia.....	40	25,000	960	81.6	24,000	2,040
Nymphaea.....	24	25,000	2,400	205.2	60,000	4,925
Cladophora.....	7	12.5	2,900	324.0	36	4
	24	1,125	100	10.8	113	4
		Length in Meters	Grams per Meter			
	1	700	220	23.8	154	17
	2	600	150	16.2	90	10
	4	1,000	14	1.4	14	1
	5	60	760	85.2	46	5
	7	25	35	3.8	1	.....
	16	600	50	5.4	30	3
	28	400	50	5.4	20	2
	30	1,200	100	10.8	120	13
	31	2,000	75	8.1	150	16
	32	300	60	6.5	18	2

TABLE 8. *Total weight and percentage of each species in Zone 1 (0–1 meter). Area: 1.424 square kilometers. From tables 6 and 7.*

Species	Kilograms		Per Cent	
	Wet	Dry	Wet	Dry
Ceratophyllum	39,900	2,900	3.6	2.1
Chara	287,600	48,100	26.1	35.1
Drepanocladus	.....	.....	.....	.....
Elodea	.....	.....	.....	.....
Myriophyllum	11,400	1,100	1.0	0.8
Naias	5,700	600	0.5	0.4
Potamogeton amplifolius	21,400	2,600	1.9	1.9
Potamogeton foliosus	5,700	600	0.5	0.4
Potamogeton heterophyllus	88,300	11,100	0.8	8.1
Potamogeton natans	25,600	3,100	2.3	2.3
Potamogeton pectinatus	74,000	9,700	6.7	7.1
Potamogeton Richardsonii	14,200	1,700	1.3	1.2
Potamogeton zosterifolius	18,500	2,300	1.7	1.7
Radicula	.....	.....	.....	.....
Ranunculus	18,500	2,000	1.7	1.4
Vallisneria	74,000	5,600	6.7	4.1
Heteranthera	41.300	3,800	3.8	2.8
Carex	4,200	400	0.4	0.3
Castalia	.....	.....	.....	.....
Cladophora	800	100	0.1	0.1
Nymphaea	60,000	4,900	5.5	3.6
Scirpus	311,100	36,500	28.2	26.2
Total	1,102,200	137,100	100.0	100.0

TABLE 9. *Total weight and percentage of each species in Zone 2 (1–3 meters). Area: 2.905 square kilometers. From tables 6 and 7.*

Species	Kilograms		Per Cent	
	Wet	Dry	Wet	Dry
Ceratophyllum	331,100	23,500	6.5	3.7
Chara	2,417,000	375,600	47.6	58.2
Drepanocladus	101,700	17,700	2.0	2.8
Eldoea	58,100	5,200	1.2	0.8
Myriophyllum	534,500	52,000	10.5	8.1
Naias	63,900	6,100	1.3	1.0
Potamogeton ampiifolius	119,100	13,400	2.4	2.1
Potamogeton foliosus	34,900	4,100	0.6	0.6
Potamogeton heterophyllus	101,800	11,300	2.0	1.8
Potamogeton natans	75,500	9,000	1.5	1.4
Potamogeton pectinatus	459,000	53,200	9.0	8.3
Potamogeton Richardsonii	119,100	14,500	2.4	2.3
Potamogeton zosterifolius	135,400	16,900	2.7	2.6
Radicula	22,500	2,200	0.4	0.4
Ranunculus	32,000	3,500	0.6	0.6
Vallisneria	363,100	24,400	7.2	3.8
Heteranthera	78,400	7,600	1.2	1.2
Carex	.....	.....	.....	.....
Castalia	24,000	2,000	0.5	0.3
Cladophora	.....	.....	.....	.....
Nymphaea	.....	.....	.....	.....
Scirpus	.....	.....	.....	.....
Total	5,075,100	642,200	100.0	100.0

TABLE 10. *Total weight and percentage of each species in Zone 3 (3–8 meters). Area: 4,234 square kilometers. From tables 6 and 7.*

Species	Kilograms		Per Cent	
	Wet	Dry	Wet	Dry
Ceratophyllum	1,816,400	125,700	26.6	16.8
Chara	2,193,200	330,300	32.1	44.1
Drepanocladus	63,500	12,700	0.9	1.7
Elodea	478,400	34,700	7.0	4.6
Myriophyllum	1,011,900	99,500	14.8	13.3
Naias	46,600	4,700	0.7	0.6
Potamogeton zosterifolius	135,400	16,900	2.7	2.6
Potamogeton foliosus	88,900	8,900	1.3	1.2
Potamogeton heterophyllus	8,500	800	0.1	0.1
Potamogeton natans	4,200	400	0.1	0.1
Potamogeton pectinatus	724,000	86,800	10.6	11.6
Potamogeton Richardsonii	4,200	400	0.1	0.1
Potamogeton zosterifolius	292,200	33,500	4.3	4.4
Radicula	.....	.....	.....	.....
Ranunculus	21,200	2,100	0.3	0.3
Vallisneria	.....	.....	.....	.....
Heteranthera	12,700	1,300	0.2	0.2
Carex	.....	.....	.....	.....
Castalia	.....	.....	.....	.....
Cladophora	.....	.....	.....	.....
Nymphaea	.....	.....	.....	.....
Scirpus	.....	.....	.....	.....
Total	6,825,200	748,600	100.0	100.0

TABLE 11. *Total weight at all depths and percentage of each species. Area: 8.573 square kilometers. From tables 8, 9, and 10.*

Species	Kilograms		Per Cent	
	Wet	Dry	Wet	Dry
Ceratophyllum	2,187,400	152,100	16.8	9.9
Chara	4,897,800	754,000	37.7	49.3
Drepanocladus	165,200	30,400	1.3	2.0
Elodea	536,500	39,900	4.1	2.6
Myriophyllum	1,557,800	152,600	12.0	10.0
Naias	116,200	11,400	0.9	0.7
Potamogeton amplifolius	199,700	22,800	1.5	1.5
Potamogeton foliosus	129,500	13,600	1.0	0.9
Potamogeton heterophyllus	198,600	23,300	1.5	1.5
Potamogeton natans	105,300	12,500	0.8	0.8
Potamogeton pectinatus	1,257,000	149,700	9.7	10.0
Potamogeton Richardsonii	137,600	16,600	1.0	1.1
Potamogeton zosterifolius	450,100	52,700	3.5	3.5
Radicula	22,500	2,200	0.2	0.1
Ranunculus	71,700	7,600	0.5	0.5
Vallisneria	437,100	30,000	3.4	2.0
Heteranthera	132,400	12,700	1.0	0.8
Carex	4,200	400	.....	.....
Castalia	24,000	2,000	0.2	0.1
Cladophora	800	100	.....	.....
Nymphaea	60,000	4,900	0.5	0.3
Scirpus	311,100	36,500	2.4	2.4
Total	13,002,500	1,527,900	100.0	100.0

TABLE 12. *Distribution of species by depth, stated in percentages. From tables 8, 9, 10, and 11.*

Species	0—1 M.		1—3 M.		3—8 M.	
	Wet	Dry	Wet	Dry	Wet	Dry
Ceratophyllum	1.8	1.9	15.1	15.5	83.1	82.6
Chara	5.9	6.4	49.3	49.8	44.8	43.8
Drepanocladus	.....	.....	61.6	58.2	38.4	41.8
Elodea	.....	.....	10.8	13.0	89.2	87.0
Myriophyllum	0.8	0.7	34.3	34.1	64.9	65.2
Naias	4.9	5.3	50.0	53.5	40.1	41.2
Potamogeton amplifolius	10.7	11.4	59.6	58.8	29.7	29.8
Potamogeton foliosus	4.4	4.4	27.0	30.2	68.6	65.4
Potamogeton heterophyllus	44.4	47.8	51.2	48.7	4.4	3.5
Potamogeton natans	24.3	24.8	71.7	72.0	4.0	3.2
Potamogeton pectinatus	5.9	6.4	36.5	35.5	57.6	58.1
Potamogeton Richardsonii	10.3	10.2	86.6	87.4	3.1	2.4
Potamogeton zosterifolius	4.2	4.4	30.3	32.0	65.5	63.6
Radicula	.....	.....	100.0	100.0	.....	.....
Ranunculus	25.8	26.3	44.6	46.1	29.6	27.6
Vallisneria	16.9	18.7	83.1	81.3	.....	.....
Heteranthera	31.2	29.9	59.2	59.9	9.6	10.2
Carex	100.0	100.0	.....	.....	.....	.....
Castalia	.....	.....	100.0	100.0	.....	.....
Cladophora	100.0	100.0	.....	.....	.....	.....
Nymphaea	100.0	100.0	.....	.....	.....	.....
Scirpus	100.0	100.0	.....	.....	.....	.....
All species	8.4	9.0	39.1	42.0	52.5	49.0

TABLE 13. *Average yield of Green Lake. From tables 6 and 11.*

Depth	Grams per Square Meter		Kilograms per Hectare		Pounds per Acre	
	Wet	Dry	Wet	Dry	Wet	Dry
0—1 M.	510	67	5,100	670	4,550	600
1—3 M.	1,731	220	17,310	2,200	15,440	1,960
3—8 M.	1,612	177	16,120	1,771	14,380	1,580
All depths.	1,518	178	15,180	1,780	13,540	1,590

TABLE 14. *Temperature of the water at different depths in summer.*

Depth	Mendota	Green Lake
	Degrees C.	Degrees C.
0 M.	26.1	24.3
5 M.	23.7	23.5
8 M.	20.4	17.7
10 M.	16.9	14 0