The Diatom Flora of the Red Lake Peatland, Minnesota

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ABSTRACT—Diatoms collected from three transects in the Red Lake Peatland occur in characteristic assemblages. One hundred two taxa were observed from 26 sample sites, with *Eunotia exigua* and *Pinnularia rupestris* the most dominant species. Clustering indicated three peatland types were present: rich fen, transitional and poor fen, and bog.

Introduction

The Red Lake Peatlands have only recently come under extensive investigation. Heinselman (1) called attention to the distinctive patterns of the Red Lake mire. Vitt and Slack (2) summarize other studies of Minnesota mire vegetation.

The peatlands in northern Minnesota are composed of complex systems of mires, patterned by water tracks, in which various landforms exist (teardrop islands, raised bogs, strings, flarks). This region is the largest uninterrupted peatland area in the contiguous 48 states and includes more than 1% of the world's peat (3). It is divided primarily into two types of peatland: fen regions and bog regions. Fen regions are minerotrophic, slightly acidic to neutral in pH (seldom alkaline), most often inhabited by grasses, sedges or reeds (often with some shrubs) and sometimes a scanty tree layer (stunted *Larix*). These areas usually possess standing water year round. Bogs are characterized as ombrotrophic and are strongly acidic and most often dominated by mosses (primarily *Sphagnum*) (3).

Algal studies in this region include Tarapchak's (4) study of the xanthophycean flora, an initial diatom analysis on Red Lake Peatland surface samples (C. Peterson, Limnological Research Center, University of Minnesota, unpublished), and an expansion of Peterson's study, which included selected samples scattered throughout bog areas outside as well as within the Red Lake Peatland (5).

The current study investigated diatom ecology along a spectrum of mire types within one geographic region in northern Minnesota and complements the *Sphagnum* study of Vitt and Slack (2). The purposes of this paper are to report the diatom flora of whole water and *Sphagnum* squeezings samples from three line transects, to compare the diatom species and diversity values with chemical data, and to select bog and fen indicator species.

Materials and Methods

The samples analyzed were collected by Vitt and Slack (2). The sampling sites were along Vitt and Slack's three transects Red Lake 1, Red Lake 2, and Red Lake 3. (See Vitt and Slack (2) for specific dates, locations, and water chemistry methodology as well as a complete description of the study area.)

Diatoms were cleaned using the nitric acid-potassium dichromate method (6) and mounted in Hyrax. Rows were counted until a minimum of 1,000 diatom valves were counted at 1,000x and identified to the lowest possible taxon. Percent occurrences for each dominant taxon were recorded at approximately 100 valve intervals for determination of how many valves were needed for an accurate count (7). (A species which comprised 5% or more of the total diatom population for any one sample was considered a dominant species.) Cluster analysis statistics (8) were then performed on the dominant species. The whole water samples and the squeezings samples (designated with an "s") were analyzed separately during all calculations.

Diatoms were counted with a Palmer-Maloney cell. Species diversity values were calculated using the Shannon-Wiener diversity equation (9). A Pearson correlation matrix (10) was calculated between dominant taxa and the chemical parameters (Na^+, K^+, Mg^{2+}, Ca^{2+}, conductivity, and pH).

Results and Discussion

Diatom Assemblages

The genus *Eunotia* had the most abundant number of taxa, 28. The next four most abundantly represented genera were *Navicula, Pinnularia, Nitzschia,* and *Gomphonema.* From 16 samples of mire water collected from natural depressions and 10 squeezing samples, 102 diatom taxa were observed. (Table 1).

The most ubiquitous taxon found was *Eunotia exigua,* which was observed in all but two fen locations and ranged in abundance from 86.4% occurrence at site 3s (a bog sample) to absent at sites 1 and 16 (fen samples). It comprised greater than 50% of the valves enumerated in 12 of the 26 samples. The taxon found in greatest abundance in any one sample was *Pinnularia rupestris.* It occurred at a frequency of 90.5% in sample 11, a bog sample. In sample 11s, it occurred at 86.4%. Both of these species were also found in great abundance by Kingston (5).

The results of a linear regression analysis (7) performed on the dominant taxa indicated that 800 valves provided accurate percent occurrence values (Table 2). While this

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Table 1. Alphabetical listing and percent occurrences of diatoms observed along three transects, Red Lake Peatland, Minnesota, 1981.

						Transect # 1								Transect # 2											Transect # 3		
	1	1s	2	2s	3	3s	4	5	5s	6	6s	7	7s	8	8s	9	9s	9AS	10	11	11s	12	13	14	15	16
Achnanthes																										
lanceolata var. dubia	2.2	—	16.4	13.9	2.1	—	0.2	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	1.4	—	—	—
sp. 1 c.f. A. conspicua	3.9	—	0.2	0.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anomoneis																										
serians var. brachysira	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.6	2.7
sp. 1	—	0.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cosinodiscus																										
sp. 1	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cyclotella																										
comta	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cymbella																										
costatii	—	0.8	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	—	—	1.5
lunata	—	4.2	5.8	7.5	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.3	10.7
minuta	—	1.0	1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	1.0	1.8
sp.1	—	—	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Denticula																										
elegans f. valida	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—
Diatoma																										
vulgare	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—
Diploneis																										
elliptica	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	0.9
Eunotia																										
curvata	6.2	—	—	—	—	—	3.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.6	—	—	0.9
diodon	—	0.8	—	0.1	—	—	1.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.7
elegans	—	3.2	—	—	8.3	1.7	2.6	14.1	28.6	0.2	1.0	0.6	0.6	0.2	—	0.2	0.2	17.6	3.6	—	0.2	0.8	14.8	17.8	0.5	0.6
exigua	—	0.4	0.7	0.3	49.0	86.4	11.5	71.4	36.9	73.3	74.2	63.2	31.8	50.7	70.1	66.9	83.1	79.7	16.4	1.7	0.6	76.2	29.9	8.9	0.9	—
fallax	—	12.5	—	—	2.2	0.2	—	—	0.2	—	0.4	2.2	—	—	—	—	—	—	—	—	—	—	0.2	0.6	—	—
flemulosa	—	—	—	—	—	—	—	—	—	—	0.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.0
fornica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—
lapponica	—	—	—	—	0.7	0.1	—	—	—	—	—	—	—	—	4.5	—	—	—	43.4	—	—	—	—	—	—	—
lunaris var. alpina	—	—	—	—	—	—	—	—	—	—	1.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
naegelii	—	1.4	1.6	1.5	2.6	—	13.0	0.2	—	—	—	0.1	—	—	—	5.6	3.1	—	—	—	1.2	—	—	6.9	—	—
paludosa	—	—	—	—	—	—	—	—	—	11.9	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
pectinalis var. minor	—	—	—	—	4.8	2.6	0.1	2.2	8.5	0.4	4.6	3.2	1.8	9.7	6.1	7.9	7.6	—	—	0.2	3.3	—	0.9	0.8	0.6	—
pectinalis	—	—	—	—	—	0.1	—	2.7	1.8	1.3	—	—	—	1.6	6.9	—	—	—	—	—	0.4	—	—	—	4.3	7.5
septentrionalis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—
serra var. diodem	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.3	—
steineckei	—	—	—	—	8.6	3.2	—	4.3	1.4	0.8	17.9	—	—	2.0	4.0	1.3	4.7	—	—	0.4	—	—	—	—	0.2	—
tenella	—	4.7	—	0.4	0.6	0.3	30.0	0.7	4.8	—	—	0.8	1.0	11.0	2.0	0.4	—	2.6	38.9	—	—	3.2	14.2	32.8	2.3	3.4
valida	1.1	0.2	—	0.8	0.2	—	17.2	—	9.0	—	—	—	0.6	—	—	—	—	—	—	—	—	—	11.3	—	—	0.2
sp. 1 c.f. exigua	—	—	8.5	3.7	1.3	0.5	—	—	4.1	6.1	—	—	—	3.2	2.2	11.3	—	—	—	9.9	6.4	7.7	—	—	1.6	—
sp. 2 c.f. fallax	0.6	—	—	—	—	—	—	—	—	0.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 3 c.f. flexulosa var. eurycephala	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.2	—
sp. 4 c.f. symaniana	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 5	—	—	—	—	—	—	—	—	—	1.0	—	0.6	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—
sp. 6	—	1.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.3	—	—	—	—	—	—	—	—	—
sp. 7	—	—	—	—	0.4	—	—	—	0.4	1.2	—	0.1	—	—	—	2.4	—	—	—	—	—	—	—	—	—	—
sp. 8	—	—	—	0.4	—	—	—	4.4	—	2.7	—	—	—	0.2	0.4	3.2	0.4	—	—	—	—	—	—	—	—	—
sp. 9	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.6	—	0.7	1.4
sp. 10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4
Fragilaria																										
construens	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	0.2	—	—	—	—	—	—	—
lapponica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.2	—
pinnata	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
vaucheriae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—
virescens	65.2	—	—	—	—	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2
Frustulia																										
rhomboides var. rhomboides	—	—	—	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
rhomoboides var capitata	—	7.6	5.5	3.5	0.6	—	0.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.4	0.6	2.0
rhomoboides	—	6.2	10.0	8.8	7.9	1.7	6.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.7	8.9	12.6	7.9

	Transect # 1									Transect # 2									Transect # 3							
	1	1s	2	2s	3	3s	4	5	5s	6	6s	7	7s	8	8s	9	9s	9AS	10	11	11s	12	13	14	15	16
Gomphonema																										
acuminatum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2
angustatum	2.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
dichotomum	2.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
gracile	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—
gracile var. naviculoides	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.6	—
parvulum var. exilis	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 1	—	1.8	0.4	1.4	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 2	1.6	0.9	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hantzschia																										
amphioxys f. capitata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	—	—	—	—	—	—	—	—	—	—
amphioxys	0.2	—	—	—	—	—	—	—	0.3	0.2	—	—	—	—	—	—	—	0.1	0.4	—	—	0.2	—	0.2	—	—
Melosira																										
granulata	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	0.1	0.2	—	—	—	—	—	—	—
itallica var. subarctica	3.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Meridion																										
circulare	6.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Navicula																										
capitata	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
festiva	—	6.1	—	1.2	2.3	1.4	3.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	1.3	0.2	—
hassiaca	1.2	8.4	0.9	5.6	0.4	—	0.2	0.4	3.8	—	—	—	—	—	—	—	—	—	0.4	—	—	0.4	14.2	2.4	5.1	3.4
mutica	0.2	—	—	0.4	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—	1.2	—	—	—	0.2
radiosa var. parva	0.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
radiosa var. tenella	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	0.1	—
seminulum var. hustedtii	—	1.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
subtilissima	—	19.5	16.5	25.2	4.1	1.1	3.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.0	9.6	1.3	0.8
sp. 1	—	—	0.8	0.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.6
sp. 2	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—
sp. 4	—	—	—	—	—	—	—	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 5	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nitzschia																										
acidoclinata	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
alexandria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	0.6
frustulum	0.2	3.6	21.9	5.8	—	0.2	0.2	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	0.4	—	—	9.0	11.6
gracilis	—	—	0.1	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 1 c.f. alpina	—	0.5	3.5	1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 2 c.f. gandersheimiensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.8
sp. 3 c.f. graciliformis	—	—	—	0.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 4	—	—	—	5.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
sp. 5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.3	—
Opephora																										
sp. 1	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pinnularia																										
abaujensis	—	—	0.4	0.4	0.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
borealis var. rectangularis	—	0.2	—	0.2	—	—	—	—	—	—	—	—	—	—	—	0.4	—	—	0.2	—	—	—	—	—	—	—
divergens var undulata	—	0.5	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	0.4
gibba	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—
mesolepta var. angusta	—	—	0.2	—	2.5	0.8	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—
rupestris	—	—	—	—	0.1	—	0.1	—	—	—	—	27.8	64.0	22.2	4.3	0.2	—	—	—	90.5	86.0	0.2	0.2	0.8	0.4	0.5
ruttneri	—	—	—	0.2	—	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	—	—	—
socialis	—	1.4	0.3	0.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
stomatophora	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
subcapitata	—	7.8	1.6	6.7	0.4	—	5.6	—	0.2	—	—	1.4	0.4	—	0.2	—	—	—	—	—	2.0	9.1	4.0	7.2	1.6	1.0
sp. 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.5
Stenoperobia																										
delicatissima	0.2	2.0	1.4	0.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	0.2
intermedia	—	0.2	1.3	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	0.2
Surirella																										
linearis var. constricta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—
Synedra																										
sp. 1 c.f. ulna var danica	0.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17.5	0.2
Tabellaria																										
fenestrata	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	1.8	0.2
flocculosa	—	—	—	—	—	—	0.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11.6	32.0

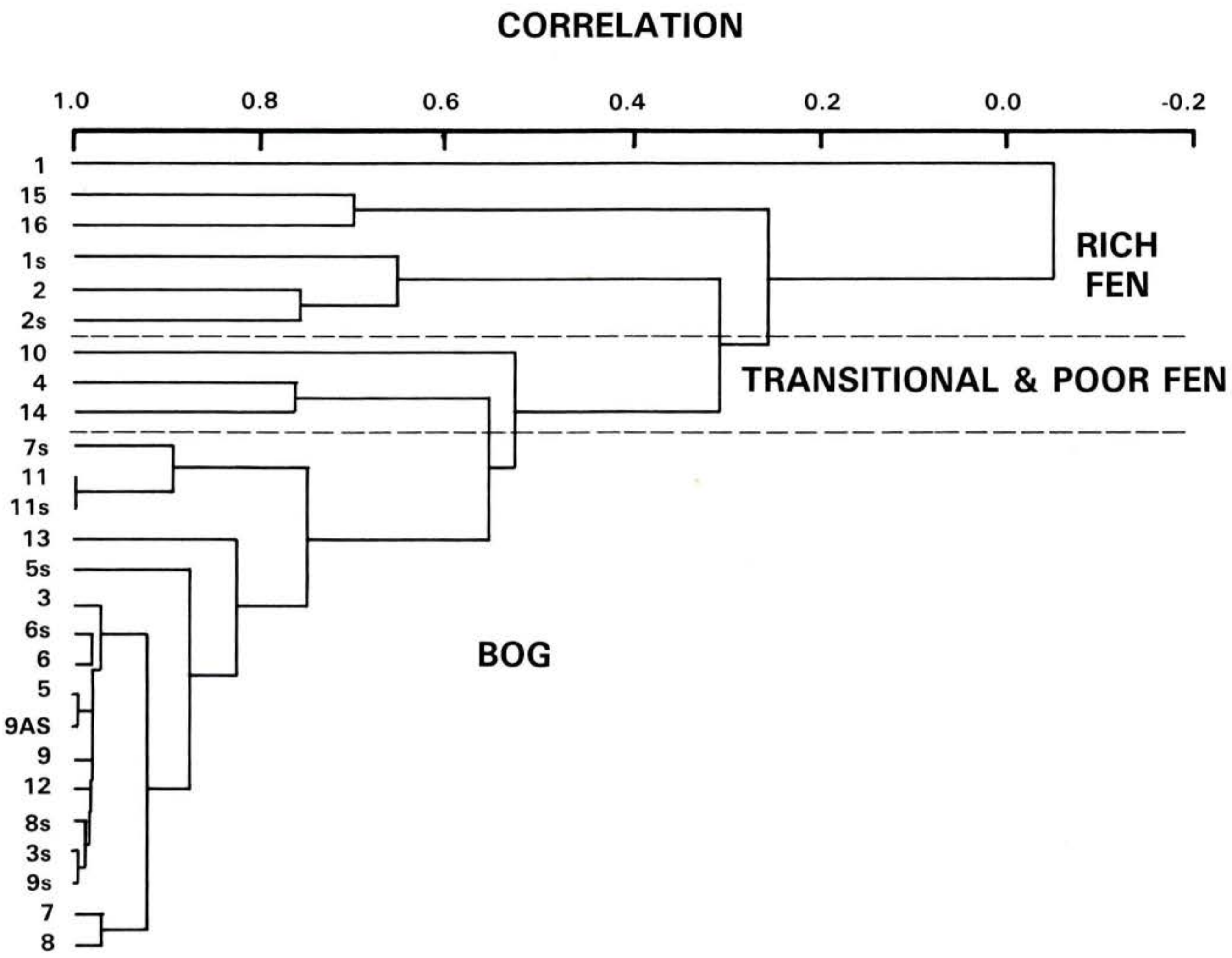

Figure 1. Dendrogram of the cluster analysis of 25 samples using 102 taxa, Red Lake Peatlands, Minnesota, 1981.

study counted 1,000 valves per sample, other bog studies (5, 11, 12) have employed counting techniques using lower valve numbers (300, 500-630, up to 500 respectively). Our data indicate that a greater number of valves need to be counted for an accurate representation of the resident diatom flora.

Table 2. Least squares regression of the dominant diatom species, Red Lake Peatlands, Minnesota; August, 1981, indicating the need for a 800 valve count.

Regression Equation	Slope	r
Y = -67.4 +2.88X	2.88 + 0.44	0.89

The Jaccard Coefficient of Similarity of the samples based on dominant organisms separates them into two groups with a transition group in between (Figure 1). A cluster of 12 very closely related sites were delineated in the bog, a result of the marked dominance of *Eunotia exigua* at those sites. The cluster of three bog sites (7s, 11, 11s) was influenced greatly by the abundance of *Pinnularia rupestris.*

A transitional and poor fen region separates the fen sites from the bog sites in each transect. The reason for the high correlation of sites within the bog region versus those within the fen regions was due to the greater diversity of fen organisms (Table 1).

Fen-region vegetative squeezing diversity tended to be greater than whole-water diversity values, whereas in the bog, the whole water samples had greater diversity values (Table 3). In almost every transect, diversity values were lower in the bog samples. This is in agreement with the vegetation analysis discussed by Heinselman (13), and agrees closely with those reported by Kingston (5).

From cluster analyses (Figure 2, Table 1), indicator organisms can be chosen to represent habitat type. *Eunotia exigua* and *Pinnularia rupestris* were the best indicators of bog habitats. These two species were also observed by Bruno and Lowe (11) and Kingston (5) as bog indicators. Fen regions were distinguished by *Frustulia rhomboides* var.*rhomboides, Navicula hassiaca, N. subtilissima,* and *Nitzschia frustulum.*

Even though Yung and Stokes (14) have shown diatoms to be less important than desmids in North American bogs, in our survey their richness is much higher than reported by Pearsall (15), Thunmark (16), Flensburg (17), Flensburg and Sparling (18) in Europe and elsewhere in North America. *Eunotia exugia, E. pectinalis, Pinnularia rupestris, Frustulia rhomboides,* and *Navicula subtilissima* are common acidophilic diatoms encountered along the belt transect and in other North American and European bogs (5, 11, 19). *Eunotia exugia* is the only diatom present in all of the bogs examined.

Table 3. Shannon-Wiener Diversity (H′) for three transects, Red Lake Peatland, Minnesota, 1981.

Site	Whole water	Wetland Type	Vegetation Squeezings
		Red Lake Peatland Transect #1	
1	2.18	fen	4.04
2	3.40	fen	3.77
3	2.92	fen	1.06
4	3.14	poor fen	—
5	1.50	bog	2.56
		Red Lake Peatland Transect #2	
10	1.78	bog	—
11	0.65	bog	0.89
12	1.34	bog	—
13	2.96	transitional fen	—
14	2.96	transitional fen	—
15	4.05	fen	—
16	3.65	fen	—
		Red Lake Peatland Transect #3	
6	1.54	bog	1.20
7	1.48	bog	1.23
8	2.09	bog	1.76
9	1.79	bog	1.01

Water Chemistry

The major cations, pH, and conductivity values for each sample are listed in Table 4. As expected, the pH values in the bog samples (4.3-6.3) ranged below those in the fen region (5.2-7.5). These data fall within the range obtained by Gorham (20) in the English Lake District bogs, where pH values ranged from 3.8 in the bogs to 6.9 in the fens and within those of Slack et al (21) where Alberta fens ranged in pH from 6.8 to 7.5. Comparable values also were observed in Glaser et al (22) in their earlier study of northern Minnesota peatland vegetation. Their values ranged from 4.3 in the bogs to 6.9 in the fens.

Variations in bog chemistry have been discussed by Heinselman (13). In his discussion, he states, "In the natural area pH, Ca^{++} and Mg^{++} values are consistently different between contrasting peatland types." Divalent cation values in our sample (Table 4) compared well with those in the Lake Agassiz peatland, which is just east of the Red Lake area. Fen Ca^{++} and Mg^{++} concentrations in the Lake Agassiz area varied from 3.3 to 25.2 and 0.1 and 8.1 mg 1^{-1} respectively. With the exception of the Ca^{++} and Mg^{++} concentrations at site 1, the values in Table 4 parallel those previously reported. Similarly, the monovalent cation concentrations and the conductivity values are within the ranges cited in other studies of peatlands (13, 21, 22, 23).

Pearson correlation values were determined for the chemical data (Table 5). Glaser et al (22) calculated an $r^2 = 0.83$ and a $p < 0.001$ for the relationship between Ca^{++} and conductivity. This correlation compares with our $r^2 = 0.86$ and a $p < 0.01$. Strom (24) in his discussion of the relationship between pH and conductance states that the positive correlation that exists at the intermediate pH range deteriorates as salinity decreases. This could account for the poor correlation (-0.02) between these same two parameters for our data. (See Table 5).

Table 4. Chemical data from three transects, Red Lake Peatland, Minnesota, 1981. Na^+, K^+, Ca^{++}, and Mg^{++} are expressed as mg 1^{-1} and conductivity as *u*ohms cm^{-1}. (Data from Vitt, unpublished).

Site	Na^+	K^+	Ca^{++}	Mg^{++}	pH	Cond.
			Red Lake Peatland Transect # 1			
1	4.58	2.04	60.20	19.93	6.2	50
2	2.48	0.90	14.00	5.40	6.1	48
3	1.06	0.56	6.54	2.60	5.7	27
4	1.88	0.10	7.76	2.60	5.2	25
5	5.00	4.00	7.76	1.00	4.8	34
			Red Lake Peatland Transect # 2			
10	6.20	7.65	6.30	1.00	5.8	39
11	1.68	1.60	4.50	1.39	6.0	25
12	6.78	10.54	9.35	1.70	5.5	72
13	3.26	0.62	21.00	3.88	7.4	42
14	11.44	37.02	10.20	6.10	6.9	25
15	2.43	0.24	7.56	3.50	7.4	12
16	2.62	0.33	13.70	3.50	7.5	36
			Red Lake Peatland Transect # 3			
6	3.44	1.02	9.35	1.39	4.7	24
7	2.36	1.39	4.09	0.80	4.3	29
8	2.38	2.80	18.00	1.70	6.3	49
9	2.06	1.82	11.50	1.39	5.7	32

Table 5. Pearson correlation matrix for chemical data from the Red Lake Peatland, Minnesota, August, 1981.

	Mg^{++}	K^+	Na^+	Ca^{++}	Cond.
pH	.64*	.35	.23	.31	-.02
Mg^{++}		.49	.47	.52	.39
K^+			.95**	-.01	-.17
Na^+				.02	.13
Ca^{++}					.86**

*= $p < 0.05$, **= $p < 0.01$

Since the two monvalent cations ($Na^+$and K^+) are abundant in numerous forms and are involved in ion transport and exchange, their concentrations seldom vary (25). These properties help explain the significant monovalent correlation (0.95) (Table 5).

A complete description of water chemistry can be found in Vitt and Slack (2).

Acknowledgements

We gratefully acknowledge Dale Vitt and Nancy Slack for collecting the samples and permission to use Dr. Vitt's unpublished data. The fieldwork for this study was carried out while D. E. Wujek was in residence at the University of Minnesota Forestry and Biology Station and I thank the director, David Parmalee, for making facilities available.

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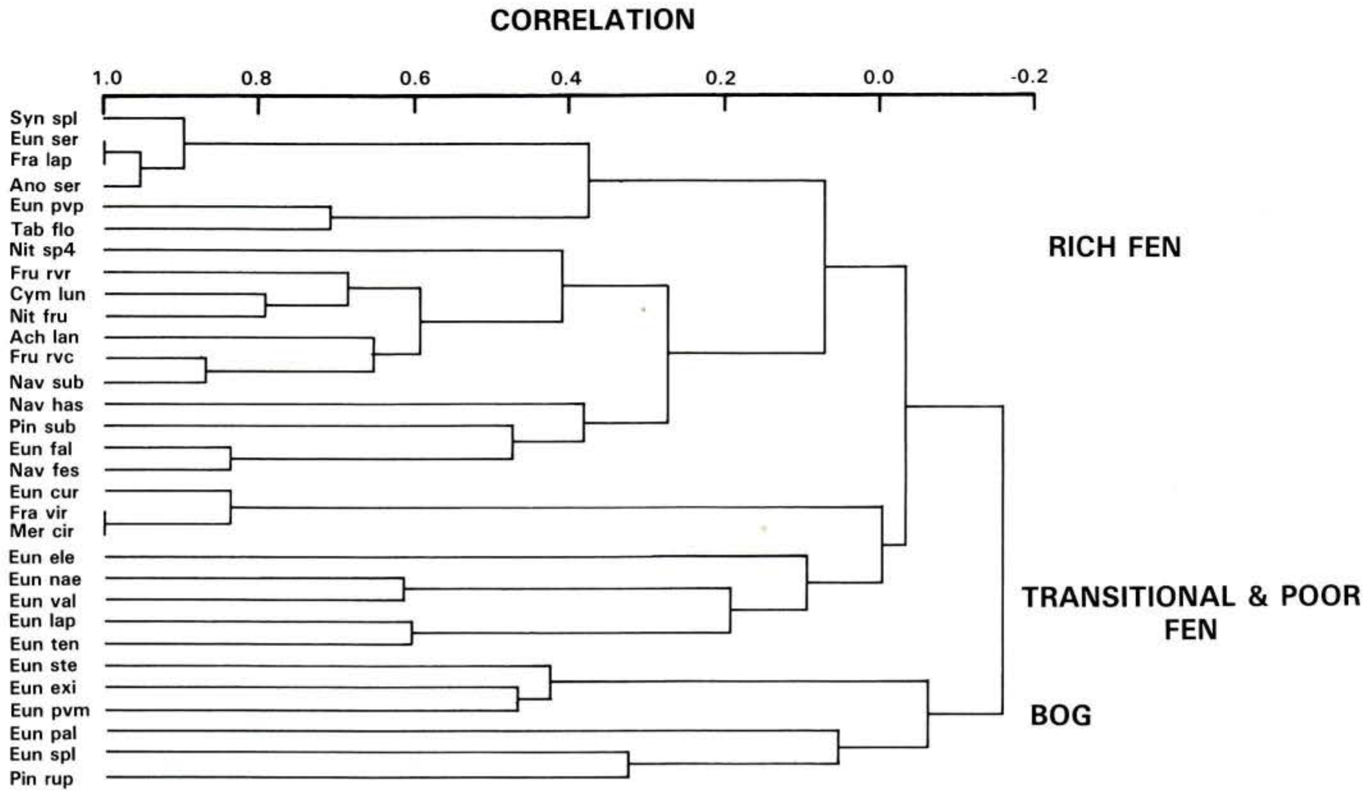

Figure 2. Dendrogram of the cluster analysis of 31 dominant diatom taxa, Red Lake Peatlands, Minnesota, 1981. Syn spl = *Synedra* sp. 1, Eun ser = *Eunotia serra,* Fra lap = *Fragilaria lapponica,* Ano ser = *Anomoneis serians* var. *brachysira,* Eun pvp = *Eunotia pectinalis* var. *pectinalis,* Tab flo = *Tabellaria flocculosa,* Nit sp4 = *Nitzschia* sp. 4, Fru rvr = *Frustulia rhomboides* var. *rhomboides,* Cym lun = *Cymbella lunata,* Nit fru = *Nitzschia frustulum,* Ach lan = *Achnanthes lanceolatum* var. *dubia,* Fru rvc = *Frustulia rhomboides* var. *capitata,* Nav sub = *Navicula subtilisma,* Nav has = *Navicula hassiaca,* Pin sub = *Pinnularia subcapitata,* Eun fel = *Eunotia fallax,* Nav fes = *Navicula festiva,* Eun cur = *Eunotia curvata,* Fra vir = *Fragilaria virescens,* Mer cir = *Meridion circulare,* Eun ele = *Eunotia elegans,* Eun nae = *E. naegelii,* Eun val = *E. valida,* Eun lap = *E. lapponica,* Eun ten = *E. tenella,* Eun ste = *E. steineckei,* Eun exi = *E. exigua,* Eun pvm = *E. pectinalis* var. *minor,* Eun pal = *E. paludosa,* Eun spl = *E.* sp. 1, Pin rup = *Pinnularia rupestris.*

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North Central Junior Science, Engineering and Humanities Symposium November 22, 23, and 24, 1987 Winners of Awards

The Academy wishes to congratulate the students who won awards at the North Central Junior Science, Engineering and Humanities Symposium held November 22-24, 1987. The names of the winners and their abstracts are published below.

First Place:	**Mary Kaye Geck**
School:	**Mandan High, Mandan, ND**
Sponsor:	**Leon Nesja**
Area of Research:	**Botany**
Title:	**Disease Analysis of Sunflowers (Helianthus annuus L.) with Nutritive Interactions**

I am investigating the types and severity of diseases on sunflowers in West-Central North Dakota, how the plant's nutrition is affected by the disease, and how mineral nutrition might be used to control the severity of the fungal effects. In 1986 and 1987, percent necrosis ratings were taken on the leaves in field plots with applications of 30, 50, 60, and 90 pounds of nitrogen per acre and a total of 11 cultivars (6 in '87). Samples were collected and plated and isolations of the fungi were made. Pathogenicity tests and hydroponic inoculations were performed. Analysis of variance was used to detect statistical differences. The 1986 results indicated that the major pathogenic organisms invading the field were *Phoma, Helminthosporium sativum, Alternaria,* and a member of Ascomycetes. The lowest necrosis ratings were found with 60 lb/A of N, and the highest with 90 lbs. Symptoms of N, Fe, Mg, and P deficiencies and a K toxicity were noted. In conclusion, the translocation of N appears to be impaired when the sunflowers are under stress. Senescing of the leaves and high concentrations of N appear to increase the severity of the disease symptoms. Low photosynthetic efficiency levels seem to promote *Alternaria* infections. By continuing my research and improving the fungal suppressant nutrient solution that I have developed, I hope to prove that the utilization of traditional fungicides can be avoided in some cases.

Second Place:	**Amber N. Foster**
School:	**Winona Senior High, Winona, MN**
Sponsor/Teacher:	**Jerry J. Foster**
Area of Research:	**Medicine and Health**
Title:	**Do Electronic Games Affect Brain Wave Frequency?**

Forty-one people were tested to determine if electronic games affect brain wave frequency. This will possibly occur because of the many other things video games can cause like high blood pressure, pulse, high stress, and eye fatigue all of which I have proven in the past four years of research. Patients were prepared for the EEG by measuring the head, making electrode contact using salt jelly and attaching Life-Paks for an ECG. The Electroencephalograph was calibrated, a montage entered, and testing began. Thirty pages of the EEG with the subject relaxed followed by math problem solving, picture scanning, sentence reading, and pattern scanning were recorded. A hyper-ventilation period and a photo-sensitive light test were administered. Warlords and Night Driver were played for 20 minutes each while recording. Results were recorded, calculated, graphed, and evaluated by age group. When considering all channels, all age groups increased overall in number of hertz while playing the games. The 0-10 year group had the largest hertz increase. When comparing individual channels, one and five had the largest hertz increase.