AN ECOLOGICAL STUDY OF THE ALGAE OF SOME SANDHILL LAKES

By Emma N. Andersen and Elda R. Walker

INTRODUCTION

Much of the western part of Nebraska consists of rolling sandhills covered with bunchgrasses, yuccas, cacti, and other dry-land plants. Cherry county which is situated in the north central part of the sandhills has in its valleys many bodies of water. In one area of 250 square miles there are about 75 lakes. This region is twenty-five miles southwest from the village of Woodlake and about the same distance south of Valentine. These lakes vary greatly in size. Some are ponds a few hundred feet in diameter while the largest of the group is about four and a half miles long and three-fourths of a mile wide. All are comparatively shallow bodies of water, varying in depth from a couple of feet to a maximum of fifteen feet. The accompanying map[1] (Fig. 1) shows the relative size and arrangement of the lakes of this region.

Surrounding the lakes are low meadows covered with grasses and prairie flowers.[2] These meadows extend back from the lakes anywhere from a rod to, in some cases, a mile or more. Surrounding the grasslands rise the "sandhills"—dunes of yellowish sand extending to the next lake with its surrounding grasslands (Fig. 2). The few native trees are stunted and produce no effect on the landscape.

The climate is that typical of the central plains, dry, windy, hot in summer, and cold in winter. In the summer of 1912, the average maximum daily temperature from June 24th to August 3rd was 91.2°, while the average minimum temperature was 59.8°. During the same period the wind velocity reached a maximum of 21.9 miles per hour, the average for a twelve hour period, while the lowest average for a similar period was 1.3 miles per hour.

[1] Furnished by Dr. G. E. Condra of the University of Nebraska.

[2] The vegetation of this region is well discussed by Pool (36).

The high daily temperature warms the water of the shallow lakes and the prevailing high winds stir it, frequently mixing the warm surface layers with those below causing thorough aëration. The climatic conditions together with the abundance of water plants, such as *Chara*, *Myriophyllum*, *Potomogeton*, *Scirpus*, *Nymphaea*, and *Zizania*, which give anchorage for attached forms, make an ideal habitat for algae.

Although complete analyses of the water of the lakes are not available, some idea of their alkalinity may be obtained from analyses made by the department of chemistry of the University of Nebraska of samples of water taken by Dr. R. H. Wolcott. These were made in 1911 and showed the following parts per million of alkali:

Watts Lake, 111
Dewey Lake, 160
Hackberry Lake (no analysis made)
Big Alkali Lake, 622
Clear Lake, 1,129

As the analyses show some of the lakes are adapted to the algae of fresher waters, while others are so alkaline that very few forms can inhabit them. There is evidence that all of the series of lakes belonged formerly to one general system. The larger lakes have well formed shore lines except at their northwest ends where many of them are swampy. This gives farther variations in the habitat for algae.

Surrounded by a large semiarid region, these lakes with their large beds of wild rice and other seed producing plants prove a most tempting resting and feeding place for migratory birds. They flock here in large numbers and, no doubt, bring on their mud-laden feet spores of algae from ponds both north and south—the only explanation for some of the species present.

Earlier students working with the higher plants of the sandhills reported a rich algal flora. This led the writers to spend the summer of 1912 in studying the algae of the region and the conditions under which they live. At first it was hoped to cover the entire group of lakes, but after a few preliminary trips through the region, the work was limited to a few localities so situated that they could be frequently visited. These were chosen to represent so far as possible the different types of habitat found in the region.

From the various localities, specimens were collected by hand either from a boat or by wading. A Birge net was also used to secure free floating forms.

The identifications of species are based upon Tilden's Myxophyceae, Collins' Green Algae of North America, and West's British Desmidiaceae. In groups such as the Oedogoniaceae, Characeae, and Helminthocladiaceae covered by special publications, the identifications were made with the works cited. Constant reference was made to the other systematic works listed at the end of this paper.

The nomenclature of DeToni is followed except for the Desmids where that of West is used. In the case of a few species not given in the above general works, the terminology of the author describing the form is used.

All diatoms were identified by Dr. C. J. Elmore. The one Volvox found was identified by Dr. J. H. Powers. Acknowledgments are also due Mr. F. H. Shoemaker for the photographs from which figures 2, 10, 11, and 12 were taken; to the Nebraska Conservation and Soil Survey for help in prosecuting the work; to Prof. B. E. Moore for suggestions as to physical problems; and to Prof. T. J. Fitzpatrick for careful reading of manuscript and proof.

HACKBERRY LAKE

Hackberry lake (Fig. 1, 3) was chosen for a study of water conditions, because it was representative and conveniently located. It is a lake two and a half miles long and one-half mile wide. In depth it varied during the summer of 1912 from three to seven feet. The maximum depth, however, was found only in a few places. Usually it did not exceed four feet.

The shore is sandy except at the northwest end where it is freshly formed by the filling in of decomposing vegetable matter. This end is swampy and passes gradually into dense beds of *Zizania*, *Scirpus*, *Myriophyllum*, *Potomogeton*, and similar water plants. Here the water is so filled with vegetation that it is almost impenetrable with a boat or otherwise.

The southeast half of the lake was more open. Dense beds of water plants were scattered through it but between them were areas of open water, (Fig. 4). Here the algae were most abundant. It was in this region that records of water conditions were made.

Algae were abundant all over the lake but more so in this part where every rush stem, every lily pad, in fact, every submerged plant was loaded with them (Figs. 5, 6). The number of species was not large, as the list which follows shows, but the number of individuals was very great. For example, a count was made of the thalli of *Chaetophora elegans.* On one old Scirpus stem there were 592 thalli. In an area one meter square, there were 103 stems loaded in a similar way, making over sixty thousand thalli of *Chaetophora elegans* in a square meter. *Chaetophora cornu-damae, Nostoc glomeratum, Gongrosira debaryana,* and *Rivularia natans* were equally abundant, while other species were only slightly less so.

Climatic Conditions

The accompanying graphs (Figs. 15, 16, 17) are intended to illustrate weather conditions surrounding the lake. The station, (C on Fig. 1) represented in Fig. 8, was in a blowout about ¼ mile from the lake. In the graph (Fig. 15) line A shows the daily variation in temperature of this station as recorded by a Fries self-registering thermograph. Line D shows the temperature on the north side of a small house, a few rods from the lake (A on Fig. 1) as registered by a maximum and minimum thermometer. Line C shows the temperature of the surface sand as recorded by a Fries self-registering soil thermograph whose bulb was barely covered with sand. B gives the temperature of the sand eight inches below the surface as recorded by a similar instrument. The wind record was made by a standard anemometer (Julien P. Fries), so only the averages of wind velocity for twelve hour periods are available, but it gives some estimate as to wind in the region. The high air temperature and its effect on the surface temperature of the light sand when compared with the temperature of the sand eight inches below the surface shows that comparatively little heat penetrates deeply into the soil—a fact that may have some bearing on the temperature of the water of the lakes in some instances. Fig. 16 is a similar record for a much cooler week taken in the grass of the meadow (Fig. 9) on the lake shore (B on Fig. 1).

Water Conditions

Temperature and Wind

For a month, July 8 to August 6, the same instruments were stationed in a boat on this lake to determine, so far as possible, the temperature conditions under which the algae were growing. During this time the anemometer was placed on a post about six feet above the surface of the water and a hundred feet from the water's edge to determine the velocity of the wind passing over the water. The thermographs in the boat recorded the temperature (A) of the air in the boat, the temperature (C) of the surface water, and the temperature (B) of the water at the bottom of the lake. Due to drifting of the boat to a slightly different position, the depth at which the temperature was taken varied from three feet the first week to four and one-half the second and fourth weeks and five feet the third week. The temperatures were not taken in deeper parts of the lake because there the algal growth was slight. As can be seen from the accompanying graph (Fig. 17) the temperatures of the surface and bottom water approach each other very closely except on days of low wind, when the temperature of the surface water varies considerably from that at the bottom. This effect of air temperature and wind was especially evident in the fourth week when great variations in air temperature occurred.

It will be noticed that during a large part of this month, the water temperatures were between 70° and 80° F., and that the temperature of the water at all levels was remarkably uniform. It is evident from the divergences of the temperature of surface and bottom water during each period of lower wind that the uniformity of the water temperature is due largely to stirring by wind. Also that a constant stirring would produce good aëration in all parts of the water is an inevitable conclusion.

Hackberry lake is one of the less alkaline of the lakes in this group. It is, however, more alkaline than some of its neighbors as was noted before.

Light

A modification of the common solio paper photometer (text Fig. 1) was devised to study the light conditions under which the algae were growing.[1] This consisted of a water tight circular drum (A) at the end of a metal tube (D). Inside of this drum was a disk (G) which revolved by means of a rod (E) passing through the tube and connected with a lever at the top. This disk (G) carried the paper (F) on its under surface. It was perforated by eight holes (B) of the same size as a clear glass window (C) in the drum. By revolving the inner disk, the areas of solio paper under the perforation of the disk could be exposed to the light through the window (C). The tube and

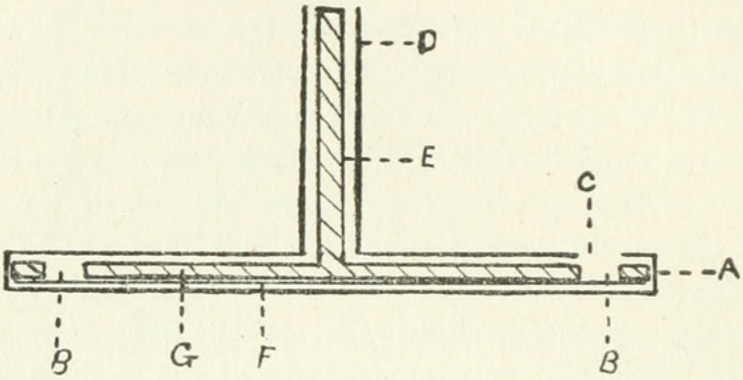


Fig. 1

rod inside of it were made in sections so they could be extended to the necessary length. The tube was marked in decimeters on the outside so the depth could be ascertained at all times. With this instrument, light readings were taken from a boat (Fig. 4) at various depths. Care was taken to have the window in the drum exposed to direct light at all times. In some instances, the period of exposure was uniform and the depth was varied; in other cases both depth and period of exposure were varied and in still others one depth was maintained during the series of readings and the period of exposure was varied.

Records taken by the last method are shown in (Fig. 7). The top row shows exposures made in the air beginning at the following hours, reading from left to right: 10:18 a.m., 10:30 a.m., and 2:10 p.m. In each record the exposures were 60, 45, 40, 30, 20, 10, 5, and 2 seconds.

Below are nine water records taken the same day and at intervals immediately following or preceding the air exposures. These are

[1] This instrument was made by the Spencer Lens Company.

arranged in order by depths, the first being one decimeter below the surface and each succeeding one a decimeter deeper, making the last nine decimeters deep. In all the periods of exposure were the same as the air records, except the last two. Here no records could be secured at the above exposure periods so the time was increased in record 8 to 2, 3, 4, 5, 6, 7, and 8 minutes and in record 9 to 1, 2, 3, 4, 5, 6, 7, and 8 minutes. All water readings were compared with exposures made in the air at the same hour. In no cases were the readings satisfactory but some facts of interest were recorded.

1. Waves on the surface water varied the record of light intensity greatly. On very windy days the intensity of light under the water was so variable that one exposure showed almost no coloration while the next at the same depth and period of exposure was deeply colored. The only explanation evident was that the change in angle of surface layer deflects the light almost entirely at times and not at other times. On account of this variability readings on windy days were early discontinued.

2. Before 9 A.M. or after 3 P.M. it was almost impossible to get a usable tint on the solio paper, although to the eye it was entirely light to the bottom of the lake. Evidently the angle between the sun's rays and the surface of the water was such that most of the rays were deflected and the water light was simply reflected light and not of a kind or quantity to affect solio paper.

3. Exposures made at a given depth but with different periods of exposure gave very different records as to relative light intensity. The shorter the exposure, the greater reduction of light, according to the readings. When the exposure required more than three minutes the error was so great that the reading was useless for comparison with readings of shorter periods. Two series will illustrate the point. The exposures were consecutive in both cases.

Time	Relative intensity All at 4 dm. deep	Time	Relative intensity All at 8 dm. deep
3 min	.111	4 min	.0083
2 min	.125	5 min	.0166
1 min	.083	6 min	.0277
½ min	.05	7 min	.0357
		8 min	.0416

Such a series can only be explained by the well known fact that the reduction of silver in a photographic paper is not a uniform process. Since these results proved a variable period impracticable, exposures were made for a given period at various depths. These readings showed clearly a constant reduction of light as the depth was increased and agreed in general with the results obtained by Needham and Lloyd (33), by Birge (11), and by Oltmanns (34).

4. Exposures made for constant periods at various depths showed the light to be reduced by passing through the water. However, this gave no accurate measure of the light at given depths, because such exposures were compared with air tints of various periods of exposure. These we have just shown to be unreliable because of the inconstant reduction of the photographic film.

5. Solio paper is sensitive only to the blue-violet end of the spectrum. It is generally conceded that it is the red-orange end of the spectrum that is most largely used by plants in photosynthesis (Dangeard 22). It is, therefore, evident that tests made with solio paper are of little value in determining the light conditions under which algae grow. Such tests show in a most general way, as noted above, that the direct rays of light are largely deflected except during the middle of the day and that the light is reduced by passing through water. Both facts are well known to physicists. This means that water plants have a shorter day than air plants and that they grow in less intense light at all times. In other words, as Oltmanns (34) states, they are all shade plants.

6. Light readings taken in October show less light penetrating the water than was found in July and August. The following table shows this as well as could be determined from solio paper records. Because of the reasons already given these records can only be regarded as a crude estimate. The figures given are compiled from a large number of readings so that the general diminution of blue light per decimeter of depth and the relative intensity between the light of midsummer and that of October are approximately correct.

Dm.	August	October
1	.5	.2
2	.25	.1
3	.173	.066

Dm.	August	October
4	.083	.05
5	.05	.033
6	.033	.016

No doubt the reduction of light in October is due to the rays of the sun striking the water more obliquely. Hence water plants have not only a shorter day but also a shorter growing season than land plants.

It is evident that the main advantage in the present attempt to measure light with reference to that used by plants under water is to prove the absolute uselessness of the solio paper method.

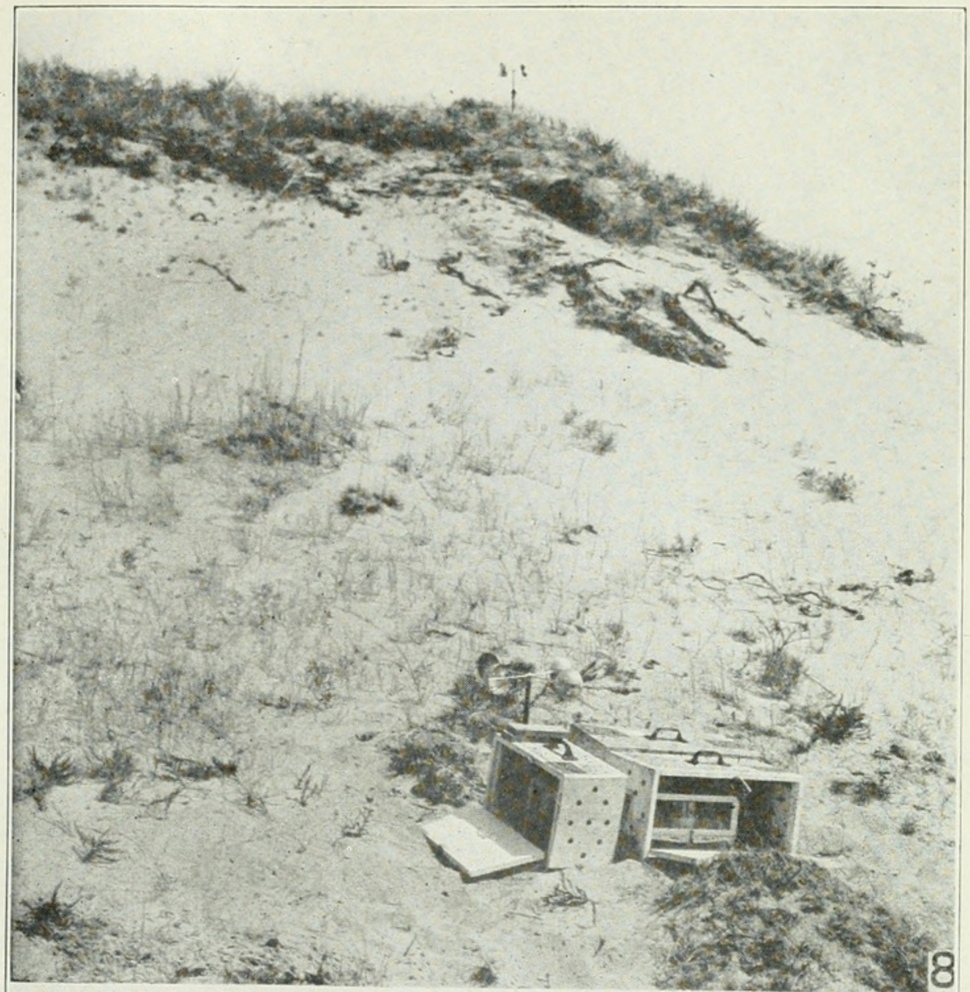
Later the same photometer was modified slightly so that plates sensitive to all kinds of light could be used in it (Figs. 10, 11, 12). A color screen was added and in that way an attempt was made to measure the red-orange light penetrating the water. Fig. 10 shows the upper side of the drum which holds the photographic plate and the detachable color screen over the exposure window. This is shown again in Fig. 12 (below) with the tube removed. At the top of Fig. 12 is shown the under side of the upper half of the drum. The inner disk shows two clips for holding the plate in place and eight perforations through which areas of the plate may be exposed to the light of the window. This disk is revolved, exposing alternately a perforation and a solid area, by a rod passing through the tube and connected with the lever at the top (Fig. 11). This apparatus for making exposures, while entirely rapid enough for solio paper, proved altogether too slow for the highly sensitive plates. The only results obtained indicated that red light penetrating many decimeters of water was too strong for more than instantaneous exposures on these plates. It is believed that a similar apparatus fitted with a shutter that would make possible exposures of a fraction of a second would come much nearer to giving an estimate of light available for the use of algae. Even here the reduction of the photographic film would not be uniform and some error would remain. Oltmanns (34) states that physicists have shown that the light from each part of the spectrum is deflected and absorbed differently by pure water. The water inhabited by algae is always modified in color and transparency both by its chemical content and by the presence of floating organisms giving turbidity to the water. An instrument such as the above would give an idea as to what effect such water conditions have upon the quality of light used by algae even tho it did not give accurate information as to the quantity of light available for them.

Murray and Hjort (32) investigating light conditions in the ocean, by means of the Helland-Hansen Photometer and pan-chromatic photographic plates found that red light penetrated the water less than did blue and indigo. This agrees with the results cited by Oltmanns (34) for pure water. This suggests, in some cases at least, that actual light available for submerged plants is far below the amount indicated by the solio paper photometer.

Distribution

As is readily seen from the physical factors noted above, this lake is characterized by fairly uniform temperature, aëration, and alkalinity. There remain but two factors that can influence the distribution of algae in this lake—light and mechanical support. The distribution may be entirely explained by these factors.

Attached forms as *Rivularia pisum*, *Nostoc glomeratum*, etc., grow at a depth of about 3–4 dm. below the surface of the water. When they are near the margin of the lake they grow on small submerged sedges, chara, etc. In deeper water they grow on Potomogeton, Myriophyllum, and such taller plants, but at remarkably uniform distances below the surface. On the other hand, *Nostoc pruniforme*, lying free at the bottom of the lake, was only found near the margin where the water was two or at most three decimeters deep. At first such forms led to the opinion that there was a zonal arrangement about the shore such as is suggested by Comère (17) but the theory did not stand the test. The distribution was entirely a vertical one caused undoubtedly by the light intensity. There were several conspicuous examples which demonstrate this. *Chaetophora elegans* extended on Scirpus stems, almost its only support, over a distance of two decimeters but the growth was constantly most abundant in the upper region, within ½–1 dm. of the surface of the water. *Chaetophora cornu-damae* had almost the same distribution while *Nostoc glomeratum* made its best growth at a depth of 2–4 dm. or even deeper. Evidently it was crowded downward by the Chaetophora with which it grew. Early in the season the Nostoc and Chaetophora grew together. Later the Chaetophora occupied the upper zone while Nostoc grew in equal abundance lower down.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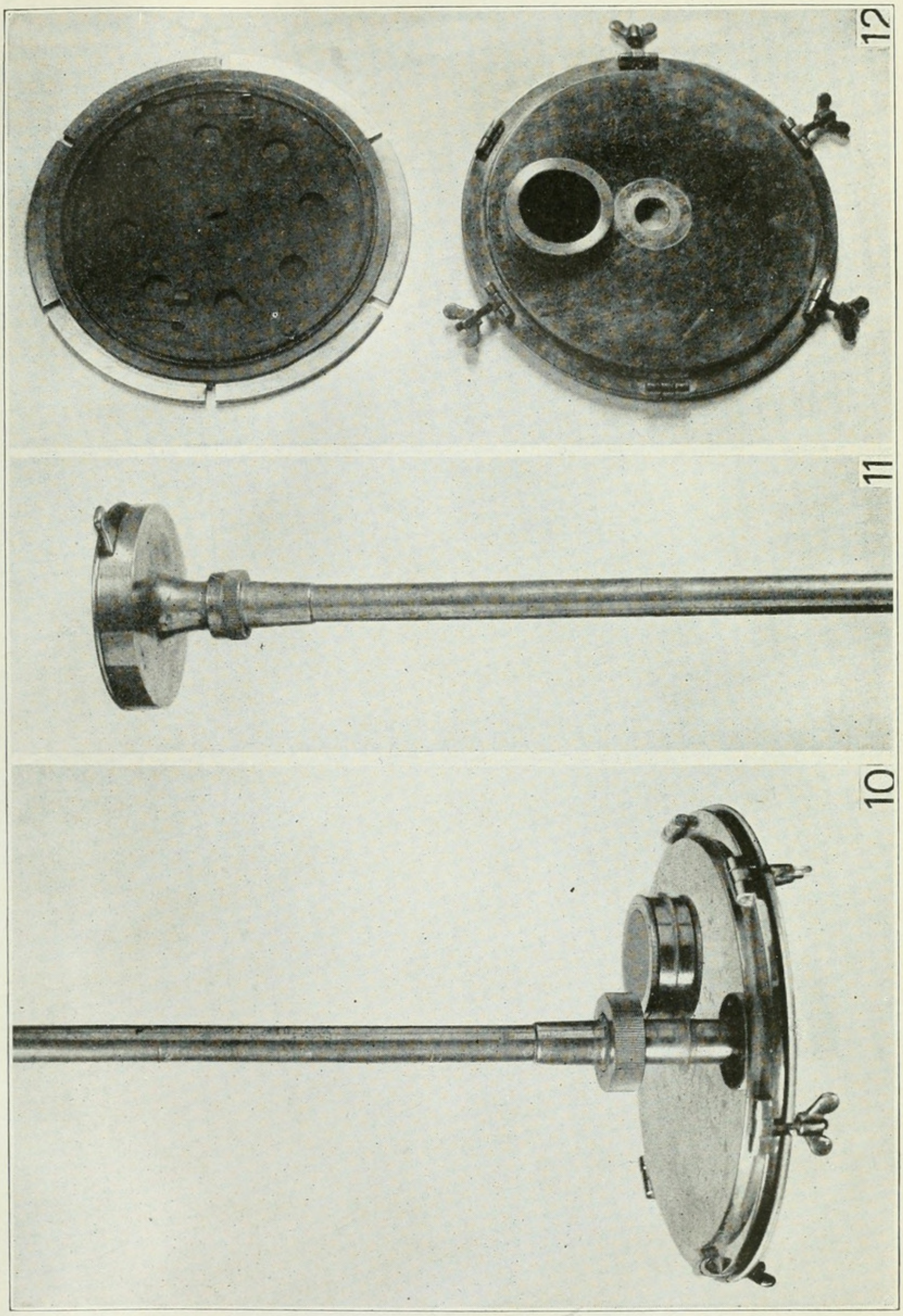

PLATE VIII ANDERSEN AND WALKER

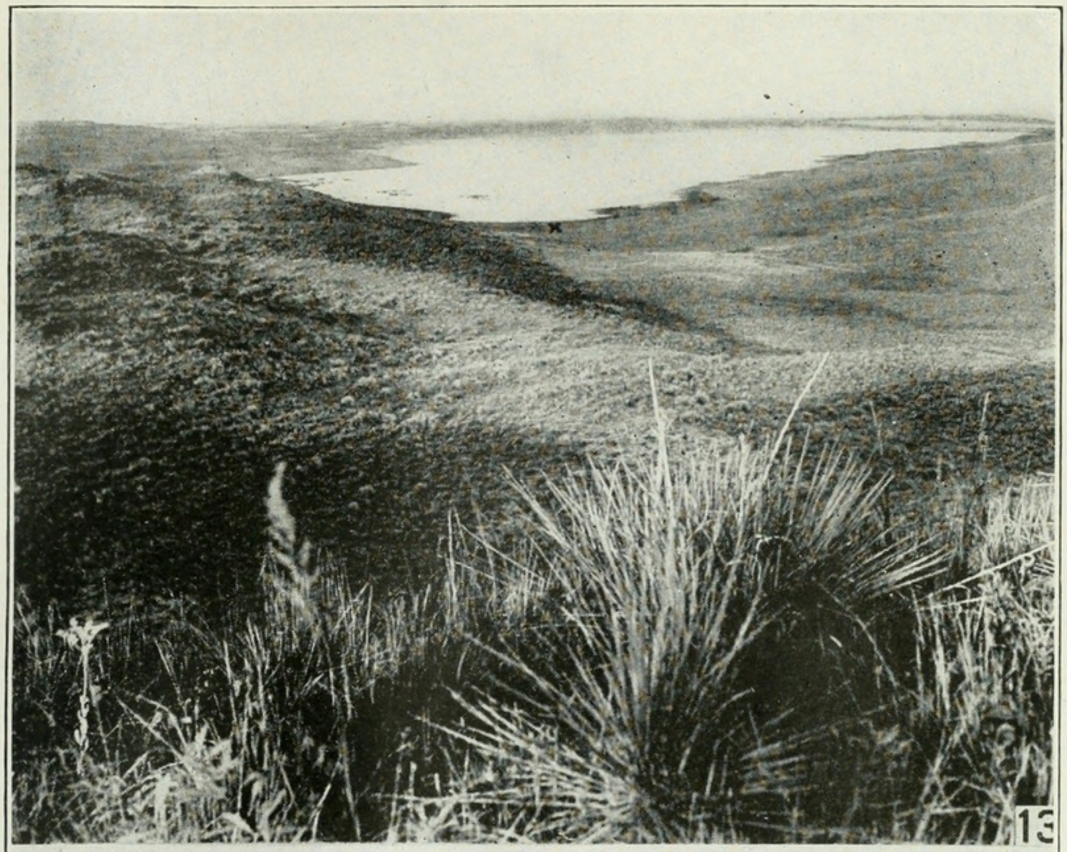

PLATE IX

ANDERSEN AND WALKER

The following forms were found floating or attached almost exclusively in the upper two decimeters of water or in water not more than 2 dm. deep.

Clathrocystis aeruginosa	Microspora amoena
Coelosphaerium Kuetzingianum	Chaetophora cornu-damae
Nostoc muscorum	Chaetophora elegans
Nostoc humifusum	Bulbochaete sp.
Nostoc minutum	Oedogonium fragile
Nostoc zetterstedtii	Coleochaete orbicularis
Phormidium tenue	Gongrosira debaryana
Chara contraria	

Mixed with these were most of the unicellular forms of the yellow-green algae and most of the desmids listed for this lake.

Such forms as the following predominated in the deeper water, 2–4 dm. from the surface: *Rivularia natans*, *Rivularia pisum*, *Nostoc glomeratum*, and *Nostoc austinii*. With these were associated *Merismopedium aerugineum*, *Oscillatoria subtilissima*, *Dictyosphaerium pulchellum*, *Gloeocystis gigas*, *Scenedesmus quadricauda*, and *S. bijugatus*. The distribution of unicellular free floating forms, however, was hard to determine because of the constant stirring of the water. It will be noted that few yellow-green algae are characteristically found in the lower zone.

Below a depth of 4 dm. many algae were found but not in any charactertistic formation. Evidently they were there because crowded out elsewhere and they were not growing as well as the same species at higher levels.

As to grouping of the algae in these zones it was found that in any given location one or two species were dominant and others grew rather indiscriminately among them. The dominant species was apparently determined by the support on which it grew. In a bed of Scirpus, one species of *Chaetophora* and *Nostoc glomeratum* were almost universally the dominating forms, the Chaetophora dominating the upper and Nostoc the lower zone. On submerged mosses, Potomogeton, etc., *Gongrosira debaryana*, *Nostoc glomeratum*, or *Rivularia pisum* dominated, while at the margin of the lake a free floating form as *Nostoc pruniforme* or *Rivularia natans* might dominate. *Clathrocystis aeruginosa* or *Anabaena flos-aquae* usually dominated the groups floating at the surface of the water, tho the constant winds kept these forms fairly well mixed.

Seasonal Distribution

Careful records of dates of collection were made to determine, so far as possible, the grouping of algae by seasons. As the study extended only from the middle of June until the middle of October, the observations included only summer and fall forms. Only the most general results were obtained. Of the species found in Hackberry lake the members of the Oscillatoriaceae were found only in the early summer, Merismopedium and Coelosphaerium only in July. Other members of the Myxophyceae were found in early stages in the first part of the season but reached full maturity and maximum abundance in October.

Most of the green algae were found throughout the period observed but they reached their maximum in midsummer except in a few cases. The species of Gloeocystis were found early in the summer. *Bulbochaete* was found late in the season (August–October) and the specimens were not fruiting. Nearly all the desmids were found during July. Only a few were present earlier or later in this lake, tho in places near by they occurred at other times in abundance.

The following table shows the forms found in the early, middle, and later summer and suggests something of the seasonal occurrence of the forms.

June 27–July 10	July 10–July 25	July 25–August
Nostoc humifusum	Nostoc zetterstedtii	Nostoc muscorum
Nostoc glomeratum	Nostoc pruniforme	Nostoc minutum
Nostoc austinii	Nostoc humifusum	Nostoc caeruleum
	Nostoc glomeratum	Nostoc pruniforme
		Nostoc glomeratum
Anabaena flos-aquae	Anabaena flos-aquae	Anabaena flos-aquae
Oscillatoria subtilissima		
Phormidium tenue		
Rivularia pisum	Rivularia pisum	Rivularia pisum
Rivularia natans (young)	Rivularia natans	Rivularia natans
	Merismopedium aeruginеum	
	Coelosphaerium kuetzingianum	

June 27–July 10	July 10–July 25	July 25–August
Clathrocystis aeruginosa	Clathrocystis aeruginosa	Clathrocystis aeruginosa
	Staurastrum gracile	
	Spirotaenia obscura	
	Netrium digitus	
	Euastrum oblongum	
Cosmarium vexatum	Cosmarium subcrenatum	
Cosmarium obtusatum	Cosmarium retusiforme	
Cosmarium kjellmani grande	Cosmarium obtusatum	
	Cosmarium laeve	
	Cosmarium granatum	
	Cosmarium formosulum nathorstii	
	Cosmarium elfingii	
Closterium lanceolatum	Closterium pritchardianum	Closterium moniliferum
	Closterium leibleinii	
Chara contraria	Chara contraria	Chara contraria
Coleochaete orbicularis	Oedogonium fragile	Bulbochaete sp.
	Gongrosira debaryana	
Chaetophora elegans	Chaetophora elegans	Chaetophora elegans
Chaetophora cornu-damae	Chaetophora cornu-damae	Chaetophora cornu-damae
Gloeocystis vesciculosa	Microspora amoena	
Gloeocystis gigas		
Scenedesmus bijugatus	Scenedesmus quadricauda	
	Scenedesmus obliquus	
	Dictyosphaerium pulchellum	
	Pediastrium tetras	
	Pediastrum boryanum	
	Tetraedron trigonum	

A very interesting group of algae was found in a small ditch carrying water from a spring into the northwest end of Hackberry lake. *Closterium lunula* was so dominant here that at first it seemed to be the only species present. Closer examination, however, showed the following species associated with it.

Eremosphaera viridis	Cosmarium umbilicatum
Cylindrospermum majus	Euastrum verrucosum
Cosmarium angulosum concinnum	Pleurotaenium trabecula
Cosmarium circulare	Staurastrum meriani
Cosmarium pachydermum	Staurastrum punctulatum

Phormidium tenue, *P. valderianum*, and *Spirulina major* were found on the lake shore just above the water's edge, making the sand green at many places.

The following algae were found in this lake:

Chroococcaceae

Clathrocystis aeruginosa
Coelosphaerium kuetzingianum
Merismopedium aerugineum

Oscillatoriaceae

Oscillatoria subtilissima
Phormidium tenue

Nostocaceae

Anabaena flos-aquae
Cylindrospermum majus
Nostoc austinii
Nostoc caeruleum
Nostoc glomeratum
Nostoc humifusum
Nostoc minutum
Nostoc muscorum
Nostoc pruniforme
Nostoc zetterstedtii

Rivulariaceae

Rivularia natans
Rivularia pisum

Bacillariaceae

Cocconeis placentula
Cymbella cymbiformis
Eunotia lunaris
Fragilaria capucina
Gomphonema acuminatum
Gomphonema parvulum
Navicula anglica
Navicula cuspidata
Navicula dicephala
Navicula sculpta
Navicula subcapitata
Navicula viridis
Nitzschia spectabilis
Nitzschia tryblionella
Surirella ovalis pinnata

Desmidiaceae

Closterium lanceolatum
Closterium leibleinii
Closterium moniliferum
Closterium pritchardianum
Cosmarium elfingii
Cosmarium formosulum nathrostii
Cosmarium granatum
Cosmarium kjellmani grande
Cosmarium laeve
Cosmarium obtusatum
Cosmarium retusiforme
Cosmarium subcrenatum
Cosmarium vexatum
Euastrum oblongum
Netrium digitus
Spirotaenia obscura
Staurastrum gracile

Tetrasporaceae

Dictyosphaerium pulchellum

Pleurococcaceae

Scenedesmus bijugatus
Scenedesmus obliquus
Scenedesmus quadricauda
Tetraedron trigonum
Urococcus insignis

Protococcaceae

Gloeocystis gigas
Gloeocystis vesciculosa

Hydrodictyaceae

Pediastrum boryanum
Pediastrum tetras

Ulotrichaceae

Microspora amoena

Chaetophoraceae

Chaetophora cornu-damae
Chaetophora elegans
Gongrosira debaryana

Oedogoniaceae

Bulbochaete sp.
Oedogonium fragile

Coleochaetaceae

Coleochaete orbicularis

Characeae

Chara contraria

CLEAR LAKE

This lake (Fig. 1, 2, 13) is a little wider and deeper than Hackberry lake and is about two-thirds of a mile distant from it. The water, however, is very alkaline (see discussion of alkalinity) and of a characteristic yellowish color. About the edge in places were rushes but there was little other vegetation in the lake. The algal flora was scarce in species but rich in individuals. Throughout the season the water was full of *Closterium aciculare*.[1] With this were found a few specimens of *Cosmarium obtusatum* and *Pediastrum boryanum*, and a few diatoms in fair abundance but that was all. Since in Clear lake the algae were all free floating, and the species were limited, no distribution studies were attempted. The same species were found throughout the summer. *Closterium aciculare* was the only characteristic form and was present throughout the season. The few other forms present with it were characteristic of the springs flowing into the lake and probably all came there by chance. It is probable that they could not have continued to live in so alkaline a water. Only one factor, alkalinity, could have influenced the algal flora of this lake.

In some places on the shore of the lake were springs whose water contained the richest algal flora found in the lake region. This was especially true at the west end (x in Fig. 13). Here the springs were on the sloping bank and the water seeped slowly down through the boggy soil. The surface was covered with grass and ferns forming sod enough to nearly support a hundred weight or more. Cattle coming to the spring for water had tramped over this sod forming holes from the size of a footprint to two or three feet in diameter. In these holes (Fig. 14) the water stood undisturbed for long periods with the thick grass sheltering the surface from the wind. The result was a large number of small aquaria. The water in these was kept uniformly fresh by seepage from the springs. While no chemical analysis was made, it was noticeable that the alkalinity was low.

[1] This form in size fits the description of the species as given by West and West (51) but may be the form referred to by West (50) as *Closteriopsis longissima* tho some of the specimens were over 600μ long and 7μ wide. He suggests that *Closteriopsis* may be a degenerate of *Closterium aciculare* var. *subpronum*.

The temperature was fairly uniform throughout the summer period varying from about 68° F. in the early morning to about 80° F. at 3 P.M. So far as was observed the ecological conditions in the various pockets were remarkably uniform in every way. Each was dominated by some one species, the usual dominants being *Anabaena torulosa,* various species of Nostoc, Spirogyra, Scytonema, Oedogonium, and Mougeotia. With these were mixed in various proportions the other species found. Attempts were made to determine whether there was any uniformity as to the species present with a given dominant but there seemed to be none.

The only ecological groupings of forms observed were seasonal. As will be seen from the accompanying list some forms were found only early in the summer, others late in the summer, and still others in the fall. The greatest variety of species was found in the middle of the summer. In the case of unicellular forms this list can only be looked upon as suggestive. Only a few specimens are found for some of them and chance in collecting may have caused others to be overlooked in one period or another. In this table early summer means from the middle of June to the middle of July; midsummer from the middle of July to the middle of August; fall is represented by collections made in October. Here fresh water, uniform temperature, protection from wind, and very shallow water form a habitat as uniform in every respect as is possible. Here the dominant forms found in a given water pocket can be due only to one of two things, seasonal periodicity which was very evident and the chance dominance of certain forms. Often the soil beneath a mass of Spirogyra, Mougeotia, or other such form was covered with desmids or diatoms. It is apparent that smaller forms, especially unicellular ones, may be shaded by the dominant species and hence their presence would be determined by their light relation. However, which of these shade loving forms should be associated with a given dominant species was chance so far as was determined. At other places on the lake shore were springs where a few algae were found but they were of so little consequence that the species were included only in the general list of species.

Clear Lake Puddles

	Early summer	Mid-summer	October
Chroococcaceae			
Aphanothece prasina	....	x	....
Clathrocystis aeruginosa	....	x	....
Gloeocapsa arenaria	....	x	....
Oscillatoriaceae			
Oscillatoria formosa	....	x	....
Oscillatoria limosa	x	....	x
Phormidium tenue	....	x	....
Phormidium valderianum	....	x	....
Nostocaceae			
Anabaena flos-aquae	x	x	....
Anabaena oscillarioides	....	x	....
Anabaena torulosa	x	x	x
Cylindrospermum comatum	....	....	x
Nodularia harveyana	....	x	....
Nostoc linckia	x	....	x
Nostoc minutum	....	x	....
Nostoc muscorum	x	x	....
Nostoc spongiaeforme	x	....	....
Scytonemaceae			
Scytonema crispum	x	x	x
Rivulariaceae			
Rivularia natans	....	....	x

*Bacillariaceae**

Achnanthes lanceolata
Cyclotella meneghiniana
Cymbella amphicephala
Cymbella cuspidata
Cymbella naviculiformis
Cymbella subaequalis
Cystopleura gibba
Cystopleura gibba ventricosa
Cystopleura zebra
Eunotia diodon
Eunotia lunaris
Eunotia major
Fragilaria construens
Gomphonema acuminatum
Gomphonema constrictum
Gomphonema gracile
Gomphonema montanum

* No seasonal studies were made of diatoms.

Melosira varians
Navicula ambigua
Navicula anglica
Navicula bacilliformis
Navicula brebissonii
Navicula cuspidata
Navicula dicephala
Navicula elliptica
Navicula gibba brevistriata
Navicula hilseana
Navicula major
Navicula mesolepta
Navicula iridis
Navicula pupula
Navicula sculpta
Navicula sphaerophora
Navicula stauroptera
Navicula viridis
Nitzschia brebissonii
Stauroneis anceps
Stauroneis anceps amphicephala
Stauroneis phoenicenteron
Surirella ovalis ovata
Synedra rumpens
Synedra ulna

	Early summer	Mid-summer	October
Desmidiaceae			
Arthrodesmus convergens	x	x	x
Closterium cynthia	x	x	x
Closterium didymotocum	x	....	....
Closterium jenneri	x	....	....
Closterium lanceolatum	....	....	x
Closterium lunula	x	x	x
Closterium moniliferum	x	x	x
Closterium parvulum	....	x	x
Closterium pritchardianum	....	....	x
Closterium siliqua	....	....	x
Closterium striolatum	x	....	....
Closterium turgidum	x	....	....
Cosmarium abruptum	....	x	....
Cosmarium angulosum	....	....	x
Cosmarium angulosum concinnum	....	x	x
Cosmarium boeckii	x	....	x
Cosmarium blyttii	....	x	x
Cosmarium botrytis tumidum	x	....	....
Cosmarium circulare	x	....	x
Cosmarium connatum	x	x	x
Cosmarium crenatum	x	....	....
Cosmarium cyclicum	x	....	....
Cosmarium cymatopleurum	x	....	....
Cosmarium formosulum nathrostii	....	x	x
Cosmarium galeritum	....	x	....
Cosmarium granatum	....	x	x

	Early summer	Mid-summer	October
Cosmarium holmiense	x	....	x
Cosmarium jkellmani grande	....	x	....
Cosmarium meneghinii	....	x	....
Cosmarium microsphinctum	x	....	....
Cosmarium notabile	x	....	....
Cosmarium obtusatum	x	....	....
Cosmarium ochthodes	....	x	....
Cosmarium pachydermum	....	x	x
Cosmarium pachydermum aethiopicum	x	....	x
Cosmarium phaseolus elevatum	....	x	....
Cosmarium phaseolus forma minor	x	....	....
Cosmarium portianum	x	....	x
Cosmarium pygmaeum	x	....	....
Cosmarium pyramidatum	....	x	x
Cosmarium rectangulare hexagonum	....	x	x
Cosmarium sportella	....	x	....
Cosmarium subcrenatum	x	x	....
Cosmarium subtumidum	....	x	....
Cosmarium subundulatum	x	....	....
Cosmarium taxichondrum	....	x	....
Cosmarium tetraophthalmum	....	x	....
Cosmarium trilobulatum	....	x	....
Cosmarium tumidum	....	x	....
Cosmarium vexatum	....	x	....
Euastrum attenuatum	....	....	x
Euastrum bidentatum	....	x	....
Euastrum binale	....	x	x
Euastrum dubium	....	x	....
Euastrum oblongum	....	x	x
Euastrum verrucosum	x	x	x
Euastrum verrucosum alatum	....	x	x
Micrasterias pinnatifida	....	x	x
Micrasterias rotata	....	....	x
Netrium digitus	....	x	x
Netrium interruptum	....	....	x
Penium libellula intermedium	....	....	x
Penium naegelii	....	x	....
Penium spirostriolatum	....	x	x
Pleurotaenium coronatum	x	x	x
Pleurotaenium nodulosum	....	x	....
Pleurotaenium trabeculata	x	....	....

	Early summer	Mid-summer	October
Spirotaenia condensata	....	x	x
Spirotaenia trabeculata	....	x	....
Staurastrum alternans	....	....	x
Staurastrum dickiei	....	x	x
Staurastrum dilatatum	....	....	x
Staurastrum dispar	....	x	....
Staurastrum hirsutum	....	x	x
Staurastrum margaritaceum	....	x	x
Staurastrum meriani	....	....	x
Staurastrum muticum	....	x	....
Staurastrum orbiculare	x	x	x
Staurastrum orbiculare ralfsii	....	x	....
Staurastrum paxilliferum	....	....	x
Staurastrum polytrichum	x	....	....
Staurastrum punctulatum	x	x	x
Staurastrum saxonicum	....	x	....
Staurastrum teliferum	....	x	....
Zygnemaceae			
Spirogyra arcta catenaeformis	x	....	....
Spirogyra crassa	x	....	....
Spirogyra dubia	x	x	x
Spirogyra lutetiana	x	....	....
Spirogyra neglecta	....	....	x
Spirogyra varians	....	....	x
Zygnema sp	x	x	x
Mesocarpaceae			
Mougeotia robusta	....	....	x
Mougeotia scalaris	....	....	x
Mougeotia viridis	x	....	....
Volvocaceae			
Volvox aureus	....	x	....
Tetrasporaceae			
Dictyosphaerium pulchellum	....	x	x
Tetraspora gelatinosa	x	....	....

	Early summer	Mid-summer	October
Pleurococcaceae			
Crucigenia rectangularis	....	....	x
Eremosphaera viridis	....	x	x
Nephrocytium naegelii	x	....	....
Oocystis solitaria	....	x	x
Rhaphidium polymorphum falcatum	....	x	x
Scenedesmus antennatus	x	....	....
Scenedesmus bijugatus	x	....	x
Tetraedron reticulatum	....	....	x
Urococcus insignis	....	....	x
Protococcaceae			
Gloeocystis vesciculosa	x	....	....
Ophiocytium capitatum	....	....	x
Hydrodictyaceae			
Coelastrum sphaericum	....	x	....
Pediastrum angulosum	....	....	x
Pediastrum boryanum	x	x	x
Pediastrum tetras	....	x	....
Ulotrichaceae			
Microspora pachyderma	....	x	....
Microspora stagnorum	....	x	....
Chaetophoraceae			
Stigeoclonium glomeratum	x	....	....
Oedogoniaceae			
Bulbochaete sp	....	....	x
Oedogonium sp	x	x	x
Oedogonium capilliforme australe	....	x	....
Oedogonium cardiacum	x	....	....
Oedogonium crispum uruguayense	x	....	....
Oedogonium fragile	....	x	....
Oedogonium varians	....	....	x
Cladophoraceae			
Rhizoclonium hieroglyphicum	x	....	....

	Early summer	Mid-summer	October
Vaucheriaceae			
Vaucheria sp	....	....	x

BIG ALKALI LAKE

Big Alkali Lake (Fig. 1) is a little larger than Clear lake. While it is more alkaline than Hackberry, Dewey, or Watts, it is far less so than Clear lake. The water had the characteristic yellow color of the alkaline lakes of this region. Here again alkalinity must be given as the factor governing the algal flora of the lake. One visit only was made here. At first sight the water seemed absolutely barren but further investigation showed the following forms to be present. The Chara was quite abundant forming very much dwarfed patches on the bottom near the shore.

Chroococcaceae
Clathrocystis aeruginosa
Merismopedium glaucum
Merismopedium tenuissimum
Oscillatoriaceae
Oscillatoria limosa
Bacillariaceae
Amphora ovalis
Campylodiscus clypeus
Cymbella cistula
Cystopleura gibba
Navicula cryptocephala veneta
Navicula gastrum
Navicula oblonga
Navicula sculpta
Desmidiaceae
Cosmarium angulosum
Cosmarium granatum
Cosmarium meneghinii
Cosmarium sexnotatum
Staurastrum gracile
Staurastrum paradoxum
Staurastrum polymorphum
Tetrasporaceae
Dictyosphaerium pulchellum
Pleurococcaceae
Scenedesmus bijugatus
Scenedesmus obliquus
Scenedesmus quadricauda
Hydrodictyaceae
Pediastrum boryanum
Pediastrum duplex clathratum
Characeae
Chara foetida rabenhorstii

DEWEY LAKE

Dewey lake (Fig. 1) is situated about half a mile from Hackberry lake. It is less alkaline, nearly three times as large and proportionally deeper. Otherwise the conditions were much the same. Temperatures taken in the region of algal growth showed little variation from those in Hackberry lake.

The algae were found along the margins of the lake and attached to submerged plants near the surface. As no attempt was made to study conditions in this lake no explanation of the conspicuous difference in the forms found can be given unless it was the larger amount of water and difference in alkalinity. Collections were made here at irregular intervals and the list must not be looked upon as complete.

Chroococcaceae
Clathrocystis aeruginosa
Merismopedium glaucum

Oscillatoriaceae
Beggiatoa alba
Lyngbya aerugineo-caerulea
Oscillatoria amphibia
Oscillatoria formosa
Oscillatoria subtilissima
Phormidium fragile
Phormidium tenue
Phormidium valderianum

Nostocaceae
Anabaena flos-aquae
Nostoc linckia
Nostoc pruniforme

Scytonemaceae
Tolypothrix distorta

Rivulariaceae
Rivularia echinulata
Rivularia natans

Bacillariaceae
Amorpha ovalis
Brebissonia vulgaris
Cocconeis placentula
Cymbella cistula
Cymbella cuspidata
Cymbella lanceolata
Encyonema turgidum
Eunotia lunaris
Fragilaria capucina
Fragilaria construens binodis
Gomphonema constrictum
Gomphonema gracile
Gomphonema montanum
Gomphonema parvulum
Navicula cuspidata
Navicula lanceolata
Navicula major
Navicula oblonga
Navicula pupula
Staureneis acuta
Stauroneis smithii
Stauroneis tenuissima
Synedra rumpens
Synedra ulna

Desmidiaceae
Closterium pritchardianum
Cosmarium blyttii
Cosmarium boeckii
Cosmarium formosulum nathorstii
Cosmarium impressulum
Cosmarium obtusatum
Cosmarium ochthodes var.
Cosmarium subcrenatum
Cosmarium turpinii podolicum
Cosmarium vexatum
Penium margaritaceum
Staurastrum orbiculare

Pleurococcaceae
Scenedesmus bijugatus
Scenedesmus obliquus
Tetraedron trigonum

Protococcaceae
Characium ambiguum
Characium subulatum
Gloeocystis vesciculosa

Hydrodictyaceae
Pediastrum boryanum

Ulotrichaceae
Hormiscia subtilis variabilis

Chaetophoraceae
Chaetophora elegans
Gongrosira debaryana
Stigeoclonium aestivale

Stigeoclonium glomeratum

Oedogoniaceae

Oedogonium grande

Oedogonium vaucherii

Helminthocladiaceae

Batrachospermum vagum

WATTS LAKE

Watts lake (Fig. 1) is about half the size of Hackberry and only about one-third of a mile from it. Conditions in the lake were very similar to those in Hackberry in every respect. It was, however, slightly less alkaline than Dewey lake.

Collections were made here about once a week but other data were not taken. No boat was available on this lake and that may account for some of the difference in the reports for Watts and Hackberry lakes. No reason for a difference in species could be given unless it were the slight difference in alkalinity. The following species were found which it will be noted are nearly all included in those found in Hackberry and Dewey lakes and the springs on the shore of Clear lake.

Chroococcaceae

Clathrocystis aeruginosa
Coelosphaerium kuetzingianum
Merismopedium tenuissimum
Microcystis marginata

Nostocaceae

Nostoc pruniforme

Bacillariaceae

Achnanthes lanceolata
Amphora ovalis
Cocconeis placentula
Gomphonema gracile
Gomphonema montanum
Homoeocladia amphioxys
Navicula gastrum
Navicula lanceolata

Desmidiaceae

Cosmarium boeckii
Cosmarium formosulum nathorstii
Cosmarium geminatum
Cosmarium granatum
Cosmarium obtusatum
Cosmarium phaseolus
Cosmarium pseudopyramidatum
Cosmarium subcrenatum
Staurastrum gracile
Staurastrum margaritaceum

Tetrasporaceae

Dictyosphaerium pulchellum

Pleurococcaceae

Oocystis solitaria
Scenedesmus bijugatus
Scenedesmus obliquus
Scenedesmus quadricauda
Tetraedron minimum

Hydrodictyaceae

Pediastrum boryanum

Characeae

Chara contraria

OTHER LAKES

One visit was made to each of the following lakes in the early summer. Trout and Dad's lakes (Fig. 1) are among the larger of the group while Phalaris (Fig. 1) is one of the smaller. The Snake Creek Falls, about 15 miles distant, were visited once. These are falls in a creek which flows through the sandhill region. These collections were made so superficially that the lists must stand only as representing some species found in these localities.

The only form found which was sufficiently conspicuous to need special mention was *Nostoc verrucosum* which was extremely abundant on rocks in the cataract below the falls in Snake Creek.

The forms found in these localities are as follows:

PHALARIS LAKE

Chroococcaceae

Coelosphaerium kuetzingianum
Merismopedium tenuissimum
Dactylococcopsis rhaphidioides

Bacillariaceae

Amphora ovalis
Cocconeis placentula
Cystopleura gibba
Cystopleura turgida
Gomphonema montanum
Homoeocladia amphibia
Navicula cryptocephala veneta
Navicula cuspidata
Navicula elliptica
Navicula gastrum
Navicula oblonga
Navicula sculpta
Navicula sphaerophora
Sceptroneis fibula

Desmidiaceae

Cosmarium angulosum
Cosmarium blyttii
Cosmarium formosulum nathorstii
Cosmarium granatum subgranatum
Cosmarium obtusatum
Cosmarium regnellii

Tetrasporaceae

Dictyosphaerium pulchellum

Pleurococcaceae

Oocystis solitaria
Pediastrum boryanum
Scenedesmus bijugatus
Scenedesmus quadricauda
Tetraedron minimum

Characeae

Chara contraria
Chara evoluta
Chara fragilis
Chara sp.

TROUT LAKE

Chroococcaceae

Clathrocystis aeruginosa

Nostocaceae

Anabaena flos-aquae
Nostoc zetterstedtii

Hydrodictyaceae

Pediastrum angulosum

Characeae

Chara sp.

DAD'S LAKE

Chroococcaceae

Clathrocystis aeruginosa

Desmidiaceae

Closterium acerosum

Tetrasporaceae

Dictyosphaerium pulchellum

Hydrodictyaceae

Pediastrum boryanum
Pediastrum duplex clathratum

SNAKE FALLS

Chroococcaceae

Merismopedium glaucum

Oscillatoriaceae

Arthrospira jenneri
Oscillatoria brevis
Oscillatoria formosa
Phormidium retzii

Nostocaceae

Nostoc pruniforme
Nostoc verrucosum

Rivulariaceae

Calothrix parietina

Bacillariaceae

Achnanthes lanceolata
Amphora ovalis
Cocconeis placentula
Cymbella amphicephala
Cymbella cuspidata
Cymbella ehrenbergii
Cymbella gastroides
Cystopleura gibba
Cystopleura ocellata
Cystopleura turgida
Cystopleura zebra
Denticula elegans
Encyonema turgidum
Eunotia major
Fragilaria mutabilis
Gomphonema acuminatum
Gomphonema herculeanum
Lysigonium crenulatum
Lysigonium distans
Navicula ambigua
Navicula anglica
Navicula appendiculata
Navicula brebissonii
Navicula cuspidata craticula
Navicula dicephala
Navicula elliptica
Navicula humilis
Navicula iridis
Navicula lanceolata
Navicula limosa
Navicula gibba brevistriata
Navicula mesolepta
Navicula pupula
Navicula radiosa
Navicula sculpta
Navicula viridis
Homoeocladia amphibia
Homoeocladia brebissonii
Homoeocladia amphioxys
Homoeocladia palea
Rhoicosphenia curvata
Sceptroneis pacifica
Stauroneis anceps
Stauroneis phoenicenteron
Surirella robusta
Surirella spiralis
Synedra ulna
Tetracyclus lacustris

Desmidiaceae

Closterium striolatum
Cosmarium microsphinctum
Cosmarium portianum
Cosmarium sportella
Cosmarium undulatum wollei
Euastrum oblongum
Euastrum verrucosum
Penium margaritaceum
Staurastrum orbiculare hibernicum

Pleurococcaceae

Scenedesmus obliquus

Protococcaceae

Chlorococcum humicola

Cladophoraceae

Cladophora glomerata

CONCLUSION

It appears even from so brief a study as the one just described that the occurrence of algae in a given body of water at a given time is due, to a certain extent, as Transeau (44), West (49), and others have said, to seasonal periodicity.

It is also evident that West (48 and 50), Oltmanns (34), Brannon (12), Wipple and Parker (53), Chambers (15), and many others are correct in their decisions that the mineral and gas content of water has much to do with its algal flora. Of these factors, alkalinity is probably to a great extent, the explanation for the wide difference in the algal flora of lakes so close together and so uniform in all other factors.

In a given lake the distribution of species may be explained by the one factor only that is variable, namely light intensity. Means for measuring this factor were entirely inefficient and only the crudest estimates can be made.

In small bodies of water where even the light is not variable to any measurable degree the dominant species and its associates are determined merely by chance except that forms lying beneath other forms are more shaded. This exception does not affect the dominant species but may affect the forms associated with it.

ALGAE FOUND IN CHERRY COUNTY

Chroccoccaceae.
- Aphanothece prasina A. Braun
- Clathrocystis aeruginosa (Kuetz.) Henfrey
- Coelosphaerium kuetzingianum Naeg.
- Dactylococcopsis rhaphidioides Hansg.
- Gloeocapsa arenaria (Hassall) Rabenh.
- Merismopedium aerugineum Bréb.
- Merismopedium glaucum (Ehrb.) Naeg.
- Merismopedium tenuissimum Lemmerm.
- Microcystis marginata (Menegh.) Kuetz.

Oscillatoriaceae.
- Arthrospira jenneri (Kuetz.) Stiz.
- Lyngbya aerugineo-caerulea (Kuetz.) Gom.
- Oscillatoria amphibia Ag.
- Oscillatoria brevis (Kuetz.) Gom.
- Oscillatoria formosa Bory.
- Oscillatoria limosa. (Roth) Ag.
- Oscillatoria princeps Vauch.
- Oscillatoria sancta (Kuetz.) Gom.
- Oscillatoria subtilissima Kuetz.
- Oscillatoria tenuis Ag.
- Phormidium fragile (Menegh.) Gom.
- Phormidium retzii (Ag.) Gom.
- Phormidium tenue (Menegh.) Gom.
- Phormidium valderianum (Delp.) Gom.
- Spirulina major Kuetz.

Nostocaceae.
- Anabaena flos-aquae (Lyngb.) Bréb.
- Anabaena oscillarioides Bory.
- Anabaena torulosa (Carmich.) Lagerheim
- Cylindrospermum comatum Wood
- Cylindrospermum majus Kuetz.
- Nodularia harveyana(Thwaites)Thuret
- Nostoc austini Wood
- Nostoc caeruleum Lyngbye

Nostoc commune Vaucher
Nostoc glomeratum Kuetz.
Nostoc humifusum Carmichael
Nostoc linckia (Roth) Bornet
Nostoc minutum Desm.
Nostoc muscorum Ag.
Nostoc pruniforme (L.) Ag.
Nostoc spongiaeforme Ag.
Nostoc verrucosum (L.) Vauch.
Nostoc zetterstedtii Areschoug
Scytonemaceae.
Scytonema crispum (Ag.) Bornet
Tolypothrix distorta (Hofm. B.) Kuetz.
Rivulariaceae.
Calothrix parietina (Naeg.) Thur.
Rivularia echinulata (Smith) Born
Rivularia natans (Hedw.) Welw.
Rivularia pisum Ag.
Bacillariaceae.
Achnanthes lanceolata (Bréb.) Gr.
Amorpha ovalis (Bréb.) Kuetz.
Brebissonia vulgaris (Thwait) Kunze
Campylodiscus clypeus Ehr.
Cocconeis placentula Ehr.
Cyclotella meneghiniana Kuetz.
Cymbella amphicephala Naeg.
Cymbella cistula (Hempr.) Kirchn.
Cymbella cuspidata Kuetz.
Cymbella cymbiformis (Kuetz.) Bréb.
Cymbella ehrenbergii Kuetz.
Cymbella lanceolata (Ehr.) Kirch.
Cymbella naviculiformis Auersw.
Cymbella subaequalis Grun.
Cystopleura gibba (Ehr.) Kunze
Cystopleura zebra (Ehr.) Kunze
Encyonema turgidum (Greg.) Grun.
Eunotia diodon Ehr.
Eunotia lunaris Grun.
Eunotia major (W. Sm.) Rabenh.
Fragilaria capucina Desmaz.
Fragilaria construens (Ehr.) Grun.
Fragilaria construens binodis (Ehr.) Grun.
Gomphonema acuminatum Ehr.
Gomphonema constrictum Ehr.
Gomphonema gracile Ehr.
Gomphonema herculeanum Ehr.
Gomphonema montanum Schum.
Gomphonema parvulum Kuetz.
Homoeocladia amphibia (Grun.) Kunze
Homoeocladia amphioxys (Ehr.) Kunze
Homoecladia brebissonii (H. Sm.) Kunze
Homoeocladia palea (Kuetz.) Kunze
Lysigonium crenulatum (Kuetz.) Kunze
Lysigonium distans (Kuetz.) Kunze
Lysigonium varians (Ag.) D.T.
Navicula ambigua Ehr.
Navicula anglica Ralfs
Navicula appendiculata (Ag.) Kuetz.
Navicula bacilliformis Grun.
Navicula brebissonii Kuetz.
Navicula cryptocephala veneta (Kuetz.) Rhabenh.
Navicula cuspidata Kuetz.
Navicula dicephala Ehr.
Navicula elliptica Kuetz.
Navicula gastrum Ehr.
Navicula gibba (Ehr.) Kuetz.
Navicula gibba brevistriata Grim.
Navicula hilseana Jan.
Navicula humilis Donk.
Navicula iridis Ehr.
Navicula lanceolata Kuetz.
Navicula limosa Kuetz.
Navicula major Kuetz.
Navicula mesolepta Ehr.
Navicula oblonga Kuetz.
Navicula pupula Kuetz.
Navicula radiosa Kuetz.
Navicula sculpta Ehr.
Navicula sphaerophora Kuetz.
Navicula stauroptera Grun.
Navicula subcapitata Greg.
Navicula viridis Kuetz.
Nitzschia brebissonii W. Sm.
Nitzschia spectabilis (Ehr.) Ralfs
Nitzschia tryblionella Hantzsch.
Rhoicosphenia curvata Grun.
Sceptroneis fibula (Bréb.) Schuett

Sceptroneis pacifica (Grun.) Elmore (In press)
Stauroneis anceps Ehr.
Stauroneis anceps amphicephala Kuetz.
Stauroneis acuta W. Sm.
Stauroneis phoenicenteron Ehr.
Stauroneis smithii Grun.
Surirella ovalis ovata (Bréb.) V.H.
Surirella ovalis pinnata (Bréb.) V.H.
Surirella robusta Ehr.
Surirella spiralis Kuetz.
Synedra rumpens Kuetz.
Synedra ulna (Nitzsch.) Ehr.
Tetracyclus lacustris Ralfs

Desmidiaceae.
Arthrodesmus convergens Ehrenb.
Closterium acerosum (Schrank) Ehrenb.
Closterium aciculare Tuffen West
Closterium cynthia DeNot.
Closterium didymotocum Corda
Closterium jenneri Ralfs
Closterium lanceolatum Kuetz.
Closterium leibleinii Kuetz.
Closterium lunula (Muell.) Nitzsch.
Closterium moniliferum (Bory). Ehrenb.
Closterium parvulum Naeg.
Closterium pritchardianum Arch.
Closterium siliqua West and G. S. West
Closterium striolatum Ehrenb.
Closterium turgidum Ehrenb.
Cosmarium abruptum Lund.
Cosmarium angulosum Bréb.
Cosmarium angulosum concinnum (Rabenh.) West and G. S. West
Cosmarium blyttii Wille
Cosmarium boeckii Wille
Cosmarium botrytis tumidum Wolle
Cosmarium circulare Reinsch.
Cosmarium connatum Bréb.
Cosmarium crenatum Ralfs
Cosmarium cyclicum Lund.
Cosmarium cymatopleurum Nordst.
Cosmarium elfingii Racib.
Cosmarium formosulum nathorstii (Boldt) West and G. S. West
Cosmarium galeritum Nordst.
Cosmarium geminatum Lund.
Cosmarium granatum Bréb.
Cosmarium granatum subgranatum Nordst.
Cosmarium holmiense Lund.
Cosmarium holmiense integrum Lund.
Cosmarium impressulum Elfv.
Cosmarium kjellmani grande Wille
Cosmarium laeve Rabenh.
Cosmarium meneghinii Bréb.
Cosmarium microsphinctum Nordst.
Cosmarium notabile Bréb.
Cosmarium obtusatum Schmidle
Cosmarium ochthodes Nordst. var.
Cosmarium pachydermum Lund.
Cosmarium pachydermum aethiopicum West and G. S. West
Cosmarium phaseolus Bréb.
Cosmarium phaseolus elevatum Nordst.
Cosmarium phaseolus minor Boldt
Cosmarium portianum Arch.
Cosmarium protractum (Naeg.) DeBary
Cosmarium pseudopyramidatum Lund.
Cosmarium pygmaeum Arch.
Cosmarium pyramidatum Bréb.
Cosmarium rectangulare hexagonum (Elf.) West and G. S. West
Cosmarium regnellii Wille
Cosmarium retusiforme (Wille) Gutw.
Cosmarium sexnotatum Gutw.
Cosmarium sportella Bréb.
Cosmarium subcrenatum Hantzsch
Cosmarium subtumidum Nordst.
Cosmarium subundulatum Wille
Cosmarium taxichondrum Lund.
Cosmarium tetraophthalmum Bréb.
Cosmarium trilobulatum Reinsch
Cosmarium tumidum Lund.
Cosmarium turpinii podolicum Gutw.
Cosmarium umbilicatum Luetkem.