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10-7-08

Date

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JASON D. ALLEN

THESIS

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I HERBY RECOMMEND THAT THIS THESIS BE ACCEPTED AS FULFILLING THIS PART OF THE GRADUATE SCHOOL DEGREE CITED ABOVE

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ABSTRACT

In the last two decades management and monitoring efforts in freshwater systems has shifted from point source pollutants to non-point source pollutants and environmental modification. Long term, large scale sampling projects necessitated by such a shift often are infeasible due to logistical, cost, and time constraints.

In recent years fish and benthic macroinvertebrate indices of biological integrity (IBI's) have been used to survey the quality of flowing (lotic) water systems, which have drastically reduced sampling time and facilitated large scale monitoring projects. However, it is unlikely that these could be adapted to lentic systems. This study was undertaken in an effort to produce phytoplankton-based IBI's that can be used to indicate the quality of a freshwater system. Phytoplankton have been widely recommended as indicator organisms for lentic systems, but presently there have been few studies exploring the feasibility of developing IBI's based on phytoplankton assemblage structure.

Through the NLA and ILA I was able to collect environmental and algal assemblage data from 50 lakes within the state of Illinois, during a single season. I then used these data to validate models that were previously developed from a large historical data set. My analyses showed that temporal variation in assemblage structure was not significant between the months of June and August. I was also able to confirm that the regional distinctions used for the state of Illinois are valid.

Through this study and that of Rasmussen (2007) I was also able to identify key indicator taxa for the state of Illinois as well as regionally indicative taxa for the southern, central, and northern regions. Meaningful clustering of lakes also was evident when based on higher-level taxa, indicating that there may be a significant link between phytoplankton assemblage structure and physical and chemical variables.

Introduction

The Clean Water Act of 1977 mandated development of water quality monitoring protocols capable of both short-term and long-term assessment of a multitude of water quality variables. The most important areas in terms of the CWA were monitoring and concomitant reduction of toxins, heavy metals and foreign chemicals. These monitoring and clean up programs have been highly successful in reducing the levels of contaminants in both lentic and lotic systems (Fisher 1994). However, over the last two decades the impacts of nutrient loading, invasive species, and alteration to the topography of water systems have become increasingly important as contributing to the decline in water quality throughout the country. Many lentic systems, especially those in the upper Midwest are phosphorous-limited in terms of algal production and higher taxa production. The increased use of phosphorus-based fertilizers and the discharge of wastewater have markedly increased the trophic state (eutrophication) of many lakes in this part of the country (Krautz 1994). Invasive species such as zebra muscles (*Driessena polymorpha*) and sea lamprey (*Petromyzon spicatum*) are having a devastating impact on the Great Lakes, whereas, Eurasian milfoil (*Myriophyllum spicatum*) is having a similar effect on smaller bodies of water throughout the Midwest (Mills et al 1994). Finally, impoundments and damming of natural water bodies has profound impacts on sediment and nutrient loading, which can effect fish and invertebrate populations as well as the more obvious destruction of habitat (Cole and Landres 1996).

Chemical, physical, and habitat assessments of the numerous lentic systems throughout the Midwest are not only time consuming, but impractical on a large scale due to the difficulty of accessing lakes in unincorporated areas and transporting samples back to a laboratory in a timely manner for evaluation. A more cost and time effective method of testing large numbers of lakes would be highly desirable in future monitoring efforts. Indicators of biological integrity (IBI's) such as macro-invertebrates and fish have been used to describe the environmental health of lotic systems for several decades, though few attempts have been made to adapt these IBI's for use in lentic systems. There has been some research into using fish and zooplankton indicators in lakes and reservoirs, but these have met with mixed results (Karr 1981, Barbour et al. 1999). Of these attempts, there been no studies that have taken place in Illinois, but in all likelihood they would be ineffective for several reasons. Many large lakes and reservoirs throughout Illinois are continually stocked with game fish, which would drastically reduce the accuracy of fish IBI's. Also, there are fewer indicator species in lentic systems. Macroinvertebrate IBI's would also be unreliable due to the fact that there are far fewer indicator species in lakes and reservoirs when compared to lotic systems these IBI's were designed to monitor (Karr 1981, Barbour et al. 1999, Wetzel 2001).

At the present time, there have been few attempts to use algae as biocriteria for the determination of water quality in lentic systems, most notably in bodies of water that are of anthropogenic origins. This is important in states such as Illinois where the vast majority of lakes are a result of diverting or damming of flowing water systems. However, algal taxa have been widely recommended in the literature as indicators of water quality (Rasmussen 2007, Stevenson and Wang 2001, Stevenson and Smol 2003). It is likely that the difficulty of identifying these taxa to species level and, in general, the large number of indicator taxa have contributed to this discrepancy. These species used as biological indicators could be highly effective . The phytoplankton assemblages are highly diverse, easily sampled and preserved, and show species level sensitivity to physical and chemical gradients (Stevenson and Smol 2003). Some notable examples of this include *Scenedesmus* sp., which are good indicators of HCO_3 alkalinity (Yang et al 2007), benthic and phytoplanktonic diatoms, which excel as indicators of sediment and dissolved silicon, respectively (Brzezinski, 1990). Stevenson and Wang (2001 and 2005) have had some success in using benthic algae as indicator taxa in lotic systems, but it is unlikely that these could be easily adapted to lentic systems due to the high turbidity and low Secchi depth of many of the lakes in Illinois.

If accurate multimetric indices could be derived from phytoplankton assemblage structure of lentic systems, they could significantly reduce the time and monetary requirements for large scale testing endeavors. Assemblage samples can be taken easily and quickly, with little need for specialized equipment, and are easily preserved. Though identification to species level, which is time consuming, especially in highly diverse assemblages, the procedures and equipment needed to preserve and identify taxa are relatively easy to obtain and implement.

Recent research by Rasmussen (2007) using historical data (ca. 1983-2003) on phytoplankton assemblages and physical and chemical variables initiated development of two phytoplankton IBI's; Lakes and Reservoirs Phytoplankton IBI (LRP-IBI), Illinois Lake and Reservoir Classification (LRC-IBI) for regional management, to be used in lentic systems in much the same way that macro-invertebrate and fish IBI's are currently used in lotic systems. The LRC model uses principle components analysis (PCA) of an environmental matrix to classify lakes based upon degrees of similarity of physical and chemical variables. The LRP-IBI expands on this by using multidimensional scaling to order the lakes based on algal assemblage structure. This effort concluded that differences among reservoirs identified by phytoplankton assemblages are reflected in the classification scheme.

Through the United States and Illinois Environmental Protection Agencies I had the opportunity to participate in the National Lakes Assessment (NLA) and Illinois Lakes Assessment (ILA) initiated sampling of 49 lakes throughout the state of Illinois during the summer of 2007. The objective of these surveys was to produce a snapshot of the water quality of lakes throughout the country (NLA) and throughout the state (ILA). These lakes would then be resampled every five years and compared over the long term to determine water quality trends on a statewide and national level. Over 900 lakes were sampled throughout the country as part of the NLA survey. Chemical and physical data as well as spatial data based on satellite images and topographical maps has been accumulated on the lakes that were sampled. (NLA Field Operations Manual 2007). Participation in both of these surveys afforded me with an opportunity to use these experimental data to evaluate the lake classification system and the response of algal community structure to these variables described by Rasmussen (2007) for the historical data.

The goal of this study was to use experimental data collected during a narrow time window to determine what factors are influencing phytoplankton community structure to the greatest extent. Based on this I hoped to identify the primary environmental variables that are driving the variation in phytoplankton community structure. The end result of this being to verify and improve upon the current models based on historical data in order to lay the framework for viable IBI's based on phytoplankton assemblage structure. The desired result is to associate differences in algal assemblage structure with chemical and physical variable gradients. In so doing it would become possible to accurately predict water quality based solely upon the taxa and density/biovolume of the algal community in a specific lake. It is hoped that identification of phytoplankton to genus or higher taxonomic groupings rather than species will allow for the development of useful biocriteria and eliminate some of the difficulties associated with identification to species level.

Methodology

Lakes included in this study were chosen based on criteria set by the National Lakes Assessment – National Lakes Survey project and include both natural and anthropogenic lakes and ponds (NLA Field Operations Manual 2007). Lakes were required to have a surface area of at least 4 hectares, >1000 m2 unvegetated surface area, must be at least 1 meter deep at the deepest point, and must be coterminous within the state they are being selected. Saline lakes, river backwaters, waste and mine tailing disposal lakes as well as aquiculture and waste treatment were excluded. Several lakes were also added as reference lakes to increase spatial coverage throughout the state, to produce a more representative sample. Based on these criteria, I identied 49 from a list of over 115 possibilities. It should be noted that one lake was eliminated after sampling to due to complications during the phytoplankton identification procedure so the total number of lakes used in this study was 48 (Table 1). For purposes of analysis lakes were divided into 3 regions for this study; northern, central, and southern. These regions are identical to those used by the IEPA and were validated by Rasmussen (2007) (Figure 1). Lakes are further divided into three subsets NLA lakes, which consisted of the 17 lakes that were sampled for the National Lakes Survey, IEPA Lakes, which were sampled for the Illinois Lakes Survey, and spatial coverage lakes, which were included to increase spatial coverage throughout the state (Figure 2).

Table 1: Lake name associated with region, sampling date and geographic coordinates and lake category (NLA – National Lakes Survey, IEPA – Illinois Lakes Survey, REF – Reference and Spatial Coverage Lakes). Coordinates in WGS84.

LAKE NAME	Sample Date	Region	Lake Cat.	LAT N:	LONG W:
Applecanyon	7/18/2007	Northern	REF	42.41891	90.16253
Argyle	7/25/2007	Central	REF	40.45066	90.78844
Baldwin	8/6/2007	Southern	IEPA	38.21389	89.87278
Battery Park	8/6/2007	Southern	IEPA	38.10556	89.69611
Bracken	7/24/2007	Central	IEPA	40.85847	90.34901
Busse	8/1/2007	Northern	IEPA	42.02395	88.00993
Cedar	7/11/2007	Southern	REF	37.65652	89.28181
Centralia	6/18/2007	Southern	IEPA	38.55824	89.00101
Coffeen	6/25/2007	Central	IEPA	39.04079	89.39619
CSCR	6/11/2007	Central	IEPA	39.47167	88.15861
Decatur	6/26/2007	Central	IEPA	39.82204	88.94804
DePue	7/17/2007	Northern	IEPA	41.32061	89.30556
Evergreen	7/10/2007	Central	REF	40.64888	89.05428
Forbes	6/18/2007	Southern	NLA	38.71383	88.75232
Gages	7/31/2007	Northern	IEPA	42.2057	87.59397
Galena	7/18/2007	Northern	IEPA	42.40081	90.34874
Gov Bond	6/25/2007	Southern	NLA	38.92656	89.39967
Highland Silver	7/9/2007	Southern	IEPA	38.7731	89.69797
Holiday	8/7/2007	Northern	IEPA	40.37755	89.44552
Holton	7/26/2007	Southern	REF	38.60272	90.10396
Horseshoe	7/26/2007	Southern	NLA	38.70285	90.08755
Iroquois	7/10/2007	Central	REF	40.53605	88.09452
Kinkaid	7/11/2007	Southern	REF	37.79123	89.4426
Lake 1060	8/14/2007	Southern	NLA	37.67001	88.83882
Lancelot	7/23/2007	Central	NLA	40.62906	89.74245
Long	7/31/2007	Northern	NLA	42.37637	88.12599
Loon	7/31/2007	Northern	IEPA	42.4511	88.08495
LotW	6/14/2007	Central	REF	40.20057	88.38171
Lou Yeager	6/29/2007	Central	IEPA	39.19126	89.59927
Mattoon	6/21/2007	Central	NLA	39.34	88.47806
Mauvaise Terre	7/5/2007	Central	IEPA	39.71749	90.21634
MD Borah	6/21/2007	Southern	NLA	38.77505	88.06881
Meredosia	7/5/2007	Central	IEPA	39.8838	90.54737
Mill Creek	6/11/2007	Central	IEPA	39.41083	87.805
Mutton	7/31/2007	Northern	NLA	42.28675	88.12445
Pana	6/5/2007	Central	NLA	39.36687	89.02121
Powderhorn	7/30/2007	Northern	NLA	41.64229	87.52937
Rend	7/16/2007	Southern	IEPA	38.05871	88.97887
Sangchris	6/29/2007	Central	IEPA	39.64767	89.47686
Shabbona	7/18/2007	Northern	REF	41.73935	88.85593
Slocum	7/31/2007	Northern	IEPA	42.25716	88.18725
Storey	7/24/2007	Central	NLA	40.98753	90.40874
Sugar Creek	7/13/2007	Central	NLA	37.39122	88.68845
Vandalia	7/9/2007	Southern	NLA	39.01183	89.12983
Vermillion	6/14/2007	Central	IEPA	40.15681	87.6501
Wee-Ma-Tuk	7/23/2007	Central	NLA	40.53216	90.14434
Whoopie Cat	7/13/2007	Southern	NLA	37.47722	89.32833
Wildwood	7/17/2007	Central	IEPA	41.07862	89.28529

Lake Sampling:

The index site, where all samples were taken was located based on the deepest point identified in each lake from available bathymetric maps and following no more than 30 minutes of searching by boat. In the case of reservoirs, where the deepest point was often located at the dam, the samples were taken 50 to 100 meters from the dam towards open water. The maximum depth point of each lake (z_{max}) was determined using a Hummingbird 500 Series sonar depth probe. Once z_{max} was determined an anchor was used to stabilize the boat at the index site. Sample and data collection procedures were performed according to strict guidelines produced for the National Lakes Assessment – National Lakes Survey (NLA Field Operations Manual 2007). Meterable data were collected at the surface (0.5m), at 1 meter and then at 1m increments using a Manta Amphibian multiprobe (Eureka Environmental, Austin, TX). The probe was calibrated prior to each sampling day to maximize accuracy and precision. At the index site, the values for temperature, dissolved oxygen (% O_2 saturation), pH, and specific conductance (μS) were recorded at each depth interval. Once the maximum depth was achieved, a reading was taken at .5 meters from the bottom, the probe was then raised back to the surface, where a duplicate surface reading was taken to verify the performance of the multiprobe.


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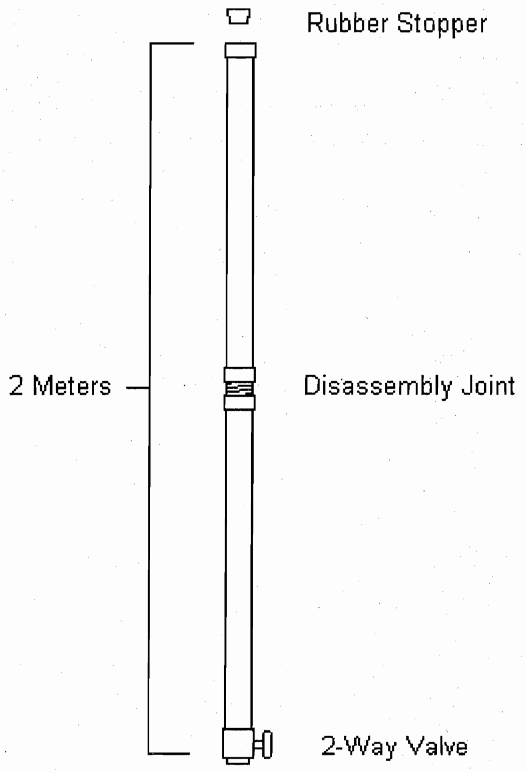
A Secchi disk was used to determine photic depth. Two measures were taken (both ascending and descending) and an average of the two were used for the final measurement. Once photic depth was determined, a customized sampling device (Figure 3) was used to take an integrated sample of the photic zone to within the nearest half-meter of the photic depth. From this, one 2-liter, clear plastic cubitainer was filled with sample water and stored on ice for return to the laboratory where it was then stored in a refrigerator at 5°C prior to chemical analysis. A second, dark 2-litre bottle was filled with sample, chilled and refrigerated in an identical manner for use in pigment determinations. Finally, an opaque 1-liter bottle was filled and preserved using acidified Lugol's Iodine. Logul's Iodine was used, because it stops cellular division and respiration, but does not damage cell integrity. This container was then stored in a dark cabinet to prevent photo-degradation of the preservative until it was processed.

Laboratory Analyses:

Chemical composition of all samples was determined within 48 hours of collection. Each lake was analyzed for NO_2+NO_3-N (TON), total phosphate (TP), soluble reactive phosphate (SRP), NH_4-N, alkalinity (phenolphthalein, total, HCO_3, and CO_3), hardness, and SO_4-N concentration. TON was determined using the cadmium reduction method, TP and SRP were determined using KSO_4 digestion and the ascorbic acid method, ammonia was determined using the phenate method, sulfate was determined using the turbidimetric method (Cleceri et al 1999). Standard curves were constructed from known substrate concentrations for each analysis cycle and were used to determine


Rubber Stopper
2 Meters
Disassembly Joint
2-Way Valve

sample concentration. Sample absorbances for all determinations were determined using uniform thickness QS cuvettes on a Beckman U-530 Spectrophotometer. Alkalinity and hardness values were determined using HCL and EDTA titration methods respectively (Cleceri et al 1999).

The sample retained in the dark, 2-litre bottle was used for solids determinations. Eighty milliliter ceramic crucibles were heated to 540°C for 20 minutes and then allowed to cool and placed in a desiccator, before their tare mass was recorded to the nearest .0001g. Subsequently, 75mL of sample was added to the crucible, which was then placed in a drying oven at 105°C for approximately 24 hours. Aluminum sample boats containing a single 2μm-pore glass fiber filter (GF/C) were also flashed in a muffle furnace and tare mass was determined. A known volume of sample (based on the turbidity of the lake being analyzed) was then passed through the filter using vacuum filtration. The filter was then returned to the boat and placed into a drying oven at 105°C for approximately 24 hours. When the crucibles and filters were completely dry they were placed into a dessicator for approximately 1 hour and the dry mass was recorded. Crucibles and boat/filters were then flashed at 550°C for 20 minutes, at which point they were allowed to cool and then weighed to determine ash-free dry mass. From these measurements I was able to determine nine solids fractions for each sample (TSS, VSS, FSS, TDS, VDS, FDS, TS, TVS, TFS).

All chemical and physical data for each lake was recorded into spreadsheets using Microsoft Excel. When all 49 lakes had been analyzed and recorded, data were compiled into a master sheet for analyses (Appendix 1). Percent of column oxygenated, percent of column anoxic, and depth oxygenated were calculated from the depth profile produced by the multiprobe. Lake surface area and shoreline development were calculated from detailed topographic and satellite images of each lake. These images were measured 3 times and the average value was recorded (Appendix 1).

Slide Preparation for Phytoplankton Enumeration:

A volume of preserved phytoplankton sample, based on turbidity of the water sample, was passed through a 0.45μm-pore (47mm) gridded, nitro-cellulose filter (Gelman). Two separate filter volumes were used for each lake, the first was the maximum amount of sample that could be passed through the filter. The second volume was approximately half the volume of the first filtration. This was done to assure that at least one of the volumes would produce quadrats that could be easily enumerated. Three replicates at each volume were filtered to facilitate production of a total of six slides per lake.

The filter from each replicate was then affixed to a standard glass microscope slide and cleared using immersion oil. This was done by first coating the slide with immersion oil and then trimming the filter along the gridlines so that it approximately matched the width of the slide (ca. 22mm). The filter was then carefully placed onto the slide to prevent trapping of air pockets under the filter, and the slides were then stored and allowed to clear for 2 to 3 days. In cases where the filters were not completely cleared using this procedure, a second addition of immersion oil was made. This was done by placing the slides on a standard slide warmer (50°C) for 2 minutes and then adding a small amount of immersion oil to the surface of the filter. Once the filter was completely cleared a 60mm x 24mm cover slip was placed over the filter and the slides were returned to storage. A mixture of type-B and type-A emersion oil in a ratio of 4:1 respectively produced the most consistent result when clearing the filters.

Phytoplankton Enumeration:

Once phytoplankton samples were fixed and cleared, they were enumerated using a Nikon Labophot-2 Phase Contrast microscope. Both filter volumes for each lake were observed at 400x and 1000x magnifications to determine the most useful filtration volume, which was based on overall density. Once this was determined, one of the three slides of the chosen volume was randomly selected and a random quadrat (one 7.84mm^2 grid) was chosen. Quadrats were then surveyed in their entirety (at 400x and 1000x) and each algal cell was counted and identified to genus. Phytoplankton were enumerated based on natural unit (cell, colony, flilament) rather than individual cells for colonial and filamentous forms. The minimum number of units counted for each lake was 300 and the number of quadrats surveyed to achieve that number ranged from 1 to 4.

Effective filtration area (1081mm^2), volume of sample, the quadrat area (7.84mm^2), and number of quadrats counted were used to calculate algal cell density for each lake:

$$\text{Density} = \left(\left(\frac{\text{Units}}{\text{\# of Quadrats}}\right) \bullet \left(\frac{1}{\text{Vol Filtered}}\right)\right)\left(\frac{\text{Effective Filtration Area}}{\text{Quadrat Area}}\right)$$

Density of phytoplankton gnera (natural units per mL) were then used for all subsequent analyses (Appendix 2). Three lakes were selected using a random number generator for recounts in order to assess precision of analyses, and a total of three counts were performed for each of these lakes. A resemblance matrix was produced for each of the three recount lakes and the average similarities were: Decatur = 0.9574, Mauvaise Terre = 0.9459, Storey = 0.9401. These analyses indicate that procedures used for filtering, fixing, and enumerating the samples produced an acceptable level of precision between counts. From these recounts a random number generator was used to select one sample for each lake, which would be used in further statistical analyses. Additional analyses were performed after aggregating phytoplankton genera into 11 higher taxonomic categories. (Appendix 3).

Statistical Analyses:

The statistical software used for all analyses performed in this study was Primer-6.1.5 multivariate statistical analysis software (Primer-e Corporation, Plymouth Marine Lab., Plymouth, UK). Physical and chemical data were first normalized and then draftsman plots (x-y coordinate plots for all pairs of variables) were produced for all variables under consideration. Using these plots, I was able to identify variables that would benefit from transformation (variables where many of the values group to the left or right edge of the y-axis). Based on this analysis I log-transformed the values for TON, SRP, and VSS then combined them with the rest of the variables that were not transformed. I also produced a log-transform for the entire data set and compared the three resemblance matrixes (untransformed, TON, SRP, VSS transform, and all variables transformed) using an MDS analysis based on Euclidean distance. From this, I was able to determine that the data set where only TON, SRP, and VSS were log-transformed had a lower 2D and 3D stress value. As a result, the TON, SRP, VSS transformed data sheet was used in all subsequent analyses.

Draftsman plots of the original data were used to assess whether pairs of variables were highly correlated and therefore, could be considered redundant. Based on this I eliminated several variables (HCO_3 alkalinity, CO_3 alkalinity, specific conductance, site depth, % column oxic, and which oxic) from subsequent analyses. ANOSIM (9999 permutations in all analyses) analyses were performed on a number of *a priori* classifications based on spatial, temporal, and chemical categories to elicit what factors may be driving the differences in chemical variables.

Phytoplankton density data based on genera as well as higher taxa were converted to relative abundances and then analyzed using three separate transforms (square root, 4th root, and log). MDS analyses were performed on the resemblance matrices produced by each of the three transforms and 2D and 3D stress was determined for each transform. From these analyses I was able to determine that square root transform produced the lowest stress for both the genera and higher taxa data. Thus subsequent analyses were performed using only the square root transformed data. ANOSIM analyses were performed on both data sets using a number of *a priori* factors to determine spatial relationships in the data. Best Fit analyses (using a BVStep procedure) were also performed on both the genera and higher taxa data to determine which taxa were driving the analyses.

A data set was then produced using a normalization of the TON, SRP, VSS transformed data. This was then compared with resemblance matrices produced from square root transform for both the genera and higher taxa data using a BIO-ENV procedure. This analysis compared any significant patterns in the phytoplankton assemblage data to any significant patterns in the environmental data. BEST analyses were then performed using several subsets of variables (based on the draftsman plot correlations and known correlated variables) to determine what combination of environmental variables were most influential in determining the structure of phytoplankton assemblages.

Results

Forty-eight lakes were sampled and analyzed for 20 chemical and physical variables as well as their phytoplankton assemblage. There were differences apparent between regions even before analysis. Table 2 shows the average and min/max values for each of the variables used in the analysis, sorted by region. There were several profound differences in average values between regions for several variables (conductance, hardness, sulfate, SRP, VDS, VSS, FSS, and FDS).

Environmental Analyses:

TON VSS and SRP variables were log transformed for the environmental data analyses, the remaining variables were left untransformed. Once normalized, a draftsman plot was produced from the resemblance matrix. From this draftsman plot HCO3 and CO3 alkalinity were found to be very highly correlated with total alkalinity and were removed from further analyses. Conductance was also removed since it was highly correlated with FDS. Finally site depth, percent of column oxygenated and depth oxygenated were removed since all three of these variables were highly correlated with percent of column anoxic. Once these variables were removed another resemblance matrix was produced and several ANOSIM analyses were run on *a priori* categorical data.

Region within the state was shown to be a significant categorical factor ($p < 0.01$, $R^2 = .144$) with significant difference in the pair-wise comparisons between Northern and Southern ($p < 0.01$, $R^2 = 0.364$) and Central and Southern ($p < 0.01$, $R^2 = 0.194$), however, there was no significant difference between Northern and Central lakes

Table 2: Average and Min/Max values for the chemical and physical variables that have been analyzed by region. All concentrations are in parts per million unless otherwise stated.

		Central	Northern	Southern
Hardness	Mean	195.56	236.20	103.96
	Min - Max	53.06 - 391.83	195.91 - 236.20	42.86 - 220.42
P'phthalein Alk.	Mean	32.28	17.29	26.69
	Min - Max	0 - 125.64	0 - 17.29	0 - 69.80
Total Alk	Mean	170.14	198.77	112.50
	Min - Max	55.84 - 293.16	132.62 - 258.96	55.84 - 209.40
HCO_3	Mean	114.88	164.19	59.12
	Min - Max	0 - 265.24	48.86 - 257.56	0 - 195.44
CO_3	Mean	64.57	34.58	53.38
	Min - Max	0 - 251.28	0 - 34.58	0 - 139.60
OH	Mean	0.00	0.00	0.00
	Min - Max	0.00	0.00	0.00
TON	Mean	0.67	1.04	0.007
	Min - Max	0 - 4.81	0 - 10.03	0 - 0.048
NH_4	Mean	0.017	0.063	0.051
	Min - Max	0 - 0.138	0 - 0.139	0 - 0.191
Sulfate	Mean	14.258	18.071	18.915
	Min - Max	1.412 - 70.805	2.150 - 19.139	3.156 - 45.378
PO_4 . TP	Mean	0.145	0.131	0.148
	Min - Max	0 - 0.877	0 - 0.184	0 - 0.61
PO_4 - SRP	Mean	0.047	0.015	0.037
	Min - Max	0 - 0.665	0 - 0.044	0 - 0.52
DO_2 (.5m)	Mean	10.83	8.58	10.98
	Min - Max	5.16 - 21.30	5.40 - 8.58	7.7 - 14.40
pH (.5m)	Mean	8.53	8.12	8.75
	Min - Max	7.70 - 9.60	6.90 - 8.12	7.80 - 9.70
Conductance (uS)	Mean	437	832	287
	Min - Max	120 - 863	408 - 1564	116 - 690
Temp. (.5m)	Mean	28.27	27.40	30.56
	Min - Max	24.80 - 31.02	24.90 - 28.90	28.80 - 36.90
Secchi Depth (m)	Mean	0.87	1.27	0.94
	Min - Max	0.18 - 2.50	0.030 - 3.50	0.31 - 2.23
VSS	Mean	9.77	19.70	11.49
	Min - Max	1.04 - 25.00	1.00 - 68.00	0 - 29.00
FSS	Mean	7.30	10.69	3.14
	Min - Max	0.50 - 50.50	0 - 23.03	0.33 - 16.87
VDS	Mean	86.62	127.70	61.05
	Min - Max	0 - 171.50	78.67 - 127.70	2.40 - 195.59
FDS	Mean	177.42	404.44	173.16
	Min - Max	36.00 - 495.16	148.33 - 452.33	8.97 - 448.17

($p = 0.114$). When analyzed to determine if the month sampled had a significant effect on the chemical data, ANOSIM showed no significant correlation ($p = 0.372$), indicating that sampling date did not significantly affect the chemical data. Secchi depth showed a significant difference between categories ($p < 0.001$, $R^2 = 0.055$), with high – medium ($p = 0.012$, $R^2 = 0.095$) and high – low ($p < 0.01$, $R^2 = 0.220$) showing significant differences, whereas the medium – low categories were not significantly different ($p= 0.06$). There were significant differences overall between total phosphate categories ($p < 0.01$, $R^2 = 0.203$) as well as significant differences between all three pair-wise comparisons: High – Low ($p < 0.01$, $R^2 = 0.333$), High – Mid ($p = .032$, $R^2 = 0.148$), and Mid – Low ($p = 0.013$, $R^2 = 0.143$). There was an overall significant difference between total alkalinity categories ($p = 0.028$, $R^2 = 0.089$), in the pair-wise comparisons there was only a significant difference between the high – low categories ($p > 0.01$, $R^2 = 0.306$), whereas high – mid and mid – low comparisons both had a $p > 0.25$. Hardness categories showed an overall significance, with high – low ($p < 0.01$, $R^2 = 0.285$) and mid – low ($p < 0.01$, $R^2 = 0.175$) significant in the pair-wise comparisons, however, high – mid comparison was not significant ($p = 0.39$). Shoreline development ($p = 0.061$), lake surface area ($p = 0.84$), and TON category ($p = .125$) were not significant categorical variables in the environmental data ANOSIM analyses.

Phytoplankton Assemblage Analyses:

Relative abundances of phytoplankton genera (Appendix 2) were transformed using a square-root transformation; the Bray-Curtis resemblance matrix produced from this transformation was used in all subsequent analyses. An MDS analysis of the resemblance matrix produced a plot with a 3D stress of 0.18 (Figure 4), in which lakes appear to be grouped by region within the state.

Figure 4: MDS plot of the genera data set, based on a square-root transformation. The points represent each of the 48 lakes used in the analysis and are sorted by region. 3D stress for this plot is 0.18.

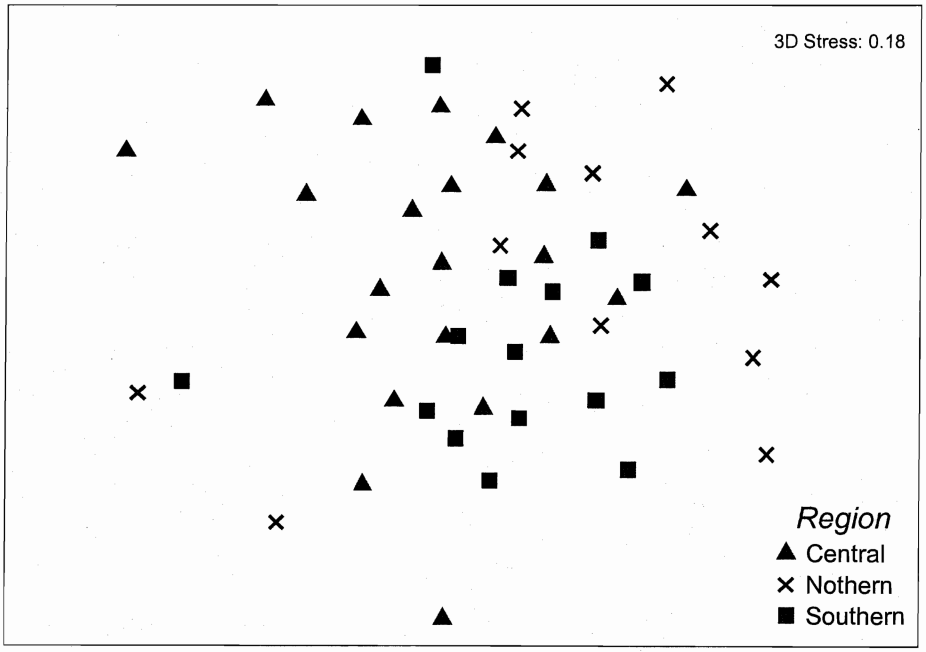
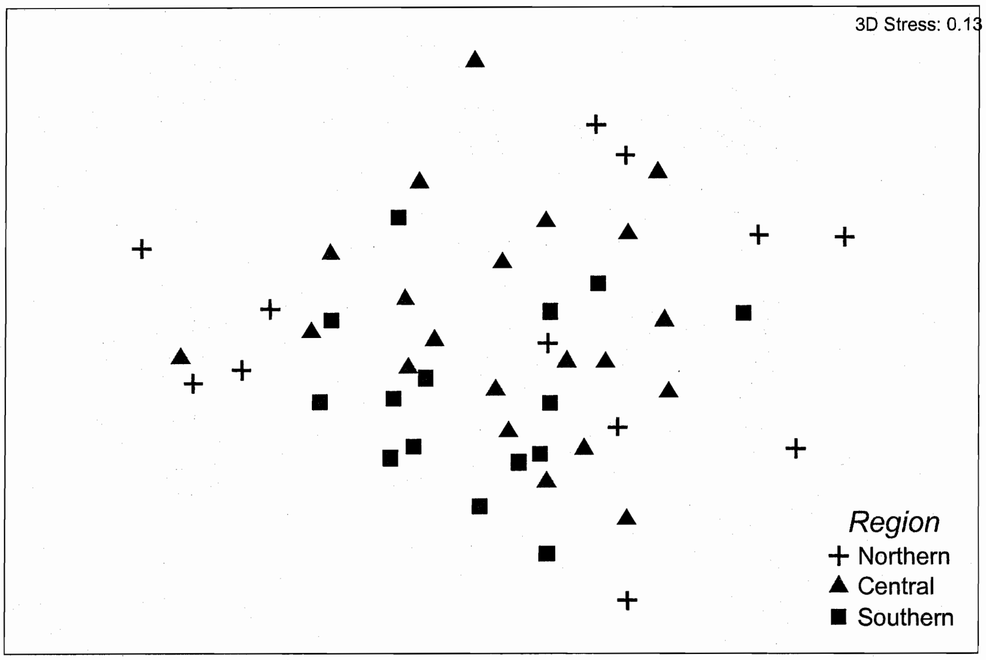

3D Stress: 0.18
Region
▲ Central
× Nothern
■ Southern

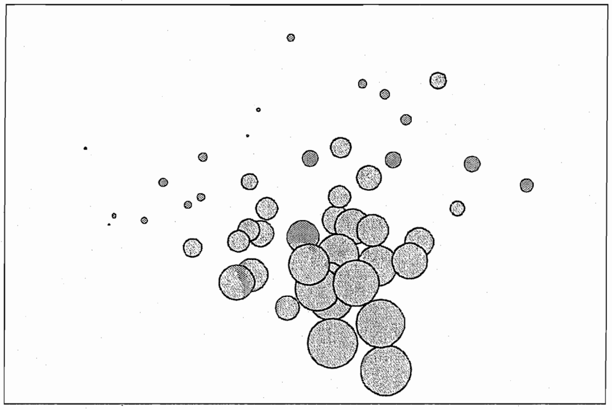
Figure 5: MDS plot higher taxa data set, based on a square-root transformation. The points represent each of the 48 lakes used in the analysis and are sorted by region. The 3D stress for this plot is 0.13


3D Stress: 0.13
Region
+ Northern
▲ Central
■ Southern

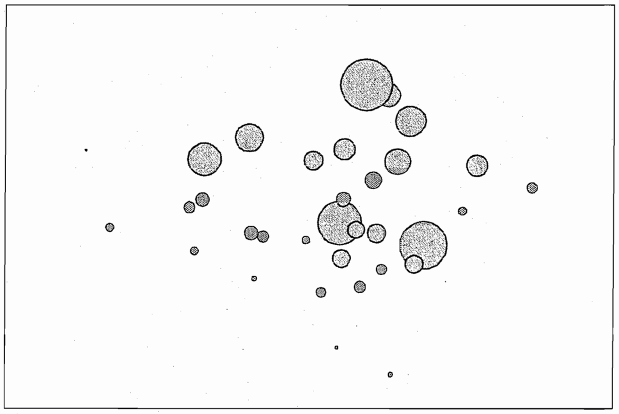
ANOSIM analyses were performed to determine if region, month sampled, and a combined category of region/month would show significant differences between the categories (9999 permutations were used for each categorical factor that was analyzed). The analysis showed a significant difference between region categories overall ($p = 0.049$, $R^2 = 0.071$) Pair-wise comparisons between the three categories showed significant differences between both Northern and Central ($p = 0.03$, $R^2 = 0.139$) and Northern and Southern ($p = 0.048$, $R^2 = 0.098$), but differences between Central and Southern regions were not significant ($p = 0.386$). Neither month sampled ($p = 0.889$) nor the combined month/region factor ($p = .459$) showed significant differences between categories. A BEST analysis was then performed to determine what genera account for the majority of variation in the data set. This analysis identified 15 genera that accounted for 95.4% of the variation in the data: *Anabaena, Aphanizomenon, Ceracium, Crucigenia, Cryptomonas, Cyclotella, Euglena, Fragilaria, Leptolyngbia, Limnothrix, Microcystis, Scenedesmus, Tetraspora, Trachelomonas, Trichocoleus*.

Higher taxa data (Appendix 3) were analyzed in a similar manner to the genera data. Data were standardized and a square-root transformation was used to produce a resemblance matrix (Figure 5). The MDS analysis produced a plot with 3D stress of 0.13, which was notably lower than that of the genera data. A BEST analysis of the higher taxa data identified 6 groupings that produced an MDS, which was as informational (0.958) as that based on the entire data set. These 6 higher taxa were: Cryptomonads, Euglenoids, araphid Diatoms, filamentous Cyanobacteria, and unicellular and filamentous Green Algae. Bubble plots of the MDS analysis were produced for

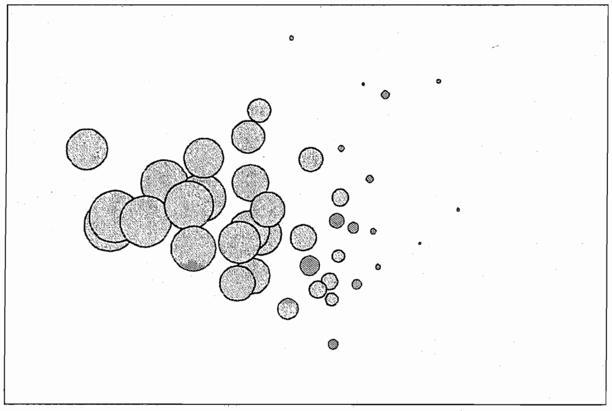
Figure 6: Bubble plots illustrating lakes with a phytoplankton assemblage that is dominated by each of the six indicative higher taxa groupings.



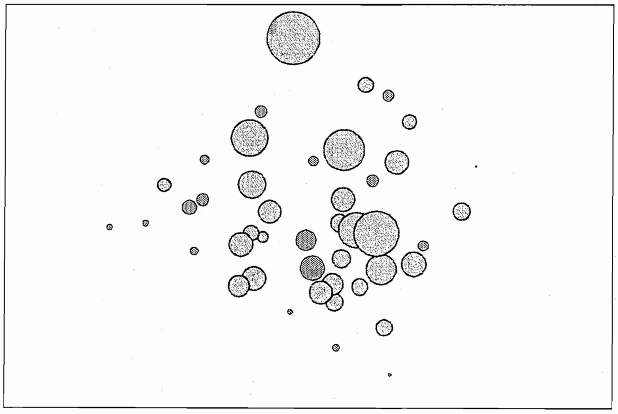
Araphid Diatoms



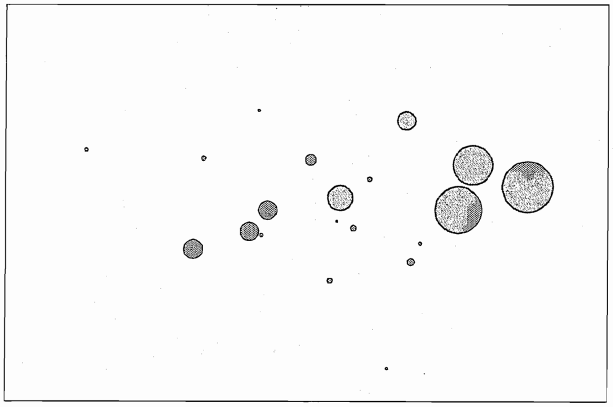
Cryptomonads.



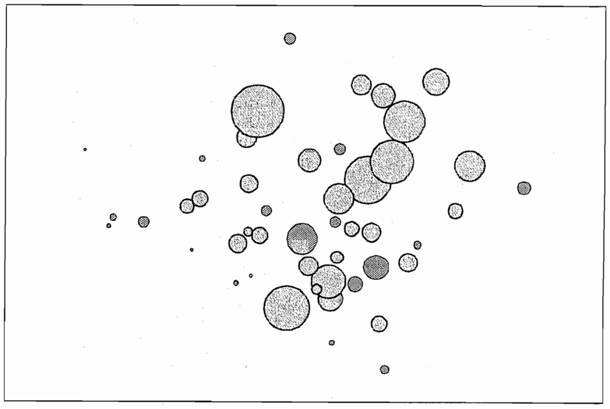
Filamentous Cyanobacteria



Euglenoids



Filamentous Green algae



Unicellular Green algae

these 6 taxonomic groups (Figures 6), which show distinct clustering. ANOSIM analyses were performed on the higher taxa data using the same categorical variables as the genera analyses. Regional categories were significantly different overall ($p = 0.035$, $R^2 = 0.079$) as well as the Northern – Southern ($p = 0.011$, $R^2 = 0.166$) and Northern – Central ($p = 0.018$, $R^2 = 0.160$) pair-wise comparisons. Central – Southern regions were not shown to be significantly different ($p = .817$). Similar to the genera abundance data, neither month sampled ($p = 0.998$), nor the region/month combination factor ($p = 0.677$) showed significant differences between the categories.

ANOSIM analyses were run in the higher taxa data using the same categories as those used for the physical and chemical data. These analyses showed that the only two factors that were significantly different were Shoreline Development and Surface Area. Shoreline development showed an overall significant difference ($p = 0.041$, $R^2 = 0.095$), and a significant difference between the high – low ($p = 0.022$, $R^2 = 0.143$) and mid – low ($p = 0.018$, $R^2 = 0.171$), but not between the high – mid ($p = 0.62$). When comparing the surface area there was a significant difference between the high and low categories ($p = 0.024$, $R^2 = 0.072$).

Bio-Environmental Analysis:

The log-transformed TON SRP VSS, normalized environmental data set was compared to both the genera and higher taxa square-root transformed resemblance matrices. This was done to determine if any combination of chemical or physical variables could be used to accurately predict the phytoplankton assemblage. A BEST analysis utilizing a BIO-ENV method was used for these comparisons, which utilized all variables except those that were eliminated during the environmental PCA analysis due to being highly correlated with other variables (HCO_3 alkalinity, CO_3 alkalinity, specific conductance, site depth, column oxic, and which oxic). The genera comparison found 5 environmental variables, which provided the power to account for 0.234 of the variation in the data set: total alkalinity, TON, NH4-N, FSS, and Secchi depth. For the higher taxa comparison 5 environmental variables accounted for 0.242 of the variation in the data set; phenolphthalein alkalinity, FSS, VDS, dissolved O_2, and Secchi depth.

Discussion

Due to the fact that current biocriteria for lotic systems are not applicable to lentic systems it has been increasingly important to develop workable systems for inferring the water quality of lakes and reservoirs. Traditionally, complex chemical analyses and physical and habitat data collection have been used for monitoring water quality in these systems. However, these analyses often are time consuming and in some cases infeasible on a large scale. Phytoplankton assemblage indicators have long been suggested as possibly useful as bio-indicators in lentic systems and the development of classification schemes based on these taxa would help to reduce some of the costs and time constraints associated with long term monitoring projects (Rasmussen 2007, Stevenson and Smol 2005, Stevenson and Wang 2001).

The intent of this study was to elaborate on the models first developed by Rasmussen (2007) and either confirm, modify, or refute these models. I have confirmed the regional variation outlined by Rasmussen and observed the same (albeit non-significant) temporal patterns. I also identified indicator genera and higher taxa for the entire state; however, my data could not determine indicator taxa for specific regions.

Regionalization

Soininen et al (2004) analyzed benthic diatom assemblage structure in 197 lotic environments throughout Ontario, Canada. They attempted to determine whether benthic diatom assemblages varied along a spatial gradient and whether these variations could be grouped into ecoregions. The authors determined that benthic diatoms do vary along a spatial gradient and that this accounted for nearly 40% of the variation in their data set. Similarly they determined that ecoregions could be derived from the patterns observed in the data. Another study by Rabeni and Doisy (2000), attempted to determine if ecoregions classifications in Missouri streams were valid by analyzing the assemblage structure of benthic macroinvertebrates. They identified strong variation between ecoregions in the assemblage structure of these organisms validating the regional designations that were previously developed.

Results from my analysis follow these same patterns as Rebeni and Doisy's study and confirm the results of Rasmussen (2007). Rasmussen indicated that a regionalization scheme segregating Illinois into northern, central, and southern regions was the most useful for classifying lakes based on environmental variables and phytoplankton assemblage. My data, derived from a mostly random sample of lakes and reservoirs throughout the state, confirm that this is indeed the case. The environmental as well as phytoplankton assemblage (both genera and higher taxa) showed strong regional variation between the three regions. Similar to Rasmussen's analysis, my study also showed that not all of the pair-wise regional comparisons were significantly different. I observed no significant difference between central and southern lakes based on phytoplankton assemblage and no significant difference between central and northern lakes based on the chemical/physical data. There could be several reasons for this. From the chemical data we can see that hardness is more similar between northern and central lakes, with southern lakes being much higher, whereas, in terms of conductivity central and southern lakes are more closely related with northern lakes having a much higher value.

These variations may be explained due to differences between lakes in the three different regions in the context of the geologic history and land use. The northern region has more urban and industrial development as well as more glacial origin lakes than either of the other two regions, whereas the central region is predominantly agricultural. The southern region has some agricultural, but is more forested and has substantially different geology. Also reservoirs are more prominent in the southern and central regions, whereas there are more lakes of natural origin in the northern region

Due to my findings and those of Rasmussen (2007) it would be beneficial to include different indicator taxa for each of the three regional groupings. Using a combination of taxa that are highly informative for all three regions (*Aphanizomenon, Ceratium, Scenedesmus,* etc…) and regionally informative taxa determined by Rasmussen would likely produce the best result when assemblage informative taxa list for each of the three regions.

In my analysis of environmental data I used several arbitrarily defined categories intended to reflect relative levels (high, medium, and/or low) of continuous variables to evaluate whether lake classification based on categories of variables was reflected in the phytoplankton assemblages. I found significant variation in phosphate, total alkalinity, and hardness. This is almost certainly due to regional variation. Phosphate is significantly higher in the central region, likely due to the high amount of agricultural runoff. It is also higher, but not significantly so in the southern region, which also has moderate degree of agricultural development. Both hardness and total alkalinity also are much higher in the northern and central regions when compared to the southern region.

Sampling Date

It is widely known that phytoplankton assemblage structure varies seasonally, with different higher taxonomic groups becoming dominant at different times of the year (Wehr and Sheath 2003). Rasmussen (2007) and Rojo and Cobelas (1993) showed that there can be multiple equilibriums within the same season. The sampling period of early June to late August were the most useful in terms of sampling period because there is the least seasonal and temporal variation in phytoplankton community structure between these months. Rasmussen (2007) determined from historical data trends that there was no significant difference between June and July and between July and August, but there was a significant difference between June and August. However, I found no overall significant difference between the three sampling months in either the physical/chemical data or the phytoplankton data. I conclude from this, based on both studies that the period of June – August is the least temporally variable period of the entire year and thus is a good time for monitoring water quality, since temporal variation between lakes can be discounted as a confounding variable.

A combined variable of sampling date and region was included in the analysis because it became evident during data compilation that there may have been a bias between the sampling region and the month that the lakes from each region were sampled. Due to logistic constraints, I sampled central and southern lakes in June – July and northern lakes in late July and August. Nonetheless, analysis of this variable showed no significant differences overall and only one of the nine pair-wise comparisons was significant. Thus, any perceived regional-temporal bias can be discounted as a confounding factor in the analyses.

Informative Taxa

It was expected that not all of the genera that have been identified would be useful as indicator taxa. Some genera such as *Actinastrum, Cymbella, Tetraedron*, and *Strombomonas* appear in three or fewer of the sample lakes. In benthic macroinvertebrate metrics, it is often the case that individuals from only three taxonomic groupings are necessary to accurately gauge water quality. The EPT (Ephemeroptera, Plecoptera, and Tricoptera) metric favored in many stream assessment studies and stream monitoring programs has been shown to be both easy to use and effective for tracking variation in water quality over time (Wallace et al 1996).

I performed BEST analysis on the phytoplankton abundance data (Appendix 2) and determined that a relatively small subset of genera could identify regional differences as readily as could analysis of the entire assemblage. This parallels the findings of Rasmussen (2007). *Aphanizomenon, Cyclotella, Cryptomonas, Ceratium, Scenedesmus* and several other genera are shared as highly informative taxa between the two studies. This would appear to confirm that phytoplankton assemblages would be effective predictors of water quality variables.

I also grouped the genera into 11 higher taxonomic groupings (Appendix 3). After performing a BEST analysis on this data I determined that abundance of 6 of the 11 taxa accounted for the majority of variation in the data. This has implications in simplifying the identification procedures in possible phytoplankton-based IBI's. Since it is far easier to identify individuals to higher-level taxonomic groupings than to genus-level, this could save a considerable amount of time in enumerating the phytoplankton assemblages of lentic systems.

Bio-Environmental

The bioenvironmental analysis identified 5 variables in the environmental data that could account for approximately 25% of the variation in the phytoplankton assemblages both at the genera level and in the higher-level taxa. In these analyses, concentrations of various forms of inorganic nitrogen seemed to be the most indicative environmental variables in determining the response of the genera-level assemblage, whereas, alkalinity and dissolved oxygen were more important in the higher taxa groupings. Both the higher taxa and genus-level analyses shared fixed suspended solids as an important contributing variable. While the ability of the environmental data to predict the algal assemblage structure may appear low, there is currently no way to gauge the significance of this level of predictability since there are no similar studies for comparison.

Conclusion

The development of phytoplankton-based IBI's will be highly beneficial in effective water quality monitoring and management. Currently large scale, single year studies using these methods are infeasible due to time and logistical constraints. As has been shown by Rasmussen (2007), temporal variation would necessarily limit such studies to a very narrow time window in order to be valid. Through my participation in the NLA and ILA, I have had the opportunity to validate the models developed by Rasmussen (2007) during a single seasonal period.

My results confirm that the regional boundaries developed for the state of Illinois based on historical data are indeed accurate and reveal significant differences between the regions in both environmental variables and phytoplankton assemblage structure. Rasmussen (2007) determined that the summer months (June through August) were the least variable months of the year in terms of temporally based variation in phytoplankton assemblage structure. Sample collection for my study was performed during these months and I found no significant temporal variation in phytoplankton assemblage structure or environmental variables. Future studies of a similar nature should take place between the months of June and August to remove seasonal variations in dominant taxa as confounding variables.

Based on indicator taxa, as determined by this study and that of Rasmussen (2007) a set of biocriterion for phytoplankton based IBI's may well be identified. Indicator taxa for the entire state have been highlighted by both studies and have indicated specific indicator taxa for each region. Based on these findings, future studies should concentrate on developing metrics based on specific environmental variables using these genera. Based on current data, a phytoplankton based IBI appears to be promising for use as biocriterion for lentic systems. Once established, such indices could vastly reduce time and logistical issues associated with large scale monitoring studies.

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Appendices

Appendix 1: Environmental, and spatial data for all lakes.

		------alkalinity------				------nitrogen------		------phosphorus------		
	hardness	p'phthalein	total	bicarbonate	carbonate	nitrate/nitrite	ammonia	total	soluble	condensed
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Applecanyon	250.2	7.0	230.3	216.4	14.0	0.014	0.001	0.028	0.001	0.027
Argyle	110.2	55.8	125.6	14.0	111.7	0.603	0.001	0.075	0.006	0.069
Baldwin	195.9	69.8	209.4	69.8	139.6	0.002	0.061	0.150	0.010	0.140
Battery Park	220.4	7.0	195.4	195.4	14.0	0.002	0.022	0.614	0.507	0.106
Bracken	179.6	118.7	349.0	7.0	237.3	1.575	0.001	0.064	0.001	0.063
Busse	240.8	7.0	147.3	145.9	1.4	0.002	0.017	0.179	0.029	0.150
Cedar	49.0	7.0	55.8	41.9	14.0	0.002	0.024	0.021	0.003	0.018
Centralia	122.4	27.9	90.7	34.9	55.8	0.002	0.047	0.053	0.001	0.052
Coffeen	228.6	27.9	146.6	90.7	55.8	0.002	0.001	0.119	0.002	0.117
CSCR	183.7	14.0	209.4	181.5	27.9	0.020	0.001	0.135	0.001	0.134
Decatur	259.2	7.0	223.4	209.4	14.0	2.313	0.001	0.238	0.131	0.107
DePue	304.1	27.9	223.4	167.5	55.8	10.030	0.428	0.710	0.158	0.552
Evergreen	216.3	97.7	195.4	7.0	195.4	4.814	0.037	0.007	0.001	0.006
Forbes	81.6	7.0	104.7	104.7	14.0	0.002	0.131	0.097	0.001	0.096
Gages	261.2	7.0	167.5	153.6	14.0	0.002	0.101	0.015	0.001	0.014
Galena	200.0	27.9	244.3	188.5	55.8	0.011	0.001	0.089	0.001	0.088
Gov Bond	130.6	41.9	153.6	69.8	83.8	0.002	0.010	0.060	0.001	0.059
Highland Silver	95.9	41.9	97.7	14.0	83.8	0.004	0.102	0.185	0.007	0.177
Holiday	267.3	7.0	230.3	230.3	14.0	0.856	0.309	0.090	0.001	0.089
Holton	100.0	34.9	125.6	55.8	69.8	0.048	0.015	0.182	0.001	0.181
Horseshoe	189.8	20.9	111.7	69.8	41.9	0.011	0.037	0.229	0.004	0.226
Iroquois	167.3	14.0	167.5	139.6	27.9	0.107	0.098	0.027	0.001	0.026
Kinkaid	85.7	7.0	104.7	90.7	14.0	0.002	0.018	0.026	0.003	0.023
Lake 1060	42.9	27.9	90.7	34.9	55.8	0.002	0.140	0.284	0.021	0.263

Appendix 1 (continued)

		--------alkalinity			--------	--------nitrogen	--------	--------phosphorus		--------
	hardness	p'phthalein	total	bicarbonate	carbonate	nitrate/nitrite	ammonia	total	soluble	condensed
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lancelot	220.4	27.9	174.5	118.7	55.8	0.002	0.027	0.066	0.007	0.059
Long	279.6	20.9	216.4	174.5	41.9	0.002	0.023	0.179	0.001	0.178
Loon	202.0	20.9	160.5	118.7	41.9	0.002	0.032	0.029	0.001	0.028
LotW	226.5	14.0	209.4	181.5	27.9	0.127	0.038	0.063	0.001	0.062
Lou Yeager	261.2	27.9	167.5	111.7	55.8	0.002	0.001	0.306	0.189	0.117
Mattoon	110.2	125.6	139.6	111.7	251.3	0.015	0.123	0.123	0.008	0.115
Mauvaise Terre	259.2	20.9	230.3	188.5	41.9	0.059	0.001	0.385	0.092	0.293
MD Borah	77.6	27.9	55.8	7.0	55.8	0.002	0.104	0.181	0.055	0.126
Meredosia	302.0	14.0	293.2	265.2	27.9	0.148	0.050	0.877	0.665	0.212
Mill Creek	100.0	7.0	125.6	125.6	14.0	0.024	0.001	0.023	0.001	0.022
Mutton	214.3	41.9	132.6	48.9	83.8	0.003	0.021	0.153	0.001	0.152
Pana	122.4	27.9	146.6	90.7	55.8	0.019	0.051	0.048	0.001	0.047
Powderhorn	216.3	41.9	209.4	125.6	83.8	0.003	0.023	0.004	0.001	0.003
Rend	49.0	34.9	104.7	34.9	69.8	0.008	0.004	0.149	0.049	0.099
Sangchris	146.9	27.9	139.6	83.8	55.8	1.296	0.007	0.064	0.013	0.050
Shabbona	236.7	20.9	209.4	167.5	41.9	1.584	0.028	0.102	0.001	0.101
Slocum	202.0	7.0	153.6	139.6	14.0	0.002	0.026	0.116	0.001	0.115
Storey	181.6	7.0	139.6	125.6	14.0	2.857	0.001	0.074	0.001	0.073
Sugar Creek	53.1	20.9	55.8	14.0	41.9	0.029	0.138	0.222	0.034	0.188
Vandalia	81.6	41.9	97.7	14.0	83.8	0.004	0.139	0.109	0.001	0.108
Vermillion	228.6	34.9	209.4	139.6	69.8	0.018	0.038	0.256	0.036	0.220
Wee-Ma-Tuk	391.8	20.9	174.5	132.6	41.9	0.011	0.002	0.076	0.001	0.075
Whoopie Cat	69.4	7.0	76.8	62.8	14.0	0.014	0.039	0.013	0.001	0.012
Wildwood	244.9	14.0	174.5	146.6	27.9	0.044	0.034	0.012	0.001	0.011

Appendix 1 (continued)

	----------solids----------								
	fixed suspended	volatile suspended	fixed dissolved	volatile dissolved	sulfate	dissolved oxygen	pH (0.5 m)	specific conductance	temperature (0.5 m)
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		µs / cm	°C
Applecanyon	8.5	1.6			5.0	7.9	8.4	408.0	25.7
Argyle	8.7	2.0	60.7	91.3	7.2	14.0	9.6	221.0	26.9
Baldwin	20.5	2.5	108.8	448.2	39.1	8.20	8.90	690.0	36.9
Battery Park	0.0	1.5	58.7	229.2	22.2	6.20	8.60	484.0	31.2
Bracken	17.6	2.0	99.7	134.0	19.8	17.6	9.2	389.0	28.3
Busse	28.0	4.5	94.7	787.5	29.5	7.7	8.1	1564.0	28.9
Cedar	2.8	1.2	38.5	38.8	3.2	7.7	8.6	116.0	30.0
Centralia	7.7	1.0	27.0	428.3	27.9	8.5	9.4	367.0	29.6
Coffeen	1.0	4.8	85.6	495.2	70.8	5.7	8.9	863.0	37.3
CSCR	11.9	9.3	101.5	96.0	11.1	13.5	8.4	378.0	28.0
Decatur	6.0	10.0	23.3	63.3	6.9	8.3	8.6	481.0	26.7
DePue	38.7	85.3	140.0	522.7	48.6	6.5	8.6	862.0	26.2
Evergreen	3.7	1.7	103.0	202.3	12.9	7.9	8.3	479.0	27.5
Forbes	6.0	1.7	24.7	265.0	9.1	7.9	8.8	210.0	28.9
Gages	3.3	4.2	188.7	691.8	21.9	7.5	7.3	1452.0	28.5
Galena	17.5	1.0	126.5	148.3	2.1	10.7	9.0	425.0	24.9
Gov Bond	8.1	16.9	49.2	137.8	15.2	12.8	8.7	282.0	28.8
Highland Silver	12.5	0.5	39.5	124.8	11.9	13.9	7.8	263.0	30.1
Holiday	4.0	3.1	78.7	246.2	25.4	5.4	8.1	561.0	28.7
Holton	26.0	4.0	47.3	200.0	18.3	13.7	8.6	436.0	31.0
Horseshoe	29.0	9.0	129.7	377.7	45.4	13.0	7.70	803.0	30.8
Iroquois	3.1	7.7	40.9	115.0	11.7	6.4	7.7	296.0	28.8
Kinkaid	3.3	0.3	34.0	85.0	18.4	8.0	8.6	200.0	29.1
Lake 1060	20.0	2.7	41.3	76.0	0.7	10.3	7.9	120.0	31.8

Appendix 1 (continued)

	----------solids----------								
	fixed suspended	volatile suspended	fixed dissolved	volatile dissolved	sulfate	dissolved oxygen	pH (0.5 m)	specific conductance	temperature (0.5 m)
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		μs / cm	°C
Lancelot	8.7	2.0	60.7	91.3	10.6	10.5	7.9	572.0	27.7
Long	14.7	1.3	149.3	448.0	0.7	12.0	8.4	923.0	27.5
Loon	1.0	0.1	133.7	313.2	14.1	8.6	6.9	717.0	28.5
LotW	4.0	4.4	98.7	236.9	9.0	7.8	7.8	556.0	29.2
Lou Yeager	4.5	1.8	171.5	206.2	16.3	5.2	8.4	372.0	26.7
Mattoon	14.0	2.5	134.0	50.8	1.4	16.6	8.9	336.0	27.8
Mauvaise Terre	23.0	20.0	129.0	228.0	2.0	6.9	8.4	509.0	27.6
MD Borah	10.5	1.0	66.8	11.0	0.7	14.4	9.2	167.0	28.9
Meredosia	25.0	35.0	123.0	339.7	0.7	7.4	8.4	682.0	30.5
Mill Creek	3.5	1.6	0.5	87.7	6.7	8.6	8.0	214.0	25.2
Mutton	42.0	8.0	156.7	422.7	5.3	11.80	9.00	967.0	28.7
Pana	4.4	2.4	2.3	116.3	5.5	13.8	8.7	275.0	24.8
Powderhorn	2.7	0.0	102.6	266.7	25.5	9.1	7.9	628.0	27.0
Rend	13.7	4.7	195.6	41.7	6.2	12.5	9.7	330.0	30.6
Sangchris	10.0	0.5	79.3	144.8	35.0	7.1	8.5	541.0	31.0
Shabbona	13.7	4.7	152.9	171.3	30.5	10.4	8.5	446.0	25.6
Slocum	68.0	20.0	104.0	382.7	8.2	13.50	8.90	879.0	28.6
Storey	10.0	3.3	106.0	142.1	15.2	17.0	8.8	410.0	28.0
Sugar Creek	14.0	2.7	3.3	36.0	0.7	9.8	7.9	120.0	29.5
Vandalia	15.0	1.5	25.0	83.8	12.4	11.8	9.5	194.0	30.1
Vermillion	16.5	2.4	142.2	174.9	17.4	21.3	8.7	437.0	27.5
Wee-Ma-Tuk	12.0	2.8	149.3	451.9	19.2	15.0	8.5	752.0	28.5
Whoopie Cat	1.6	0.6	2.4	40.7	0.7	8.3	8.2	136.0	30.5
Wildwood	1.5	1.3	167.8	229.4	13.4	8.2	9.1	502.0	26.1

Appendix 1 (continued)

	Site Depth	oxic depth	% column oxygenated	% column anoxic	Secchi depth
Units	meters	meters			meters
Applecanyon	20.0	6.0	0.30	0.70	1.2
Argyle	9.0	8.0	0.89	0.11	1.0
Baldwin	10.0	7.0	0.70	0.30	0.5
Battery Park	5.0	5.0	1.00	0.00	0.9
Bracken	9.0	9.0	1.00	0.00	0.6
Busse	2.5	2.5	1.00	0.00	0.3
Cedar	12.5	12.5	1.00	0.00	1.8
Centralia	5.5	4.0	0.73	0.27	1.1
Coffeen	13.4	6.0	0.45	0.55	1.3
CSCR	3.1	3.1	1.00	0.00	0.3
Decatur	4.4	4.4	1.00	0.00	0.5
DePue	2.0	2.0	1.00	0.00	0.2
Evergreen	13.7	9.0	0.66	0.34	1.3
Forbes	8.2	4.0	0.49	0.51	1.2
Gages	6.0	6.0	1.00	0.00	1.7
Galena	12.0	8.0	0.67	0.33	0.5
Gov Bond	7.0	4.0	0.57	0.43	0.1
Highland Silver	5.0	5.0	1.00	0.00	0.5
Holiday	5.0	5.0	1.00	0.00	1.3
Holton	2.5	2.5	1.00	0.00	0.4
Horseshoe	2.0	2.0	1.00	0.00	0.3
Iroquois	3.7	3.7	1.00	0.00	0.7
Kinkaid	20.4	14.0	0.69	0.31	1.5
Lake 1060	2.0	2.0	1.00	0.00	0.4

Appendix 1 (continued)

	Site Depth	oxic depth	% column oxygenated	% column anoxic	Secchi depth
Units	meters	meters			meters
Lancelot	9.0	9.0	1.00	0.00	1.7
Long	8.0	8.0	1.00	0.00	0.9
Loon	11.0	11.0	1.00	0.00	4.3
LotW	6.4	3.0	0.47	0.53	1.3
Lou Yeager	8.0	8.0	1.00	0.00	0.7
Mattoon	7.2	4.0	0.56	0.44	0.6
Mauvaise Terre	1.8	1.8	1.00	0.00	0.2
MD Borah	6.7	3.0	0.45	0.55	0.8
Meredosia	1.2	1.2	1.00	0.00	0.2
Mill Creek	14.9	9.0	0.60	0.40	0.9
Mutton	1.5	1.5	1.00	0.00	0.3
Pana	10.7	7.0	0.65	0.35	0.9
Powderhorn	5.0	5.0	1.00	0.00	3.5
Rend	8.0	8.0	1.00	0.00	1.9
Sangchris	10.5	10.5	1.00	0.00	1.0
Shabbona	11.6	8.0	0.69	0.31	0.7
Slocum	1.0	1.0	1.00	0.00	0.4
Storey	10.0	7.0	0.70	0.30	1.1
Sugar Creek	2.2	2.2	1.00	0.00	0.4
Vandalia	8.7	7.0	0.80	0.20	0.5
Vermillion	5.5	5.5	1.00	0.00	0.7
Wee-Ma-Tuk	6.5	6.5	1.00	0.00	0.7
Whoopie Cat	5.0	5.0	1.00	0.00	2.2
Wildwood	16.9	12.0	0.71	0.29	2.5

Appendix 1 (continued)

	Secchi category	total phosphorus category	hardness category	total alkalinity category	Region	Month	shoreline development category	surface area category
Applecanyon	H	L	H	H	Northern	7	High	High
Argyle	M	L	L	M	Central	7	Mid	Low
Baldwin	L	M	M	H	Southern	8	Low	High
Battery Park	M	H	H	M	Southern	8	Low	Low
Bracken	M	L	M	H	Central	7	Mid	Low
Busse	L	M	H	M	Northern	8	Mid	High
Cedar	H	L	L	L	Southern	7	High	High
Centralia	H	L	M	L	Southern	6	High	High
Coffeen	H	M	H	M	Central	6	High	High
CSCR	L	M	M	H	Central	6	Mid	High
Decatur	L	H	H	H	Central	6	Mid	High
DePue	L	H	H	H	Northern	7	Mid	High
Evergreen	H	L	H	M	Central	7	High	High
Forbes	H	M	L	L	Southern	6	High	High
Gages	H	L	H	M	Northern	7	Low	Low
Galena	L	L	M	H	Northern	7	Mid	Low
Gov Bond	L	L	M	M	Southern	6	High	High
Highland Silver	L	M	L	L	Southern	7	Mid	High
Holiday	H	L	H	H	Northern	8	Mid	High
Holton	L	M	L	M	Southern	7	Low	Low
Horseshoe	L	H	M	L	Southern	7	Mid	High
Iroquois	M	L	M	M	Central	7	Mid	Low
Kinkaid	H	L	L	L	Southern	7	High	High
Lake 1060	L	H	L	L	Southern	8	Low	Low

Appendix 1 (continued)

	Secchi category	total phosphorus category	hardness category	total alkalinity category	Region	Month	shoreline development category	surface area category
Units								
Lancelot	H	L	H	M	Central	7	Mid	Low
Long	M	M	H	H	Northern	7	Low	High
Loon	H	L	M	M	Northern	7	Low	Low
LotW	H	L	H	H	Central	6	Mid	Low
Lou Yeager	M	H	H	M	Central	6	Mid	High
Mattoon	M	M	L	M	Central	6	High	High
Mauvaise Terre	L	H	H	H	Central	7	Mid	Low
MD Borah	M	M	L	L	Southern	6	Mid	Low
Meredosia	L	H	H	H	Central	7	Mid	High
Mill Creek	M	L	L	M	Central	6	High	High
Mutton	L	M	H	M	Northern	7	Mid	Low
Pana	M	L	M	M	Central	6	High	Low
Powderhorn	H	L	H	H	Northern	7	Low	Low
Rend	H	M	L	L	Southern	7	Mid	High
Sangchris	M	L	M	M	Central	6	Low	High
Shabbona	M	M	H	H	Northern	7	Mid	High
Slocum	L	M	M	M	Northern	7	Low	Low
Storey	M	L	M	M	Central	7	Mid	Low
Sugar Creek	L	H	L	L	Central	7	Mid	Low
Vandalia	M	M	L	L	Southern	7	High	High
Vermillion	M	H	H	H	Central	6	Low	High
Wee-Ma-Tuk	M	L	H	M	Central	7	Mid	Low
Whoopie Cat	H	L	L	L	Southern	7	Low	Low
Wildwood	H	L	H	M	Central	7	Mid	Low

Appendix 2: Phytoplankton abundance data (genera) for all lakes

	Achnanthes	Actinastrum	Actinella	Aulacosira	Anabaena	Ankistrodesmus	Aphanizomeno	Aphanothece
Applecanyon	0	0	0	0	284	0	0	0
Argyle	0	0	0	0	6	0	0	0
Baldwin	21	0	0	0	400	28	0	0
Battery Park	0	6	0	6	61	0	0	83
Bracken	0	0	0	0	14	0	0	0
Busse	0	14	0	0	83	83	14	0
Cedar	3	0	0	7	52	0	0	0
Centralia	0	0	0	18	2510	129	18	0
Coffeen	2	0	0	0	33	44	0	0
CSCR	0	0	0	142	0	0	0	0
Decatur	0	0	0	214	28	0	0	0
DePue	0	0	0	0	14	0	0	0
Evergreen	0	0	0	9	0	97	0	0
Forbes	5	0	0	44	32	5	0	0
Gages	5	0	0	0	5	9	0	0
Galena	0	0	0	0	1675	0	0	0
Gov Bond	0	0	0	0	4440	48	0	0
Highland Silver	0	0	0	87	1374	0	0	0
Holiday	0	0	0	0	0	0	0	0
Holton	3	0	0	24	141	0	0	0
Horseshoe	28	0	0	28	395	0	0	0
Iroquois	0	0	0	132	28	0	0	0
Kinkaid	2	0	0	4	20	0	0	0

Appendix 2 (continued)

	Achnanthes	Actinastrum	Actinella	Aulacosira	Anabaena	Ankistrodesmus	Aphanizomenon	Aphanothece
Lake 1060	0	0	0	41	55	1213	0	0
Lancelot	0	0	0	0	101	9	0	0
Long	0	0	0	0	9	0	18	0
Loon	0	0	2	0	0	0	0	0
LotW	33	0	0	0	0	1224	0	0
Lou Yeager	0	0	0	3	17	0	0	0
Mattoon	0	0	0	55	4288	0	0	0
Mauvaise Terre	0	0	0	110	0	0	0	0
MD Borah	0	0	0	132	113	6	223	0
Meredosia	0	0	0	0	165	0	0	0
Mill Creek	2	0	0	0	65	0	118	0
Mutton	0	0	0	0	0	41	10231	0
Pana	0	0	0	0	1358	28	365	0
Powderhorn	0	0	0	0	50	0	0	0
Rend	0	0	0	22	800	0	0	0
Sangchris	0	0	0	0	0	0	0	0
Shabbona	0	0	0	0	0	0	0	0
Slocum	0	0	0	41	0	0	11776	0
Storey	0	0	0	0	0	9	23	0
Sugar Creek	17	0	0	28	447	17	0	0
Vandalia	0	0	0	105	3784	0	1158	0
Vermillion	0	0	0	0	0	37	0	0
Wee-Ma-Tuk	5	0	0	0	32	5	0	0
Whoopie Cat	0	0	0	0	3	0	639	0
Wildwood	0	0	0	0	22	0	0	0

Appendix 2 (continued)

	Amphipleura	Arthrodesmus	Basichlamys	Bernardinium	Coelastrum	Ceracium	Chlorella	Chlorococcus
Applecanyon	0	0	0	0	0	121	0	0
Argyle	0	0	0	0	0	44	0	0
Baldwin	0	0	0	0	0	0	0	0
Battery Park	0	0	0	0	0	99	0	0
Bracken	0	0	0	0	0	62	0	0
Busse	0	0	0	0	0	0	0	0
Cedar	0	0	0	0	0	3	0	0
Centralia	0	0	0	0	0	28	0	0
Coffeen	0	0	0	0	0	2	0	0
CSCR	0	0	0	0	0	216	0	0
Decatur	0	0	0	0	0	34	0	0
DePue	0	14	14	0	0	0	0	0
Evergreen	0	0	0	5	0	83	0	0
Forbes	0	5	0	0	0	67	0	0
Gages	0	0	14	0	5	5	0	0
Galena	0	0	0	0	0	34	0	0
Gov Bond	0	0	0	0	0	0	0	0
Highland Silver	0	0	0	0	0	46	0	0
Holiday	0	0	0	0	0	22	0	0
Holton	0	21	0	0	0	0	28	0
Horseshoe	0	0	0	0	0	0	0	0
Iroquois	0	0	0	0	0	563	0	0
Kinkaid	2	2	0	0	0	4	0	0

Appendix 2 (continued)

	Amphipleura	Arthrodesmus	Basichlamys	Bernardinium	Coelastrum	Ceracium	Chlorella	Chlorococcus
Lake 1060	0	0	0	0	0	0	0	14
Lancelot	0	0	0	0	0	29	0	18
Long	0	0	0	0	0	1397	0	0
Loon	0	0	0	0	0	3	0	0
LotW	0	33	0	0	0	143	55	0
Lou Yeager	0	0	0	0	0	0	0	0
Mattoon	0	0	14	0	0	0	0	0
Mauvaise Terre	0	0	0	0	0	41	0	0
MD Borah	0	0	11	0	0	39	0	0
Meredosia	0	0	0	0	0	248	0	0
Mill Creek	0	0	2	0	0	2	0	0
Mutton	0	0	28	0	41	0	0	0
Pana	0	0	14	0	0	145	0	0
Powderhorn	0	22	33	0	0	0	0	0
Rend	0	0	0	0	0	0	0	0
Sangchris	0	0	0	0	0	0	0	0
Shabbona	0	0	0	0	0	74	0	0
Slocum	0	0	124	0	0	0	0	0
Storey	0	0	0	0	0	28	0	0
Sugar Creek	0	0	11	0	0	0	0	0
Vandalia	0	0	0	0	0	77	0	0
Vermillion	0	0	0	0	0	1425	0	0
Wee-Ma-Tuk	0	0	0	0	0	87	0	0
Whoopie Cat	0	0	0	0	0	0	0	0
Wildwood	0	2	0	0	0	39	0	0

Appendix 2 (continued)

	Chlorogonium	Chlorosarcina	Chroococcus	Chroomonas	Chlamydomonas	Closterium	Cocconeis	Cosmarium
Applecanyon	0	0	0	0	0	11	0	0
Argyle	0	0	0	0	0	0	0	0
Baldwin	0	0	0	0	0	0	0	0
Battery Park	1395	0	0	0	0	0	0	0
Bracken	0	0	0	0	76	0	0	0
Busse	0	0	0	5984	0	14	0	0
Cedar	0	0	0	0	0	0	0	0
Centralia	0	0	0	0	0	18	0	0
Coffeen	0	0	0	0	0	0	0	0
CSCR	0	0	0	0	64	32	0	0
Decatur	0	0	41	0	0	0	0	0
DePue	0	0	0	0	0	0	0	0
Evergreen	0	0	0	0	0	0	0	0
Forbes	0	0	0	2	0	0	5	0
Gages	0	0	5	0	0	0	0	0
Galena	0	0	0	0	28	0	7	0
Gov Bond	0	0	0	0	0	21	0	0
Highland Silver	0	0	0	0	0	0	0	0
Holiday	0	0	0	0	44	0	0	0
Holton	0	0	0	0	14	0	0	0
Horseshoe	0	0	0	0	0	0	0	0
Iroquois	0	0	0	0	0	0	0	0
Kinkaid	0	0	0	0	0	0	4	0

Appendix 2 (continued)

	Chlorogonium	Chlorosarcina	Chroococcus	Chroomonas	Chlamydomonas	Closterium	Cocconeis	Cosmarium
Lake 1060	0	0	0	0	0	0	0	0
Lancelot	498	0	0	0	6	0	0	0
Long	0	0	0	0	0	0	0	0
Loon	0	0	0	0	0	0	2	0
LotW	0	0	0	0	0	0	0	0
Lou Yeager	0	0	0	0	0	22	0	0
Mattoon	0	0	0	0	0	0	0	0
Mauvaise Terre	0	0	0	0	0	124	0	0
MD Borah	0	0	0	63	0	0	3	0
Meredosia	0	0	0	0	786	0	0	0
Mill Creek	0	0	0	2	0	0	0	0
Mutton	0	0	0	2427	0	0	0	0
Pana	0	0	0	0	0	0	0	0
Powderhorn	0	0	0	0	0	0	6	0
Rend	0	0	0	0	127	0	0	0
Sangchris	0	3	0	0	0	0	0	0
Shabbona	0	0	0	0	0	0	0	37
Slocum	0	0	0	400	0	0	0	0
Storey	0	0	0	0	0	0	0	0
Sugar Creek	6	0	0	0	0	0	0	6
Vandalia	0	0	0	0	0	0	0	0
Vermillion	0	0	0	0	18	0	0	0
Wee-Ma-Tuk	0	0	0	0	0	0	0	0
Whoopie Cat	0	0	0	2	0	0	0	0
Wildwood	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Crucigenia	Cryptomonas	Ctenophora	Cyclotella	Cylindrospermum	Cymbella	Dinobryon	Diploneis
Applecanyon	0	0	0	0	0	0	0	8
Argyle	0	1748	0	734	0	0	0	0
Baldwin	110	0	0	14	0	0	0	0
Battery Park	143	243	0	210	0	0	0	0
Bracken	0	338	0	21	0	0	0	0
Busse	28	28	0	2896	0	0	0	0
Cedar	0	3	0	45	0	0	0	0
Centralia	138	156	0	294	0	0	0	0
Coffeen	7	0	0	13	0	0	0	0
CSCR	0	0	0	0	0	0	0	0
Decatur	0	200	0	172	0	0	0	0
DePue	0	138	0	2468	0	0	0	0
Evergreen	14	381	0	41	0	0	0	0
Forbes	5	64	0	347	0	0	0	0
Gages	83	0	0	133	0	0	0	0
Galena	0	0	0	0	0	0	0	0
Gov Bond	34	296	0	34	7	0	0	0
Highland Silver	14	0	0	786	0	0	0	0
Holiday	0	0	0	11	0	0	0	0
Holton	93	0	0	62	0	0	0	0
Horseshoe	18	101	0	1250	0	0	0	0
Iroquois	61	243	22	0	0	0	0	0
Kinkaid	0	2	0	382	0	0	0	0

Appendix 2 (continued)

	Crucigenia	Cryptomonas	Ctenophora	Cyclotella	Cylindrospermum	Cymbella	Dinobryon	Diploneis
Lake 1060	165	5598	0	0	0	0	0	0
Lancelot	0	0	0	4	0	0	0	0
Long	0	5	0	9	0	0	0	0
Loon	0	5	0	739	0	5	0	0
LotW	0	541	0	188	0	0	0	0
Lou Yeager	14	39	0	673	0	0	0	0
Mattoon	14	234	0	55	14	0	0	0
Mauvaise Terre	138	331	0	1406	0	0	0	0
MD Borah	47	0	0	30	0	0	0	0
Meredosia	0	1282	0	4798	0	0	0	0
Mill Creek	0	53	0	179	0	0	0	0
Mutton	538	221	0	786	0	0	0	0
Pana	0	0	0	552	0	0	0	0
Powderhorn	127	314	0	0	0	0	44	0
Rend	0	0	0	149	0	0	0	0
Sangchris	21	0	0	7	0	0	0	3
Shabbona	28	1448	0	41	0	0	0	0
Slocum	0	28	0	703	0	0	0	0
Storey	0	1053	0	60	0	0	0	0
Sugar Creek	44	33	0	441	0	0	0	0
Vandalia	0	171	0	430	0	0	0	0
Vermillion	9	0	0	83	0	0	0	0
Wee-Ma-Tuk	0	0	0	2652	0	0	0	0
Whoopie Cat	29	16	0	67	0	12	0	0
Wildwood	6	57	0	45	0	0	0	0

Appendix 2 (continued)

	Dispora	Excentrosphaera	Epithemia	Euastrum	Eucocconeis	Eudorina	Euglena	Eunotia
Applecanyon	0	0	0	0	0	0	3	0
Argyle	0	0	0	22	0	11	6	0
Baldwin	0	0	0	0	0	0	14	0
Battery Park	0	0	0	0	0	0	77	0
Bracken	0	0	0	0	0	0	97	0
Busse	0	0	0	0	0	0	427	0
Cedar	0	0	0	0	2	0	16	0
Centralia	0	0	0	0	0	0	0	0
Coffeen	0	0	0	0	0	0	33	0
CSCR	5	0	0	0	0	0	198	0
Decatur	0	0	0	0	0	0	228	0
DePue	0	0	0	0	0	0	400	0
Evergreen	0	0	0	0	0	336	9	0
Forbes	0	0	0	0	0	0	2	0
Gages	0	0	0	0	0	0	0	0
Galena	0	0	0	0	0	0	0	0
Gov Bond	0	0	0	0	0	0	0	0
Highland Silver	0	0	0	0	0	0	9	0
Holiday	0	0	0	0	0	0	33	0
Holton	0	0	0	0	0	0	31	0
Horseshoe	0	0	0	0	0	0	147	0
Iroquois	0	0	0	0	0	0	171	0
Kinkaid	0	0	0	2	0	0	0	14

Appendix 2 (continued)

	Dispora	Excentrosphaera	Epithemia	Euastrum	Eucocconeis	Eudorina	Euglena	Eunotia
Lake 1060	0	97	0	0	0	41	2316	0
Lancelot	0	0	0	0	0	0	0	0
Long	0	0	0	0	0	0	0	0
Loon	0	0	2	0	0	2	2	5
LotW	0	0	0	0	0	0	77	0
Lou Yeager	0	0	0	0	0	0	3	0
Mattoon	0	0	0	0	0	0	0	0
Mauvaise Terre	0	0	0	0	0	0	234	0
MD Borah	0	0	11	0	0	28	0	3
Meredosia	0	0	0	0	0	0	3930	0
Mill Creek	0	0	0	0	0	6	6	0
Mutton	0	0	0	0	0	0	14	0
Pana	0	0	0	0	0	0	0	0
Powderhorn	0	0	0	0	0	0	33	0
Rend	0	0	0	0	0	0	11	0
Sangchris	0	0	0	0	0	0	28	0
Shabbona	0	0	0	0	0	0	32	0
Slocum	0	0	0	0	0	0	0	0
Storey	0	0	0	0	0	5	5	0
Sugar Creek	0	0	0	0	0	0	0	0
Vandalia	0	0	0	0	0	0	0	0
Vermillion	0	0	0	0	0	18	1903	0
Wee-Ma-Tuk	0	0	0	0	0	170	142	0
Whoopie Cat	0	0	0	0	0	0	3	0
Wildwood	0	0	0	0	0	14	12	0

Appendix 2 (continued)

	Fottea	Fragilaria	Frustulia	Gleocapsopsis	Gleocapsa	Gonium	Gomphosphaeria	Gonphonema
Applecanyon	0	30	0	0	25	0	0	0
Argyle	0	121	0	0	0	17	0	0
Baldwin	0	496	0	0	97	0	0	0
Battery Park	0	314	0	0	0	0	0	0
Bracken	0	0	0	0	0	7	0	0
Busse	0	248	0	0	0	14	0	0
Cedar	0	109	0	0	0	2	0	2
Centralia	0	0	0	0	0	0	0	46
Coffeen	0	366	0	0	0	0	0	4
CSCR	0	0	0	0	23	0	0	0
Decatur	0	0	0	0	172	55	0	0
DePue	0	0	0	0	0	0	0	0
Evergreen	0	9	0	0	55	78	0	0
Forbes	0	117	0	0	0	2	0	7
Gages	14	5	0	0	0	83	0	0
Galena	0	0	0	0	28	0	0	0
Gov Bond	0	55	0	0	0	0	0	0
Highland Silver	0	469	0	0	0	0	0	0
Holiday	0	11	0	0	0	44	0	0
Holton	0	417	0	0	0	0	0	14
Horseshoe	0	1039	0	0	0	9	0	0
Iroquois	0	0	0	0	0	0	0	0
Kinkaid	0	295	0	0	0	0	0	6

Appendix 2 (continued)

	Fottea	Fragilaria	Frustulia	Gleocapsopsis	Gleocapsa	Gonium	Gomphosphaeria	Gonphonema
Lake 1060	0	0	0	0	0	0	41	0
Lancelot	0	0	0	0	29	17	0	2
Long	0	0	0	0	0	0	0	0
Loon	0	112	0	0	0	12	0	19
LotW	0	0	0	0	0	0	0	110
Lou Yeager	0	83	0	0	0	0	0	0
Mattoon	0	28	0	0	0	14	0	0
Mauvaise Terre	0	55	0	0	0	0	0	0
MD Borah	0	28	0	0	0	8	0	14
Meredosia	0	41	0	0	0	0	0	0
Mill Creek	0	6	0	0	0	0	0	12
Mutton	0	1007	0	0	0	0	0	14
Pana	0	21	0	0	76	0	0	28
Powderhorn	0	28	0	72	61	11	0	0
Rend	0	0	0	0	0	6	0	0
Sangchris	0	779	3	0	0	0	0	3
Shabbona	0	9	0	0	0	0	0	0
Slocum	0	41	0	0	41	0	0	0
Storey	0	32	0	0	0	0	0	23
Sugar Creek	0	154	0	0	6	77	0	0
Vandalia	0	706	0	0	0	0	0	0
Vermillion	0	0	0	0	64	0	0	0
Wee-Ma-Tuk	0	55	0	0	0	230	0	0
Whoopie Cat	0	0	0	0	9	2	0	28
Wildwood	0	8	0	0	191	47	0	6

Appendix 2 (continued)

	Gyrosigma	Haematococcus	Hantzschia	Homeothrix	Hydrosera	Keratococcus	Lauterbourniell	Leptolyngbia
Applecanyon	0	0	0	0	0	0	0	0
Argyle	0	0	0	0	0	0	0	0
Baldwin	0	0	0	0	0	0	0	0
Battery Park	0	0	0	0	0	0	0	0
Bracken	0	0	0	0	0	0	0	90
Busse	0	0	0	0	0	0	0	538
Cedar	0	0	3	0	0	0	0	165
Centralia	0	0	0	0	0	0	0	0
Coffeen	0	0	0	0	0	0	0	0
CSCR	0	0	0	0	0	0	0	0
Decatur	0	0	0	0	0	0	0	110
DePue	0	0	0	0	0	0	0	0
Evergreen	0	0	0	0	0	0	0	0
Forbes	0	0	0	0	0	0	0	16
Gages	0	0	0	0	0	0	0	0
Galena	0	0	0	0	0	0	0	1248
Gov Bond	0	0	0	0	0	0	0	55
Highland Silver	0	0	0	0	0	0	0	0
Holiday	0	0	0	0	0	0	0	4236
Holton	0	0	0	0	0	0	10	0
Horseshoe	0	0	0	0	0	0	0	0
Iroquois	0	0	0	0	0	0	0	0
Kinkaid	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Gyrosigma	Haematococcus	Hantzschia	Homeothrix	Hydrosera	Keratococcus	Lauterbourniell	Leptolyngbia
Lake 1060	0	0	0	0	0	0	0	1848
Lancelot	0	0	0	0	0	0	0	0
Long	0	0	0	0	0	0	0	2220
Loon	0	0	0	0	0	0	0	0
LotW	0	0	0	0	0	0	0	0
Lou Yeager	8	0	0	0	3	0	0	19
Mattoon	0	0	0	0	0	0	0	1737
Mauvaise Terre	0	0	0	0	0	0	0	0
MD Borah	0	0	0	0	0	0	0	0
Meredosia	0	0	0	0	0	0	0	0
Mill Creek	0	0	0	0	0	0	0	565
Mutton	0	0	0	0	0	372	0	0
Pana	0	0	0	0	0	0	0	48
Powderhorn	0	0	0	0	0	0	0	0
Rend	0	0	0	33	0	0	0	0
Sangchris	0	3	0	0	0	0	0	0
Shabbona	0	0	0	0	0	0	0	0
Slocum	0	14	0	0	0	0	0	0
Storey	0	0	0	0	0	0	0	1737
Sugar Creek	0	0	0	0	0	0	0	33
Vandalia	0	0	0	0	0	17	0	3320
Vermillion	0	0	0	0	0	0	0	28
Wee-Ma-Tuk	0	0	0	0	0	0	0	579
Whoopie Cat	0	0	0	0	0	0	0	0
Wildwood	0	0	0	0	0	0	0	102

Appendix 2 (continued)

	Leibleinia	Limnothrix	Lobomonas	Lyngbia	Melosira	Merismopedia	Microcystis	Microspora
Applecanyon	0	772	0	0	3	17	0	0
Argyle	0	0	0	0	0	0	0	0
Baldwin	0	0	0	0	0	110	0	0
Battery Park	0	0	0	0	22	50	0	22
Bracken	0	0	0	0	0	0	0	0
Busse	0	97	0	0	0	0	0	0
Cedar	2	0	0	0	3	0	0	0
Centralia	0	0	0	0	754	0	0	0
Coffeen	0	0	0	0	0	0	0	0
CSCR	0	735	0	0	0	0	0	0
Decatur	0	0	0	0	0	0	0	28
DePue	0	0	0	28	193	28	0	0
Evergreen	0	0	0	0	0	0	0	161
Forbes	0	0	0	0	21	0	0	0
Gages	0	0	0	0	0	32	988	0
Galena	0	0	0	0	0	0	0	0
Gov Bond	0	0	0	0	21	0	0	0
Highland Silver	0	0	0	0	23	0	0	0
Holiday	0	0	0	0	33	0	11	0
Holton	0	0	0	0	172	0	0	0
Horseshoe	0	0	0	0	74	0	0	0
Iroquois	0	0	0	0	0	0	0	0
Kinkaid	8	0	0	0	4	2	0	0

Appendix 2 (continued)

	Leibleinia	Limnothrix	Lobomonas	Lyngbia	Melosira	Merismopedia	Microcystis	Microspora
Lake 1060	0	0	0	0	0	55	248	0
Lancelot	0	0	0	85	0	0	0	0
Long	0	0	5	0	0	0	0	0
Loon	0	0	0	0	2	0	0	0
LotW	0	0	0	0	33	0	0	0
Lou Yeager	0	0	0	0	8	8	0	0
Mattoon	0	0	0	0	0	0	0	0
Mauvaise Terre	0	0	0	0	965	0	0	0
MD Borah	0	0	0	0	0	0	22	0
Meredosia	0	0	0	0	0	0	0	0
Mill Creek	2	0	0	0	2	0	0	0
Mutton	0	0	0	0	41	14	427	0
Pana	0	0	0	0	0	0	76	0
Powderhorn	0	0	0	0	0	11	877	0
Rend	0	0	0	138	0	6	0	0
Sangchris	0	0	0	0	31	24	0	0
Shabbona	0	0	0	0	0	0	0	0
Slocum	0	0	0	0	69	0	0	41
Storey	0	0	0	0	0	0	0	198
Sugar Creek	0	0	0	0	39	0	44	0
Vandalia	0	0	0	0	17	0	0	0
Vermillion	0	0	0	0	0	0	0	0
Wee-Ma-Tuk	0	0	0	0	0	0	69	0
Whoopie Cat	0	0	0	0	0	0	0	0
Wildwood	0	0	0	0	0	0	0	22

Appendix 2 (continued)

	Monoraphidium	Navicula	Naviculla	Nephrocytium	Nitzschia	Ochromonas	Oedogonium	Oscilatoria
Applecanyon	0	0	0	0	0	0	0	0
Argyle	0	0	0	0	0	0	0	0
Baldwin	0	0	0	0	28	0	0	0
Battery Park	0	0	0	0	0	0	0	0
Bracken	0	0	0	0	0	0	0	0
Busse	14	14	0	0	41	0	0	0
Cedar	0	0	0	0	2	0	0	0
Centralia	0	0	0	0	9	0	0	0
Coffeen	0	2	0	0	0	0	0	0
CSCR	0	0	0	0	0	0	0	0
Decatur	0	0	0	0	0	0	0	0
DePue	0	0	0	0	0	0	0	0
Evergreen	0	0	0	0	0	0	0	0
Forbes	0	0	0	0	2	0	0	0
Gages	0	0	0	0	0	0	0	5
Galena	0	0	0	0	0	0	0	0
Gov Bond	228	7	0	0	0	0	0	0
Highland Silver	0	0	0	0	0	0	0	0
Holiday	0	0	0	11	0	0	0	0
Holton	0	0	0	0	0	0	0	3
Horseshoe	0	0	0	0	28	0	0	0
Iroquois	0	39	0	0	0	0	0	0
Kinkaid	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Monoraphidium	Navicula	Naviculla	Nephrocytium	Nitzschia	Ochromonas	Oedogonium	Oscilatoria
Lake 1060	0	0	0	83	0	0	0	0
Lancelot	0	0	0	0	0	0	2	0
Long	0	0	0	0	0	28	0	0
Loon	0	2	0	0	0	16	0	0
LotW	0	0	0	0	0	0	0	0
Lou Yeager	0	0	0	0	0	0	0	0
Mattoon	193	0	0	0	0	0	0	0
Mauvaise Terre	0	0	0	0	0	0	0	0
MD Borah	61	17	0	22	0	0	0	0
Meredosia	0	0	0	0	0	0	0	0
Mill Creek	0	4	0	0	6	0	0	0
Mutton	0	0	0	0	0	0	0	0
Pana	21	62	0	0	0	0	0	0
Powderhorn	0	0	0	0	0	0	0	0
Rend	0	0	0	0	11	0	0	33
Sangchris	0	0	0	0	0	0	0	0
Shabbona	0	0	0	0	0	0	0	5
Slocum	97	0	0	0	0	0	0	0
Storey	0	0	0	0	0	175	0	0
Sugar Creek	0	0	0	0	0	0	0	22
Vandalia	0	0	0	0	44	0	0	0
Vermillion	0	0	0	0	0	0	0	0
Wee-Ma-Tuk	0	0	0	0	0	0	0	0
Whoopie Cat	0	0	0	0	0	0	0	0
Wildwood	0	0	0	0	2	0	0	0

Appendix 2 (continued)

	Pascherina	Pediastrum	Peridenium	Peridiniopsis	Phacus	Pinnularia	Plagioselmis	Planktolyngbia
Applecanyon	0	0	0	0	6	0	0	0
Argyle	0	0	0	0	6	0	0	0
Baldwin	0	0	0	0	0	0	0	0
Battery Park	0	0	0	0	11	0	0	0
Bracken	0	0	7	7	0	0	0	0
Busse	0	0	41	0	138	0	0	14
Cedar	0	0	0	0	9	2	0	0
Centralia	0	0	0	0	0	0	0	0
Coffeen	0	0	0	0	0	0	0	0
CSCR	0	9	0	0	0	0	0	0
Decatur	0	14	41	0	103	0	0	0
DePue	0	0	0	0	55	0	0	0
Evergreen	18	0	0	0	0	0	0	0
Forbes	0	5	2	0	2	0	9	0
Gages	0	0	0	0	0	0	0	0
Galena	0	7	0	0	0	0	0	0
Gov Bond	0	0	0	0	0	0	0	0
Highland Silver	0	0	0	0	0	0	0	0
Holiday	0	33	0	0	0	0	0	0
Holton	0	0	0	0	17	0	0	0
Horseshoe	0	0	0	0	28	0	0	0
Iroquois	0	0	0	0	0	0	0	0
Kinkaid	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Pascherina	Pediastrum	Peridenium	Peridiniopsis	Phacus	Pinnularia	Plagioselmis	Planktolyngbia
Lake 1060	0	0	0	0	165	0	0	0
Lancelot	0	0	0	0	28	0	0	0
Long	0	0	0	0	0	0	0	0
Loon	0	0	0	0	0	0	0	0
LotW	0	33	0	0	0	0	0	0
Lou Yeager	0	19	0	0	0	0	0	0
Mattoon	0	0	0	0	0	0	0	0
Mauvaise Terre	0	0	0	0	0	0	0	0
MD Borah	0	0	0	0	0	0	0	0
Meredosia	0	0	0	0	0	0	0	0
Mill Creek	0	0	2	0	4	0	0	0
Mutton	0	0	0	0	0	0	0	0
Pana	0	21	0	0	0	0	0	0
Powderhorn	0	0	0	0	22	0	0	0
Rend	0	0	0	0	17	0	0	0
Sangchris	0	3	0	0	10	0	0	0
Shabbona	0	0	0	18	18	0	0	0
Slocum	0	0	0	0	0	0	0	0
Storey	0	0	0	0	5	0	0	0
Sugar Creek	0	28	0	0	0	0	0	0
Vandalia	0	0	0	0	0	0	0	0
Vermillion	0	18	0	0	478	0	0	0
Wee-Ma-Tuk	0	0	0	0	0	0	0	0
Whoopie Cat	0	0	0	0	0	0	0	0
Wildwood	0	4	0	0	0	0	0	0

Appendix 2 (continued)

	Planktothrix	Pleodorina	Pleurosigma	Pseudanabaena	Quadrigulla	Rhaphidiopsis	Rhisosolenium	Rhizoclonium
Applecanyon	0	0	0	0	0	0	0	0
Argyle	0	11	0	0	0	0	0	11
Baldwin	0	0	0	0	0	0	0	0
Battery Park	0	0	0	0	0	0	0	0
Bracken	0	0	0	0	0	0	0	0
Busse	0	0	0	0	0	165	0	0
Cedar	0	0	0	0	0	0	0	0
Centralia	0	0	0	0	0	0	0	0
Coffeen	0	0	0	0	0	0	0	0
CSCR	0	0	0	0	0	0	0	0
Decatur	0	0	0	0	0	0	0	0
DePue	0	0	0	0	0	0	0	0
Evergreen	0	60	0	0	0	0	0	0
Forbes	0	0	5	0	0	0	0	0
Gages	0	0	0	0	0	0	0	0
Galena	0	0	0	0	0	0	0	0
Gov Bond	0	0	0	0	0	0	0	0
Highland Silver	0	0	0	0	0	0	0	0
Holiday	0	0	0	0	0	0	0	0
Holton	0	0	0	0	0	0	0	14
Horseshoe	0	0	0	0	0	0	0	0
Iroquois	0	0	0	0	0	0	0	0
Kinkaid	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Planktothrix	Pleodorina	Pleurosigma	Pseudanabaena	Quadrigulla	Rhaphidiopsis	Rhisosolenium	Rhizoclonium
Lake 1060	0	0	0	5212	0	2606	0	0
Lancelot	0	0	0	0	0	0	0	0
Long	0	0	0	0	0	0	0	0
Loon	0	0	0	0	0	0	0	0
LotW	0	0	0	0	0	0	0	0
Lou Yeager	0	0	0	0	0	0	0	0
Mattoon	14	0	0	0	0	0	0	0
Mauvaise Terre	0	0	0	0	0	0	0	0
MD Borah	0	0	0	0	0	0	0	0
Meredosia	0	0	0	0	0	0	0	0
Mill Creek	0	0	0	0	0	0	0	0
Mutton	0	0	0	0	14	0	0	0
Pana	0	0	0	0	0	0	0	0
Powderhorn	0	0	0	0	0	0	0	0
Rend	0	0	0	0	0	0	0	0
Sangchris	0	0	0	0	0	0	0	0
Shabbona	0	0	0	0	0	0	0	0
Slocum	0	0	0	0	0	0	0	0
Storey	0	0	0	0	0	0	0	0
Sugar Creek	0	0	0	0	0	0	0	0
Vandalia	0	0	0	0	0	0	0	0
Vermillion	0	0	0	0	0	0	0	0
Wee-Ma-Tuk	0	0	0	0	0	0	0	0
Whoopie Cat	0	0	0	0	12	0	0	0
Wildwood	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Rhizosolenia	Rhopalodia	Roicosphenia	Scenedsemus	Selenastrum	Snowella	Spaerocystis	Spirulina
Applecanyon	0	0	0	0	0	0	0	3
Argyle	11	0	0	0	0	0	0	0
Baldwin	0	0	0	393	0	0	0	0
Battery Park	0	0	0	50	83	0	0	0
Bracken	0	0	0	0	0	0	0	0
Busse	0	0	0	152	0	0	0	0
Cedar	0	0	0	0	0	0	0	0
Centralia	0	0	0	0	0	0	0	0
Coffeen	0	0	0	35	0	0	0	0
CSCR	0	0	0	41	0	0	0	0
Decatur	0	0	0	62	0	0	0	0
DePue	0	0	0	662	41	0	0	0
Evergreen	0	0	0	0	0	23	0	0
Forbes	0	0	0	18	0	0	0	0
Gages	0	0	0	9	0	0	0	0
Galena	0	0	0	0	0	0	0	0
Gov Bond	0	0	0	28	0	0	0	21
Highland Silver	0	0	0	5	0	0	0	0
Holiday	0	0	0	0	0	0	0	0
Holton	0	0	0	279	0	0	0	0
Horseshoe	0	0	0	37	18	0	0	0
Iroquois	0	0	0	0	0	0	0	0
Kinkaid	0	0	0	6	0	0	0	0

Appendix 2 (continued)

	Rhizosolenia	Rhopalodia	Roicosphenia	Scenedsemus	Selenastrum	Snowella	Spaerocystis	Spirulina
Lake 1060	0	0	0	276	441	0	0	0
Lancelot	0	0	4	0	0	0	63	0
Long	0	0	0	0	0	0	0	0
Loon	0	0	0	0	0	0	0	0
LotW	0	0	0	33	0	0	0	0
Lou Yeager	14	0	0	28	0	0	0	0
Mattoon	0	0	0	97	14	0	0	0
Mauvaise Terre	0	0	0	207	0	0	0	0
MD Borah	0	0	0	55	0	0	0	0
Meredosia	0	0	0	41	0	0	0	0
Mill Creek	0	0	0	10	0	0	0	0
Mutton	0	0	0	2937	565	0	0	0
Pana	0	0	0	0	0	0	0	0
Powderhorn	0	0	0	6	0	22	0	0
Rend	0	0	0	0	0	0	0	6
Sangchris	0	0	0	34	0	0	0	0
Shabbona	0	0	0	165	0	0	0	0
Slocum	0	0	0	234	69	0	0	0
Storey	0	0	0	0	9	0	0	0
Sugar Creek	0	0	0	276	0	0	0	6
Vandalia	0	0	0	0	0	0	0	0
Vermillion	0	0	0	9	0	0	0	0
Wee-Ma-Tuk	0	0	0	28	0	0	0	0
Whoopie Cat	0	2	0	3	0	0	0	0
Wildwood	0	0	0	0	0	0	2	0

Appendix 2 (continued)

	Staurastrum	Stephanodiskus	Strombomonas	Surirella	Synedra	Synura	Tetrabaena	Tetraedriella
Applecanyon	0	0	0	0	0	0	0	0
Argyle	0	0	0	0	0	0	0	0
Baldwin	0	0	0	0	21	0	0	0
Battery Park	6	6	0	0	116	0	11	0
Bracken	0	0	0	0	0	0	0	0
Busse	0	0	0	0	0	0	0	0
Cedar	0	0	0	0	22	0	0	0
Centralia	37	0	0	0	0	0	0	0
Coffeen	0	0	0	0	13	0	0	0
CSCR	0	0	0	0	0	0	0	5
Decatur	0	862	0	0	0	0	7	0
DePue	0	0	55	0	0	0	14	0
Evergreen	0	0	0	0	0	0	0	0
Forbes	2	0	0	0	5	0	0	0
Gages	0	0	0	0	5	0	18	0
Galena	0	0	0	0	21	0	0	0
Gov Bond	0	0	0	0	0	0	0	0
Highland Silver	0	0	0	0	0	0	0	0
Holiday	0	11	0	0	0	0	0	0
Holton	0	0	0	0	3	0	0	0
Horseshoe	9	175	0	0	28	0	9	0
Iroquois	0	149	28	0	0	0	0	0
Kinkaid	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Staurastrum	Stephanodiskus	Strombomonas	Surirella	Synedra	Synura	Tetrabaena	Tetraedriella
Lake 1060	0	0	0	0	0	0	207	0
Lancelot	0	0	0	0	2	0	0	0
Long	0	0	0	0	0	0	0	0
Loon	0	0	0	0	10	0	3	0
LotW	44	0	0	0	33	0	0	0
Lou Yeager	0	0	0	0	8	0	0	0
Mattoon	0	0	0	0	0	0	0	0
Mauvaise Terre	0	0	0	0	0	0	0	0
MD Borah	6	0	0	0	0	0	8	0
Meredosia	0	0	0	0	0	0	0	0
Mill Creek	0	0	0	0	4	0	0	0
Mutton	345	14	0	0	28	0	83	0
Pana	55	0	0	0	7	0	0	0
Powderhorn	17	0	0	0	39	116	44	0
Rend	0	17	0	0	88	0	0	0
Sangchris	0	10	0	0	3	0	0	0
Shabbona	9	0	0	0	0	0	0	0
Slocum	0	14	0	0	28	0	0	0
Storey	0	0	0	0	0	0	0	0
Sugar Creek	6	110	0	0	0	0	22	0
Vandalia	0	0	0	0	0	0	0	0
Vermillion	0	0	0	0	0	0	0	0
Wee-Ma-Tuk	0	0	0	0	0	0	0	0
Whoopie Cat	0	0	0	9	5	0	0	0
Wildwood	0	0	0	0	0	0	0	0

Appendix 2 (continued)

	Tetraedron	Tetraspora	Tetrastrum	Trachelomonas	Trebouxia	Treubaria	Tribonema	Trichocoleus
Applecanyon	0	0	0	41	0	0	0	0
Argyle	0	0	0	50	0	0	0	0
Baldwin	0	772	0	0	0	0	0	0
Battery Park	0	61	0	6	0	0	0	0
Bracken	0	0	0	28	0	0	0	18270
Busse	0	0	14	179	0	0	0	0
Cedar	0	0	0	33	0	0	0	0
Centralia	0	0	9	101	0	0	0	0
Coffeen	0	0	0	4	2	0	0	0
CSCR	0	0	0	51	0	0	0	0
Decatur	0	0	0	496	0	0	0	0
DePue	0	0	0	359	0	0	0	0
Evergreen	0	37	0	55	0	0	0	0
Forbes	0	0	0	55	0	0	0	0
Gages	0	18	0	0	0	0	0	0
Galena	0	0	0	0	0	0	0	0
Gov Bond	0	7	0	172	0	0	0	0
Highland Silver	0	0	0	285	0	0	0	0
Holiday	0	0	0	0	0	0	0	0
Holton	0	0	0	93	0	0	0	0
Horseshoe	0	0	0	239	0	0	0	0
Iroquois	0	0	0	474	0	0	0	0
Kinkaid	0	0	0	8	0	0	0	0

Appendix 2 (continued)

	Tetraedron	Tetraspora	Tetrastrum	Trachelomonas	Trebouxia	Treubaria	Tribonema	Trichocoleus
Lake 1060	55	0	0	4647	0	0	0	0
Lancelot	0	33	0	0	0	0	0	0
Long	0	0	0	0	0	0	0	0
Loon	0	0	0	0	0	0	0	0
LotW	0	0	0	265	0	0	0	0
Lou Yeager	0	0	0	58	0	0	0	0
Mattoon	0	28	0	303	0	0	0	0
Mauvaise Terre	0	0	0	234	0	0	620	0
MD Borah	0	0	0	130	0	0	0	0
Meredosia	0	0	0	1861	372	0	0	0
Mill Creek	0	4	0	43	0	0	0	0
Mutton	14	69	0	0	0	14	0	0
Pana	0	0	0	352	0	0	0	0
Powderhorn	0	77	0	0	0	0	0	0
Rend	0	0	0	171	0	0	0	0
Sangchris	0	0	0	21	0	0	0	0
Shabbona	0	0	0	46	0	0	0	0
Slocum	0	83	0	0	0	0	0	0
Storey	0	9	0	51	0	0	0	0
Sugar Creek	0	0	0	176	0	17	0	0
Vandalia	0	0	0	121	0	0	0	0
Vermillion	0	28	0	156	0	0	0	0
Wee-Ma-Tuk	0	14	0	427	0	0	0	0
Whoopie Cat	0	7	0	53	0	0	0	0
Wildwood	0	6	0	0	0	0	0	0

Appendix 2 (continued)

	Ulothrix	Woronichinia
Applecanyon	0	0
Argyle	0	0
Baldwin	0	0
Battery Park	0	0
Bracken	0	0
Busse	0	83
Cedar	0	0
Centralia	0	0
Coffeen	0	0
CSCR	0	0
Decatur	0	0
DePue	0	14
Evergreen	0	0
Forbes	0	0
Gages	0	0
Galena	0	0
Gov Bond	0	0
Highland Silver	0	0
Holiday	0	0
Holton	0	0
Horseshoe	0	0
Iroquois	0	0
Kinkaid	0	0

Appendix 2 (continued)

	Ulothrix	Woronichinia
Lake 1060	0	0
Lancelot	0	0
Long	0	0
Loon	2	0
LotW	0	0
Lou Yeager	0	0
Mattoon	0	0
Mauvaise Terre	69	0
MD Borah	0	0
Meredosia	0	0
Mill Creek	0	0
Mutton	0	55
Pana	0	0
Powderhorn	0	0
Rend	0	0
Sangchris	0	0
Shabbona	0	0
Slocum	0	248
Storey	0	0
Sugar Creek	0	0
Vandalia	0	0
Vermillion	0	0
Wee-Ma-Tuk	0	0
Whoopie Cat	0	0
Wildwood	0	0

Appendix 3: Higher taxa groupings (based on abundance data) for all lakes

	Baci (raphid)	Baci (araphid)	Cyano (cocc)	Cyano (fil)	Cryptomonas	Dinoflagellate	Euglenoid	Green
Applecanyon	8	33	41	1059	0	121	50	0
Argyle	11	855	0	6	1748	44	61	39
Baldwin	48	531	207	400	0	0	14	1303
Battery Park	0	673	132	61	243	99	94	1748
Bracken	0	21	0	18373	338	76	124	83
Busse	55	3144	83	896	6012	41	745	317
Cedar	12	186	0	221	3	3	57	2
Centralia	55	1066	0	2510	156	28	101	276
Coffeen	7	392	0	33	0	2	37	88
CSCR	0	142	23	735	0	216	248	120
Decatur	0	1248	214	138	200	76	827	138
DePue	0	2661	41	41	138	0	869	731
Evergreen	0	60	78	0	381	87	64	639
Forbes	23	533	0	48	76	69	60	34
Gages	5	142	1025	9	0	5	0	253
Galena	7	21	28	2923	0	34	0	34
Gov Bond	7	110	0	4523	296	0	172	345
Highland Silver	0	1365	0	1374	0	46	294	18
Holiday	0	66	11	4236	0	22	33	132
Holton	17	679	0	145	0	0	141	424
Horseshoe	55	2593	0	395	101	0	414	92
Iroquois	61	281	0	28	243	563	673	61
Kinkaid	28	685	2	28	2	4	8	6

Appendix 3 (continued)

	Baci (raphid)	Baci (araphid)	Cyano (cocc)	Cyano (fil)	Cryptomonas	Dinoflagellate	Euglenoid	Green
Lake 1060	0	41	345	9721	5598	0	7129	2592
Lancelot	6	6	29	186	0	29	28	643
Long	0	9	0	2229	5	1397	0	5
Loon	36	864	0	0	5	3	2	17
LotW	143	254	0	0	541	143	342	1346
Lou Yeager	22	778	8	36	39	0	61	61
Mattoon	0	138	0	6053	234	0	303	372
Mauvaise Terre	0	1668	0	0	331	41	469	345
MD Borah	47	190	22	113	63	39	130	245
Meredosia	0	4840	0	165	1282	248	5791	1200
Mill Creek	24	191	0	632	55	4	53	22
Mutton	14	1875	496	0	2647	0	14	4702
Pana	90	579	152	1406	0	145	352	83
Powderhorn	6	66	1042	50	314	0	55	298
Rend	11	276	6	1009	0	0	199	132
Sangchris	10	831	24	0	0	0	59	65
Shabbona	0	51	0	5	1448	92	97	193
Slocum	0	896	290	0	427	0	0	620
Storey	23	92	0	1935	1053	28	60	32
Sugar Creek	17	772	50	507	33	0	176	480
Vandalia	44	1258	0	7104	171	77	121	17
Vermillion	0	83	64	28	0	1425	2537	138
Wee-Ma-Tuk	5	2707	69	611	0	87	570	446
Whoopie Cat	50	72	9	3	17	0	57	53
Wildwood	8	53	191	124	57	39	12	79

Appendix 3 (continued)

	Green (fil)	Green (conj)	Chrysophyta
Applecanyon	0	11	0
Argyle	11	22	0
Baldwin	0	0	0
Battery Park	22	6	0
Bracken	0	0	0
Busse	14	14	0
Cedar	0	0	0
Centralia	18	55	0
Coffeen	0	0	0
CSCR	0	32	5
Decatur	28	0	0
DePue	0	14	0
Evergreen	161	0	0
Forbes	0	7	0
Gages	0	0	0
Galena	0	0	0
Gov Bond	0	21	0
Highland Silver	0	0	0
Holiday	0	0	0
Holton	14	21	0
Horseshoe	0	9	0
Iroquois	0	0	0
Kinkaid	0	4	0

Appendix 3 (continued)

	Green (fil)	Green (conj)	Chrysophyta
Lake 1060	0	0	0
Lancelot	2	0	0
Long	18	0	28
Loon	2	0	16
LotW	0	77	0
Lou Yeager	0	22	0
Mattoon	0	0	0
Mauvaise Terre	69	124	620
MD Borah	223	6	0
Meredosia	0	0	0
Mill Creek	118	0	0
Mutton	10231	345	0
Pana	365	55	0
Powderhorn	0	39	160
Rend	0	0	0
Sangchris	0	0	0
Shabbona	0	46	0
Slocum	11817	0	0
Storey	23	0	175
Sugar Creek	0	11	0
Vandalia	1158	0	0
Vermillion	0	0	0
Wee-Ma-Tuk	0	0	0
Whoopie Cat	639	0	0
Wildwood	22	2	0