A STUDY OF THE PLANT MICROFOSSIL SUCCESSION IN THE BOTTOM DEPOSITS OF CRYSTAL LAKE, VILAS COUNTY, WISCONSIN, AND THE PEAT OF AN ADJACENT BOG.

L. R. WILSON AND A. T. CROSS.

ABSTRACT. Microfossil analyses of lake bottom samples from cores taken at eight stations in the deeper water of Crystal Lake and at regular depths in the peat of an adjacent bog show the plant succession of the surrounding region. The lake and bog deposits were found to be coextensive in time.

Only one of the nine species of large aquatic plants found in Crystal Lake contributed microfossils to the lake deposits; the others came from land plants, chiefly trees and shrubs. Spruce pollen is more abundant in the lower than in the upper strata of the deposits. Pine pollen is most abundant in the middle of the deposits, while those of oak, birch, elm, willow, poplar, grasses, sedges and composites is found chiefly in the upper strata. The pollen spectrum of the bog agrees with the results of previous investigations in this region. With two exceptions the microfossils found in the core samples of the lake correlated closely with those of corresponding depths in the bog deposit. These two exceptions might be attributed to accidental confusion of two samples of lake sediments.

INTRODUCTION.

A STUDY of the plant succession in the region surrounding Crystal Lake in northern Wisconsin was attempted by a stratigraphic and statistical analysis of the microfossils in the lake sediments and the peat of an adjacent bog.

Crystal Lake is an oligotrophic lake in Vilas County, Wisconsin. It covers an area of about 75 acres in sections 27 and 28, Township 41 North, Range 7 East. The lake lies in a deep kettle hole located in a pitted outwash plain. As the name would suggest, the waters are crystal clear, having a color of zero, and are exceedingly soft. The bound carbon dioxide content of the water is 1.3-2.8 p.p.m. and the pH is about 5.9-6.7. The sediments in the lake are sandy down to a depth of 12 meters where they gradually pass into finely divided organic sediments.

The plants of Crystal Lake have been discussed by Fassett (1930), who states that there is practically no littoral vegetation except for a few overhanging alders. The vegetation of the lake is of the "rosette" growth form type, and nine species are recorded. With the exception of the spores of *Isoetes*, none of these plants has contributed microfossils to the present study. The majority of the microfossils observed in the Crystal Lake sediments and bog peat were derived from the vegetation of the upland, which is essentially the same around both lake and bog. This consists largely of *Abies balsamea*, *Picea mariana*, *Pinus Banksiana*, *P. resinosa*, *P. strobus*, *Acer saccharinum*, *A. saccharum*, *Alnus incana*, *Betula papyrifera*, *Populus tremuloides*, *Prunus pennsylvanicum*, *Quercus ellipsoidalis*, *Salix* sp., *Tilia americana* and *Ulmus americana*. There is also an abundance of grasses, sedges, heaths, and composites in the vicinity.

The bog, which is about a quarter of a mile north of Crystal Lake, is approximately one-eighth as large as the lake. It is covered by a dense growth of leather leaf (*Chamydaphne*). Spruce trees formerly covered the bog but have been recently destroyed by fire.

METHODS OF STUDY.

In the present investigation, core samples of the lake sediments were secured and supplied to the writers by Dr. W. H. Twenhofel and the Wisconsin Geological and Natural History Survey. The methods of collection and the physical description of the sediments are given in a paper by Twenhofel and Broughton (1939). The cores were collected from the bottom of the lake by a special apparatus designed for this purpose. Eight cores were taken from various locations in the lake as shown in Fig. 1. The cores represent sections through sediments of about three meters in thickness. A sample was studied from the top, middle, and bottom of each.

From the bog a single section was secured and studied. This was taken from near the center with a modified Davis peat borer. Samples were obtained at one foot intervals to a depth of about ten and one-half feet. This level marks the bottom of the peat.

The samples of the lake sediments and peat were preserved dry in glass or celluloid vials. This material was prepared for microscopic analysis in the following manner. One cubic centimeter of each sample was placed in a clean bottle containing 5 cc. of ten normal sodium hydroxide. This was allowed to stand for a week and then about 15 cc. of water were added. Temporary mounts were made from these disintegrated sediments as needed. The samples were mixed thoroughly, both by shaking the bottle and stirring the contents before making up a slide. This insured the uniformity of the counts.

Four counts, fifty microfossils to each count, were taken from the contents of each sample bottle. If there were not fifty microfossils on one slide, additional slides were made until the proper number had been recorded. Thus, 200 spores or pollen

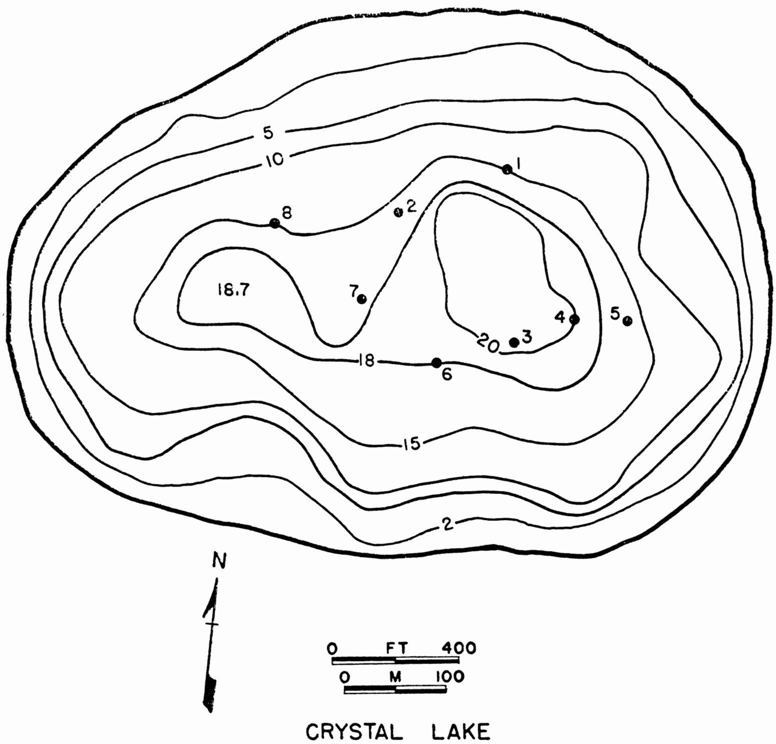

Fig. 1. Hydrographic map of Crystal Lake showing locations of core samples. The depth of the lake is shown in meters.

grains were counted from each level of the eight cores taken from the Crystal Lake sediments and from the twelve levels of the peat samples secured from the bog. These results were tabulated and the percentages computed. (Table 1).

RESULTS OF STUDIES.

From the microfossil studies, it is quite apparent that the ten and one-half feet of peat in the bog were deposited over the same period of time as the three meters of organic sediments

TABLE 1. Microfossil percentages in cores of

Sample Horizon	1			2			3		
	L	M	U	L	M	U	L	M	U
Sphagnum				0.5	0.5				3.5
Isoetes									0.5
Pinus strobus—P. resinosa	36.0	12.0	56.0	44.0	70.0	46.5	15.0	78.5	44.0
Pinus banksiana	4.5		10.5	3.0	2.0	8.5	1.0	3.0	11.5
Picea	44.5	84.5	7.5	35.5	3.0	11.5	59.5	4.0	11.0
Abies		2.0	6.0			4.0	4.5		5.0
Gramineae	3.0	0.5	4.5	4.5	2.0	5.0	3.0	0.5	4.5
Cyperaceae	1.5		1.5			0.5			1.5
Salix				1.0	1.5		2.5	1.5	
Betula	1.5		0.5	2.5	6.5	6.5	2.0	3.5	5.0
Alnus					1.0	2.5	0.5		6.5
Quercus		1.0	9.0		1.0	7.0	3.5	2.0	2.5
Ulmus					1.5	0.5			
Acer	3.5		0.5	1.5	6.5		2.0	5.5	1.0
Tilia			2.5			1.5			0.5
Fraxinus						2.0			
Ericaceae									
Compositae	5.5		1.5	7.5	4.5	4.0	6.5	1.5	3.0

* Columns marked L, M, and U represent lower, middle and upper parts of the core respectively.

in Crystal Lake. Also it appears that a study of the peat gives a microfossil spectrum that is a more accurate picture of the regional plant succession than the lake sediments. This is probable since the samples of peat can be more accurately collected than samples of the lake sediments.

Certain successions illustrated by the microfossils of the bog appear significant. Of these, the following may be cited. The *Picea* spectrum in the bog shows that spruce was more abundant in the bottom levels than it is on the peat surface. Upward, there is a gradual decrease in spruce pollen until at the depth of one and one-half feet a slight increase occurs. Most of the early spruce is that of *P. glauca* while the latter is *P. mariana*. *Pinus strobus* and *P. resinosa* are grouped together because of the similarity of their pollen, and together these species are more abundant in the middle layers of the bog.

Quercus, *Betula*, *Alnus* and Compositae are more abundant in the upper strata of the peat than in the lower.

Acer occurs in the lower peat layers of the bog and is less abundant in the middle and is absent from the surface sample.

Spores of *Sphagnum* increase toward the top of the deposit and are indicative of the part played by *Sphagnum* moss in the

Crystal Lake sediments and an adjacent bog.*

4			5		6			7			8		
L	M	U	M	U	L	M	U	L	M	U	L	M	U
		4.0		0.5			0.5		0.5	3.0		1.5	1.0
16.0	72.5	47.0	57.0	63.0		13.0	56.0	4.5	62.5	53.0	61.5	67.5	57.5
11.5	3.0	3.5	0.5	11.5		1.5	8.0		4.0	12.0		1.5	6.5
59.0	8.0	10.5	21.0	7.0	100.0	84.0	8.5	85.0	15.0	5.0	34.0	12.0	5.5
		2.5		3.5			2.5	3.5		1.0	0.5	1.0	7.0
2.0		5.0	0.5	3.5			9.0	1.0	2.5	4.5			
		1.0		0.5			0.5			1.5			
4.5		0.5	0.5				0.5	1.5		0.5		0.5	
1.5	4.0	7.5	4.5	3.0		0.5	2.5	0.5	3.5	2.0	0.5	6.5	13.0
1.5	0.5	3.5	0.5	1.0			0.5		1.0	1.5		2.0	2.5
		5.0	1.0	2.0			5.0		1.5	6.0		1.0	4.0
		0.5					0.5					2.0	
3.0	8.0	2.0	11.0			1.0	2.0	2.0	9.0	3.0	3.5	4.5	
		1.0											0.5
1.0	4.0	6.5	3.5	4.5			4.0	2.0	0.5	7.0			2.5

formation of peat. An increase in *Picea mariana* pollen and *Sphagnum* spores in the uppermost layers of a bog has been interpreted by Wilson and Galloway (1937) as evidence for the formation of a peat mat around a lake as it nears extinction. This theory is further supported in the present study, for the peat changes from a limnic type to a subaërial type at the level where spruce and *Sphagnum* spores increase in abundance. It should be further pointed out that a change to a cooler climate such as suggested by Von Post (1936) would likely increase the abundance of spruce and *Sphagnum* in this region. *Sphagnum* spores also occur in the Crystal Lake sediments although there is at present no bog of this sort entering the lake. There is, however, at the western end, some evidence of a bog having existed there, and, in relatively recent time, having been buried by sand pushed up by an ice rampart.

The microfossil succession shown by the bog is not peculiar to this deposit but agrees very well with previous findings in the region (Wilson and Webster, 1941).

Using the microfossil percentages in the bog as the normal microfossil spectrum one may compare the findings in the core samples of Crystal Lake. To make microfossil comparisons between the bog samples and the lake sediment samples it would seem best to compare only those species whose pollen is similarly

TABLE 1. (*Concluded*)

Bog
(Depth in feet)

Horizon	10.5	9.5	8.5	7.5	6.5	5.5	4.5	3.5	2.5	1.5	0.5	Surface
Sphagnum		2.0	12.0	13.0	17.0	4.0	19.5	11.5	3.5	6.0	5.5	12.5
Isoetus	8.5		62.0	36.0	34.0	53.0	46.5	61.5	73.5	62.5	56.5	8.5
Pinus strobus— P. resinosa	1.5		14.5	7.0	2.5	5.5	1.5	4.5	0.5	2.5	4.5	1.5
Pinus banksiana	77.5	76.0	4.5	28.0	16.5	21.0	5.5	4.0	6.5	10.0	16.0	4.0
Picea	3.5			8.0	9.5	6.0	13.5	8.0	1.0		2.0	1.5
Abies		0.5			0.5							1.0
Gramineae								0.5			1.0	1.5
Cyperaceae	1.0	5.0	4.0	1.0	2.5	1.5	3.5		0.5	1.5	2.0	1.5
Salix		2.0	1.5	3.0	2.5	1.5	2.5	2.5	8.5	7.5	8.5	21.5
Betula					2.5	2.0	2.5	3.5	2.0	1.0	1.5	12.0
Alnus			0.5	2.0	2.5	0.5	0.5	0.5	1.0	1.5	1.0	1.5
Quercus					1.5		0.5		1.5	2.0		
Ulmus	7.5	8.5			2.5	1.5	2.0	2.0		1.5		
Acer				0.5					0.5			
Tilia												
Fraxinus												
Ericaceae						1.5	2.0		0.5	1.0	0.5	15.0
Compositae	0.5	6.0	1.0	1.5	6.0	2.0		1.5	0.5	3.0	1.0	18.0

dispersed and likely to be uniformly abundant in both deposits. Therefore such species of plants as are peculiar to the lake or bog should not be used for correlation work; instead the upland vegetation, particularly the wind pollinated trees will serve well in this respect, since they produce an abundance of pollen, and by wind action are likely to be distributed widely and uniformly. In the list of tree species that may be used there are some that produce more pollen and which may preserve better than other species. In this group are spruce and pine. In the group that produces less pollen, or whose pollen does not preserve as well, are the oaks, maples and birch. In a statistical analysis of the microfossils in the sediments these latter species occur in relatively small and frequently uniform amounts. For these reasons they appear to be of little stratigraphic value. The pollen of *Abies* may also be included in this second group since it is not very abundant and it has little stratigraphic value in this particular region. In contrast to this group, spruce and pine pollen preserves well and is abundant in nearly all levels of the sediments and peat. These pollen are relatively more frequent in certain levels as above described. Here, then, are microfos-

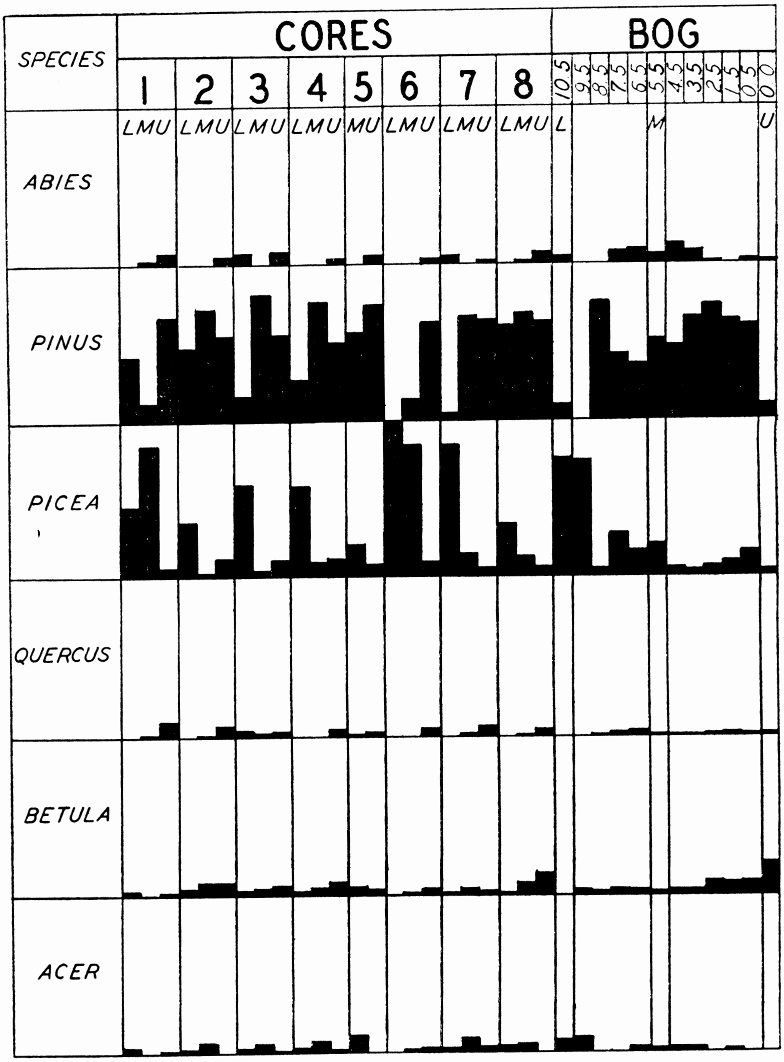

Fig. 2. Graphs showing the percentages of the more abundant tree pollen in eight cores from Crystal Lake and one from an adjacent peat bog. The height of the rectangle represents one-hundred per cent. The letters "L. M. U." refer to "lower, middle, and upper" core samples and the depths in the bog are shown in feet.

sils that have stratigraphic value, and greater consideration should be given to them than to species that are relatively infrequent.

To make absolute correlations between samples is not probable since the chances of securing such contemporary deposits are remote. To state that any one level is of the same age as another taken from a like level is not possible since compression of the sediment in the cores must be considered. Also the speed and uniformity of the sedimentation in any two areas differs. The most likely samples to correlate should be the surface sample of the bog and the upper samples in the lake, yet when consideration is given to the condition of the top organic sediments in lakes it will be seen that these are in a highly fluid state and are difficult to collect. Therefore, only a general correlation is possible.

Table I gives the percentages of microfossils in the lower, middle and upper samples respectively, and those in the bog at various levels in feet. Figure 2 shows these percentages graphically and reference to the table and the graphs shows marked correlations between the core and bog samples. This is particularly true with those samples from the top. However, a careful study of the microfossil spectra indicates that not all of the lower, middle and upper samples are comparable to each other. This is indicated very well by the fossil spectra of *Pinus* and *Picea*. An examination of the spectrum of *Pinus* in the bog shows that the greatest abundance of fossils of this genus occurs in the middle of the core. An examination of the spectra of the cores of Crystal Lake for this pollen form shows that cores 2, 3, 4, 7 and 8 have a spectrum which resembles that of the bog. The upper samples in cores 1, 5 and 6 appear to be comparable to the middle samples of the other cores and of the bog. In cores 5 and 6, the middle samples appear to be comparable to lower levels. The lower sample of core Number 5 was not secured. The lower sample of core Number 6 indicates by the absence of *Pinus* and the complete dominance of *Picea* that it is probably the oldest sample of the sediments examined, since spruce appears to have been the first tree to forest the region after the retreat of the glacial ice.

The bog spectrum of *Picea* indicates that this pollen was abundant in the lower levels and became progressively less in the middle and upper samples. This same spectrum is to be found in cores 5, 6, 7 and 8 but cores 2, 3 and 4 show a slight variation from the normal. This might be accounted for by the possibility that the lower and middle samples of these cores came from levels not comparable to those of the other cores. Their approximate location in the column may be established by reference to Figure 2.

The lower and middle samples of core Number 1 do not correlate in microfossil content with others from the same level. It would seem from a study of the microfossil content of these two samples that the samples have been accidentally confused, and the middle sample is actually the lower sample and *vice versa.* If this is true, the fossil spectrum will be corrected to resemble more closely that of the normal microfossil spectrum for the region. An examination of the two core samples show that the one labelled "middle of core" contains more silt and clay and less organic matter than the samples labelled "bottom of core." This might further support the above theory.

The authors wish to express their appreciation to Dr. W. H. Twenhofel and the Wisconsin Geological and Natural History Survey for the opportunity of examining the sediments of Crystal Lake.

Literature.

Conger, Paul S.: 1939, The contribution of diatoms to the sediments of Crystal Lake, Vilas County, Wisconsin. Amer. Jour. Sci., 237: 324-340.

Fassett, N. C.: 1930, The plants of some northeastern Wisconsin lakes. Trans. Wis. Acad. Sci., 25: 157-168.

Twenhofel, W. H. and Broughton, W. A.: 1939, The sediments of Crystal Lake, an oligotrophic lake in Vilas County, Wisconsin. Amer. Jour. Sci., 237: 231-252.

Von Post, L.: 1930, Problems and working lines in the post-arctic history of Europe. Rept. Proc. 5th Intern. Bot. Congr. Cambridge, 48-54.

Wilson, L. R. and Galloway, E. F.: 1937, Microfossil succession in a bog in northern Wisconsin. Ecology, 18: 113-118.

Wilson, L. R. and Webster, R. M.: 1942. Microfossil studies of three northcentral Wisconsin bogs. Trans. Wis. Acad. Sci., Arts, and Letts., 34: 177–193.

Coe College,
Cedar Rapids, Iowa.