THE SPATIAL DISTRIBUTION OF DESMIDS IN CERTAIN NORTHERN MINNESOTA LAKES

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INTRODUCTION

A literature survey has indicated that there are considerable gaps in our knowledge concerning the spatial distribution of desmids in lakes. Most of the previous research in this area has been concerned with the geographic distribution of these algae (Fritsch 1935), in which some attempts have been made to relate such distribution to geologic conditions and water chemistry (West and West 1903, 1906, and 1912; Pearsall 1932; Prescott 1936; Teiling 1916; Nygaard 1949).

However, no single lake has been thoroughly investigated over an extended period to determine in detail the spatial distribution of these organisms within it. Our only certain knowledge is the general observation that desmids are more abundant in the littoral than in the limnetic zones. According to Nichols and Ackley (1932), Stokes (1893), Ralfs (1848), Wolle (1894), and Prescott (1935), desmids are most abundant in the vicinity of aquatic macrophytes, while Prescott and Scott (1942) state that the richest desmid floras are found in cloud-like masses of filamentous algae of many genera (Spirogyra, Mougeotia, Oedogonium, and Zygnema) growing on Isoetes, Myriophyllum, and other associated aquatics. Prescott (1936) found that plants of the genus Utricularia always had large populations of desmids associated with them, and has used this observation to collect desmid populations in lakes for taxonomic investigations.

There are three major desmid communities; the terraqueous, in bogs; the benthoplanktonic, associated with aquatic plants; and the limnoplanktonic, in open water (Griffiths 1928). Wesenberg-Lund (1905), West and West (1909), and Griffiths (1928) believed that the limnoplankters actually evolved from terraqueous or benthoplanktonic forms. Griffiths (1928) suggested that this "evolutionary" process could occur in as little as 40 years in any lake. In contrast, Brook (1959) suggested that the differences were only morphological, and that this "evolutionary" process could occur annually for certain species. He further stated that the principal distinction between limnoplankters and facultative plankters is that the morphology of facultative plankters does not change significantly when they occur in the plankton, while the morphology of limnoplankters is variable. Limnoplankters capable of changing their morphology when changing habitats have been documented in the literature by both Brook (1959, 1960) and Teiling (1947), who demonstrated that many limnoplankters are only morphological variants of benthoplanktonic taxa. The morphology of species found in these two environments is so different that many variants have been described as separate species.

The source of planktonic desmids has long been the subject of considerable speculation. As pointed out by Fritsch (1931), we shall never arrive at a full understanding of the phytoplankton until we know its origin and its relationship to other algal communities. He postulated that desmids occur in the littoral zone or on the bottom during the winter, because they do not form cysts or spores, but Brook (1959) suggested that some over-winter in the plankton, and others in the benthos or terraqueous habitats.

The most complete study with desmids in this respect was undertaken by Duthie (1965), who found that desmids were present on the sediments first, and later appeared in the plankton. Duthie found that the sinking rates of desmids corresponds to their ecological status in the lake (*i.e.* the benthic taxa sank more rapidly than planktonic taxa), and that cellular processes and mucilage sheaths increased cell bouyancy.

There have been very many studies of desmid taxonomy, but few on their distribution or ecology. However, two observations concerning planktonic diatoms may be relevant to desmids. Lund (1949) found that *Asterionella* is always planktonic, and does not originate in littoral zones. Another diatom (*Melosira italica* var. *subarctica*, Lund 1954) sinks to the sediments during summer stratification and remains there until resuspended during the autumn circulation period. Water circulation is, therefore, crucial for the survival of this planktonic diatom, and possibly many desmids as well. Because of the importance of circulation to certain algae, it might be that the morphometry of the lake basin is an important factor contributing to the specific composition and abundance of phytoplankton. In support of this view, Rawson (1955) states that morphometry is the dominant factor in the primary productivity of large lakes, and Round (1965) that the spatial distribution of phytoplankton is affected by the shape and size of a lake's basin and patterns of circulation.

Little is known about which ecological factors determine the spatial distribution of desmids; although some authors (West and West 1909; Pearsall 1931) have studied the occurrence of desmids in lakes of diverse character, and have attempted to relate their observations to certain environmental influences, there is little experimental evidence in support of their hypotheses. Indeed, much remains to be discovered about the physical and nutritional requirements of these organisms and their relationships (*e.g.* antagonism, parasitism, etc.) with other organisms before definitive conclusions can be reached.

The present study is concerned with the factors influencing the spatial distribution of desmids in certain lakes of the Itasca State Park region (Text Figure 1) of Northwestern Minnesota (Latitude 47° 10' N. : Longitude 95° 12' W.). The general features of limnological significance are described by Meyer and Brook (1969). This study's objectives have been to study and gain some insight into the following aspects of desmid distribution:

1. their spatial distribution and the effects of seasonal environmental changes on such distribution.

2. the relationship between desmid populations in littoral and limnetic zones, particularly in relation to the distribution of aquatic macrophytes.

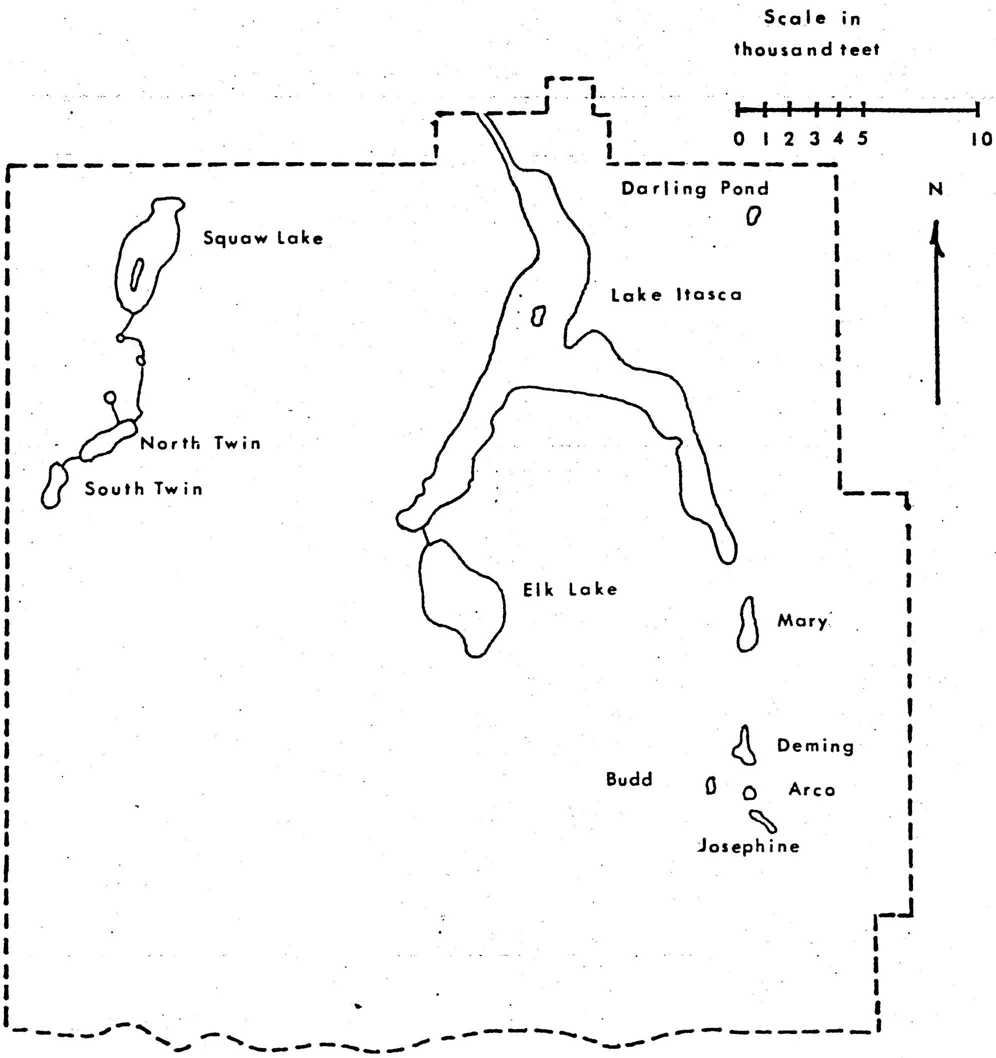
3. the origin and fate of desmid populations from year to year within a lake.

MATERIALS AND METHODS

Collection and Counts of Planktonic Desmids

Samples were collected at one-meter intervals with a 1 liter Kemmerer water sampler and preserved with Lugol's solution. Counts were made with a Unitron Inverted Microscope and ten-milliliter counting chambers. Because planktonic desmids occur in low frequencies, the entire bottom surface of the counting chamber was examined.

Text Figure I: A Map of the Itasca region showing the locations of the lakes sampled for this study. (Modified from Meyer and Brook 1969).



<u>Quantitative Assessment of Desmids from Aquatic Plants</u>

When it was first recognized that desmids had their greatest abundance in association with aquatic macrophytes in littoral zones, the problem of standardizing samples collected from these plants became apparent. At first, a portion of the aquatic was caught in the Kemmerer water sampler, the sampler shaken, and a 25 ml. sample was taken and treated with Lugol's solution. This procedure proved to be unsatisfactory, because morphological differences in the species of aquatics studied, and the incorporation of unknown portions of the plants in the sampler, produced considerably different results.

Later, entire plants were brought into the laboratory and examined; also, underwater leaves and stems were scraped and these scrapings were examined. It was soon found that each species of aquatic macrophyte varied with respect to the desmid population it harbored, but the problem of sampling still remained.

After much investigation of individual plants, cuttings measuring 1 cm. were taken from those portions of the plants with the most desmids. These cuttings were placed into 1 ml. of water, diluted, treated with Lugol's solution, placed in counting chambers, and counted. Population densities of desmids on different macrophytes of the same species from a particular area were usually very similar (Text Tables 1-4).

TEXT TABLE 1: Counts of desmids found on <u>Utricularia vulgaris</u> in North Twin Lake. The 25 samples are from 1 cm. cuttings which were placed in 1 ml. of water, diluted, sedimented, and counted.

	Desmid Genera								
SAMPLE NO.	Closterium	Cosmarium	Desmidium	Euastrum	Gymnozyga	Hyalotheca	Micrasterias	Netrium	Onychonema
1	16	136		21	2		7		5
2	3	103		17		1	5		
3	6	118	2	17		1			
4	9	138	2	16			1	1	6
5	3	91	2	10	1		5		1
6	6	104	1	16			6		2
7	8	134	6	11	2		3	1	2
8	11	117	1	22	3	1	3		5
9	8	90		12		1	6		
10	7	96	2	18					
11	10	131	2	28					1
12	9	163	1	18			1		
13	7	155		23			3		3
14	9	57	2	10	1		2		1
15	3	106		10					
16	4	92		14					3
17	4	82	1	15	1		3		
18	2	78		7					
19	6	102		20	3	1	4		
20	5	45		10			2		1
21	4	61		12	1				1
22	7	73	2	9	1	1			
23	9	109	2	13	1		3		3
24	8	88	1	6					2
25	4	44	2	10	2	3	2		1
To-Tals	168	2513	30	364	18	9	56	2	37

TEXT TABLE 1: Continued.

SAMPLE NO.	Pleurotaenium	Sphaerozosma	Spinoclosterium	Spondylosium	Staurastrum	Staurodesmus	Xanthidium	TOTAL IN SAMPLES
1		10		7	49	12	3	268
2		5		1	42	12	1	190
3		6		2	30	4		186
4		6		2	42	9	1	233
5		9		2	42	9	5	180
6		12			40	13	2	202
7		3			51	13	2	236
8		6			36	19	1	224
9	1	13		1	49	20	2	203
10	2	5			35	10		175
11		10		4	34	15	4	239
12	1	12		1	45	9	2	263
13		6			40	11	3	251
14		6		2	24	7	2	123
15		4			31	5	2	161
16		4		3	26	9		155
17		5		2	28	18	1	160
18		1			20	5	1	114
19		6		2	37	18	1	200
20		4		1	26	10	2	106
21		4			20	6		109
22	1	4			32	12	1	143
23		9			44	14	2	209
24		6		2	26	16	1	156
25		4		1	23	11	3	110
Totals	5	160	0	33	872	287	42	4596

TEXT TABLE 2: Counts of desmids found on <u>Potamogeton Robbinsii</u> in North Twin Lake. The 25 samples are from 1 cm. cuttings which were placed in 1 ml. of water, diluted, sedimented, and counted.

	Desmid Genera								
SAMPLE NO.	Closterium	Cosmarium	Desmidium	Euastrum	Gymnozyga	Hyalotheca	Micrasterias	Netrium	Onychonema
1	10	23				2			
2	20	31	1						
3	22	56		2			2		
4	57	101		3			2		
5	29	113		2		1			
6	32	121							
7	30	122		4			1	1	
8	24	92		1			1		
9	31	127		1					
10	24	115		1	1		2		
11	36	115		2			1		
12	35	111					2		
13	19	133		4			1		1
14	19	106		2					
15	30	106					2		
16	21	98							1
17	24	97		1					
18	13	71		1					
19	36	108		1			1		
20	22	87		2					
21	36	143		2			1		
22	14	97		2					
23	16	94		3					
24	14	99		1					
25	24	112		2			1		
Totals	638	2478	1	37	1	3	17	1	2

TEXT TABLE 2: Continued.

SAMPLE NO.	Desmid Genera: Pleurotaenium	Sphaerozosma	Staurastrum	Staurodesmus	Xanthidium	TOTAL IN SAMPLES
1	1	1	2	2		41
2	1		3	3		59
3	1		6	9	2	100
4			9	4	1	177
5		1	7	3		156
6			3	3		159
7			4	1	1	169
8			2	1		121
9		1	5	6		171
10		1	7	2		153
11		1	6	4		165
12		1	6	8		163
13		1	4	1		164
14		1	3		1	132
15		3	6	2		149
16			2	1		123
17		2	7	2	1	134
18		1	1			87
19		1	2	2		151
20			2	2		115
21		1	7	5		195
22		2	4	2		121
23	1		4	1		119
24		1	5	1	1	122
25			4	3	1	147
To-tals	4	19	111	68	8	3388

TEXT TABLE 3: Counts of desmids found on *Potamogeton amplifolius* in North Twin Lake. The 25 samples are from 1 cm. cuttings which were placed in 1 ml. of water, diluted, sedimented, and counted.

	Desmid Genera								
SAMPLE NO.	Closterium	Cosmarium	Desmidium	Euastrum	Micrasterias	Onychonema	Pleurotaenium	Sphaerozosma	Spondylosium
1	1	68		1				2	
2	3	79		6					
3	3	74		6					
4	5	48		3				2	1
5	1	75		3	1				
6	2	84		5					
7		100		1				4	
8	3	100		5		1		4	
9	2	106							
10	1	102	1	6				1	
11	7	102		4		1		1	
12	1	95		6					
13		92		2					
14	2	99		4				2	
15		88		2					
16	7	86		2					
17		99		6				2	
18		90		1					
19	1	80		5			1		
20	2	96		1					
21	1	99		3					
22	1	84	1						
23	2	80		1			1		
24	2	121		6				3	
25	1	86		1		1			
Totals	48	2233	2	80	1	3	2	21	1

TEXT TABLE 3: Continued.

	Desmid Genera			
SAMPLE NO.	*Staurastrum*	*Staurodesmus*	*Xanthidium*	TOTAL IN SAMPLES
1	7	2		81
2	10	8		106
3	10	5		98
4	12			71
5	9	5		94
6	14	3		108
7	11	3		119
8	9		1	123
9	10	1	1	120
10	9	1		121
11	8	1		124
12	1	2		105
13	3	2		99
14	1	2		110
15	9	2		101
16	8	4		107
17	9	1		117
18	5	1		97
19	13	2		102
20	9	1		109
21	2	4		109
22	3	3		92
23	6	2		92
24	6	4		142
25	8			97
Totals	192	59	2	2644

TEXT TABLE 4: Counts of desmids found on *Myriophyllum exalbescens* in North Twin Lake. The 25 samples are from 1 cm. cuttings which were placed in 1 ml. of water, diluted, sedimented, and counted.

	Desmid Genera								
SAMPLE NO.	Closterium	Cosmarium	Desmidium	Euastrum	Hyalotheca	Micrasterias	Onychonema	Pleurotaenium	Sphaerozosma
1	4	59		8					1
2		66		4				1	2
3	6	70		21				2	1
4	3	46		7					
5	1	67		6	1	1	1	1	
6	3	20		6				3	
7	3	28		1			1		1
8	3	24		5	1				1
9	3	53		10				2	1
10	1	74		11					1
11	2	65		3		1		2	
12		66		7					1
13	3	54		6					
14	3	65		4					
15	5	52		6				1	
16	1	57		6					
17		65	1	3					
18	3	47		3		1			3
19	1	72	1	3					2
20	4	23		4				1	1
21	2	37		5				1	1
22	6	62		6					
23	4	44		3			1	1	
24	1	63		3				1	1
25	5	60		4			2		
Totals	67	1339	2	145	2	3	5	16	17

TEXT TABLE 4: Continued.

	Desmid Genera				
SAMPLE NO.	*Spondylosium*	*Staurastrum*	*Staurodesmus*	*Xanthidium*	TOTAL IN SAMPLES
1		15	6		93
2		8	4		85
3	1	13	3	1	118
4	1	8	2		67
5	2	10	4		94
6		9	7	1	49
7		11	7		52
8		9	5	2	50
9		12	6	1	88
10		15	8		110
11	1	11	3		88
12		8	5		87
13		7	3		73
14	2	5	6		85
15		18	5	1	88
16		6	6		76
17		15	5		89
18		12	4		73
19	1	25	1		59
20		16	9		71
21		20	4		98
22		21	8		82
23		19	6		94
24		33	7	2	117
25	4	16	3		99
Totals	12	342	127	8	2085

Chemical and Physical Measurements

Because oxygen and temperature data give valuable information about the circulation patterns in lakes, measurements of these two parameters were made routinely in the lakes which were studied in detail (*i.e.* Squaw and North Twin).

Oxygen determinations were made by the Winkler method. The Winkler reagents were added to the samples in the field, and titrations were done in the laboratory.

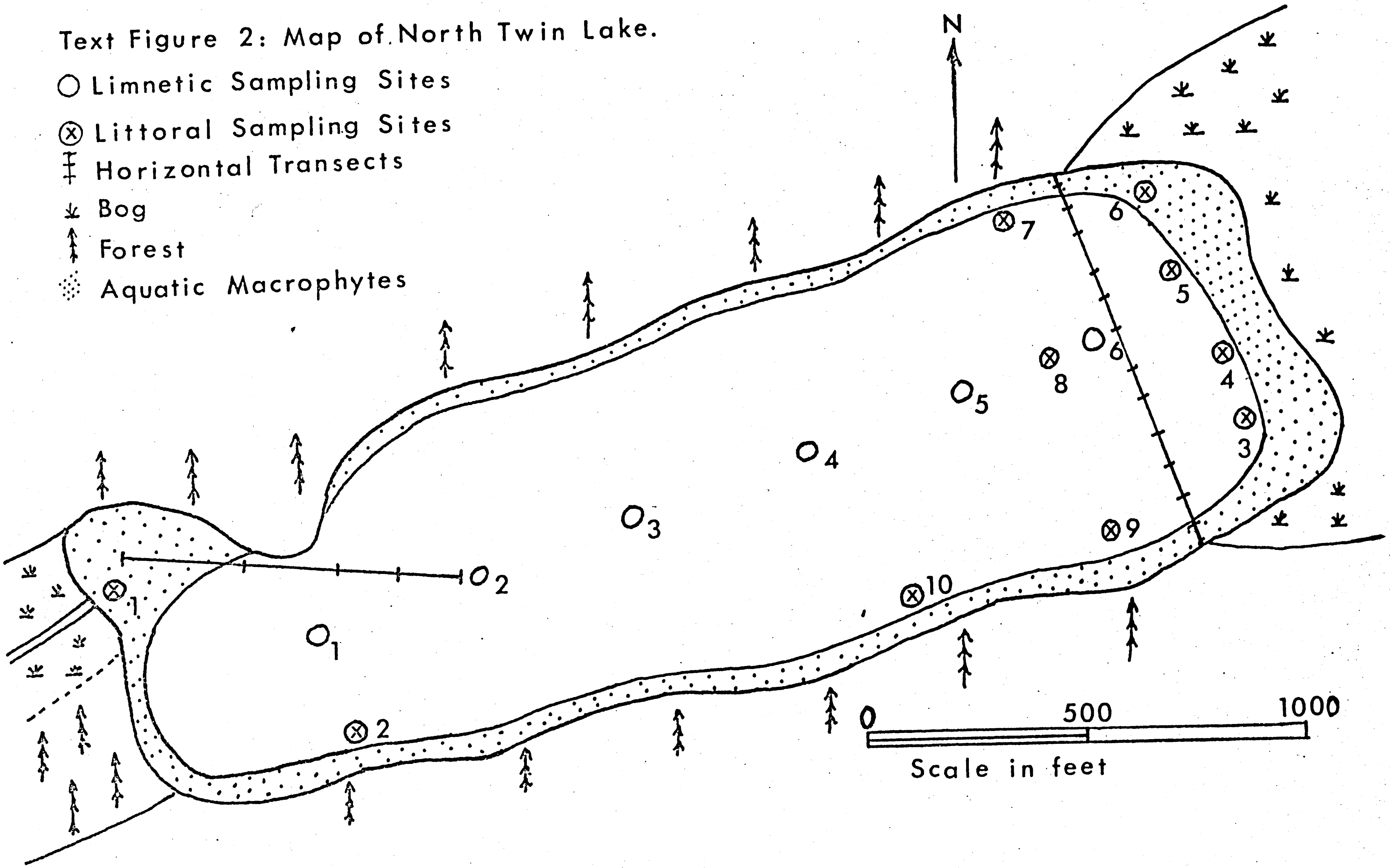
A Y.S.I. thermistor was used to measure temperatures at either 0.5 M. or 1.0 M. intervals, depending upon the depth of the thermocline, and the readings were recorded to the nearest 0.1°C.

DESCRIPTION OF THE LAKES STUDIED

North Twin Lake is located in Clearwater County, Section 18; T143N; R36W (Text Figures 1 and 2). The morphometric data are presented in Text Table 5. The lake is connected to South Twin Lake by a narrow channel leading through a small bog. Both appear to be well-protected from the wind; the shorelines ascend sharply from the margins, and the surrounding terrestrial vegetation is dense except for a bog northeast of North Twin Lake.

Even though the longest axis of the lake lies from the northeast to the southwest, and prevailing

Text Figure 2: Map of North Twin Lake.



TEXT TABLE 5: Morphometric data: North Twin Lake: Squaw Lake.

	North Twin	Squaw
Length:	890 Meters	1600 Meters
Width:	330 Meters	660 Meters
Surface Area:	180 Hectares	645 Hectares
Maximum Depth:	12 Meters	23 Meters

TEXT TABLE 6: A comparison of the number of samples taken from aquatic macrophytes, and the percentage of desmid taxa identified from lakes studied at Itasca.

Lake Sampled	Macrophyte Samples	% *	% **
North Twin	127	153.0%	100.0%
Squaw	83	100.0	100.0
Darling	1	1.2	83.1
Budd	1	1.2	81.9
Deming	2	2.4	76.5
Arco	2	2.4	58.0
Josephine	2	2.4	74.9
Mary	5	6.0	81.9
Elk	2	2.4	76.1
Itasca	2	2.4	82.8

* This percentage represents the number of aquatic macrophytes sampled as compared with the 83 sampled from Squaw Lake.

** This percentage represents the total number of desmid species identified from each lake as compared with the 243 species identified from North Twin and Squaw Lakes.

winds are from the southwest, the surrounding topography prevents southwest winds from greatly influencing the lake. However, the northeast end of the lake is open and wind from this direction can more readily reach and influence the lake's surface.

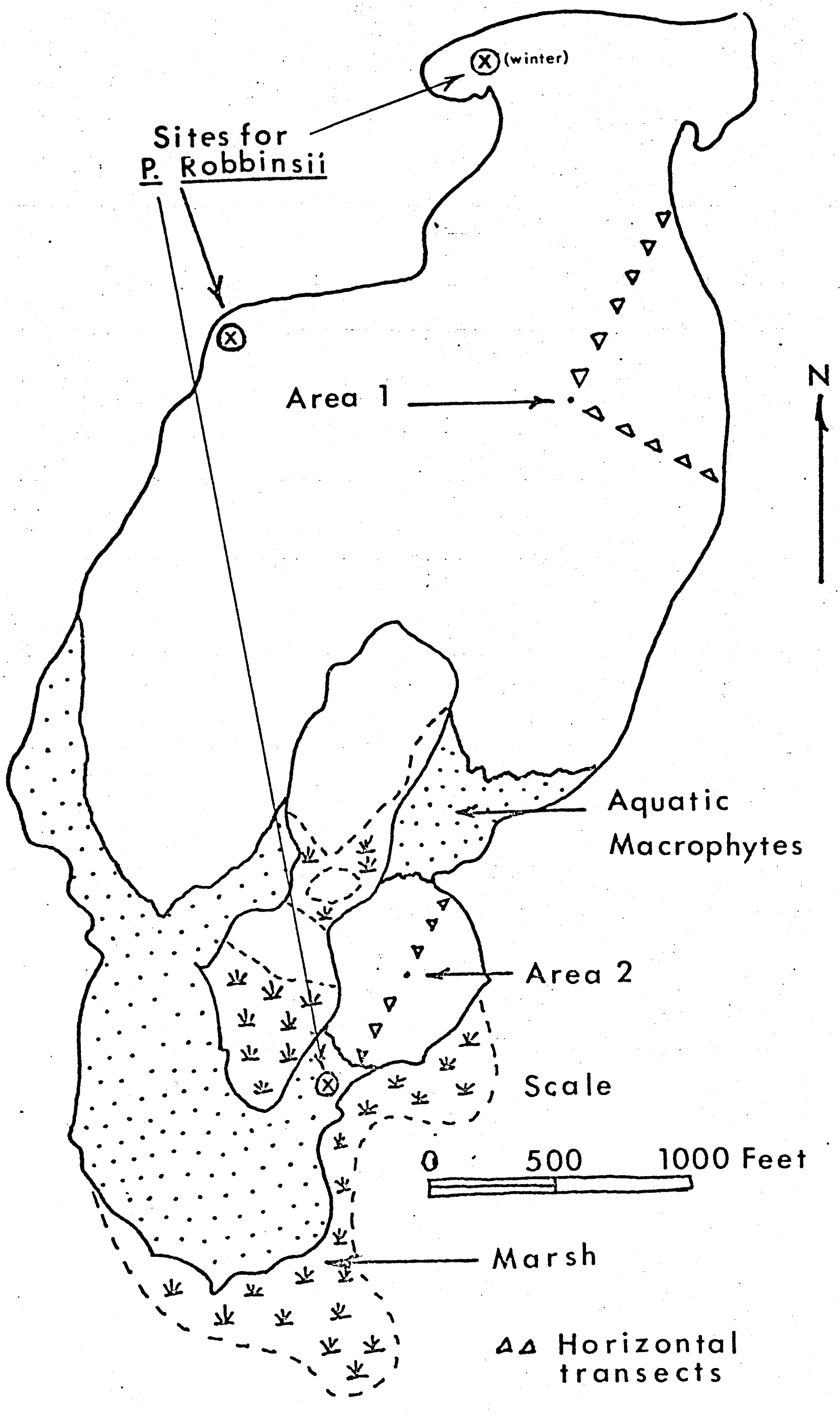
As a partial result of this factor, the southwest end of the lake has fewer aquatic macrophytes than the northeast end, even though many aquatic macrophytes are found in the well-protected area which connects North Twin with South Twin Lake (Text Figure 2). (Table 1 in the Appendix lists the aquatic macrophytes identified from North Twin Lake).

Squaw Lake is located in Clearwater County, Section 5; T143N; R36W; (Text Figure 3). The morphometric data are presented in Text Table 5.

The long axis of this lake is oriented from north to south, and the lake is slightly longer than wide. It lies about one-half mile north of North Twin Lake. A bog lies between the two lakes (Text Figure 1). The south shore of Squaw Lake merges with this bog, but elsewhere hillsides rise sharply from the margins. A further important feature is the small island near the south end (Text Figure 3).

As in North Twin Lake, the distribution of aquatic macrophytes appears to be influenced by wind-driven circulation. Macrophytes are most abundant at the south end of the lake, which is shallow and protected from

Text Figure 3: Map of Squaw Lake.



wind. Table 2 in the Appendix presents the list of aquatic macrophytes identified in this lake.

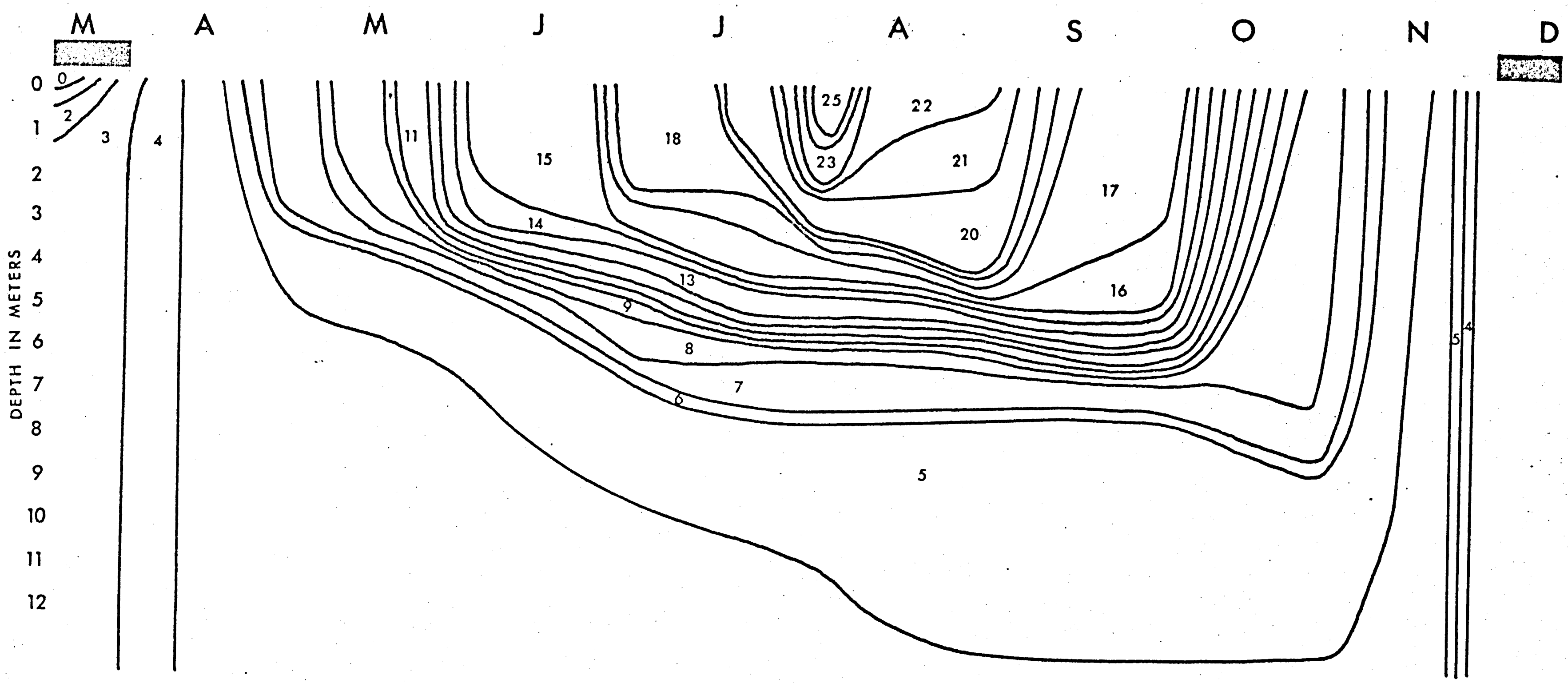
The other eight lakes sampled during this study were not examined in the same detail as North Twin and Squaw Lakes, but the aquatic macrophytes were identified, and relevant lists are presented in Tables 3-10 in the Appendix. The other lakes sampled during this study were as follows: Darling Pond; Budd Lake; Deming Lake; Arco Lake; Josephine Lake; Mary Lake; Elk Lake; and Lake Itasca (Text Figure 1).

Patterns of Water Circulation as Indicated by Temperature and Oxygen Profiles

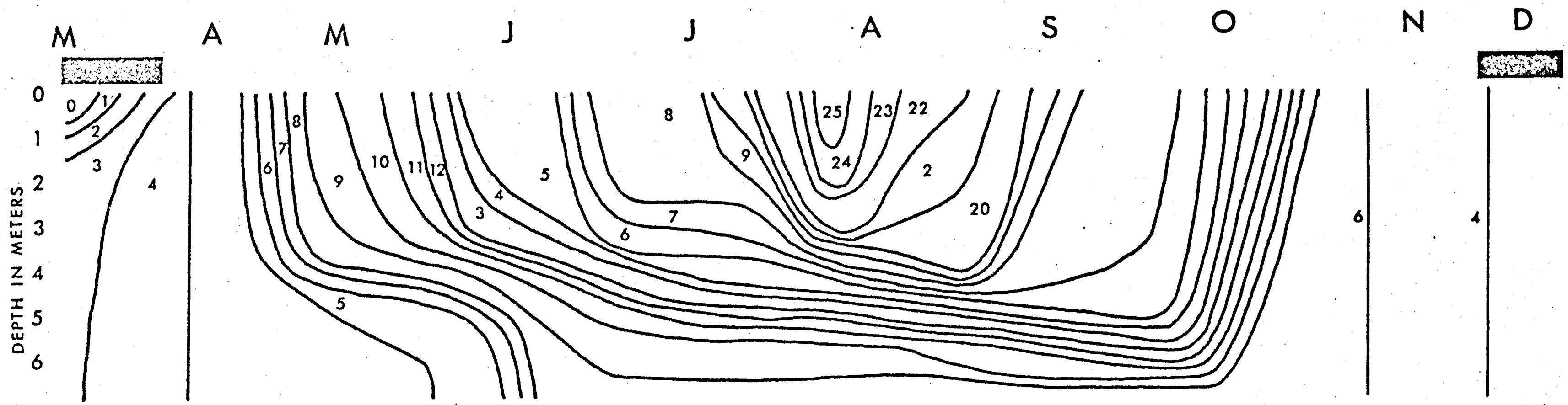
Annual temperature profiles have indicated that the protected region in Squaw Lake (Area 2) and North Twin Lake are protected from wind-driven circulation (Text Figures 4-7). It can be noted from these temperature profiles that the epilimnion in the open region (Area 1) of Squaw Lake reaches a greater depth than it does in the protected region or than it does in North Twin Lake. Further, the hypolimnion of the more open region of Squaw does not become oxygen depleted, while both the protected area of Squaw and North Twin Lake do (Text Figures 8-11). (Tables 11-18; Appendix: Temperature and Oxygen readings from North Twin and Squaw Lakes).

Considering these profiles of temperature and oxygen along with the distribution of aquatic macrophytes in the two areas of Squaw Lake as well as in

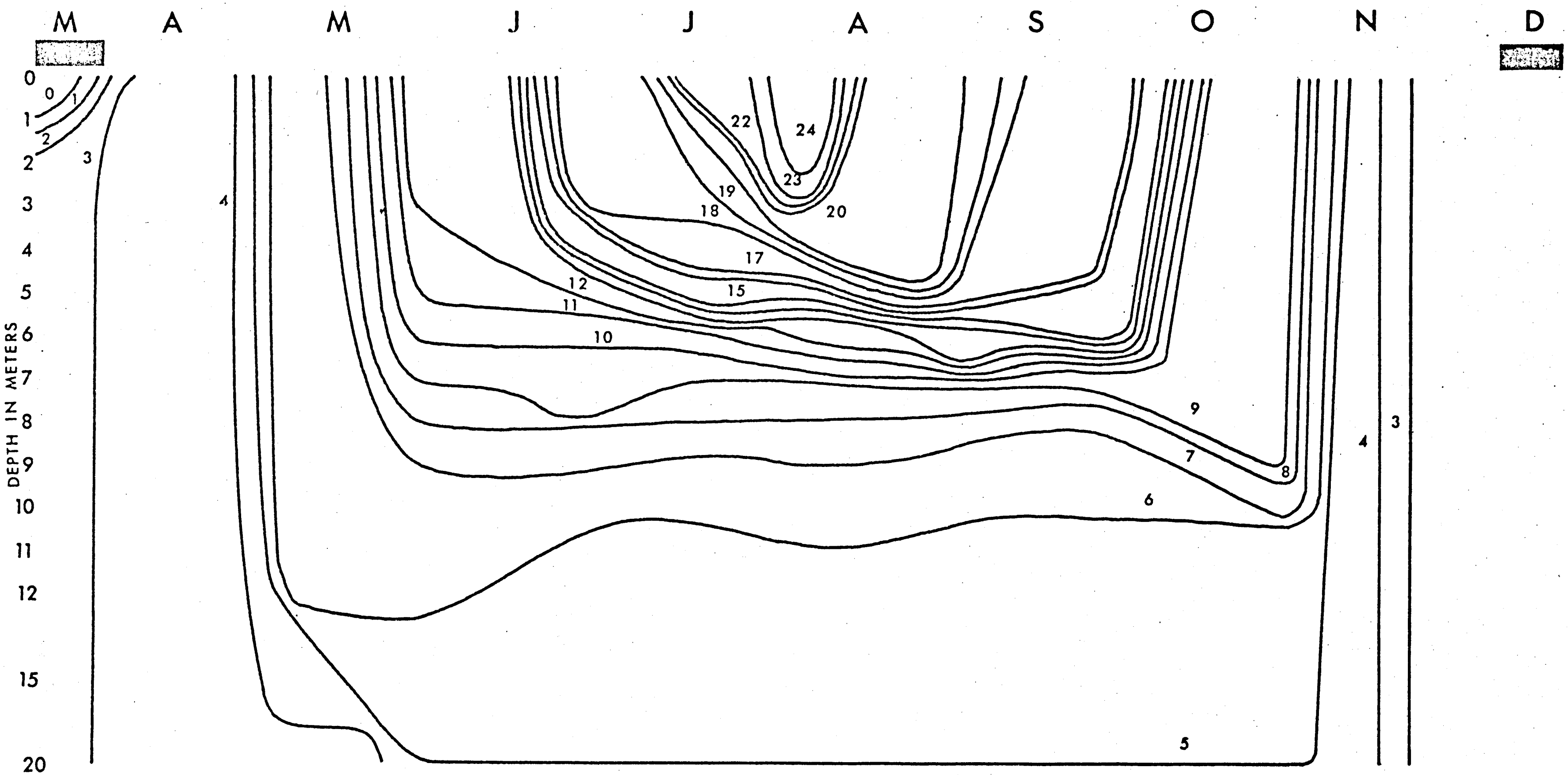
Text Figure 4: North Twin Lake, Area 2. Depth-time diagram showing changes in the thermal stratification during 1968. The Isotherms are given at intervals of 1.0° C.



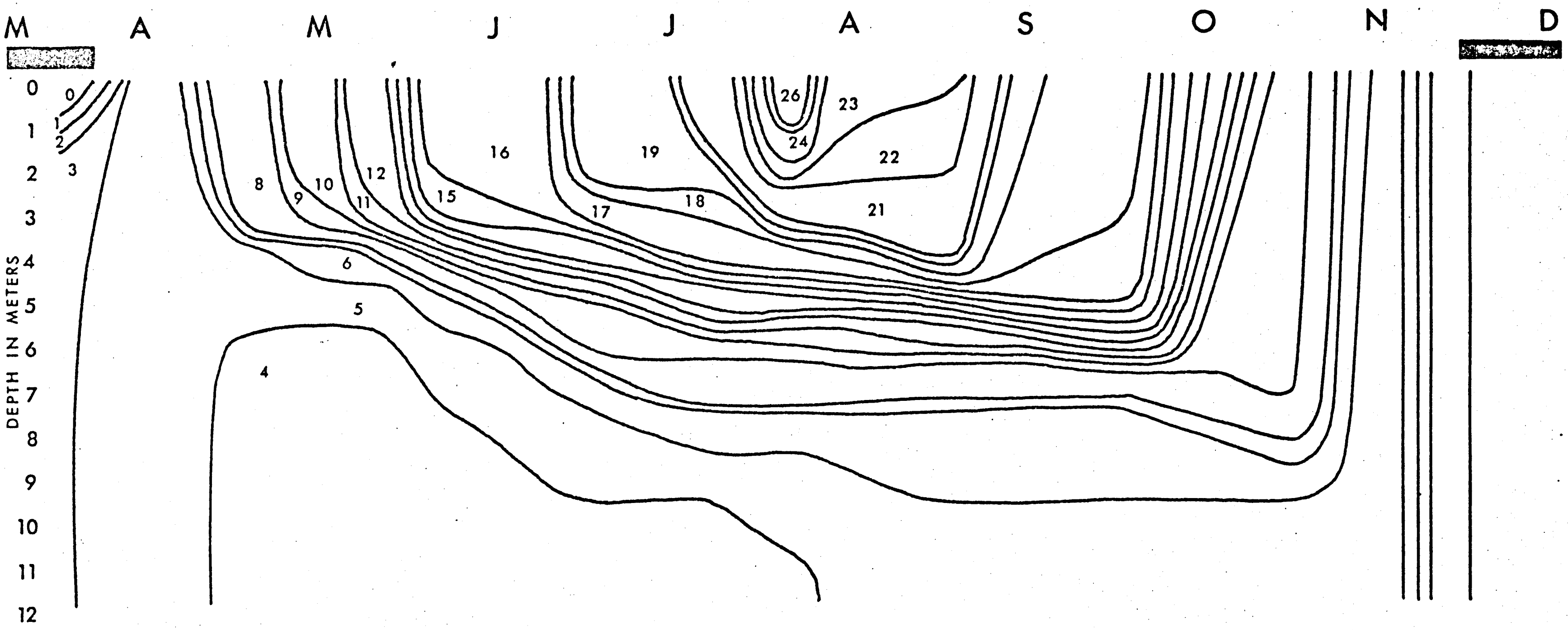
Text Figure 5: North Twin Lake, Area 6. Depth-time diagram showing changes in the thermal stratification during 1968. The Isotherms are given at intervals of 1.0°C.



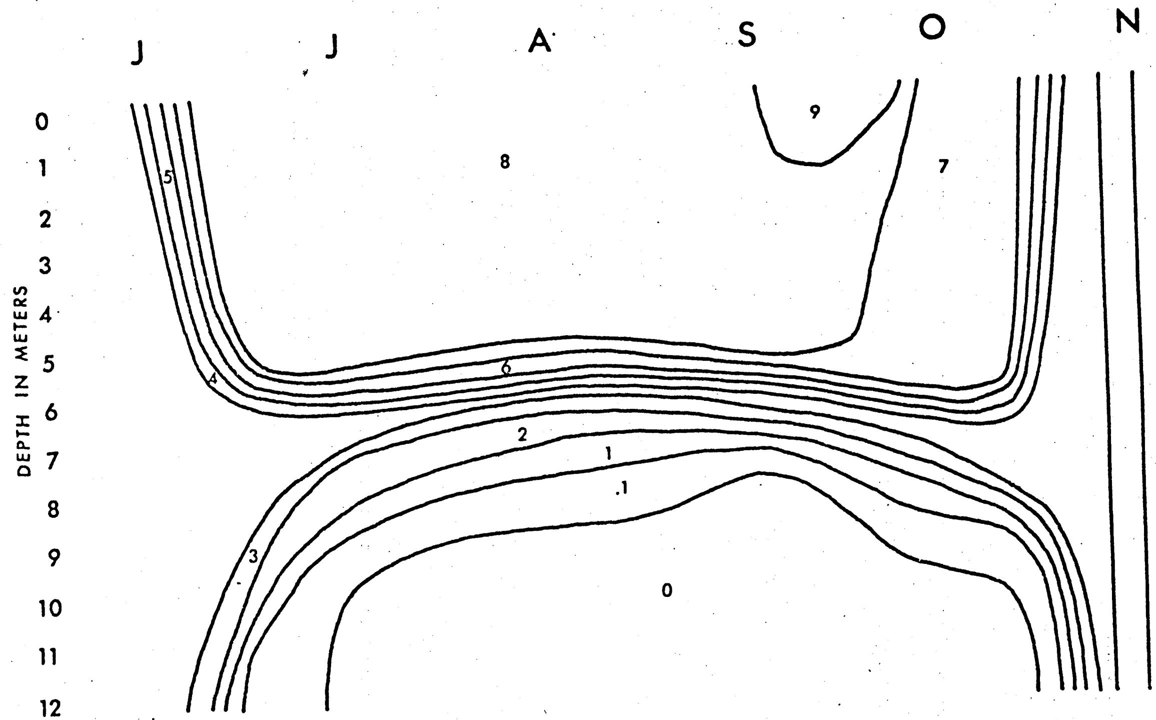
Text Figure 6: Squaw Lake, Area 1. Depth-time diagram showing changes in the thermal stratification during 1968. The Isotherms are given at intervals of 1.0°C.



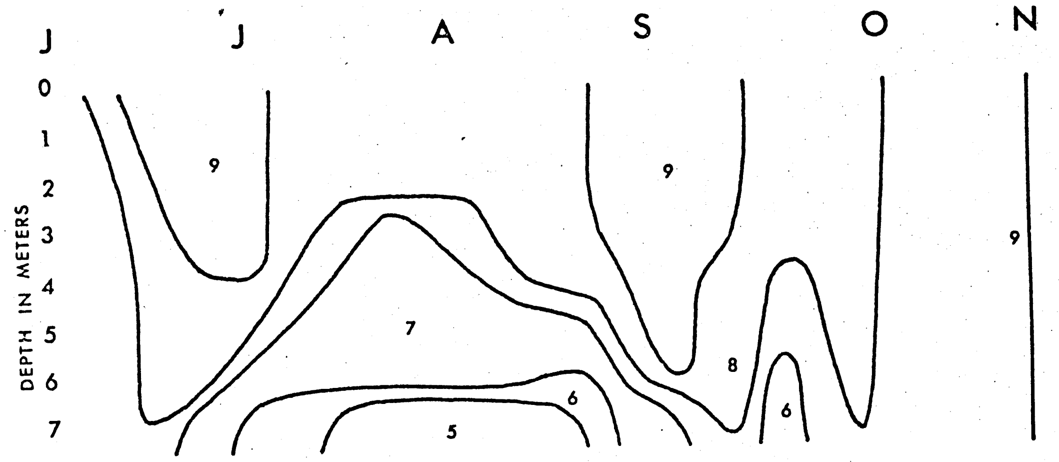
Text Figure 7: Squaw Lake, Area 2. Depth-time diagram showing changes in the thermal stratification during 1968. The Isotherms are given at intervals of 1.0 °C.



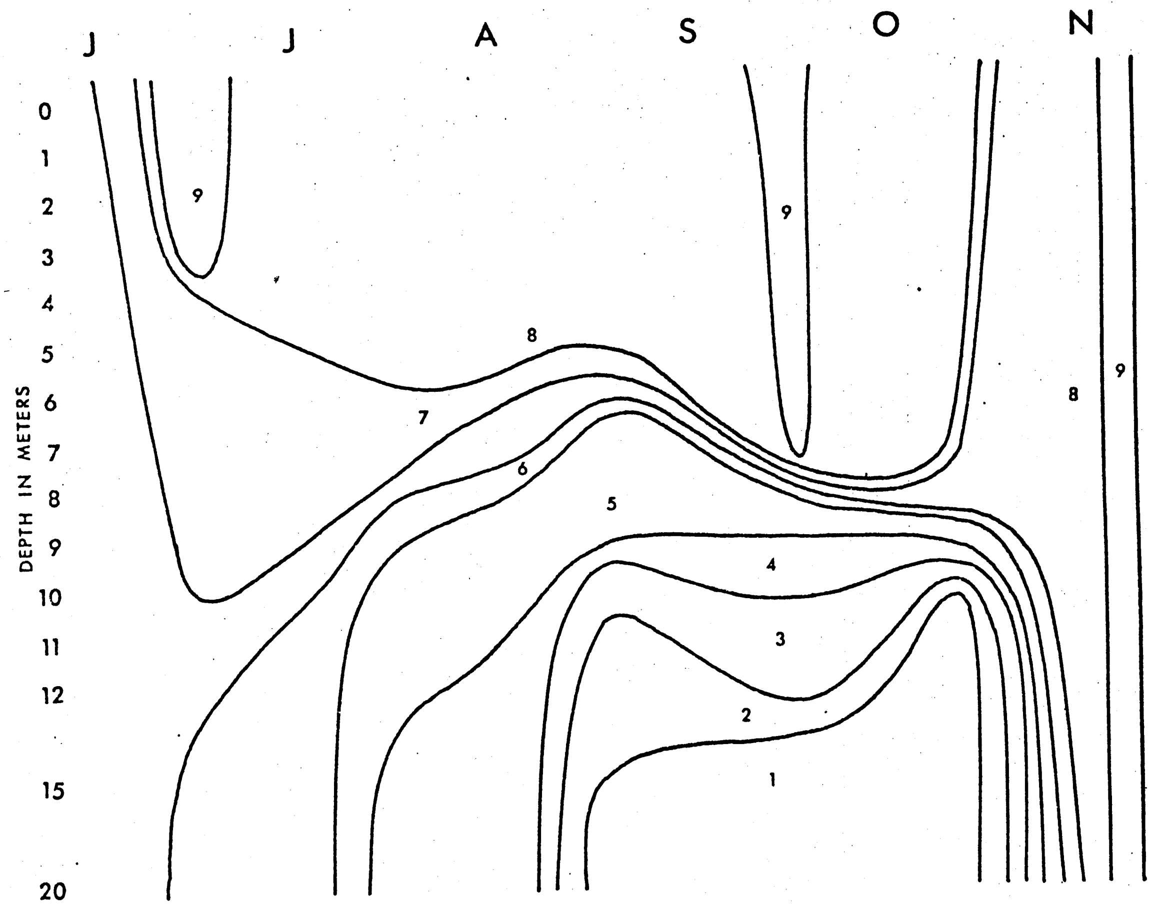
Text Figure 8: North Twin Lake, Area 2. Depth-time diagram showing changes in Oxygen concentrations during 1968. The Isopleths are given in p.p.m.



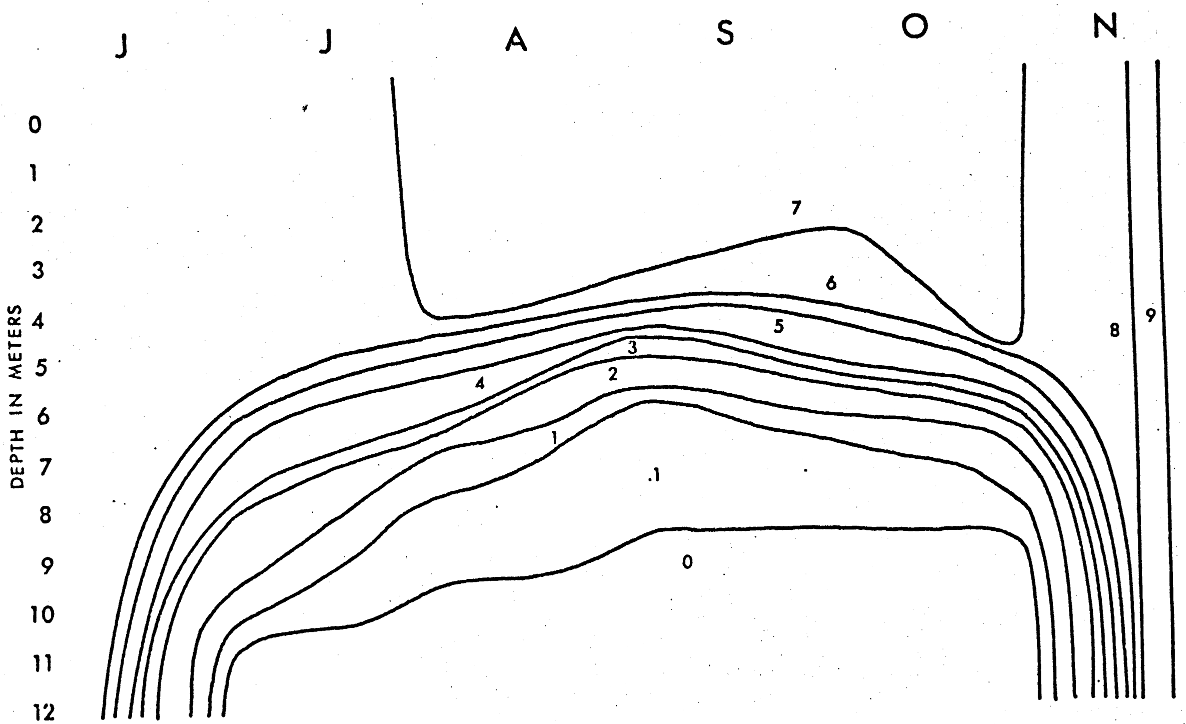
Text Figure 9: North Twin Lake, Area 6. Depth-time diagram showing changes in Oxygen concentrations during 1968. The Isopleths are given in p.p.m.



Text Figure 10. Squaw Lake, Area 1. Depth-time diagram showing changes in Oxygen concentrations during 1968. The Isopleths are given in p.p.m.



Text Figure 11: Squaw Lake, Area 2. Depth-time diagram showing changes in Oxygen concentrations during 1968. The Isopleths are given in p.p.m.



North Twin Lake, it has been postulated that wind-driven circulation has a more significant effect on the open region of Squaw Lake than it does on either the protected region of Squaw Lake or on North Twin Lake.

THE DESMID FLORA OF THE ITASCA LAKES

Distribution in Lakes

243 species and varieties of desmids were identified from North Twin and Squaw Lakes (Appendix Tables 19 and 20). Not all these same desmid taxa were found in the other eight lakes sampled, but a high proportion of the total were found in a small number of samples, and it is therefore probable that all the taxa are present in every lake of the Itasca region.

Between 75 and 83% of the species identified in North Twin and Squaw Lakes were also identified in the other eight lakes, even though only 1-6% as many samples were examined from the other lakes (Text Table 6).

The most frequently occurring desmids within the ten lakes are presented in Text Table 7. However, it should be pointed out that these desmids were frequent only within the limited area which was sampled. It would be impossible to state that these desmids are the most frequently occurring species unless a systematic sampling of the entire lake was undertaken.

TEXT TABLE 7: The most frequently occurring desmid taxa in the lakes of the Itasca region. This Table has been derived from Table 21 in the Appendix and lists only those taxa which had a frequency of occurrence greater than 10% in any of the lakes.

Desmid taxa *	Lake **							
	1	2	3	4	5	6	7	8
Closterium								
parvulum	0.2	1.4	7.0		0.4	1.6	20.0	1.6
Cosmarium								
angulare	1.4	0.4	0.8			4.0	1.0	18.6
angulosum	35.6	1.8	1.8	1.6	11.6	8.8		1.8
bioculatum	3.0	10.6	2.4	1.6	6.0	7.2	3.0	2.0
portianum	4.0	0.6	2.0		2.0	2.4	12.0	0.6
punctulatum	1.0	10.8	2.0		6.0	3.2		20.2
subdeplanatum	1.8	19.0		0.8	4.4			0.6
Staurastrum								
tetracerum		1.6	5.6	4.8	16.4		1.0	
Staurodesmus								
extensus	0.2	0.2		72.8				

* Identification of taxa made from samples taken from littoral zones.

** 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

DESMIDS IN LITTORAL HABITATS

As stated in the introduction, desmids occur in greatest abundance in littoral zones as a component of the metaphyton. This sub-community includes many species that are neither floating nor attached, but trapped among the macroscopic algae and the leaves of mosses and aquatic Phanerogams (Behre 1956). The metaphyton consists of many species of flagellates, Chlorococcales, desmids and diatoms (Round 1965). In all cases the desmid populations were found to be associated with aquatic plants within dense masses of filamentous green algae. The position and size of the underwater leaves and branches of these plants contribute significantly to the density of the desmid population which they can support.

Unfortunately, it is not possible to compare the surface areas of the plants used for this study, because the plants undergo rapid morphological change throughout the growing season. It is possible, however, to compare the morphologies of mature plants and the habitats which they thereby provide for desmid populations (Text Table 8). The plants used for this comparison exhibit morphological characteristics that illustrate the range of differences between species of aquatic macrophytes and their associated desmid populations.

TEXT TABLE 8: A list of the aquatic macrophytes sampled in this study in order to compare their morphologies (see text) and the sizes of their associated desmid populations.

Aquatic Macrophytes	Total number of desmid taxa	Total number of desmids *
Brasenia Schreberi	0	0
Nymphaea tuberosa	7	19
Nuphar variegatum	5	13
Zizania aquatica	14	20
Megalodonta Beckii	19	46
Myriophyllum exalbescens	29	102
Ceratophyllum demersum	38	150
Potamogeton Robbinsii	75	260
P. amplifolius	56	259
Utricularia vulgaris	84	286
U. intermedia	19	88
U. minor	15	45

* The figures in this column represent the total number of desmids encountered in one horizontal transect of the counting chamber at a magnification of 300x. The samples are 1 ml. samples taken from that part of the plant where desmids were known to occur in greatest abundance.

Morphology of the Larger Aquatic Plants and the Occurrence of Desmids

No desmids are associated with Brasenia, and there are relatively few on Nymphaea, Nuphar, and Zizania. A very thick gelatinous sheath covers all vegetative and floral parts of Brasenia, which has few branches, and attached algae are absent.

Nymphaea tuberosa and Nuphar variegatum are morphologically similar to Brasenia, but they have a much thinner gelatinous sheath. The sparse desmid populations on these plants are associated with attached structures such as leech egg casings, which are frequently present on the undersurfaces of the leaves (Text Table 8).

Zizania aquatica has very few desmids associated with it because it lacks underwater branches and leaves. The strap-shaped floating leaves are wrapped tightly around the stem and provide only a very limited area for algae to accumulate, and hence, the associated desmid populations are small (Text Table 8). This plant differs from the plants thus far described in that it lacks a gelatinous covering.

The desmid populations are restricted to the finely divided, whorled leaves in both Megalodonta Beckii and Myriophyllum exalbescens. Megalodonta probably has fewer desmids than Myriophyllum because its underwater leaves are more flexible and are possibly more readily disturbed by water movements. It is not always possible to find these plants in similar habitats, so it is difficult to ascertain the other factors that may be involved in determining desmid distribution.

Ceratophyllum demersum supports more desmids than Myriophyllum (Text Table 8). Its leaves are rigid, and the entire plant compact, especially in the terminal, actively growing shoot. This compact arrangement may restrict the numbers of algae that can accumulate on its underwater leaves (Text Table 8).

Potamogeton Robbinsii and *P. amplifolius* both harbor sizeable desmid populations (Text Table 8). These two species of *Potamogeton* were studied in considerable detail, because they are the only two species of Potamogeton found in almost every lake, and also they are the only species that remain partially intact under the ice during the winter (Moore 1915).

Potamogeton Robbinsii has narrow, v-shaped leaves arranged in two ranks on the stem, separated by short internodes. The bases of the leaves are extended into short rounded lobes, and the plants branch profusely under the water. The principal means of reproduction is vegetative and the buds so produced are very similar to the normal vegetative shoots, and appear to be smaller branches of the vegetative axis. The plants disintegrate during the spring overturn and the buds are a means of reproducing new plants in other areas of the lake.

Potamogeton amplifolius has leaves which are joined to the stem by short petioles, but it has large stipules, and when these are intact, they provide excellent habitats for algae. (The stipules can be broken apart by the accumulation of marl or by wave action). Its mode of vegetative reproduction is the same as P. Robbinsii, and the plants disintegrate in the spring (Moore 1915).

The remaining three species of aquatic macrophytes studied are all members of the genus Utricularia, and generally, they can be found in the same location in a lake. In North Twin Lake, for example, all three species are found in greatest abundance in the channel which connects North and South Twin Lakes. The vegetative plants are loosely rooted, submerged aquatics which produce emergent floral axes. The three species differ in leaf size and character, internodal length, the arrangement and size of bladders, and the spatial arrangement of the plant in the water. Utricularia vulgaris has the largest leaves and bladders of the three species and the shortest internodes. Its bladders are produced on the whorled leaves, and because of this, the vegetative parts of the plant are disposed horizontally in the water. The only vertical axes are those for the floral organs and roots. Another important morphological feature is the presence of minute spine-like teeth on the margins of the very finely divided leaves.

Utricularia minor is similar to U. vulgaris in the arrangement of leaves and bladders, but the entire plant is much smaller. The bladders are produced on the leaves which suspends the plant horizontally in the water, but its leaves lack the minute spine-like teeth. Its internodes are slightly longer than those of U. vulgaris, but the leaves are about half the size.

Utricularia intermedia differs from the other two species in having its bladders produced on separate branches from the leaves. As a result, its vegetative body does not lie horizontally in the water as do the other two species. Its leaves and internodes are much the same size as those of U. minor, but the leaves are copiously spine-toothed rather than smooth (Fassett 1957).

As with the other aquatic macrophytes, the density of the desmid populations appears to be related to the morphology of the plant. The Utricularia plants studied all came from the same area of the lake, and in fact, occurred close together. However, the density of their desmid populations suggests that some other factor than the location of the plant in the lake contributes to this difference (Text Table 8).

Even the two smaller species of _Utricularia_ also showed a difference in the size of the desmid populations they contain, yet these plants are very similar (Text Table 8). _Utricularia intermedia_, however, has minute, spine-like teeth on the leaves, and it harbors desmid populations significantly larger than those found on _U. minor_. These minute teeth provide additional places for filamentous algae to accumulate, and thus, are important for the colonization by desmid populations.

The Effects of Wave Action on Littoral Desmid Populations

An extremely important factor relevant to the desmid populations associated with aquatic macrophytes is the location of the plant in the lake. The same species of aquatic macrophyte taken from two different regions of the same lake have very different desmid floras. Samples of _P. Robbinsii_ were collected from two areas of Squaw Lake (Text Figure 3). One area was well-protected, while the other was in a region more often subject to wind and wave action. Twenty-five 1 ml. samples were taken from _P. Robbinsii_ plants in each of the two regions and counts of their desmid floras were made (Text Tables 9 and 10). In the protected region, 2,473 desmids were found in the 25 samples, while only 94 desmids were found in the same number of samples from the open region. The

TEXT TABLE: 9: Counts of desmids found on <u>Potamogeton Robbinsii</u> taken from a protected region in Squaw Lake. The 25 samples are from 1 cm. cuttings which were placed in 1 ml. of water, diluted, sedimented, and counted. September 3, 1969.

	Desmid Genera								
SAMPLES	Closterium	Cosmarium	Desmidium	Euastrum	Gymnozyga	Hyalotheca	Micrasterias	Onychonema	Pleurotaenium
1	6	55	1	8		2	2	4	
2	5	59	1	9	1		3	3	1
3	7	41		7		3	3	4	
4	5	48	1	8		1	1	2	
5	4	59	1	6	1		3	5	1
6	7	57	1	8		1	1	5	1
7	8	59		5		1	2	3	1
8	4	42		5			2	6	
9	1	58	1	7	1		2	5	
10	5	49	1	5			3	3	1
11	4	57	2	9		1	3	7	
12	2	61		6		1	4	4	
13	3	54	1	4			4	3	2
14	1	64		8	1		3	5	
15		52		8		2	4	3	
16		75	2	9			2	5	1
17	7	57		7			3	2	1
18	3	64	2	8			4	1	
19	5	81		9			3	2	
20	4	62		7		1	2	5	1
21	4	85	1	8	1		3	3	
22	2	71		8			2	3	
23		65	3	8		1	2	2	1
24	1	72		7	1		4	4	
25	4	50		8			4	8	
Totals	92	1496	18	182	6	14	69	97	11
(%)	(3.8)	(59.8)	(0.8)	(7.4)	(0.2)	(0.7)	(2.9)	(3.9)	(0.5)

TEXT TABLE 9: Continued.

SAMPLES	Sphaerozosma	Spondylosium	Staurastrum	Staurodesmus	Xanthidium	TOTAL OF ALL GENERA	Cells in Division	Dead Cells
	Desmid Genera							
1			8	3	2	91	7	2
2			15	6	2	104	8	5
3	1		14	8	4	92	9	6
4	1		13	8	1	89	9	5
5			14	10		104	8	4
6			12	5	2	100	7	3
7		2	10	2	1	94	9	3
8	1	1	15	5	2	83	6	3
9			9	3	1	88	6	6
10	1		14	7	2	91	6	4
11		1	13	4	1	102	8	4
12		2	9	5	2	96	6	5
13		2	13	6	2	94	7	6
14			10	6	2	100	6	6
15			13	3	1	86	8	6
16	1		10	5	1	111	12	2
17		1	10	5	3	96	10	3
18			11	4	3	100	10	4
19	2	1	12	4	2	121	13	4
20	1		10	10	1	104	9	7
21			9	4	2	120	14	4
22		1	11	4	4	106	10	3
23			8	4	2	96	9	5
24		3	12	4	2	110	11	4
25		2	10	3	6	95	6	5
Totals	8	16	285	128	51	2473	314	109
(%)	(0.4)	(0.7)	(11.5)	(5.2)	(2.1)	(100.0)	(12.7)	(4.4)

TEXT TABLE 10: Counts of desmids found on <u>Potamogeton Robbinsii</u> taken from an open region in Squaw Lake. The 25 samples are from 1 cm. cuttings which were placed in 1 ml. of water, diluted, sedimented, and counted. September 3, 1969.

	Desmid Genera							
SAMPLES	Closterium	Cosmarium	Euastrum	Staurastrum	Staurodesmus	TOTAL OF ALL GENERA	CELLS IN DIVISION	DEAD CELLS
1		3				3		3
2		3				3		2
3		6	1			7		3
4		1				1		1
5		2	1	1		4		3
6	1	1				2		
7		2				2		
8		2		1	1	4		3
9	2	4		1		7		3
10		3				3		
11	1	3				4		2
12	1	3				4		2
13		5				5		4
14		3				3		3
15	3	2				5		2
16		2		1		3		2
17		1	1	1		3		3
18		4				4		2
19		4	1			5		3
20		3	1			4		3
21		4				4		1
22		4				4		3
23		3	1			4		2
24	1	3				4		1
25		2				2		
Totals	9	73	6	5	1	94	0	53
(%)	(9.6)	(77.7)	(6.3)	(5.3)	(1.1)	(100.0)	(0.0)	(56.38)

number of dead cells and those in some stage of cell division were recorded from these samples. In the protected region these cells comprised 4% and 12% of the total cells respectively, while 56% of the cells were dead and none were dividing on plants from the open water. An analysis of variance table was constructed to compare these samples statistically. At the 5% level of significance the null hypothesis of equal means is rejected (Text Table 11). From counts made of dead and dividing cells, it is apparent that the desmid population in the protected region was actively increasing, while that in the open region was decreasing.

Seasonal Variations in the Desmid Populations from Littoral Regions

During the winter months two aquatics, *Potamogeton Robbinsii* and *P. amplifolius* remain intact under the ice, and have been demonstrated to harbor desmid populations. *Potamogeton Robbinsii* from a protected region was sampled after ice had formed in December and the desmids counted (Text Table 12). The winter desmid populations from protected regions are smaller than summer populations from protected regions, but are larger than summer populations from open regions. In comparing the winter sample with one taken from an open region during the summer, it was found that at the 5% level of significance, a null hypothesis of

TEXT TABLE 11: Squaw Lake: Analysis of variance comparing samples taken from *Potamogeton Robbinsii* in an open region with those taken from *P. Robbinsii* in a protected region. The data have been taken from Text Tables 9 and 10.

Source	d.f.	S.S.	M.S.
Blocks	24	6,140.72	255.86
Treatments	1	113,192.32	113,192.82
Error	24	3,856.32	160.68

$\frac{T}{E} = 704.46 \qquad F_{.05,1,24} = 4.2597$

H_o : equal means: $704.46 > 4.2597$: H_o rejected.

TEXT TABLE 12: Counts of desmids found on <u>Potamogeton Robbinsii</u> taken from a protected region in Squaw Lake. The 25 samples are from 1 cm. cuttings which were placed in 1 ml. of water, diluted, sedimented, and counted. December 6, 1969.

	Desmid Genera								
SAMPLES	Closterium	Cosmarium	Euastrum	Micrasterias	Onychonema	Pleurotaenium	Staurastrum	Staurodesmus	Xanthidium
1	2	7				1	1		1
2	1	8					1	1	
3		8					3	1	1
4	1	8					1	2	
5	3	7					1	1	
6		7			1		3		1
7	1	9					4	1	
8	2	8				1	2		
9	3	8					2		
10	2	9							1
11		6				1	2		
12	3	8					1		
13	1	6					3	1	
14		6		1			2		1
15	3	9	1						1
16	1	7					1	2	
17		9	3			1	2		
18	2	8							1
19		8	1	1		1	2	1	
20	3	9	4				1		
21	3	7					3		1
22		9	2				4	1	
23	3	10	1	1			1		
24	2	7					1	1	1
25	1	9	2				2		
Totals	37	197	14	3	1	5	43	12	9
(%)	(11.5)	(61.3)	(4.3)	(0.9)	(0.3)	(1.6)	(13.5)	(3.8)	(2.8)

TEXT TABLE 12: Continued.

SAMPLES	TOTAL OF ALL GENERA	CELLS IN DIVISION	DEAD CELLS
1	12		1
2	11		3
3	13		3
4	12		1
5	12		
6	12	1	
7	15		3
8	13		
9	13		1
10	12		
11	9		
12	12		1
13	11		4
14	10		3
15	14		
16	11		3
17	15		5
18	11		2
19	14		4
20	17		3
21	14		3
22	16		1
23	16		3
24	12		1
25	14		1
Totals	321	1	43
(%)	(100.0)	(0.311)	(13.40)

equal means is rejected (Text Table 13).

By late fall many of the aquatics (Nymphaea, Nuphar, Brasenia, Megalodonta, and Zizania) have degenerated and are deposited in the sediments of the lake. Others produce buds which overwinter, and the rest of the plant is lost to the sediments. Plants of this type are Myriophyllum, Ceratophyllum, and Utricularia. The buds are produced terminally on the shoots and consist of rounded masses of densely crowded leaves. By the time these buds have completely formed, most of the plant has disappeared and neither filamentous greens nor desmids can be found either on the vegetative remains of the plant or on the buds. In the Itasca region this disappearance of vegetation coincides with the onset of autumnal circulation.

The Potamogetons also produce buds as was described on p. 35. Because of these buds, these plants can harbor desmids in the same manner in the winter as in the summer. Most of these plants may partially decay and be lost to the sediments, but the buds persist with their desmid populations.

Of considerable importance is the fact that desmids overwinter on the Potamogeton plants that remain intact under the ice. Since the other plants lose their desmid populations and do not reappear until the following spring, it is postulated that P. Robbinsii and P. amplifolius are partially responsible for the

TEXT TABLE 13: Squaw Lake: Analysis of variance comparing samples taken from Potamogeton Robbinsii in an open area (September) and from under the ice (December). The data have been taken from Text Tables 9 and 12.

Source	d.f.	S.S.	M.S.
Blocks	24	75.0	3.125
Treatments	1	1,030.58	1.030.58
Error	24	64.92	2.705

$\frac{T}{E} = 380.99 \quad F_{.05,1,24} = 4.2597$

H_o : equal means: 380.99 > 4.2597 : H_o rejected.

TEXT TABLE 14: Squaw Lake: The open region and the protected region are compared fro the three year period by an analysis of variance. The desmid counts used for this analysis are in Tables 22 and 23 of the Appendix.

Source	d.f.	S.S.	M.S.
Among groups	1	4,435.208	4,435.208
Within groups	26	6,978.042	268.386

$\frac{T}{E} = 16.525 \quad F_{.05,1,26} = 4.2252$

H_o : equal means: 16.525 > 4.2252: H_o rejected.

redistribution of desmids during the spring. When the *Potamogeton* plants break-up during the spring, the vegetative buds are carried to various parts of the lake and re-establish themselves, and the desmids they harbor are carried with them. The other aquatics begin their growth at this time and filamentous greens and desmids are brought into the proximity of the new vegetation by circulation of the water. Thus, new populations of desmids are established in the littoral zones and these increase in density as the macrophytes grow and increase in number.

DESMIDS IN THE PLANKTON

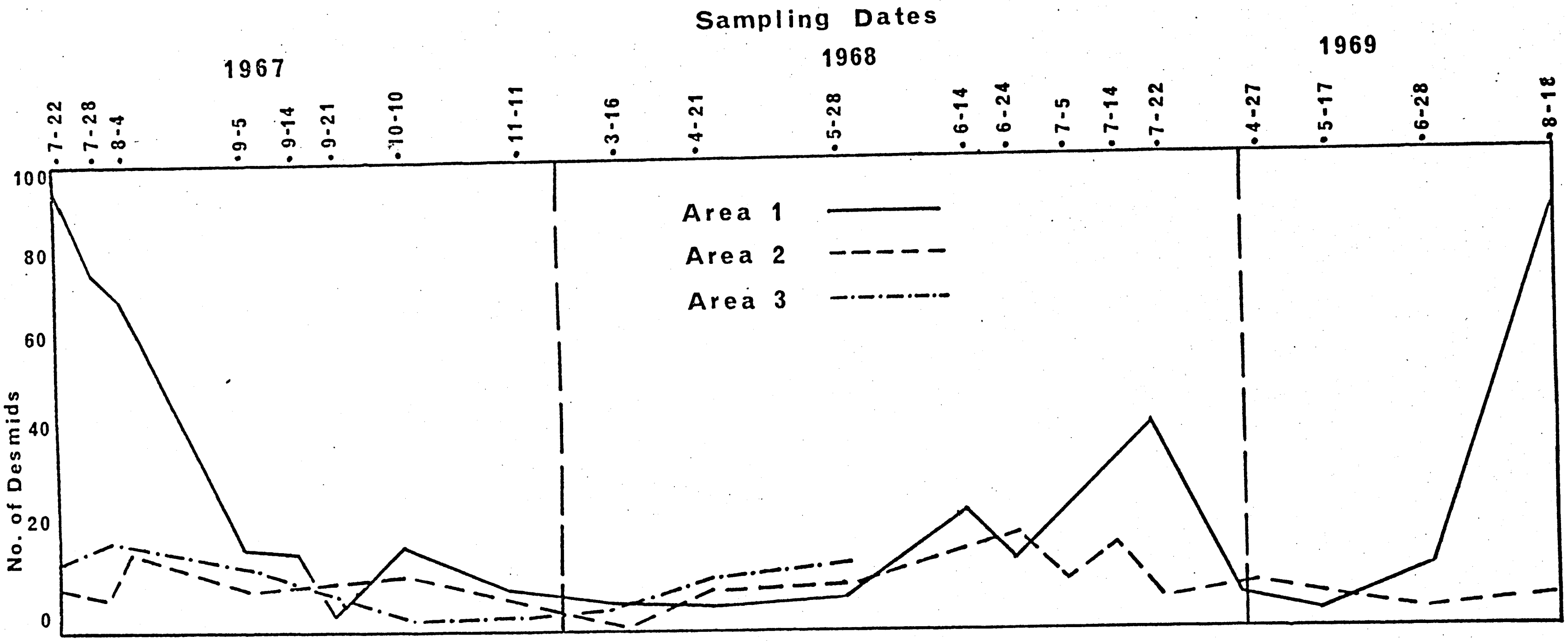
Desmids that occur and reproduce in the plankton of lakes are generally regarded as euplanktonic (Brook 1959). Those desmids usually found in littoral zones of lakes but sometimes carried into limnetic regions are regarded as chance, or tychoplankters. Euplanktonic species in one lake may be tychoplankters in another lake or in different areas of the same lake. The status of any particular species, then, depends upon certain physical and biological characteristics of the lake.

Occurrence and Frequency of Planktonic Desmids in Exposed and Protected Regions

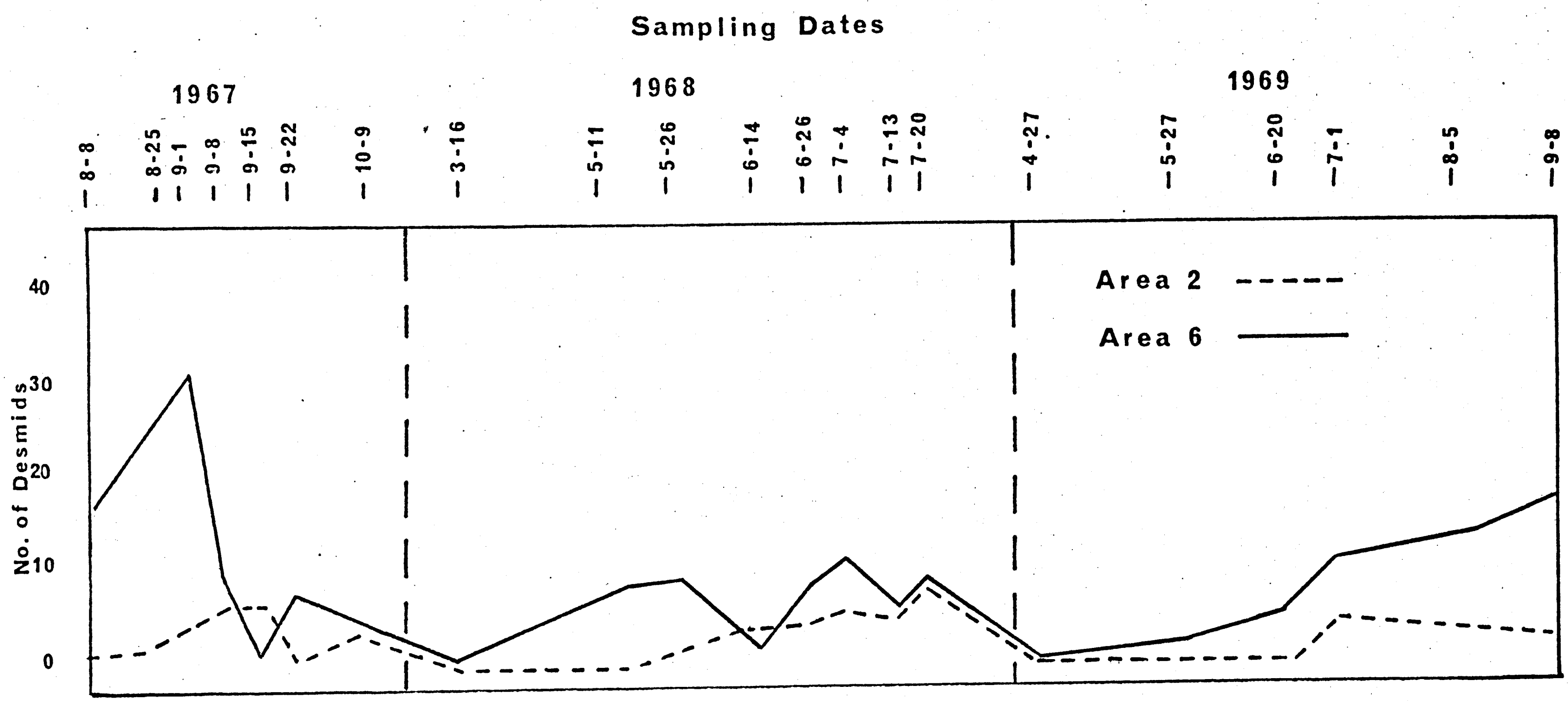
One of the initial observations in this study was that different limnetic regions of the same lake did not support the same kinds of desmid populations, and in some regions there were practically no desmids at all. This was first observed in Squaw Lake during the first year at three different sampling sites (Text Figure 12; Tables 22-24; Appendix). (Text Figure 3 shows the location of the three sampling sites used for this comparison). When the study was expanded to include North Twin Lake a similar situation was encountered (Text Figures 13 and 14; Tables 25-30; Appendix). (Text Figure 2 shows the location of the sampling sites represented in Text Figures 13 and 14). Statistical treatment of the data from two regions in Squaw Lake rejects a null hypothesis of equal means at the 5% level of significance (Text Table 14).

It was found that the number of desmid cells in the plankton decreased in protected areas or restricted areas as distance from aquatic macrophytes increased. This was observed along horizontal transects in the protected region of Squaw Lake, in North Twin Lake, and in Darling Pond (Text Tables 15-19; Text Figures 15 and 16). (Text Figures 2 and 3 show the approximate location of the transects in North Twin and Squaw Lakes). Peripheral samples taken in littoral zones in North Twin Lake have also shown this same relationship (Text Table 20). (Text Figure 2 shows the approximate location of the peripheral sampling sites in North Twin Lake).

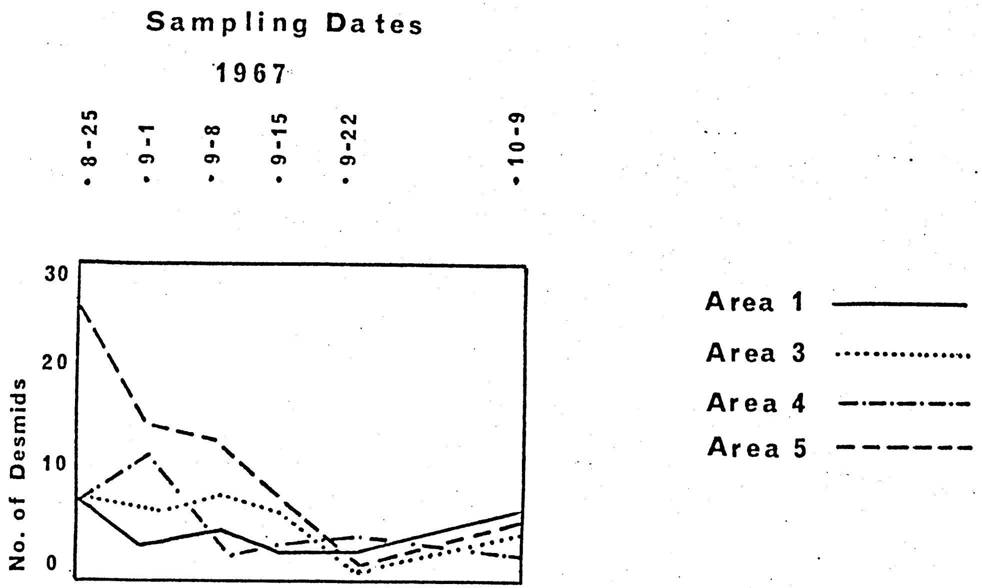
Text Figure 12: Squaw Lake: The total number of desmids found in a water column sampled at one meter intervals during 1967, 1968, and 1969 from Areas 1, 2, and 3.



Text Figure 13: North Twin Lake: The total number of desmids found in a water column sampled at one meter intervals during 1967, 1968, and 1969 from Areas 2 and 6.



Text Figure 14: North Twin Lake: The total number of desmids found in a water column sampled at one meter intervals during 1967 from Areas 1, 3, 4, and 5.



TEXT TABLE 15: Desmid counts along a horizontal transect in the open region of Squaw Lake. The figures are the number of desmids in 10ml. of lake water. August 16, 1969.

Depth Meters	Sampling sites along transect						
	1	2	3	4	5	6	7
0	11	6	4	6	0	7	0
1	10	4	4	7	0	8	14
2		8	7	5	8	6	
3		2	3	2	10	5	
4		3	4	4	7	4	
5		6	7	4	0	0	
6			13	5	4		
7			11	3	0		
8			7	2	1		
9			4	2	4		
10			2	2	0		
11				0			
12				0			
15				0			
20				0			

TEXT TABLE 16: Desmid counts along a horizontal transect in the protected region of Squaw Lake. The figures are the number of desmids in 10 ml. of lake water. August 16, 1969.

Depth Meters	Sampling sites along transect										
	1	2	3	4	5	6	7	8	9	10	11
0	11	4	1	0	0	0	0	0	0	1	12
1	110	45	2	0	0	0	0	0	2	10	140
2		144	0	0	0	0	0	0	0	150	
3			1	0	0	0	0	0	0		
4				0	0	0	0	0			
5				0	1	0	0	0			
6					0	0	0				
7					0	0	0				
8					0	0	0				
9						0					
10						0					
11						0					
12						0					

TEXT TABLE 17: A horizontal transect from an area of aquatic vegetation to the deepest area of North Twin Lake. The figures are the number of desmids in 10 ml. of lake water. August 22, 1968.

Depth Meters	Sampling sites along transect 1	2	3	4	5
0	555	0	1	0	0
1	1066	1	1	4	0
2		8	0	0	0
3		95	0	3	0
4			0	0	0
5			0	1	0
6				0	0
7				0	0
8				0	0
9					0
10					0
11					0
12					0

TEXT TABLE 18: A horizontal transect across the Northeast end of North Twin Lake. The figures are the number of desmids in 10 ml. of lake water. August 22, 1968.

Depth Meters	Sampling sites along transect 1	2	3	4	5	6	7	8	9	10	11
0	66	0	0	0	0	2	0	0	1	0	1
1	13	0	0	1	0	3	1	1	0	2	11
2		4	0	0	0	2	0	1	0	0	
3			0	0	0	1	0	0	0		
4				0	1	1	0	1			
5					0	0	0				
6						0					

TEXT TABLE 19: A horizontal transect across Darling Pond. The figures are the number of desmids in 10 milliliters of water.

Depth	Sampling sites along transect 1	2	3	4	5	6	7	8	9
Surface	440	25	17	11	7	20	9	12	34
1 Foot	366	556	356	327	20	14	11	48	18
2 Feet	*	1184	720	372	17	11	*	*	*
3 Feet		*	358	176	25				
4 Feet			*	*	302				
1 Meter					*	17	604		

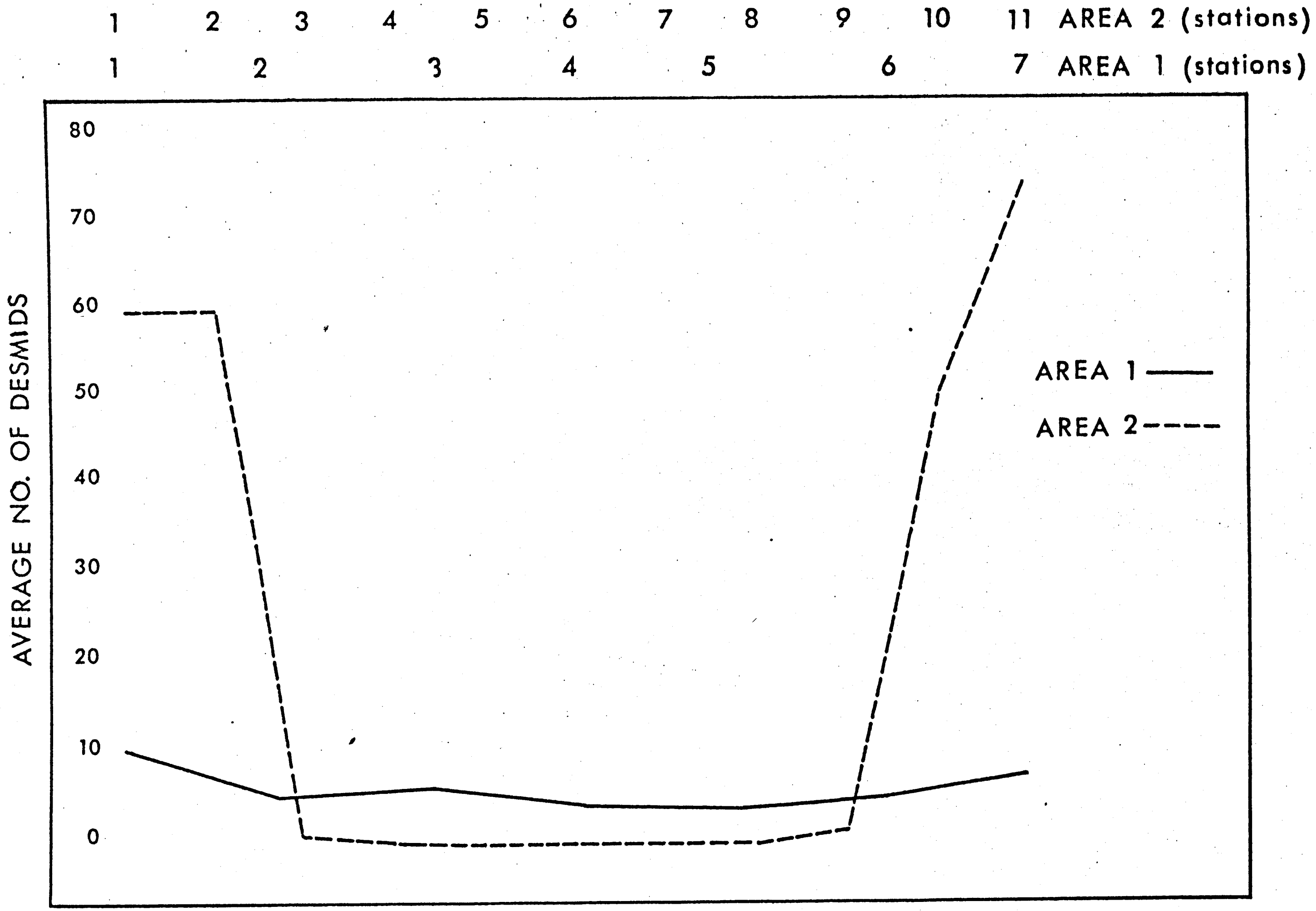
* Bottom

TEXT TABLE 20: Samples from peripheral areas in North Twin Lake. The figures are the number of desmids in 10 milliliters of lake water.

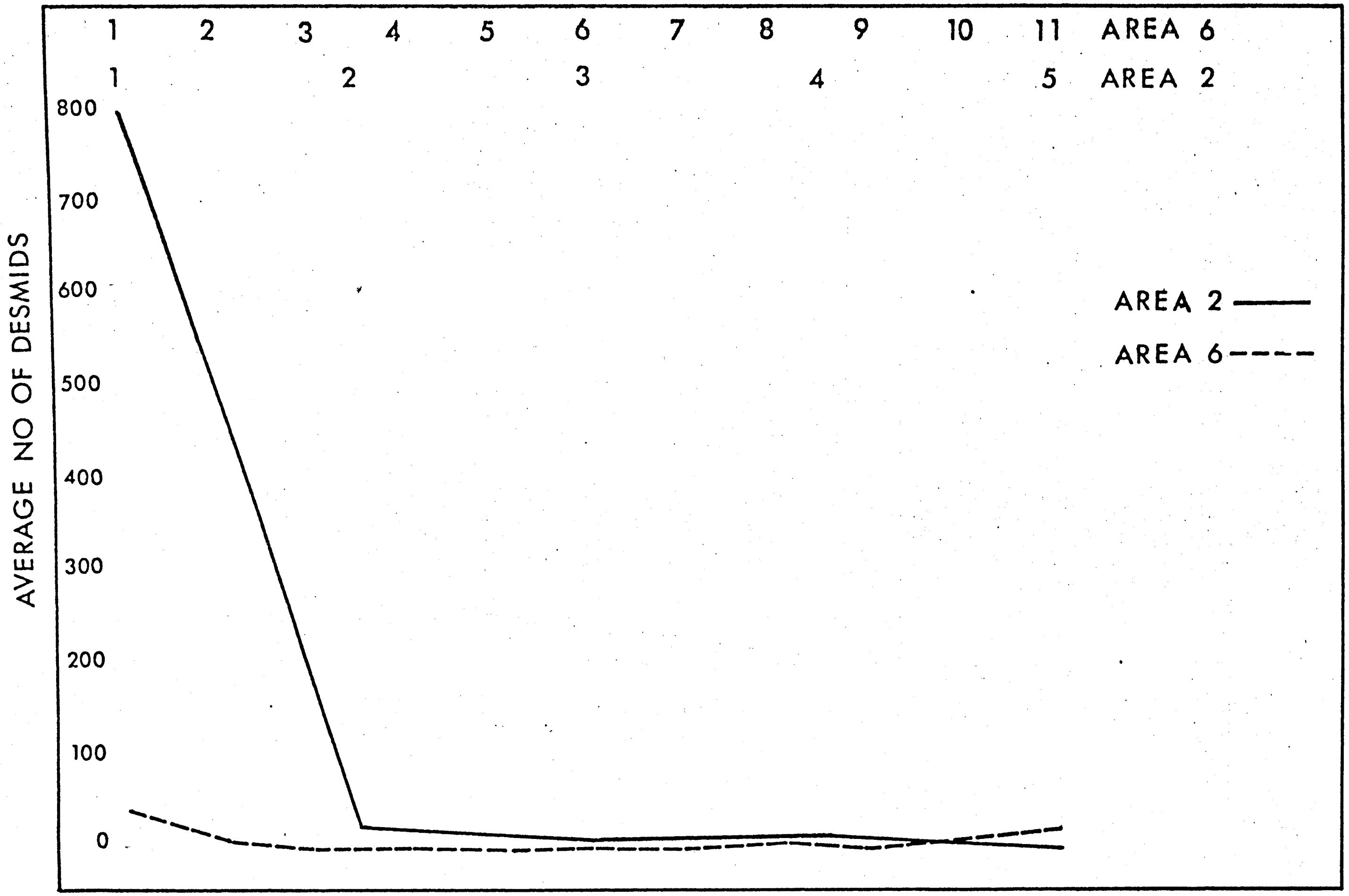
Depth Meters	Sampling Sites 1	2	3	4	5	6	7	8	9
0	5	1	0	0	0	0	0	0	0
1	62	2	0	0	1	5	9	8	0
2	23	1	1	0	0	34	0	0	*
3	*	1	*	*	0	*	0	*	
4		0			0		*		

* Bottom

Text Figure 15: Squaw Lake; horizontal transects across Areas 1 & 2. The figures given are the average number of desmids at the different sampling stations, although the number of samples from each station is different.



Text Figure 16: North Twin Lake; horizontal transects across Areas 2 & 6. The figures given are the average number of desmids at the different sampling stations, although the number of samples from each station is different.



The evidence from these samplings leads to the conclusion that desmids sink rapidly with increasing distance from aquatic vegetation. Desmids were always found in samples taken in the vicinity of rooted vegetation.

Desmids are most abundant at the northeast end of North Twin Lake. This area is near aquatic vegetation and where wave action is greatest. The fact that desmids are most abundant near aquatic vegetation is demonstrated by the first year's data from six different sampling sites (Text Figures 13 and 14; Tables 25-30; Appendix). Another supporting factor for this contention is the fact that in horizontal transects the desmid maxima were at greater depths when distance from aquatic macrophytes was increased (Text Tables 16-19).

The major sampling sites in North Twin Lake showed consistent differences during the three year period, as can be seen by statistical treatment of the data (Text Table 21). The horizontal transects in North Twin Lake and Darling Pond also showed consistent differences between the sampling sites when compared statistically (Text Tables 22-24). A similarity between the sampling site with the least desmids in North Twin Lake and the protected region in Squaw Lake can be shown by statistical comparison. Using the same number of samples, a null hypothesis of equal

TEXT TABLE 21: The principal sampling sites in North Twin Lake are analyzed for the three year period by an analysis of variance. The data for this analysis were taken from Tables 25 and 26: Appendix.

Source	d.f.	S.S.	M.S.
Among groups	1	2,017.063	2,017.063
Within groups	18	725.737	40.319

$\frac{T}{E} = 50.028 \quad F_{.05,1,18} = 4.4139$

H_o : equal means: $50.028 > 4.4139$: H_o rejected.

TEXT TABLE 22: The horizontal transect in the deeper area of North Twin Lake analyzed by an analysis of variance. The data for this analysis were taken from Text Table 17.

Source	d.f.	S.S.	M.S.
Among groups	4	1,230,531.84	307,632.96
Within Groups	29	136,960.731	4,722.78

$\frac{T}{E} = 65.138 \quad F_{.05,4,29} = 2.7014$

H_o : equal means: $65.138 > 2.7014$: H_o rejected.

TEXT TABLE 23: The horizontal transect at the north-east end of North Twin Lake is analyzed by comparing the means. The data are taken from Text Table 18.

Total desmids in each column in the transect.	Mean
79	40.0
4	1.2
0	0.0
1	0.2
1	0.2
9	1.2
1	0.2
3	0.4
1	0.25
2	0.66
12	6.0

TEXT TABLE 24: The horizontal transect in Darling Pond is analyzed by comparing the means. The data are taken from Text Table 19.

Total desmids in each column in the transect.	Mean
806	403
1765	588
1451	362
886	221
371	74
62	15
624	208
60	30
52	26

means is accepted at the 5% level of significance (Text Table 25).

Desmids in the Plankton and Seasonal Development of Aquatic Macrophytes

Seasonal redistribution is a factor contributing to the greater diversity of species in a larger lake. Waves and currents in such lakes would redistribute the Potamogetons which harbor desmids during the winter more effectively, and thus ensure the redistribution of desmids seasonally. Even though there may be fewer rooted aquatic plants in larger well-circulated lakes, their associated desmid populations would be transported more often, and more desmids would be carried into the limnetic environment where they might survive.

A further aspect of this study involves the growth of aquatic vegetation and the seasonal changes of desmids which have been observed to occur in the limnetic regions. Desmids are often most abundant in limnetic regions during the late summer or early fall, when temperatures are high and nutrients are low (Fogg 1966). The abundance of desmids at these times is also related to events occurring in the littoral zone. Desmid populations develop on rapidly growing aquatic vegetation during spring when filamentous algae, including some desmids, and unicellular desmids exploit the micro-habitats that develop on certain submerged

TEXT TABLE 25: The deeper area in North Twin Lake and the protected area in Squaw Lake are compared by an analysis of variance. The data are taken from Tables 22 and 25; Appendix.

Source	d.f.	S.S.	M.S.
Among groups	1	58.499	58.499
Within groups	24	506.616	21.109

$\frac{T}{E} = 2.777$ $F_{.05,1,24} = 4.2597$

H_0 : equal means: $2.777 < 4.2597$: H_0 accepted.

TEXT TABLE 26: Counts of desmids found in the water immediately adjacent to a Potamogeton Robbinsii plant and a few feet from it. The figures are the number of cells in 10 ml. of lake water.

Depth Feet	Away from plant* (Cells)	(%)	Adjacent to plant (Cells)	(%)
0	0	0.0%	0	0.0%
1	1	16.6	4	3.0
2	1	16.7	51	39.3
3	4	66.7	75	57.7
Totals	6	100.0%	130	100.0%

* The number of cells found in the region away from the aquatic plant contained 4.6% as many cells as were found in the area adjacent to the plant.

aquatic macrophytes. These algal associations accumulate and populations increase as the aquatics grow.

Desmids are dispersed from the growing macrophytes by waves and currents, and they appear in the open water later than other phytoplankters. Although the physical and biological characteristics of the water are undoubtedly important to the maintenance of desmids once they reach limnetic zones, they must be transported initially into the open water. A further factor contributing to their low numbers is that desmid cells have been observed to divide more slowly than virtually all other planktonic algae (Lund 1964). Initially, most desmids seem to be restricted to the micro-habitats provided by aquatic vegetation, but during periods of circulation, some are carried passively from the vegetation and then sediment rapidly.

This was demonstrated by sampling near aquatic vegetation during autumnal circulation. A vertical column of samples was taken at one foot intervals from surface to bottom near a Potamogeton Robbinsii plant, without incorporating leaves in the Kemmerer sampler. Similar samples were taken two feet away from this plant where there were no aquatic macrophytes. The analysis of the counts of these samples is given in Text Table 26. It was indicated that the desmid cells were sinking, because the maximum number of desmids near the plant was at three feet (57%). The almost complete absence of desmids at a distance of two feet from this plant also indicates that desmids were sinking very rapidly. Only 5% as many cells were found at a distance of two feet from the plant, and of these 67% were at the bottom. Since the desmids found in these samples are clearly the same kinds found in metaphyton communities, it can be concluded that during fall overturn, desmids originating from the metaphyton sediment very rapidly. The cells probably are not dividing at this time, and they probably are not buoyant enough to float very long. In consequence, desmids are absent from limnetic samples during the period of overturn, having sedimented from the plankton during the late summer.

Because of the foregoing considerations, it is postulated that a large well-circulated lake will tend to support more desmids in its limnetic zones than a smaller lake.

Lake Morphology, Water Circulation, and Desmid Distribution

The importance of the size of the lake basin and its patterns of circulation in relation to the ability of desmids to become established in the plankton became apparent when several lakes were sampled and when horizontal transects were made across sampling sites in Squaw, North Twin, and Darling Pond (Text Figures 15, and 16; Text Tables 15-19). During the summer of 1967, Squaw Lake was sampled periodically in three limnetic areas, while North Twin was sampled in six equally spaced areas from the southwest to the northeast end of the lake. After this first season, only two limnetic regions were sampled in these two lakes, these being the areas which had contained respectively the greatest and the least number of desmids during the first season. The summaries of these counts are found in Text Figures 12, 13, and 14.

The importance of circulation patterns in the water was first indicated by the examination of samples from horizontal transects across the two sampling sites in Squaw Lake (Text Figure 15; Text Tables 15 and 16). In the large, open area counts revealed that desmids were fairly evenly distributed spatially throughout the entire region. This was not the case in the well-protected region. Although desmids were found at all depths in the littoral zones, their abundance as well as their presence at the surface and shallower depths decreased as distance from littoral zones increased. As can be noted from Text Table 16 and Text Figure 15, there are very few, if any desmids at any depth in most of the limnetic regions along the transect. Statistical treatment of the data concerning these horizontal transects has shown that at the 5% level of significance a null hypothesis of equal means is accepted for the large, open area, but is rejected for the well-protected area (Text Tables 27 and 28).

It is deduced from these observations that the morphology of the lake basin and its patterns of circulation are the major factors involved in the establishment of the desmid floras of the limnetic regions. This concept is further supported when horizontal transects of the two sampling sites in North Twin Lake are considered (Text Figure 2 shows the approximate location of these transects). At no time in this lake were desmids observed to be evenly distributed spatially in the limnetic regions as they were in the open area of Squaw Lake (Text Figure 16; Text Tables 17 and 18). The results of these transects can be interpreted in the following manner; The size of the lake basin does not permit circulation to maintain desmid cells in suspension in great numbers in the limnetic regions. Further, the limnetic region which consistently had the greatest number of desmids was also the closest to aquatic vegetation, and therefore, most of the desmids found in this lake are chance or tychoplankters.

<u>Lake Dimensions and Cell Size of Desmids</u>

In larger well-circulated lakes there is a greater species diversity of planktonic desmids, and population densities are greater than in smaller, poorly circulated lakes. The euplanktonic species of desmids in the smaller lakes are of much smaller size than euplanktonic desmids of larger lakes.

TEXT TABLE 27: The horizontal transect in the open area of Squaw Lake analyzed by an analysis of variance. The data are taken from Text Table 15.

Source	d.f.	S.S.	M.S.
Among groups	6	169.615	28.269
Within groups	42	416.201	9.909

$\frac{T}{E} = 2.853 \quad F_{.01,6,40} = 3.2910$

H_o : equal means: $2.853 < 3.2910$: H_o accepted.

TEXT TABLE 28: The horizontal transect in the protected region of Squaw Lake analyzed by an analysis of variance. The data are taken from Text Table 16.

Source	d.f.	S.S.	M.S.
Among groups	10	233.116	23.312
Within groups	50	168.555	3.371

$\frac{T}{E} = 6.933 \quad F_{.05,10,40} = 2.0772$

H_o : equal means: $6.933 > 2.0772$: H_o rejected.

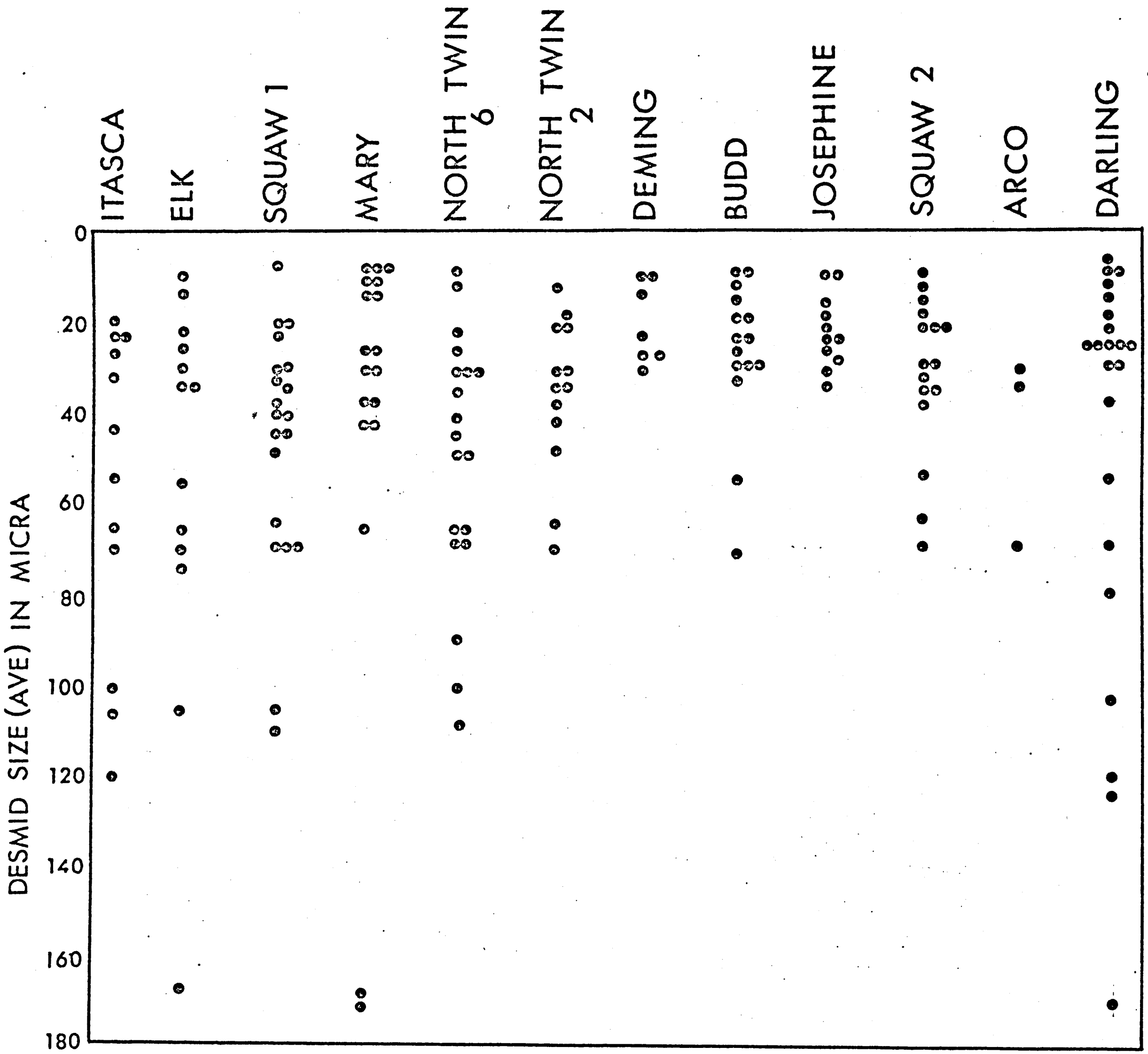
When this study was expanded to include several other lakes of the Itasca region, it was found that the same relationship between basin size, circulation patterns, and desmid distribution existed as was observed in North Twin and Squaw Lakes (Text Table 29). To illustrate this more fully, the sizes of the desmid cells were compared with the lake's surface area (Text Figure 17). The surface areas of the lakes or the areas of the lakes presented in this figure decrease from the left to the right, while the sizes of the desmids increase from the top to the bottom of the figure. Text Table 30 gives the frequency of each of the points found in Figure 17. These are arranged according to increasing size in the columns under each lake or area heading.

It can be seen that larger desmids are either entirely absent from small lakes or very infrequent in the open water. Therefore, it has been concluded that the larger species which are euplanktonic in larger bodies of water are tychoplanktonic in a smaller lake. Their adaptations for flotation are not sufficient to keep them suspended and thus they sink from the plankton. In agreement with Ruttner (1963), it seems that regardless of the adaptations which planktonic organisms have for flotation, the single most important influence is the eddy diffusion currents of the water. Unless cells have a specific gravity

TEXT TABLE 29: Counts of planktonic desmids from the other eight lakes sampled during the study. The figures are the number of desmids in 10 ml. of water.

Depth Meters	Lakes							
	Deming	Josephine	Elk	Itasca	Budd	Arco	Mary	Darling Pond
0	54	47	7	9	0	0	3	7
1	30	69	8	9	1	2	2	20
2	30	75	7	8	5	1	3	17
3	27	103	6	7	3	0	4	25
4	14	74	1	7	3	0	4	155
5	24	32	2	5	14	0	3	*
6	*	11	4	4	22	0	2	
7		*	6	2	25	0	2	
8			2	2	13	0	5	
9			3	0	12	0	*	
10			1	*	7	0		
11			2		*	*		
12			2					
13			1					
14			4					
15			8					

* Bottom



Text Figure 17: The points in this figure are the average sizes of the desmids identified from plankton samples in each of the lakes or areas of lakes.

TEXT TABLE 30: The relative frequency of occurrence of desmid taxa in selected samples from lakes in the Itasca region, arranged by their average sizes. The percentages of occurrence given here, correspond to the points in Text Figure 17.

	Lake or Area *					
Size	I	E	S-1	M	N-6	N-2
8						
9		11.4	0.7	11.8	1.8	
11						
12		17.1		5.9	0.9	2.2
13						
14				5.9		
15						
16						
19						
20	9.3		0.7			2.2
21			2.6			4.4
22		2.9	1.4		30.4	15.6
23	32.6					
24						
25	4.7					
26		11.4		29.4		
27					0.6	
30		2.9	1.2		1.8	6.6
31			6.9		6.3	15.6
32	9.3	11.5	72.8	11.8	32.1	17.8
35			0.9		1.8	2.2
37				5.9		
38			0.2			4.4
40			0.7			
42			1.0	5.9	0.9	4.4
43	2.3			5.9		
45			1.9		1.6	
50			1.7		4.5	4.4
54	2.3	5.7				
55						
65	4.7	11.5	1.0	5.9	2.7	8.8
70	13.9	14.3	4.0		9.8	11.0
75		2.9				
80						
90					0.9	
100	2.3				0.9	
105	7.0	5.7	1.0		1.8	
110			0.2		0.9	
120	11.6					
125						
165		2.9		5.9		
200				5.9		
250						
Dead	2.3	0.0	1.7	0.0	1.8	22.2

TEXT TABLE 30: Continued.

	Lake or Area *					
Size	De	B	J	S-2	A	Da
8						1.8
9	85.8	3.7	81.25	3.2		5.3
11		0.5				
12				1.6		1.8
13		78.4				
14						
15	0.6			1.6		
16			2.5			1.8
19			2.5			
20		1.0		3.2		8.8
21			1.0	12.7		
22	1.1	0.5	0.75	1.6		5.3
23						
24		1.6				
25		0.5				7.1
26	1.1					8.8
27	8.5	6.3	10.25			10.6
30	2.8	4.2	0.5	3.2	33.3	10.6
31				15.9		5.3
32			1.0	28.6	33.3	
35		1.1	0.25			
37				4.8		
38						
40				1.6		1.8
42						
43						
45						
50						
54						
55		0.5		7.9		7.0
65				7.9		1.8
70		1.6		6.3	33.3	3.5
75						
80						1.8
90						
100						
105						1.8
110						
120						7.0
125						1.8
165						
200						
250						3.5
Dead	0.0	0.0	3.0	17.5	0.0	1.8

TEXT TABLE 30: Continued.

Lake or Area *

* I= Itasca
E= Elk
S-1 = The open area of Squaw Lake
M = Mary Lake
N-6 = The northeast end of North Twin Lake
N-2 = The deeper area of North Twin Lake
De = Deming Lake
B = Budd Lake
J = Josephine Lake
S-2 = The protected region of Squaw Lake
A = Arco
Da = Darling Pond

less than that of the surrounding water, they will sink.

It will be noted that the results from Darling Pond do not agree with this general conclusion concernig planktonic desmids. However, when the depth of this pond and its aquatic vegetation are considered, the abundance of desmids in its limnetic zones becomes more apparent. Although circulation patterns are probably poor, it has much aquatic vegetation, especially, Utricularia vulgaris. The limnetic regions are very limited in size and very close to aquatic vegetation, and therefore, the desmids of the limnetic regions can be regarded as tychoplankters.

Buoyancy, Periodicity, and Reproduction

Desmids are usually infrequent in plankton samples. This seems to be related to several ecological factors. First, planktonic desmids are found in greatest abundance in late summer and early fall when the water temperatures are at their maxima. Second, desmids which are euplanktonic are either small in size, or are found only in large, well-circulated lakes. Finally, desmid cells divide slowly when compared to other planktonic species of algae (Lund 1964). These factors, considered together, can explain the observed low frequency of planktonic desmids.

If planktonic desmids originate in the littoral zone, then desmid occurrence depends upon the presence of aquatic macrophytes in the littoral zones and they become more numerous as the season progresses. When environmental conditions are suitable for their growth, they proliferate in the littoral zones and many are carried out into the limnetic regions by circulation of the water. This concept is supported in this work by two observations. The horizontal transects which were discussed on page 65, and the following observation: Meyer and Brook (1969) published a list of algae which they found in the lakes of the Itasca region, which included desmids. Of the 201 desmids listed, 125 were considered euplanktonic. During this study, 92 of these same 125 desmids were found in the littoral zones as a part of the metaphyton. The other 33 euplanktonic desmids that appeared in their list were not identified in this study.

DISCUSSION AND CONCLUSIONS

The annual spatial distribution of desmids within lakes in northwestern Minnesota depends largely on the area of the lake and the season of the year. Desmids always occur in the littoral zone on certain aquatic macrophytes, although the abundance of these algae declines during the winter. The aquatic macrophytes grow in spring and summer and their desmid populations increase. They are most numerous in late summer in the littoral zone. In the fall many of the aquatic plants disintegrate, and the desmids sink to the bottom. Those aquatics which remain intact during the winter continue to harbor desmid populations, although these populations decrease in size.

Desmids appear in the open water after thermal stratification develops. They increase in abundance in late summer, decline in the autumn, and disappear from the plankton in the late autumn.

Desmids are most abundant in littoral zones, because they sink so rapidly that most of them cannot survive in the open water. As Duthie (1965) pointed out, the littoral species sink more rapidly, because they do not have the buoyant mucilage sheath found on planktonic species. The most common flotation adaptations of these algae are the various kinds of processes on the semicells and gelatinous sheaths. The processes increase the surface to volume ratio of the cell which offers more area to resist sinking, while the gelatinous sheath lowers the specific gravity of the cell in relation to the surrounding water. In discussing these two developments, Ruttner (1963) observes that one of these adaptations often replaces the other among desmids. In the genus, Staurastrum, for example, those cells with longer processes have less well-developed sheaths than those lacking sheaths, while those without processes have better developed gelatinous sheaths.

Another adaptation of desmids discussed by Ruttner (1963) concerns that of orthogonal projection. The best example of this is found in the genus Closterium. To illustrate this, the reader must consider that a stick sinks more slowly in a horizontal position than in a vertical position. Cells which have such an adaptation also have a slight curvature that stabilizes the cell and helps maintain it in a horizontal position.

Ruttner (1963) considers the size of planktonic organisms to be important to their ability to stay suspended in the water. To illustrate the importance of this fact he uses Stoke's law concerning the free fall of small spheres in a liquid medium. Stoke's law states that the rate of sinking varies directly with the square of the radius. In applying this principle to the common sizes of planktonic organisms, namely 0.1, 0.01, and 0.001 mm. under identical conditions of density and viscosity, a spherical cell of 0.01 mm. diameter will sink 100 times more slowly, and a similar cell of 0.001 mm., 10,000 times more slowly, than a cell 0.1 mm. in diameter. Desmids commonly found in the plankton are usually fairly large and range in size between 0.1 and 0.01 mm. in diameter.

Ruttner (1963) further states that even all these "flotation adaptations" however, with the exception of the reduction of the density of the organism to that of the surrounding water or even less, are not sufficient to prevent non-motile plankters from sinking. Thus, most of the living organisms in a plankton sample soon sediment to the bottom of the container. That this settling does not occur in lakes, and that even fairly large and rounded forms remain suspended in the water means that the forces controlling flotation lie outside the organisms. This force is the turbulence of the water (the unorganized eddy diffusion currents), which maintains a state of continuous mixing action particularly in the epilimnion, which is where the non-motile phytoplankton chiefly occur. We must, therefore, look upon the turbulence as the most important factor influencing flotation of plankton, and may in consequence assign a purely supporting role to the so-called flotation adaptations. Ruttner (1963) further states that these eddy diffusion patterns are of greater significance in larger, more open lakes which receive more wind and as the size and depth of lakes increases, the effect of the eddy diffusion currents increase in the hypolimnion.

As a component or as constituents of the metaphyton, desmids become associated with aquatic macrophytes by a network of green algae. This supportaing network retains cells in one position in the water and prevents their loss, and they proliferate here. The desmids in the limnetic zones do not have this support and appear to be prevented from sinking by cellular adaptations, particularly the extrusion of mucilage sheaths, or eddy diffusion currents. Patterns of circulation vary from day to day as well as seasonally, and many planktonic desmids in smaller lakes sink to the sediments, whereas in littoral zones such losses are not as great.

The evidence suggests that desmids overwinter in the sediments of the littoral zones and on Potamogetons that survive under the ice. The off-shore sediments probably are not important, because desmids are not found in the plankton during periods of circulation, and also because certain of these lakes are anoxic during stratification. Fritsch (1931) states that desmids may overwinter on the bottom or in littoral zones, and Wesenberg-Lund (1905) states that those sedimenting in deeper regions may eventually perish. However, Brook (1965) has observed desmids in the plankton throughout the entire year in certain lakes in England and Scotland, but these lakes often are not ice covered or are for only short periods. Thus they are in continuous circulation during the winter unlike the lakes of the Itasca region.

Lund (1954) has found that Melosira italica v. subarctica sinks from the plankton and lives on the sediments during the summer. Asterionella formosa however, is always present in the plankton (Lund 1949). The first of these diatoms can only exist in the plankton when the water is circulating because after the lakes in which it occurs have become thermally stratified, its sinking rate is then too rapid. *Asterionella* does not appear to sink so rapidly and is always present in the plankton. Possibly it could not tolerate the anoxic conditions of the sediments as does *Melosira italica* v. *subarctica*. The absence of desmids from the plankton of the Itasca lakes during fall and winter indicates that they neither overwinter in the plankton, nor are they in the sediments and recirculated at the time of overturn. If they were on the sediments, at least a few should be detected at the time of fall overturn. If they rise from the deeper sediments later in the summer, they would have to survive anoxic conditions in some of the lakes. Thus, it seems that the deeper sediments are to be excluded as regions where desmids survive in the Itasca lakes. The sediments of the littoral zones, however, could be a source of planktonic desmids in succeeding seasons as Duthie (1965) found in the lake Llyn Ogwyn, North Wales. However, this lake has an average depth of only 2.1 meters, and supports few aquatic macrophytes.

The annual redistribution of desmids in a lake is still a matter of speculation, but certain factors revealed during this study lead to the following conclusions.

Desmids occur throughout the entire year on at least two species of Potamogeton. These plants disintegrate during the spring overturn, and the fragments establish roots elsewhere. These vegetative shoots have desmids on the underwater leaves which have persisted during the winter. The other aquatics begin to grow at this time, and it is possible that desmids from these Potamogetons reach the other aquatics by water circulation.

Planktonic desmids occur in littoral zones associated with aquatic plants, and an origin from this region seems to be a reasonable explanation for their occurrence in the plankton. As the summer progresses, the aquatics grow and accumulate more desmids on their underwater leaves and stems. Desmids reproduce slowly and would, as a result, not reach a peak in abundance very early in the summer. Water movements in the vicinity of the aquatics disperses many of the desmids into the surrounding regions. If the cells adapt to the new environment and reproduce there, they will then become a part of the phytoplankton, while others will sink to the sediments.

The morphological variants of desmids discussed in the Introduction lends further support to the assumption that desmids originate annually from littoral zones.

In smaller lakes the circulation in the littoral zones would not be as great as in the same zone in a larger lake, and as a result, larger desmids originating from the sediments or from aquatics would not be as likely to be brought into limnetic regions by water circulation. The planktonic desmids of smaller lakes would be limited by their size and sinking rate, and therefore, only smaller desmids would persist in the limnetic environment. The larger planktonic species would sink too rapidly for survival in these lakes and would have to be considered to be tychoplankters if they reached these areas at all.

In larger lakes the existing aquatics will lose more of their desmids to the surrounding water as a result of better circulation. Those desmids which are carried away from these plants either survive or sink, and since it has been shown that larger lakes can support larger desmid cells, there would be a greater variety of planktonic species. This effect of wind and wave action on desmids from littoral zones is in agreement with both Fritsch (1931) and Pearsall (1924).

It has been concluded that by observing the species composition and abundance of the aquatic macrophytes in a given lake, predictions concerning the Lake's desmid population within littoral zones can be made. For example, a lake having a great deal of *Utricularia vulgaris* could be expected to have an abundant desmid flora, while a lake with an abundance of <u>Nymphaea</u> or <u>Nuphar</u> would support smaller desmid populations. Thus, the aquatic macrophytes within a lake can be a valuable indicator of the nature of its desmid population.

In conclusion it can be stated that the spatial distribution of planktonic desmids within lakes of the Itasca region depends upon the following ecological considerations; the season of the year when the samples are taken; the region of the lake sampled; the species composition and abundance of the aquatic macrophytes; the size of the lake basin and its patterns of circulation; and finally, the cellular adaptations which appear to assist the desmid cells in their flotation.

LITERATURE CITED

Behre, K. (1956).
Ver. Inst. Meeresk. Bremerhaven 4, 221.

Brook, A. J. (1959).
The status of desmids in the plankton and the determination of phytoplankton quotients.
J. Ecol. 47: 429-445.

------ (1960).
The varieties of Staurastrum paradoxum Meyen-nomen dubium.
Nova Hedwigia 1(3+4): 431-446.

------ (1965).
Planktonic algae as indicators of lake types with special reference to the Desmidiaceae.
Limnol. and Oceanogr. 10(3): 403-411.

Duthie, H. C. (1965).
Some observations on the ecology of desmids.
J. Ecol. 53: 695-703.

Fassett, N. C. (1966).
A manual of aquatic plants.
Univ. of Wis. Press, Madison.

Fogg, G. E. (1966).
Algal cultures and phytoplankton ecology.
Univ. of Wis. Press, Madison.

Fritsch, F. E. (1931).
Some aspects of the ecology of fresh-water algae.
J. Ecol. 19: 233-272.

------ (1935).
The structure and reproduction of the algae I.
New York, Macmillan; Cambridge Univ. Press.

Griffiths, B. M. (1928).
On desmid plankton.
New Phytol. 27: 98-107.

Lund, J.W.G. (1949).
Studies on Asterionella, I. The origin and nature of the cells producing seasonal maxima.
J. Ecol. 37: 389-419.

------ (1954).
The seasonal cycle of the plankton diatom, Melosira italica (Ehr.). Kütz. subsp. subarctica O. Müll.
J. Ecol. 42: 151-179.

Meyer, R. L. and A. J. Brook, (1969).
Freshwater algae from the Itasca State Park, Minnesota.
Nova Hedwigia. 16: 251-266

Moore, E. (1915).
The Potamogetons in relation to pond culture.
Bull. Bur. Fish. 33: 255-291.

Nichols, G. E. and A. B. Ackley, (1932).
The desmids of Michigan, with particular reference to the Dougals Lake region.
Mich. Acad. Sci., Arts, and Letters. 15: 113-140.

Nygaard, G. (1949).
Hydrobiological studies on some Danish ponds and lakes, Part II: The quotient hypothesis and some new or little known phytoplankton organisms.
K. danske. videnske Selsk. Biol. Skr. 8: 1-293.

Pearsall, W. H. (1922).
A suggestion as to the factors influencing the distribution of free-floating vegetation.
J. Ecol. 9: 241-253.

------ (1924).
Phytoplankton and environment in the English Lake district.
Rev. Algol., 1: 54-67.

------- (1932).
Phytoplankton in the English Lakes II. The compostion of the phytoplankton in relation to dissolved substances.
J. Ecol. 20: 241-262.

Prescott, G. W. (1935).
Notes on the desmid flora of New England II. Desmids from Cape Cod and the Elisabeth Islands.
Rhod. 37: 113-121.

------- (1936).
Preliminary notes on the desmids of Isle Royale, Michigan.
Mich. Acad. Sci., Arts and Letters. 22; 201-213.

------- and Scott, A. M. (1942).
The fresh-water algae of the Southern United States I. Desmids from Mississippi, with descriptions of new species and varieties.
Trans. Amer. Micros. Soc. 61(1): 1-29.

Ralfs, J. (1848).
The British Desmidiaceae.
Reeve, Benham, and Reeve, London

Rawson, D. S. (1955)
Morphometry as a dominant factor in the productivity of large lakes.
Internat. Assoc. of Theor. and Appl. Limnol. 12: 164-175.

Round, F. E. (1965).
The biology of the algae.
Edward Arnold Ltd., London.

Stokes, A. C. (1893).
Fresh-water algae and the Desmidiaceae of the United States.
Edward F. Bigelow, Portland, Conn.

Teiling, E. (1916).
En Kaledonisk fytoplankton-formation.
Svensk. Botan. Tidskr. 10: 506-519.

------ (1947).
Staurastrum planktonicum and St. pingue. A study of planktonic evolution.
Svensk. Bot. Tidskr. 41: 218-234.

Wesenberg-Lund, C. (1905).
A comparative study of lakes of Scotland and Denmark.
Proc. Roy. Soc. Edinburgh. 25: 401-448, 1158-1161.

West, W. and G. S. West, (1903).
Scottish freshwater plankton I.
J. Linn. Soc. Bot. 35: 519-556.

------ (1906).
A comparative study of plankton of some Irish Lakes.
Trans. Roy. Irish. Acad. 33B: 77-116.

------ (1909).
The British freshwater phytoplankton with special reference to the desmid plankton and the distribution of British desmids.
Proc. Roy. Soc. B, 81; 165-206

------(1912).
On the periodicity of phytoplankton of some British lakes.
J. Linn. Soc. Bot. 40: 395-432.

Wolle, F. (1884).
Desmids of the United States.
Moravian Publ. Off., Bethlehem, Pa.

APPENDIX

TABLE 1: North Twin Lake: Aquatic Vegetation.

Aquatics

Acorus calamus
Brasenia Schreberi
Calla palustris
Ceratophyllum demersum
Dulichium arundinaceum
Eleocharis palustris
Equisetum fluviatile
Megalodonta Beckii
Myriophyllum exalbescens
Najas flexilis
Nuphar variegatum
Nymphaea tuberosa
Polygonum amphibium
Potamogeton amplifolius
P. gramineus
P. natans
P. Robbinsii
P. strictifolius
P. vaseyi
P. zosteriformis
Sagittaria latifolia
S. rigida
Scirpus validus
Sparganium angustifolium
S. fluctuans
Utricularia intermedia
U. minor
U. vulgaris

Shoreline

Alnus rugosa
Aster ciliolatus
Bidens comosa
Calamogrostis canadensis
Campanula aparinoides
Carex intumescens v. *fernaldii*
C. lanuginosa
C. pseudo-cyperus
C. stricta
Cicuta bulbifera
C. maculata
Cornus stolonifera
Equisetum hyemale
E. pratense
E. sylvaticum
Eupatorium maculatum
E. perfoliatum
Galium trifidum
Glyceria canadensis
G. grandis
Hypericum virginicum
Hystrix patula
Impatiens capensis
Iris versicolor
Juncus tenuis
Lycopus americanus
L. uniflorus
Lysimachia thyrsiflora
Mentha arvensis
Phleum pratense
Polygonum coccineum
P. punctatum
P. sagittatum
Potentilla palustris
Ranunculus pensylvanicus
Salix bebbiana
S. interior
S. lucida
Scirpus atrocinctus
Scutellaria epilobiifolia
S. lateriflora
Sium suave
Solidago graminifolia
S. uliginosa
Sonchus arvensis
Spirea alba
Thelypteris palustris

TABLE 2: Squaw Lake: Aquatic Vegetation.

Aquatics	Shoreline
Brasenia Schreberi	Alnus rugosa
Chara sp.	Bidens comosa
Elodea canadense	Calamogrostis canadensis
Equisetum fluviatile	Carex rostrata
Hypericum majus	Equisetum arvense
Megalodonta Beckii	Eupatorium perfoliatum
Myriophyllum exalbescens	Lobelia syphiletica
M. verticillatum	Lycopus americana
Najas flexilis	Oenothera parviflora
Nitella sp.	Salix amygdaloides
Nuphar variegatum	S. bebbiana
Nymphaea tuberosa	S. discolor
Potamogeton amplifolius	S. gracilis
P. berchtoldi	S. interior
P. foliosus	S. lucida
P. friesii	S. rigida
P. gramineus	Scirpus atrocinctus
P. natans	S. cyperinus
P. praelongus	Spirea alba
P. Robbinsii	Typha latifolia
P. strictifolius	
P. zosteriformis	
Ranunculus longirostris	
Scirpus validus	
Sparganium chlorocarpum	
S. fluctuans	

TABLE 3: Darling Pond: Aquatic Vegetation.

Aquatics	Shoreline
Bracsenia Schreberi	*Alnus rugosa*
Dulichium arundinaceum	*Aster junciformis*
Nuphar variegatum	*A. puniceus*
Nymphaea tuberosa	*Bidens comosa*
Potamogeton epihydrus	*Campanula aparinoides*
P. strictifolius	*Carex rostrata*
Sagittaria cristata	*Cicuta bulbifera*
S. latifolia	*Eleocharis palustris*
Sparganium angustifolium	*Equisetum fluviatile*
S. fluctuans	*Gallium asprellum*
S. minimum	*G. boreale*
Utricularia vulgaris	*G. trifidum*
	Hypericum muticum
	H. virginicum
	Iris versicolor
	Lemna minor
	Mentha arvensis
	Polygonum lapathifolium
	Potentilla palustris
	Ricciocarpus natans
	Rumex crispus
	R. mexicana
	Salix amygdaloides
	S. gracilis
	S. lucida
	S. pedicellaris
	S. rigida
	Scirpus cyperinus
	Scutellaria epilobiifolia
	Solidago gigantea
	S. graminifolius
	Thelypteris palustris
	Typha latifolia

TABLE 4: Budd Lake: Aquatic Vegetation

Aquatics
Brasenia Schreberi
Chara sp.
Drosera rotundifolia
Isoetes echinospora
Megalodonta Beckii
Myriophyllum exalbescens
Nuphar variegatum
Nymphaea tuberosa
Polygonum amphibium
Potamogeton amplifolius
P. gramineus
P. natans
P. Robbinsii
Sparganium fluctuans
S. minimum
Utricularia vulgaris

TABLE 5: Deming Lake: Aquatic Vegetation

Aquatics	Shoreline
Brasenia Schreberi	Agrostis alba
Chara vulgaris	Alnus rugosa
Dulichium arundinaceum	Aster puniceus
Eleocharis communis	Bidens comosa
Equisetum fluviatile	Bromus inermis
Najas flexilis	Calamogrostis canadensis
Nuphar variegatum	Carex sp.
Nymphaea tuberosa	Carex stricta
Polygonum amphibium	Cicuta bulbifera
Potamogeton amplifolius	Cirsium arvense
Sagittaria cristata	Eupatorium perfoliatum
S. latifolia	Glyceria canadensis
Scirpus atrocinctus	Hypericum sp.
S. cyperinus	H. virginicum
Sparganium angustifolium	Impatiens capensis
S. fluctuans	Iris versicolor
	Juncus sp.
	Lycopus americanus
	Mentha arvensis
	Rhus radicans
	Rosa blanda
	Salix discolor
	Scutellaria epilobiifolia
	Solidago gigantea
	S. graminifolius
	Spirea alba
	Thelypteris palustris

TABLE 6: Arco Lake: Aquatic Vegetation.

Aquatics
Iris versicolor
Nuphar variegatum
Polygonum amphibium
Sagittaria cristata
Typha latifolia

TABLE 7: Josephine Lake: Aquatic Vegetation.

Aquatics
Brasenia Schreberi
Chara vulgaris
Equisetum fluviatile
Myriophyllum exalbescens
Najas flexilis
Nuphar variegatum
Nymphaea tuberosa
Polygonum amphibium
Potamogeton amplifolius
P. Robbinsii
Sparganium fluctuans
Typha latifolia

TABLE 8: Mary Lake: Aquatic Vegetation.

Aquatics

Brasenia Schreberi
Chara vulgaris
Ceratophyllum demersum
Dulichium arundinaceum
Eleocharis communis
Elodea canadense
Equisetum fluviatile
Myriophyllum exalbescens
Najas flexilis
Nuphar variegatum
Nymphaea tuberosa
Polygonum amphibium
Potamogeton amplifolius
P. foliosus
P. natans
P. obtusifolius
P. praelongus
P. Richardsonii
P. Robbinsii
P. strictifolius
P. zosteriformis
Sagittaria cristata
S. latifolia
Scirpus validus
Typha latifolia
Utricularia vulgaris
Zizania aquatica

Shoreline

Alnus rugosa
Alopecuris aequalis
Aster junciformis
Aster puniceus
Bromus ciliatus
Bidens comosa
Betula pumila
Calamogrostis canadensis
C. inexpansa
Calla palustris
Campanula aparinoides
Carex bebbii
C. comosa
C. hystericina
C. lanuginosa
C. pseudo-cyperus
C. rostrata
C. stricta
Cicuta bulbifera
Cirsium arvense
C. muticum
Cornus stolonifera
Equisetum arvense
E. hyemale
Eupatorium maculatum
Gallium asprellum
Geum allepicum
Glyceria canadense
Hypericum virginicum
Impatiens capensis
Iris versicolor
Juncus brevicaudatus
Lycopus uniflorus
Mentha arvensis
Phleum sp.
Phragmites communis
Picea glauca
P. mariana
Poa palustris
Polygonum lapathifolium
Potentilla palustris
Rhus radicans
Rumex crispus
R. orbiculatus
Salix bebbiana
S. candida
S. discolor
S. interior
S. pedicellaris
Scutellaria epilobiifolia
Sium suave
Solidago gigantea
Thelypteris palustris
Triglochin maritima

TABLE 9: Elk Lake: Aquatic Vegetation.

Aquatics
Brasenia Schreberi
Ceratophyllum demersum
Chara vulgaris
Elodea canadense
Myriophyllum exalbescens
Najas flexilis
Nuphar variegatum
Nymphaea tuberosa
Phragmites communis
Potamogeton amplifolius
P. illinoensis
P. natans
P. pectinatus
P. praelongus
P. Robbinsii
P. strictifolius
P. vaginatus
P. zosteriformis
Ranunculus longirostris
Scirpus acutus
Zizania aquatica

TABLE 10: Lake Itasca: Aquatic Vegetation.

Aquatics
Ceratophyllum demersum
Dulichium arundinaceum
Elodea canadense
Heteranthera dubia
Lemna minor
L. trisulca
Najas flexilis
Nuphar variegatum
Nymphaea tuberosa
Polygonum amphibium
P. coccineum
Potamogeton filiformis
P. friesii
P. gramineus
P. illinoensis
P. natans
P. pectinatus
P. praelongus
P. Richardsonii
P. strictifolius
P. vaginatus
P. zosteriformis
Ranunculus longirostris
Sagittaria cuneata
S. latifolia
Scirpus acutus
S. validus
Sparganium eurycarpum
Spirodella polyrhiza
Utricularia intermedia
U. vulgaris
Zizania aquatica

TABLE 11: North Twin Lake; Temperatures in the deeper region in degrees centigrade. 1967, 1968, and 1969.

Depth	Dates									
Meters	8/24/67	8/29/67	8/30/67	8/31/67	9/1/67	9/2/67	9/9/67	9/15/67	9/22/67	10/13/67
0.0	21.5	20.0	19.5	19.5	19.5	19.0	19.0	16.5	15.8	8.3
0.5	21.0	20.0	19.5	19.5	19.5	19.0	19.0	16.5	15.8	8.1
1.0	21.0	20.0	19.5	19.5	19.5	19.0	19.0	16.5	15.8	8.1
1.5	20.5	20.0	19.5	19.5	19.0	19.0	19.0	16.5	15.8	8.1
2.0	20.5	20.0	19.5	19.5	19.0	19.0	19.0	16.5	15.8	8.1
2.5	20.0	20.0	19.5	19.0	19.0	18.5	18.5	16.5	15.8	8.1
3.0	20.0	20.0	19.5	19.0	18.5	18.5	18.5	16.5	15.8	8.1
3.5	19.5	20.0	19.5	18.5	18.5	18.5	18.5	16.0	15.8	
4.0	19.5	20.0	19.5	18.0	18.5	18.5	18.0	16.0	15.5	8.1
4.5	18.0	17.5	18.0	18.0	18.0	18.0	18.0	16.0	15.5	
5.0	14.0	15.0	15.0	15.0	15.5	14.5	15.5	15.5	15.1	8.1
5.5	11.0	12.5	11.0	11.5	12.0	13.0	11.0	13.0	15.0	
6.0	9.0	9.5	8.5	9.5	9.0	10.0	9.0	10.0	11.5	8.1
6.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.4	
7.0	7.0	7.0	7.0	7.5	7.5	7.5	6.5	7.0	7.5	8.1
7.5	6.5	6.5	6.5	7.0	7.0	7.0	6.0	6.5	6.5	
8.0	6.0	6.0	6.0	6.5	6.0	6.5	5.5	6.0	6.0	7.5
8.5	6.0	6.0	5.5	6.0	6.0	6.0	5.5	5.5	5.5	
9.0	6.0	5.5	5.5	5.5	5.5	5.5	5.0	5.5	5.5	6.0
10.0	5.5	5.0	5.0	5.5	5.5	5.5	5.0	5.5	5.5	5.3
11.0	5.0	5.0	5.0	5.0	5.5	5.0	5.0	5.0	5.0	5.0
12.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

TABLE 11: Continued.

Depth Meters	Dates 3/16/68	5/11/68	5/26/68	6/14/68	7/4/68	7/13/68	7/20/68	7/31/68	8/14/68	10/3/68
0.0	0.0	10.5	12.0	17.5	20.0	25.0	25.0	21.0	21.5	12.0
0.5						25.0				
1.0	1.2	10.5	12.0	17.5	19.5	24.5	25.0	21.0	21.0	12.0
1.5					18.0	24.0				
2.0	2.1	10.5	12.0	17.5	17.5	23.0	24.5	20.5	20.5	12.0
2.5				17.0	17.0	22.0	24.0	20.0	20.5	
3.0	2.1	10.0	12.0	15.5	16.5	19.5	22.0	20.0	20.0	12.0
3.5				13.5	16.0	18.0	19.5	20.0	20.0	
4.0	2.2	6.0	11.5	12.5	15.5	16.0	17.0	19.5	20.0	12.0
4.5		5.5	9.5	10.5	15.0	14.5	15.5	14.5	17.0	
5.0	2.5	5.0	8.0	9.0	11.5	12.5	12.5	13.0	14.5	12.0
5.5		4.5		8.5	9.5	10.5	10.5	11.0	12.5	
6.0	2.5	4.5	7.5	7.5	8.0	9.0	9.0	9.5	10.0	12.0
6.5				6.5	7.0	7.0	8.0	8.0	8.5	11.0
7.0	2.5	4.5	6.0	6.0	6.5	6.5	7.0	7.0	7.0	10.5
7.5				5.5		6.0		6.5	6.0	8.0
8.0	2.5	4.5	5.0	5.0	5.5	5.5	6.0	6.0	6.0	7.0
8.5										7.0
9.0	3.0	4.5	4.5	5.0	5.0	5.0	5.0	5.5	5.5	6.0
10.0	2.8	4.5	4.5	4.5	4.5	5.0	5.0	5.0	5.0	6.0
11.0	2.8	4.5	4.5	4.5	4.5	4.5	5.0	5.0	5.0	6.0
12.0	2.8	4.5	4.5	4.5	4.5	4.5	5.0	5.0	5.0	5.5

TABLE 11: Continued.

Depth Meters	11/14/68	4/27/69	5/17/69	6/20/69
	Dates			
0.0	4.0	8.5	15.1	19.0
0.5				
1.0	4.0	8.5	15.0	19.5
1.5				
2.0	4.0	8.5	14.5	19.0
2.5		8.0	14.0	19.0
3.0	4.0	7.5	13.5	19.0
3.5		7.0	11.9	18.5
4.0	4.0	5.5	9.0	18.0
4.5		5.0	6.8	13.0
5.0	4.0	4.5	5.8	11.0
5.5			5.4	9.5
6.0	4.0	4.5	5.0	8.0
6.5			5.0	7.0
7.0	4.0	4.5	4.8	6.8
7.5			4.7	6.0
8.0	4.0	4.5	4.5	5.5
8.5				5.5
9.0	4.0	4.5	4.5	5.0
10.0	4.0	4.5	4.5	5.0
11.0	4.0	4.5	4.5	5.0
12.0	4.0	4.5	4.5	5.0

TABLE 12: North Twin Lake; Temperatures at the sampling site at the Northeast end of the lake. The figures are degrees centigrade. (1967, 1968, and 1969).

Depth Meters	8/24/67	8/29/67	8/30/67	8/31/67	9/1/67	9/2/67	9/9/67	9/15/67	9/22/67	10/13/67
	Dates									
0.0	22.0	29.5	29.5	20.0	19.5	19.5	20.0	17.0	16.2	8.1
0.5	21.5	19.5	19.5	20.0	20.0	19.5	20.0	17.0	16.2	8.1
1.0	21.5	19.5	20.0	20.0	20.0	19.5	19.5	17.0	16.2	8.1
1.5	21.5	19.5	19.5	20.0	19.5	19.5	19.5	16.5	16.2	8.1
2.0	21.5	19.5	19.5	19.5	19.5	19.0	19.5	16.5	16.0	8.1
2.5	21.0	19.5	19.5	19.5	19.5	19.0	19.0	16.5	16.0	8.1
3.0	21.0	19.5	19.5	19.5	19.0	19.0	19.0	16.5	16.0	8.1
3.5	21.0	19.5	19.0	19.5	19.0	19.0	19.0	16.5	16.0	8.1
4.0	20.0	19.0	18.5	18.5	18.5	18.5	19.0	16.0	15.8	8.1
4.5	20.0	18.5	18.5	18.0	18.5	18.5	17.5	16.0	15.6	8.1
5.0	14.5	17.5	16.0	14.5	16.0	15.5	14.0	15.5	15.5	8.1
5.5	12.5	11.0	14.0	11.5	12.5	11.5	12.5	13.5	15.1	8.1
6.0	11.5	10.5	12.0	10.0	10.0	10.0	12.0	11.0	10.8	8.1

TABLE 12: Continued.

Depth Meters	Dates 3/16/68	5/11/68	5/26/68	6/14/68	7/4/68	7/13/68	7/20/68	7/31/68	8/14/68	10/3/68
0.0	0.0	10.5	12.0	17.5	20.0	25.0	25.5	21.0	22.0	12.0
0.5					19.0	25.0				
1.0	1.2	10.5	12.0	17.5	18.5	24.5	25.0	21.0	21.0	12.0
1.5					18.0	24.0				
2.0	2.1	10.5	12.0	17.5	17.5	24.0	25.0	20.5	21.0	12.0
2.5				17.5	17.0	21.5	24.5	20.5	20.5	
3.0	2.1	10.0	12.0	16.0	17.0	20.5	21.5	20.0	20.0	12.0
3.5		7.0	11.0	14.0	16.5	18.0	19.0	20.0	20.0	
4.0	2.2	6.0	11.0	12.5	15.0	16.5	17.5	20.0	20.0	12.0
4.5		5.5		11.5	13.0	14.5	15.5	14.5	17.0	
5.0	2.5	5.0	9.5	9.5	10.5	12.5	13.5	13.5	13.0	12.0
5.5		4.5		8.5	9.5	10.0	11.0	11.0	11.5	
6.0	2.5	4.5	9.5	8.5	9.0	9.0	9.5	9.5	10.0	12.0

TABLE 12: Continued.

Depth Meters	Dates 11/14/68	4/27/69	5/17/69	6/20/69
0.0	4.0	8.5	15.1	19.5
0.5				
1.0	4.0	8.5	15.0	19.5
1.5				
2.0	4.0		14.2	19.0
2.5		8.0	13.8	19.0
3.0	4.0	7.5	13.3	19.0
3.5		7.0	11.5	18.5
4.0	4.0	5.5	8.6	18.0
4.5		5.0	6.8	13.0
5.0	4.0	4.5	5.5	11.0
5.5			5.1	9.5
6.0	4.0	4.5	5.0	8.5

TABLE 13: North Twin Lake: Oxygen determinations in p.p.m. from from the deeper area. 1968.

Depth Meters	Dates 6/18/68	7/4/68	7/13/68	7/20/68	7/31/68	8/14/68	8/22/68	8/26/68	9/2/68	9/9/68
0	8.95	7.46	7.87	7.69	7.96	7.92	7.28	8.18	8.66	8.70
1			7.87	7.60		8.05	7.69	8.18	8.57	8.61
2	9.00		8.05	7.69	7.96	7.60	7.51	8.09	8.61	7.57
3	8.88		7.87	7.19		7.60	7.74	8.09	8.27	8.00
4	9.20	8.55	8.33	8.46	7.78	7.78	7.42	8.09	8.48	8.22
5	7.55	7.83	6.78	7.05		6.96	6.87	7.66	8.05	8.74
6			5.19	5.00	4.23	5.76	3.87	6.74	6.26	7.13
7	3.70	1.37	3.46	2.41	0.46	1.09	0.55	0.86	0.52	6.22
8			0.32	0.27	0.18	0.045	0.00	0.00	0.00	0.044
9			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 13: Continued.

Depth Meters	Dates 9/16/68	10/3/68	11/14/68
0	8.66	7.60	9.78
1	8.05	7.51	
2	7.48	7.51	
3	7.27	7.51	
4	7.13	7.51	
5	7.22	7.51	
6	7.57	6.87	9.78
7	5.96	6.37	
8	0.75	0.96	
9	0.087	0.18	
10	0.00	0.00	
11	0.00	0.00	
12	0.00	0.00	9.78

TABLE 14: North Tain Lake: Oxygen determinations in p.p.m. from the area at the Northeast end of the lake, 1968.

Depth Meters	Dates 6/18/68	7/4/68	7/13/68	7/20/68	7/31/68	8/14/68	8/22/68	8/26/68	9/2/68	9/9/68
0	8.75	9.05	7.37	7.37	7.78	8.19	8.13	8.84	8.74	8.61
1			8.19	7.64	7.92	8.11	8.28	9.87	9.44	8.48
2			6.14	7.28	7.74	7.87	7.78	9.92	9.53	8.61
3	8.45	9.01	6.96	7.33	7.96	7.92	8.10	8.92	9.40	7.87
4			7.51	8.42	7.96	7.42	7.46	8.31	9.18	8.40
5			7.05	7.28	4.10	7.33	6.37	7.66	8.87	8.35
6	7.65	6.05	4.37	5.23	4.00	4.50	4.23	6.69	6.92	8.10

Depth Meters	Dates 9/16/68	10/3/68	11/14/68
0	8.00	8.50	9.78
1	7.30	8.40	
2	8.35	8.30	
3	7.05	8.30	9.78
4	7.31	8.30	
5	6.48	8.25	
6	6.35	8.25	9.78

TABLE 15: Temperatures in the open region of Squaw Lake. The figures are degrees centigrade. 1967, 1968, and 1969.

Depth	Dates									
Meters	7/22/67	7/23/67	7/28/67	8/4/67	9/9/67	9/14/67	9/16/67	9/21/67	10/14/67	11/11/67
0.0	27.0	25.5	23.5	23.8	19.0	16.5	16.0	15.5	9.2	3.2
0.5	27.0	25.5	23.5		19.0	16.5	16.0	16.5		
1.0	27.0	25.5	23.5	23.2	19.0	16.5	16.0	16.5	9.0	3.0
1.5	26.5	25.5	23.5		19.0	16.5	16.0	16.5		
2.0	26.5	25.5	23.5	22.9	19.0	16.5	16.0	16.5	8.9	3.0
2.5	26.0	25.5	23.5	22.5	19.0	16.5	16.0	16.2		
3.0	22.0	25.5	23.5	22.2	19.0	16.5	16.0	16.2	8.9	3.0
3.5	21.5	21.0	23.5	22.1	18.5	16.5	16.0	16.2		
4.0	19.5	19.0	23.5	21.8	18.5	16.5	16.0	16.2	8.6	3.0
4.5	18.0	17.0	16.5	18.0	18.5	16.5	16.0	16.2		
5.0	15.5	15.0	14.5	15.5	18.5	16.5	16.0	16.0	8.6	3.0
5.5	12.0	13.0	13.5	13.5	18.0	16.5	16.0	15.5		
6.0	11.0	10.5	11.0	11.2	13.0	16.0	16.0	15.0	8.5	3.0
6.5	10.0	9.0	9.5	9.8	11.5	13.5	13.5	13.8		
7.0	8.5	8.0	8.0	8.5	8.5	10.0	10.0	11.0	8.5	3.0
7.5	8.0	7.0	6.5	7.5	7.5	7.5	7.5	8.5		
8.0	7.0	6.5	6.0	6.7	7.0	6.5	6.5	7.0	8.5	3.0
8.5	6.0	6.0	5.5	6.0	6.0	6.5	6.5	6.0		
9.0	6.0	5.5	5.0	5.8	5.5	6.0	6.0	5.8	8.5	3.0
10.0	5.5	5.0	5.0	5.2	5.0	5.5	5.5	5.1	6.8	3.0
11.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1	3.0
12.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0
15.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0
20.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0

TABLE 15: Continued.

Depth Meters	Dates 3/16/68	4/21/68	5/25/68	6/14/68	6/18/68	6/20/68	6/24/68	7/5/68	7/14/68	7/22/68
0.0	0.0	5.5	12.0	17.5	17.0	18.5	20.0	21.5	23.5	23.0
0.5									23.5	
1.0	1.2	5.5	12.0	17.5	17.0	18.5	19.5	20.0	23.5	23.0
1.5								19.0	23.5	
2.0	1.8	5.5	11.5	17.5	17.0	18.5	19.0	18.5	23.5	23.0
2.5								18.0	23.0	23.0
3.0	1.9	5.5	11.5	17.5	17.0	18.5	19.0	17.5	22.5	22.5
3.5			11.0	17.5			18.0	17.0	21.5	22.5
4.0	1.9	5.5	10.5	14.5	16.5	18.0	17.0	17.0	20.0	20.0
4.5			10.5	13.0	14.0	14.5	16.0	16.5	17.5	17.5
5.0	1.9	5.2	10.5	12.0	12.0	12.0	12.5	16.5	15.0	16.0
5.5			10.0	10.5	10.5	11.0	11.0	13.0	13.0	14.0
6.0	1.9	4.5	9.5	10.0	10.0	10.0	10.0	11.0	11.5	12.0
6.5						9.5	9.5	10.0	10.0	11.0
7.0	2.0	4.0	9.0	9.0	9.0	8.5	9.0	9.0	9.5	9.0
7.5			8.5			8.0	8.5	8.0	8.5	8.0
8.0	2.0	4.0	8.0	8.5	8.0	7.5	8.0	7.5	7.5	7.5
8.5			7.5					7.0	7.0	
9.0	2.0	4.0	6.5	6.5	6.5	6.0	7.0	6.0	6.5	6.0
10.0	2.1	3.5	4.5	5.5	5.5	5.0	6.0	5.5	5.5	5.5
11.0	2.1	3.5	4.5	5.0	5.0	5.0	5.0	5.0	5.5	5.5
12.0	2.1	3.5	4.5	4.5	4.5	5.0	5.0	5.0	5.0	5.0
15.0	2.1	3.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
20.0	2.2	3.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5

TABLE 15: Continued.

Depth Meters	Dates 8/1/68	8/16/68	4/27/69	5/17/69	6/28/69
0.0	21.0	20.0	6.5	13.1	21.0
0.5	21.0				
1.0	21.0	20.0	6.0	13.8	20.0
1.5	21.0				
2.0	21.0	20.0	6.0	13.8	19.5
2.5	21.0			13.8	19.0
3.0	21.0	20.0	6.0	13.1	19.0
3.5	21.0			13.0	19.0
4.0	20.5	20.0	6.0	13.0	19.0
4.5	20.0			12.5	18.5
5.0	15.0	20.0	6.0	12.0	18.5
5.5	14.0	19.5	6.0	10.5	17.0
6.0	12.0	13.5	6.0	8.0	11.5
6.5	11.5	11.0	6.0	7.0	10.5
7.0	10.0	10.0	6.0	6.1	9.0
7.5	9.0	8.5		5.8	7.5
8.0	8.0	7.5	6.0	5.2	7.0
8.5	7.5	7.0	6.0	5.2	6.5
9.0	6.5	6.0		5.0	6.0
10.0	6.0	5.5	6.0	4.9	6.0
11.0	5.0	5.0	6.0	4.5	5.5
12.0		5.0	5.0	4.5	5.0
15.0	5.0	5.0		4.5	5.0
20.0	5.0	5.0	4.0	4.5	5.0

TABLE 16: Squaw Lake: Oxygen determinations in p.p.m. in the open area, 1968.

Depth Meters	Dates 6/18/68	6/20/68	6/24/68	7/5/68	7/14/68	7/22/68	8/1/68	8/16/68	8/22/68	9/9/68
0	9.15	8.85	8.75	8.24	8.01	7.60	7.96	7.60	7.74	8.44
1	8.65	8.70		8.42	8.10	7.23		5.51	8.11	8.31
2		8.75	8.96	8.65	8.86	7.28	8.11	7.64	7.78	8.27
3	8.75	8.45		8.69	8.10	7.37	7.92	7.28	7.78	8.40
4	8.70	8.00	8.64	8.42	8.10	7.19	7.64	7.42	7.42	8.44
5	9.60	8.35	9.61	8.28	8.33	7.64	7.87	7.51	4.10	8.44
6	10.30	7.75	9.50	8.19	7.78	7.14	6.32	7.69	7.14	8.31
7		7.45	8.86	8.10	7.46	6.87	6.69	5.46	5.00	8.40
8		7.45	8.53	7.78	7.05	6.28	7.05	6.14	5.41	5.39
9		7.25	7.78	6.14	5.87		4.96		4.69	3.57
10	6.95	6.70	7.13	5.51	4.87		4.55	3.32	2.78	4.00
11									2.09	3.13
12			6.26	5.19		3.87	3.41	1.96	1.68	2.87
15	6.00	6.00	5.80	4.87	4.19	3.41	2.64	1.09	0.96	1.48
20	5.85	5.80	5.51	4.60	4.10	3.14	2.37	0.46	0.91	0.74

TABLE 16: Continued.

Depth Meters	9/16/68	10/5/68	11/14/68
0	8.53	7.82	9.60
1	8.44	7.82	
2	8.53	7.82	
3	8.48	7.78	
4	8.48	7.78	9.60
5	8.44	7.82	
6	8.18	7.82	
7	8.18	7.78	
8	8.06	7.92	
9	4.61	4.73	
10	3.65	0.23	9.60
11	3.13		
12	2.74		
15	1.31	0.23	9.60
20	0.35	0.23	9.60

TABLE 17: Temperatures in the protected region of Squaw Lake. The figures are degrees centigrade. 1967, 1968, and 1969.

Depth Meters	Dates 7/23/67	7/28/67	8/4/67	8/12/67	9/9/67	9/14/67	9/16/67	9/21/67	10/14/67	11/11/67
0.0	25.5	23.5	24.5	23.5	19.5	16.0	16.0	16.0	7.5	2.0
0.5	25.5	23.5		23.2	19.5	16.0	16.0	16.0		
1.0	25.5	23.5	22.8	23.2	19.5	16.0	16.0	16.0	7.5	2.5
1.5	25.5	23.5		21.5	19.0	16.0	16.0	16.0		
2.0	23.5	23.5	21.5	20.9	18.0	16.0	16.0	16.0	7.5	2.5
2.5	20.5	21.5	21.0	20.0	17.5	15.5	16.0	15.5		
3.0	18.0	18.5	20.0	19.2	17.0	15.5	16.0	15.0	7.4	2.5
3.5	16.0	16.5	17.5	17.5	16.5	15.0	15.5	14.5		
4.0	13.0	13.5	14.0	14.5	15.0	14.0	14.0	14.0	7.0	2.7
4.5	10.5	11.0	11.5	12.0	14.0	13.0	13.0	13.0		
5.0	9.0	9.0	10.0	10.5	11.5	11.5	11.5	11.0	6.8	2.8
5.5	7.5	8.0	8.5	8.8	9.5	9.5	9.5	10.0		
6.0	7.0	7.0	7.5	7.5	8.0	8.0	8.0	8.0	6.5	2.8
6.5	6.5	6.5	6.5	7.0	7.0	7.0	7.0	7.0		
7.0	6.0	6.0	6.0	6.5	6.5	6.0	6.0	6.5	6.5	2.8
7.5	5.5	6.0	5.5	5.8	6.0	6.0	6.0	6.0		
8.0	5.0	5.0	5.2	5.2	5.5	5.5	5.5	5.5	5.9	2.8
8.5	5.0	5.0	5.0	5.0	5.5	5.5	5.5	5.5		
9.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.2	5.5	3.0
10.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.2	3.0
11.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0
12.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0

TABLE 17: Continued.

Depth Meters	3/16/68	4/21/68	5/25/68	6/14/68	6/18/68	6/20/68	6/24/68	7/5/68	7/14/68	7/22/68
	Dates									
0.0	0.0	7.0	12.5	17.0	17.5	19.5	20.0	22.0	26.0	23.0
0.5									25.5	
1.0	1.6	6.5	12.5	17.0	17.5	19.5	20.0	20.0	23.5	23.0
1.5								19.0	23.0	
2.0	2.9	6.0	12.0	17.0	17.5	19.0	19.0	17.5	22.5	22.0
2.5					16.0	17.5	18.0	16.0	20.0	21.5
3.0	3.1	5.5	11.0	14.5	14.0	15.0	17.0	15.5	17.5	18.0
3.5			10.0	12.0	12.5	13.0	14.0	15.0	16.0	16.5
4.0	3.1	4.5	9.0	11.0	11.0	11.5	12.0	12.5	14.0	14.5
4.5			8.5	10.0	9.5	10.0	10.5	10.5	12.0	12.0
5.0	3.1	4.5	7.5	8.5	8.5	9.0	9.5	9.0	10.0	9.5
5.5			7.0	7.5	7.5	8.0	8.0	7.5	8.5	8.5
6.0	3.7	4.5	6.5	6.5	7.0	7.0	7.0	7.0	7.5	7.5
6.5						5.5	6.0	6.0	6.5	6.5
7.0	3.2	4.0	5.0	5.0	5.0	5.0	5.5	6.0	6.0	6.0
7.5								5.0	5.5	6.0
8.0	3.2	4.0	4.5	4.5	5.0	4.5	5.0	5.0	5.5	5.5
8.5								5.0	5.5	5.5
9.0	3.2	4.0	4.0	4.5	4.5	4.5	4.5	4.5	5.5	5.0
10.0	3.3	4.0	4.0	4.5	4.5	4.5	4.5	5.0	5.0	5.0
11.0	3.4	4.0	4.0	4.5	4.5	4.5	4.5	4.5	5.0	5.0
12.0	3.5	4.0	4.0	4.5	4.5	4.5	4.5	4.5	5.0	5.0

TABLE 17: Continued.

Depth Meters	Dates 8/1/68	8/16/68	4/27/69	5/17/69	6/28/69
0.0	21.0	19.0	6.5	14.1	22.5
0.5					
1.0	20.5	19.0	6.5	14.1	21.0
1.5					
2.0	22.0	19.5	6.5	12.5	20.0
2.5	19.0	19.0		12.4	19.5
3.0	19.0	18.5	6.5	12.0	19.0
3.5	18.0	18.0		8.9	17.0
4.0	14.0	14.0	6.5	5.5	14.0
4.5	11.5	13.0		5.0	11.0
5.0	10.5	10.5	6.5	5.0	8.5
5.5	10.0	9.5		4.8	7.5
6.0	8.0	8.0	6.5	4.5	6.5
6.5	7.0	7.0		4.5	6.0
7.0	6.5	6.5	6.5	4.5	6.0
7.5	6.0	6.0			5.5
8.0	5.5	5.5	6.5	4.5	5.0
8.5	5.5	5.0			5.0
9.0	5.0	5.0	6.5	4.5	5.0
10.0	5.0	5.0	5.0	4.5	5.0
11.0	5.0	5.0	5.0	4.5	5.0
12.0	5.0	5.0	4.5	4.5	5.0

TABLE 18: Squaw Lake: Oxygen determinations in p.p.m. in the protected area, 1968.

Depth	Dates									
Meters	6/18/68	6/20/68	6/24/68	7/5/68	7/14/68	7/22/68	8/1/68	8/16/68	8/22/68	9/9/68
0	8.25	7.80	8.32	8.25	7.23	6.14	7.36	7.19	7.74	8.53
1	8.25	7.70	8.21	8.14	7.05	6.14		7.05	7.96	8.53
2		7.80	7.56	8.19	6.69	6.78	7.83	6.83	7.87	8.35
3	8.00	7.70	7.24	8.05	6.87	5.69	7.19	6.87	7.46	8.40
4	10.45	9.65	9.94	7.28	7.19	5.64	6.87	5.87	5.69	7.44
5	9.85	9.00	10.91	9.33	8.33	7.42	4.78	2.41	0.86	4.13
6		6.15	6.59	5.55	4.78	1.23	0.50	0.27	0.23	0.65
7	3.95	3.05	2.16	0.91	0.68	0.23	0.14	0.09	0.09	0.35
8		2.50	2.05	0.41	0.18	0.18	0.09	0.045	0.045	0.30
9		2.15	0.97	0.23	0.09	0.14	0.00	0.00	0.00	0.13
10	1.10	0.95	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.75	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 18: Continued.

Depth Meters	9/16/68	10/5/68	10/10/68	11/14/68
			Dates	
0	6.70	7.05	7.87	8.65
1	7.87	7.05	7.87	
2	7.92	7.05	7.87	
3	6.00	7.05	7.87	
4	6.05	7.05	7.87	
5	5.09	7.05	7.87	8.65
6	2.35	6.46	7.87	
7	0.31	0.91	7.87	
8	0.17	0.05	0.23	
9	0.008	0.00	0.00	8.65
10	0.00	0.00	0.00	
11	0.00	0.00	0.00	
12	0.00	0.00	0.00	8.65

TABLE 19: A checklist of the desmid taxa occurring in the 10 lakes of the Itasca region which were sampled for this study. If a desmid occurs in a particular lake, it is represented by an "X". The lakes sampled are as follows: 1 North Twin; 2 Squaw; 3 Darling Pond; 4 Budd; 5 Deming; 6 Arco; 7 Josephine; 8 Mary; 9 Elk; 10 Itasca.

Desmid Taxa	Lakes Sampled 1	2	3	4	5	6	7	8	9	10
Closterium aciculare v. _subpronum_	X	X	X	X	X	X	X	X	X	X
C. acutum	X	X	X	X	X		X	X	X	X
C. angustatum	X	X	X	X	X		X	X		X
C. Braunii	X	X	X	X	X		X	X		X
C. cynthia	X	X	X	X	X	X	X	X	X	X
C. dianae	X	X	X	X	X	X	X	X	X	X
C. ehrenbergii	X	X	X	X	X	X	X	X	X	X
C. gracile	X	X	X	X	X	X	X	X	X	X
C. incurvum	X	X	X	X	X	X	X	X	X	X
C. Kutzingii	X	X	X					X		
C. Leibleinii	X	X	X	X	X	X	X	X	X	X
C. libellula	X	X	X	X	X	X	X	X	X	X
C. lineatum	X	X								
C. litorale	X	X	X	X	X	X	X	X	X	X
C. navicula	X	X	X				X			
C. parvulum	X	X	X	X	X	X	X	X	X	X
C. praelongum	X	X	X			X	X	X		X
C. pronum	X	X	X		X	X	X	X		
C. ralfsii	X	X			X			X		X
C. setaceum	X	X	X			X	X	X	X	X
C. strigosum	X	X	X	X			X		X	
C. striolatum	X	X	X				X	X	X	X
C. venus	X	X	X	X	X	X	X	X	X	X
Cosmarium amoenum v. _mediolaeve_	X	X	X							X
C. angulare	X	X	X	X	X	X	X	X	X	X
C. angulosum	X	X	X	X	X	X	X	X	X	X
C. bioculatum	X	X	X	X	X	X	X	X	X	X
C. bireme	X	X	X	X	X	X	X	X	X	X
C. bitriangulum	X	X	X	X	X		X	X		X
C. Blytii	X	X	X	X	X		X	X	X	X
C. Botrytis	X	X	X	X	X	X	X	X	X	X
C. Botrytis v. _subtumidum_	X	X	X	X	X	X	X	X	X	X
C. commisurale	X	X	X	X	X	X	X	X	X	X

TABLE 19: Continued.

Desmid Taxa	Lakes Sampled 1	2	3	4	5	6	7	8	9	10
Cosmarium connatum	X	X	X	X	X	X	X	X	X	X
C. contractum	X	X	X	X	X	X	X	X	X	X
C. contractum v. ellipsoideum	X	X	X	X	X	X	X	X	X	X
C. depressum	X	X	X	X	X	X	X	X	X	X
C. depressum v. minutem	X	X	X	X	X	X	X	X		X
C. difficile	X	X	X	X	X	X	X	X	X	X
C. difficile v. dilatatum	X	X	X	X	X	X	X	X	X	X
C. elegantissimum	X	X								
C. eloisianum v. depressum	X	X	X		X		X	X	X	X
C. furcatospermum	X	X	X	X	X	X	X	X	X	X
C. garrolense	X	X		X	X	X	X	X	X	X
C. granatum	X	X	X	X	X		X	X	X	X
C. humile	X	X	X	X	X	X	X	X	X	X
C. impressulum	X	X	X	X	X		X	X	X	X
C. isthmium forma hibernica	X	X	X	X	X	X	X	X	X	X
C. margaritatum	X	X	X	X	X	X	X	X	X	X
C. margaritatum forma minor	X	X	X	X	X		X	X	X	X
C. moniliforme	X	X	X	X	X	X	X	X	X	X
C. moniliforme v. limneticum	X	X				X			X	
C. moniliforme forma panduriformis	X	X	X	X	X	X	X	X	X	X
C. ornatum	X	X	X	X	X	X	X	X	X	X
C. ovale	X	X	X	X	X	X	X	X	X	X
C. Phaseolus v. minus	X	X	X	X	X	X	X	X	X	X
C. portianum	X	X	X	X	X	X	X	X	X	X
C. protractum	X	X	X	X	X	X	X	X	X	X
C. pseudopyramidatum	X	X	X	X	X	X	X	X	X	X
C. punctulatum	X	X	X	X	X	X	X	X	X	X
C. punctulatum v. subpunctulatum	X	X	X	X	X	X	X	X	X	X
C. pyramidatum	X	X	X	X	X	X	X	X	X	X
C. quadratulum	X	X	X	X	X	X	X	X	X	X
C. quadrifarius v. hexasticha	X	X	X	X	X		X	X	X	X
C. regnelii	X	X						X		
C. regnesii	X	X						X		
C. reniforme	X	X	X	X	X	X	X	X	X	X
C. retusiforme	X	X	X	X	X	X	X	X	X	X

TABLE 19: Continued.

Desmid Taxa	Lakes Sampled 1	2	3	4	5	6	7	8	9	10
Cosmarium retusum	X	X	X	X	X	X	X	X	X	X
C. subcrenatum	X	X	X	X	X	X	X	X	X	X
C. subdeplanatum	X	X	X	X	X	X	X	X	X	X
C. subdepressum	X	X	X	X			X			X
C. subtumidum	X	X	X	X	X	X	X	X	X	X
C. taxichondrum	X	X	X	X	X	X	X	X	X	X
C. triplicatum	X	X	X	X	X	X	X	X	X	X
C. Turpinii	X	X	X	X			X	X	X	
Desmidium aptogonum	X	X	X	X	X	X	X	X	X	X
D. Baileyi	X	X	X	X	X	X	X	X	X	X
D. grevellii	X	X	X						X	X
D. Swartzii	X	X	X	X	X	X	X	X	X	X
D. Swartsii v. amblyodon	X	X	X	X		X	X		X	X
D. quadrangulata	X	X								
Gymnozyga moniliformis forma maxima	X	X	X	X	X	X	X	X	X	X
Hyalotheca dissiliens	X	X	X	X	X	X	X	X	X	X
H. mucosa	X	X	X	X	X	X	X	X	X	X
Netrium digitus	X	X		X						
Onychonema filiforme	X	X	X	X	X	X	X	X	X	X
O. laeve v. latum	X	X	X	X	X	X	X	X	X	X
O. laeve v. micracanthum	X	X								X
Tetmemorus granulatus	X	X	X							
Sphaerozosma excavatum	X	X	X	X	X	X	X	X	X	X
S. granulatum	X	X	X	X	X	X	X	X	X	X
Spin=oclosterium sp.	X	X	X			X	X			
Spondylosium planum	X	X	X	X	X	X	X	X	X	X
S. pulchrum	X	X	X							
S. secedens	X	X	X				X	X		X
Euastrum abruptum forma minus	X	X	X	X			X	X	X	X
E. affine	X	X	X	X			X	X	X	X
E. attenuatum	X	X	X	X	X		X	X	X	X

TABLE 19: Continued.

Desmid Taxa	Lakes Sampled 1	2	3	4	5	6	7	8	9	10
Euastrum bidentatum	X	X	X	X			X	X	X	X
E. binale	X	X	X	X	X	X	X	X	X	X
E. binale v. *minus*	X	X	X	X	X	X	X	X	X	X
E. didelta	X	X		X				X	X	X
E. divaricatum	X	X	X	X			X	X	X	X
E. elegans	X	X	X	X	X	X	X	X	X	X
E. elegans v. *bidentatum*	X	X	X	X	X	X	X	X	X	X
E. elegantissimum	X	X								
E. gemmatum	X	X	X	X	X	X	X	X	X	X
E. humerosum v. *evolutum*	X	X	X	X	X		X	X		X
E. insulare	X	X	X	X	X	X	X	X	X	X
E. pectinatum v. *brachylobum*	X	X	X		X			X	X	X
E. sinuosum v. *reductum*	X	X		X			X		X	
E. verrucosum	X	X	X	X	X	X	X	X	X	X
Micrasterias apiculata f. *spinosa*	X	X	X	X		X	X	X	X	X
M. apiculata v. *fimbriata*	X	X	X	X		X	X	X	X	X
M. crux-militensis	X	X	X	X			X	X	X	X
M. furcatas	X	X								
M. laticeps	X	X	X	X	X	X	X	X	X	X
M. mahabuleshwarensis	X	X								
M. mahabuleshwarensis ad forma *dichotoma*	X	X	X	X			X	X	X	X
M. mahabuleshwarensis forma *dichotma*	X	X	X	X				X	X	X
M. mamillata	X	X								
M. pinnatifida	X	X	X	X	X	X	X	X	X	X
M. radiata	X	X	X	X	X	X	X	X	X	X
M. radiosa v. *ornata*	X	X	X	X	X		X	X	X	X
M. rotata	X	X	X	X	X			X	X	X
M. truncata	X	X		X	X		X			X
M. truncata v. *semiradiata*	X	X	X	X	X	X	X	X	X	X
Pleurotaenium constrictum	X	X		X						
P. Ehrenbergii	X	X	X	X	X	X		X	X	X
P. Ehrenbergii v. *elongatum*	X	X	X	X			X	X	X	X

TABLE 19: Continued.

Desmid Taxa	Lakes Sampled 1	2	3	4	5	6	7	8	9	10
Pleurotaenium nodosum	X	X		X						
P. trabecula	X	X	X	X						
P. trabecula v. *rectum*	X	X	X	X	X	X	X	X	X	X
P. trochiscum v. *tuberculatum*	X	X		X						
P. truncatum	X	X	X	X				X	X	X
Staurastrum alternans	X	X	X	X	X	X	X	X	X	X
S. anatinum	X	X	X	X	X	X	X	X	X	X
S. anatinum v. *curtum*	X	X	X							X
S. anatinum v. *longibrachiatum*	X	X	X	X	X			X	X	X
S. anatinum v. *truncatum*	X	X	X	X	X	X	X	X	X	X
S. ankyroides	X	X	X	X	X		X		X	X
S. arachnae	X	X	X	X	X	X	X	X	X	X
S. arctiscon	X	X	X	X	X	X	X	X	X	X
S. avicula v. *subarcuatum*	X	X	X	X	X	X	X	X	X	X
S. borgeanum	X	X			X		X	X		X
S. brachiatum	X	X	X	X	X	X	X	X	X	X
S. Brebissonii v. *brevispinum*	X	X	X			X				
S. breviaculeatum	X	X	X	X	X	X		X	X	X
S. Bullardii	X	X			X					X
S. cingulum	X	X		X	X		X		X	X
S. contectum	X	X	X	X	X	X	X	X	X	X
S. cornutum	X	X	X	X	X	X	X	X	X	X
S. crenulatum	X	X	X	X	X	X	X	X	X	X
S. dilatatum	X	X	X	X	X	X	X	X	X	X
S. forficulatum	X	X			X					
S. furcatum	X	X	X	X	X	X	X	X	X	X
S. furcatum f. *elegantior*	X	X	X	X	X		X	X	X	X
S. furcatum v. *pisciforme*	X	X	X	X	X		X	X	X	X
S. furcatum v. *subsenarium*	X	X		X	X		X	X	X	X
S. furcigerum	X	X	X	X	X	X	X	X	X	X
S. furcigerum v. *armigerum*	X	X	X	X	X	X	X	X	X	X
S. gracile	X	X	X	X	X	X	X	X	X	X
S. gracile v. *nanum*	X	X	X	X	X	X	X	X	X	X

TABLE 19: Continued.

Desmid Taxa	Lakes Sampled 1	2	3	4	5	6	7	8	9	10
Staurastrum gyrans	X	X	X	X						
S. gyrans f. quadrata	X	X		X						
S. hexacerum	X	X	X	X	X	X	X	X	X	X
S. inconspicuum	X	X	X	X	X	X	X	X	X	X
S. inflexum	X	X	X	X	X	X	X	X	X	X
S. iotanum	X	X	X	X	X	X	X	X	X	X
S. Johnsonii	X	X	X	X	X	X	X	X	X	X
S. Johnsonii v. depauperatum	X	X	X		X		X			
S. leptacanthum	X	X		X	X			X		
S. leptocladum	X	X	X	X	X	X	X	X	X	X
S. lunatum	X	X			X					
S. manfeldtii	X	X	X	X	X		X	X	X	X
S. margaritaceum	X	X	X	X	X	X	X	X	X	X
S. micron	X	X	X	X	X	X	X	X	X	X
S. micron f. biradiata	X	X	X	X	X	X	X	X	X	X
S. muticum	X	X	X	X	X	X	X	X	X	X
S. natator	X	X	X	X	X	X	X	X	X	X
S. ophiura	X	X	X	X	X		X	X	X	X
S. pentacerum	X	X	X	X	X			X	X	X
S. pentacladum	X	X								
S. pinque	X	X		X	X		X	X		X
S. planitonicum	X	X		X	X					
S. protectum	X	X	X	X	X	X	X	X	X	X
S. pseudopelagicum	X	X			X				X	
S. quadrangulare v. armatum	X	X		X	X				X	X
S. quebescense	X	X	X	X	X	X	X	X	X	X
S. Ravenelii	X	X	X	X	X	X	X	X	X	X
S. Rotula	X	X	X	X	X		X	X	X	X
S. rugulosum	X	X	X	X	X	X	X	X	X	X
S. Sebaldi	X	X	X	X	X		X	X	X	X
S. setigerum	X	X	X	X	X			X	X	X
S. simonyi	X	X	X	X	X	X	X	X	X	X
S. spiculiferum	X	X	X	X	X			X	X	X
S. sublaevispinum	X	X	X	X	X	X	X	X	X	X
S. tetracerum	X	X	X	X	X	X	X	X	X	X
S. tohopekaligense v. nonanum	X	X	X	X	X			X		
S. trifurcatum	X	X			X	X		X	X	X
S. vestitum	X	X	X	X	X	X	X	X	X	X

TABLE 19: Continued.

Desmid Taxa	Lakes Sampled 1	2	3	4	5	6	7	8	9	10
Arthrodesmus octocornis	X	X	X	X	X	X	X	X	X	X
Staurodesmus brevispinus	X	X	X	X	X	X	X	X	X	X
S. Bulnheimii	X	X			X		X	X	X	X
S. Bulnheimii v. *subincus*	X	X	X		X			X	X	X
S. clepsydra	X	X	X	X	X	X	X	X		X
S. connatus	X	X	X	X						X
S. convergens	X	X	X	X	X			X	X	X
S. cuspidatus	X	X	X	X	X	X	X	X	X	X
S. cuspidatus v. *canadense*	X	X	X	X	X	X	X	X	X	X
S. cuspidatus v. *curvatus*	X	X	X		X			X	X	X
S. cuspidatus v. *divergens*	X	X	X	X	X		X	X	X	
S. curvatus	X	X	X		X		X	X	X	X
S. dejectus	X	X	X	X	X	X	X	X	X	X
S. dejectus v. *apiculatus*	X	X	X	X	X	X	X	X	X	X
S. Dickiei	X	X	X	X	X	X	X	X	X	X
S. Dickiei v. *circularis*	X	X	X	X	X	X	X	X	X	X
S. Dickiei v. *maximus*	X	X	X	X	X	X	X	X	X	X
S. Dickiei v. *rhomboideus*	X	X	X	X	X	X	X	X	X	X
S. extensus	X	X	X	X	X	X	X	X		X
S. glaber	X	X		X						
S. glaber Facies 2	X	X								
S. grandis	X	X	X	X	X			X	X	X
S. grandis v. *parvus*	X	X	X	X	X	X		X	X	X
S. isthmosus	X	X	X	X						
S. mamillatus	X	X	X	X	X	X	X	X	X	X
S. michiganensis	X	X	X	X	X	X	X	X	X	X
S. patens v. *maximus*	X	X	X	X	X		X	X	X	X
S. pachyrhynchus v. *convergens*	X	X	X	X	X	X	X	X	X	X
S. phimus	X	X	X	X	X	X		X		
S. subtriangularis v. *inflatus*	X	X	X	X	X		X	X	X	X
S. subulatus	X	X	X	X	X			X	X	X

TABLE 19: Continued.

Desmid Taxa	Lakes Sampled									
	1	2	3	4	5	6	7	8	9	10
Xanthidium antilopaeum	X	X								
Xanthidium antilopaeum v. *hebridarum*	X	X	X	X			X	X	X	X
X. antilopaeum v. *minneapoliense*	X	X		X				X		X
X. antilopaeum v. *polymazum*	X	X	X	X	X	X	X	X	X	X
X. cristatum	X	X	X	X	X	X	X	X	X	X
X. cristatum v. *uncinatum*	X	X	X	X	X		X	X		X
X. pseudobengalicum	X	X						X		
X. subhastiferum	X	X	X	X	X	X	X	X	X	X
X. sp.	X	X			X					X

TABLE 20: A summary of Table 19; Appendix: The total number of desmid taxa in ten lakes of the Itasca region.

Genus	Lakes * 1	2	3	4	5	6	7	8	9	10
<u>Closterium</u>	23	23	21	15	16	14	20	20	15	18
<u>Cosmarium</u>	53	53	48	47	46	40	48	49	46	48
Misc. **	20	20	17	13	11	13	14	12	13	15
<u>Euastrum</u>	18	18	15	17	11	8	15	16	16	16
<u>Micrasterias</u>	15	15	11	12	7	6	10	11	11	12
<u>Pleurotaenium</u>	8	8	5	8	2	2	2	4	4	4
<u>Staurastrum</u>	66	66	52	56	61	38	47	52	52	55
<u>Staurodesmus</u>	31	31	28	26	27	17	20	27	24	26
<u>Xanthidium</u>	9	9	5	6	5	3	5	7	4	7
TOTALS	243	243	202	200	186	141	181	198	185	201

* Lakes:

1	North Twin	6	Arco
2	Squaw	7	Josephine
3	Darling	8	Mary
4	Budd	9	Elk
5	Deming	10	Itasca

** Misc. represents the sum of the following genera: <u>Desmidium</u>, <u>Gymnozyga</u>, <u>Hyalotheca</u>, <u>Netrium</u>, <u>Onychonema</u>, <u>Tetmemorus</u>, <u>Sphaerozosma</u>, <u>Spinoclosterium</u>, and <u>Spondylosium</u>.

TABLE 21: The relative frequency of occurrence of desmids in eight lakes of the Itasca region as calculated from selected samples.

The genus *Closterium* species	Lakes * 1	2	3	4	5	6	7	8
aciculare v. *subpronum*		0.2	0.8					
Braunii	0.2							
dianae	0.2	0.2	2.8					1.0
Ehrenbergii	0.2		0.6					
gracile	0.2	0.2			0.8	0.8	3.0	
incurvum								0.2
Kützingii		0.2						
Leibleinii	0.4	0.4	3.6		0.4	2.4		1.4
libellula	0.4	0.2	0.6					
littorale	0.2							
navicula							1.0	
parvulum	0.2	1.4	7.0		0.4	1.6	20.0	1.6
praelongum		0.2						
pronum		0.2						
ralfsii		0.2						0.6
strigosum		0.2						
striolatum		0.2	1.0					
venus			1.0		0.4		1.0	

* 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

TABLE 21: Continued

The genus *Cosmarium* species	Lakes* 1	2	3	4	5	6	7	8
angulare	1.4	0.4	0.8			4.0	1.0	18.6
angulosum	35.6	1.8	1.8	1.6	11.6	8.8		1.8
bioculatum	3.0	10.6	2.4	1.6	6.0	7.2	3.0	2.0
bireme	0.4	0.2				1.6		
bitriangulum	0.2	0.2			0.4			
Blytii	0.2	0.2						
Botrytis	0.8	0.8			0.4			0.2
Botrytis v. *subtumidum*	0.4	0.4				2.4	2.0	1.0
commissurale	0.2							0.2
connatum	0.2	0.6	0.6		1.2	3.2	1.0	
contractum		0.8						0.4
contractum v. *ellipsoideum*					1.2			
depressum	0.2	1.4	2.4		2.0			8.6
depressum v. *minutem*		0.6			3.6	8.8		
difficile	0.8	0.2	0.6		0.8			
difficile v. *dilatatum*	0.2				0.4		1.0	
furcatospermum	2.0	3.2	0.2		2.8			
garrolense		0.2						
granatum	0.4	0.4						0.2
humile		0.2			0.8	0.8		
impressulum	3.2	0.4						
isthmium f. *hibernica*	0.4	0.2	0.6	0.8		0.8		0.8
margaritatum	1.2	0.8			1.2	0.8	3.0	
margaritatum v. *minor*		0.2	0.2		0.4			2.4

* 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

TABLE 21: Continued.

The genus Cosmarium Continued. species	Lakes* 1	2	3	4	5	6	7	8
moniliforme		0.6	0.4	0.8	1.2	0.8	1.0	1.2
moniliforme v. limneticum					0.8	0.8		
moniliforme v. panduriformis	0.4	0.2						1.0
ornatum	0.4	0.4	1.4	1.6				
ovale	0.2		2.2			0.8		
Phaseolus v. minus		0.2	0.4		2.4	2.4		0.6
portianum	4.0	0.6	2.0		2.0	2.4	12.0	0.6
protractum	1.0	0.2						
pseudopyramidatum	2.6	1.2			0.4			0.4
punctulatum	1.0	10.8	2.0		6.0	3.2		20.2
punctulatum v. subpunctulatum			2.2	0.8	1.6	0.8	2.0	2.8
pyramidatum	0.8	0.4						
quadratulum		0.4						
quadrifarius v. hexasticha	0.2				0.4			
regnelii	0.6							
regnesii	0.2	0.2						
reniforme	0.2	0.8	2.0		0.4	8.8	8.0	5.2
retusiforme	0.2	0.2			1.6	0.8		
retusum		0.2						0.2
subcrenatum		0.8		0.8	0.4			
subdeplanatum	1.8	19.0		0.8	4.4			0.6
subtumidum	0.6	0.4			0.4	0.8	1.0	1.2
taxichondrum	0.6	0.2	0.6			2.4	1.0	
triplicatum	0.2							4.4
Turpinii		0.2					1.0	

* 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

TABLE 21: Continued.

Genera: Desmidium, Euastrum, Gymnozyga, Hyalotheca	Lakes * 1	2	3	4	5	6	7	8
Desmidium								
aptogonum			0.4					
Baileyi	0.4	0.6						
Grevellii			0.8					
Swartzii		0.4	0.4					
Euastrum								
abruptum f. minus	0.2	0.2						0.6
affine		0.4	0.4					
attenuatum		0.2						
bidentatum		0.2					2.0	
binale	3.6	1.2	0.6					1.2
binale v. minor	0.8							
didelta		0.2						
divaricatum	0.2	0.6						
elegans	0.4	1.8						
elegans v. bidentatum							4.0	5.2
gemmatum		0.6				0.8		
insulare	0.4	1.6						0.2
pectinatum v. brachylobum			0.2					
sinuosum			0.2					
verrucosum		0.6						
Gymnozyga								
moniliforme v. maximum		0.2	0.2					
Hyalotheca								
dissiliens		0.6						

* 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

TABLE 21: Continued.

Genera: Micrasterias, Onychonema, Pleurotaenium, Sphaerozosma, Spondylosium	Lakes *							
	1	2	3	4	5	6	7	8
Micrasterias								
apiculatus v. fimbriata		0.2	0.2					
apiculatus v. spinosa		0.2						
laticeps	0.2	0.4				3.2	3.0	
mahabuleshwarensis f. dichotoma		0.2						
pinnatifida		0.4						
radiata		0.2						0.2
radiosa v. ornata	0.2	0.6						
truncata		0.2						
truncata v. semiradiata		0.2						0.4
Onychonema								
filiforme		3.2	1.0					0.2
laeve v. latum		1.4						
Pleurotaenium								
Ehrenbergii	0.2	0.2	0.4					
Ehrenbergii v. elongatum	0.4							
trabecula v. rectum	0.4		0.4				2.0	
truncatum	0.2	0.2	0.8					
Sphaerozosma								
excavatum	0.6	0.2	0.6	1.6				
Spondylosium								
planum	0.2	0.2		1.6				

* 1 North Twin, 2 Squaw, 3 Darling, 4 Budd, 5 Deming, 6 Arco, 7 Josephine, 8 Mary

TABLE 21: Continued.

The genus *Staurastrum* species	Lakes * 1	2	3	4	5	6	7	8
alternans	7.4	1.0		0.8	0.4	0.8		
anatinum	0.2	0.4					1.0	1.0
anatinum v. *longibrachiatum*								0.8
anatinum v. *truncatum*	0.6	0.2	1.4	0.8				
arachnae		0.4						
arctiscon	0.2	0.8						0.8
avicula v. *subarcuatum*			0.2		0.4			
brachiatum			0.4					
breviaculeatum	0.2	0.4	0.2					
Bullardii		0.2						
connectum					0.4		1.0	
cornutum		0.6			0.4			0.6
crenulatum		0.4	2.8		1.6	1.6		0.4
dilatatum	0.6	0.2						
furcatum		0.2	2.4		0.4			
furcatum f. *elegantior*		0.6	1.0					
furcatum v. *pisciforme*	0.2							
furcigerum		0.2			0.4			
furcigerum v. *armigerum*							2.0	
gracile	0.8	0.4	3.0				2.0	2.6
gracile v. *nanum*	2.6	0.2	4.2	4.0	3.2	6.4	2.0	4.0
gyrans		0.2						
hexacerum	0.4							
inconspicuum		0.2			0.4			0.2

* 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

TABLE 21: Continued.

The genus *Staurastrum* continued. Lakes *	1	2	3	4	5	6	7	8
inflexum	0.2		1.6		2.0			0.2
iotanum			8.0	2.4	1.2			
Johnsonii	0.6							
leptocladum		0.4	0.4			0.8		
manfeldtii			0.4					
margaritaceum			1.2		0.4	0.8	1.0	
micron		0.4	1.4		0.4			
micron facies *biradiata*	0.2		1.0					
muticum	0.8	0.4				4.0	1.0	0.2
natator						1.6		
ophiura	0.2	0.2						
pentacerum		0.2						
protectum			0.4					
pseudopelagicum		0.2			0.4			
quebescense								0.6
ravenelii			0.2		0.8			
rotula		0.2						
rugulosum	1.6	0.2	0.2			0.8		
setigerum		0.2						
simonyi			0.2					
spiculiferum		0.2	0.4					
sublaevispinum			7.6					
tetracerum		1.6	5.6	4.8	16.4		1.0	
trifurcatum	0.2							
vestitum			0.6					

* 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

TABLE 21: Continued.

Genera: *Arthrodesmus* *Staurodesmus*	Lakes *							
	1	2	3	4	5	6	7	8
Arthrodesmus								
octocornis	0.2		0.2					
Staurodesmus								
brevispinus	0.2				2.0	1.6	1.0	
Bulnheimii		0.2						
Bulnheimii v. *subincus*			0.4					
clepsydra		0.4						
convergens	0.8							
cuspidatus	0.4	1.0		1.6	3.6		5.0	0.2
cuspidatus v. *canadense*			1.8			0.8	2.0	
cuspidatus v. *curvatus*		0.2						
cuspidatus v. *divergens*		0.2	0.4					
dejectus	0.4		1.6		4.0	2.4		
dejectus v. *apiculatus*		0.2	0.2					
Dickiei	0.2		0.2					
Dickiei v. *circularis*	0.6	0.2			0.8	2.4	1.0	
Dickiei v. *maximus*		0.6			0.4			
Dickiei v. *rhomboideus*	0.2			0.8				
extensus	0.2	0.2		72.8				
grandis	0.6							
grandis v. *parvus*					0.8			0.4
isthmosus				1.6				
mamillatus	0.6					0.8	3.0	
michiganensis	0.4	0.4						

* 1 North Twin; 2 Squaw; 3 Darling; 4 Budd; 5 Deming; 6 Arco; 7 Josephine; 8 Mary

TABLE 21: Continued.

Genera: Staurodesmus continued. Xanthidium

	Lakes *							
	1	2	3	4	5	6	7	8
Staurodesmus								
pachyrhynchus v. convergens	1.0	1.2	2.2			1.6	3.0	
patens v. maximus	0.2	0.2						
phimus	0.2	0.4			0.4	2.4		
subtriangularis v. inflatus			0.2					
subulatus		0.2						
Xanthidium								
antilopaeum v. hebridarum		0.2						
antilopaeum v. minneapoliense	0.4	0.4						
antilopaeum v. polymazum	0.2	0.6	0.4		0.4		1.0	
cristatum			0.2					
cristatum v. uncinatum			0.4					
subhastiferum	0.2	0.6	0.2					0.8

* 1 North Twin
2 Squaw
3 Darling
4 Budd
5 Deming
6 Arco
7 Josephine
8 Mary

TABLE 22: Squaw Lake: Desmid counts from the open area. 1967, 1968, and 1969.
The figures are the number of desmids in 10 ml. lake water.

Depth			1967				Dates				1968			
Meters	7/22	7/28	8/4	9/5	9/14	9/21	10/10	11/11	3/16	4/21	5/28	6/14	6/24	7/5
0	8	7	5	3	0	0	2	0	0	0	0	0	1	1
1	10	3	6	0	1	0	2	0	0	0	1	1	0	1
2	8	5	5	1	2	0	1	0	0	0	0	0	0	3
3	12	5	8	1	0	0	1	0	0	0	0	3	0	3
4	12	3	2	1	0	0	0	0	0	0	0	2	1	8
5	8	14	12	1	1	0	0	0	0	0	1	2	3	1
6	14	13	4	1	1	0	2	0	0	0	0	4	0	0
7	5	5	9	1	0	1	0	0	0	0	0	1	1	0
8	3	5	5	3	2	0	1	0	0	0	0	2	0	0
9	3	5	1	0	0	0	1	0	0	0	0	1	1	1
10	2	0	0	2	1	0	1	0	0	0	0	2	1	1
11	0	3	4	0	3	0	0	0	0	0	0	0	2	0
12	3	3	2	0	1	0	1	0	0	0	0	1	1	0
15	1	2	2		0	0	0	0	0	0	0	0	0	0
20	1	2	1	0	0	0	0	0	0	0	0	0	0	0
TOTALS	90	75	66	14	12	1	12	0	0	0	2	19	11	19

TABLE 22: Continued.

Depth Meters	1968 7/14	7/22	Dates 10/5	4/27	1969 5/17	6/28	8/18
0	0	1	0	0	0	1	16
1	0	8	1	0	0	0	9
2	3	5	3	0	0	0	11
3	5	4	0	0	0	4	15
4	2	6	0	0	0	1	11
5	8	6	0	1	0	0	11
6	3	6	0	0	0	0	8
7	2	2	0	0	0	0	5
8	1	0	0	0	0	0	3
9	0	0	0	0	0	0	1
10	2	0	0	0	0	0	0
11	1	0	0	0	0	0	0
12	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
Totals	27	38	4	1	0	6	90

TABLE 23: Squaw Lake: Desmid counts from the protected area. The figures are the number of desmids in 10 milliliters of lake water. (1967, 1968, and 1969).

Depth Meters	7/22	7/28	8/4	1967 9/5	9/14	9/21	10/10	Dates 11/11	3/16	1968 4/21	5/28	6/14	6/24	7/5
0	2	0	0	0	0	0	1	0	0	0	0	1	1	0
1	0	0	3	2	0	0	0	0	0	0	2	1	0	1
2	0	2	1	2	1	2	0	0	0	0	0	1	3	1
3	0	0	2	1	0	0	0	0	0	0	0	0	4	3
4	1	0	1	0	0	2	0	0	0	0	0	1	0	0
5	0	1	2	1	0	0	0	0	0	0	0	1	0	1
6	1	0	0	0	2	0	3	0	0	0	0	2	2	0
7	0	0	0	0	2	0	1	0	0	0	0	2	2	0
8	0	0	0	0	0	0	0	0	0	0	0	1	0	1
9	0	0	0	0	0	0	1	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Totals	4	3	9	6	5	4	6	0	0	1	2	11	12	7

TABLE 23: Continued.

Depth	1968			Dates		1969	
Meters	7/14	7/22	10/5	4/27	5/17	6/28	8/18
0	3	0	0	0	0	1	0
1	1	0	0	0	0	3	0
2	0	1	0	1	0	0	0
3	4	1	0	1	0	0	0
4	1	0	0	0	0	0	1
5	0	0	0	0	0	0	0
6	1	0	0	0	0	0	0
7	0	0	0	0	0	0	1
8	0	0	0	0	1	0	0
9	0	0	0	0	1	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	2	0
Totals	10	2	0	2	2	6	2

TABLE 24: Squaw Lake: Desmid counts from sampling site # 3 during 1967 and 1968. The figures are the total number of desmids in 10 milliliters of lake water.

Depth Meters	7/23	7/28	1967 8/4	9/5	9/14	Dates 9/21	10/10	1968 6/14
0	0	0	1	1	0	0	0	2
1	0	1	1	1	1	0	0	1
2	3	1	3	3	1	0	0	1
3	4	0	3	2	0	0	0	1
4	1	0	3	1	1	0	0	2
5	0	0	0	0	2	0	0	0
6	1	1	0	*	*	*	0	*
Totals	9	3	11	8	5	0	0	7

* Bottom

TABLE 25: North Twin Lake: Desmid counts from the deeper area of the lake. 1967, 1968, and 1969. The figures are the number of desmids in 10 milliliters of lake water.

Depth Meters	Dates 1967 8/8	8/25	9/1	9/8	9/15	9/22	10/9	1968 3/16	5/11	5/26	6/14	6/26	7/4	7/13	7/20
0	1	0	2	0	1	0	2	0	0	0	0	0	1	0	1
1	0	0	0	0	0	0	0	0	0	0	2	0	1	0	1
2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
3	0	0	0	0	0	0	1	0	0	1	0	2	2	0	2
4	0	1	0	0	1	0	0	0	0	0	1	0	0	1	1
5	0	1	1	1	2	0	0	0	0	0	0	0	1	1	1
6	0	0	1	2	0	0	0	0	0	1	0	1	0	1	0
7	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0
8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	1	2	4	6	6	0	4	0	0	2	3	3	5	4	8

TABLE 25: Continued.

Depth Meters	Dates 1969 4/27	5/27	6/20	7/1	8/15	9/8
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	1	0
3	0	0	0	0	0	1
4	0	0	0	3	1	1
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
Totals	0	0	0	3	2	2

TABLE 26: North Twin Lake: Desmid counts from the Northeast area of the lake. 1967, 1968, and 1969. The figures are the number of desmids in 10 ml. of lake water.

Depth			1967				Dates			1968				
Meters	8/8	8/25	9/1	9/8	9/15	9/22	10/9	3/16	5/11	5/26	6/14	6/26	7/4	7/13	7/20
0	2	2	3	1	0	2	0	0	1	0	0	2	1	0	0
1	8	4	5	2	0	3	2	0	0	3	0	0	2	0	0
2	2	4	4	0	0	0	0	0	2	0	0	3	3	0	1
3	2	4	4	4	0	0	0	0	1	2	0	1	1	0	1
4	1	7	8	2	1	0	1	0	0	1	0	0	1	2	0
5	0	4	5	2	0	1	1	0	1	1	1	1	2	1	0
6	1	1	2	0	0	1	0	0	1	0	0	0	0	1	0
Totals	16	26	31	11	1	7	4	0	6	7	1	7	10	4	2

TABLE 26: Continued.

Depth Meters	Dates 1969 4/27	5/27	6/20	7/1	8/15	9/8
0	0	0	0	0	0	1
1	0	0	1	1	2	3
2	0	1	2	3	4	3
3	0	0	0	3	2	4
4	0	0	1	2	3	2
5	0	0	0	0	1	2
6	0	0	0	1	0	2
Totals	0	1	4	10	12	17

TABLE 27: North Twin Lake: Desmid counts from sampling site # 1 during 1967 and 1968. The figures are the total number of desmids in 10 milliliters of lake water.

Depth	1967					Dates		1968	
Meters	8/8	8/25	9/1	9/8	9/15	9/22	10/9	3/16	5/11
0	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	1	0	0	0
2	0	1	0	1	1	0	0	0	0
3	0	0	0	1	0	0	1	0	0
4	0	3	0	0	0	0	0	0	0
5	0	1	0	0	0	0	0	0	0
6	0	2	0	1	0	0	1	0	0
7	0	0	0	0	0	0	1	0	0
8	0	0	1	0	0	0	2	0	0
9	0	0	1	0	0	0	0	0	0
10	0	*	*	*	*	*	*	0	*
Totals	1	7	2	3	1	1	5	0	0

* Bottom

TABLE 28: North Twin Lake: Desmid counts from sampling site # 3 during 1967. The figures are the total number of desmids in 10 milliliters of lake water.

Depth				Dates		
Meters	8/25/67	9/1/67	9/8/67	9/15/67	9/22/67	10/9/67
0	0	0	1	0	0	1
1	0	0	1	0	0	0
2	1	0	1	0	0	0
3	0	2	0	0	0	0
4	1	2	0	0	0	0
5	2	1	0	0	0	1
6	0	0	1	3	0	0
7	1	0	2	1	0	0
8	2	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	1	0	0
Totals	7	5	6	5	0	2

TABLE 29: North Twin Lake: Desmid counts from sampling site # 4 during 1967. The figures are the total number of desmids in 10 milliliters of lake water.

Depth Meters	Dates 8/25/67	9/1/67	9/8/67	9/15/67	9/22/67	10/9/67
0	0	3	0	0	0	0
1	1	1	0	0	0	0
2	1	2	1	0	1	0
3	0	1	1	0	1	0
4	1	1	0	1	0	0
5	2	0	1	1	0	1
6	2	1	0	0	0	0
7	0	0	0	0	0	0
8	0	1	0	0	0	0
Totals	7	10	3	2	2	1

TABLE 30: North Twin Lake: Desmid counts from sampling site # 5 during 1967. The figures are the total number of desmids in 10 milliliters of lake water.

Depth Meters	Dates 8/25/67	9/1/67	9/8/67	9/15/67	9/22/67	10/9/67
0	1	3	0	0	0	0
1	4	3	7	3	0	0
2	3	3	2	0	0	1
3	8	1	1	0	0	0
4	4	1	0	0	0	0
5	7	2	1	1	0	0
6	0	2	1	2	0	1
7	1	0	0	1	0	0
Totals	28	15	12	7	0	2