RESULTS OF SEDIMENT CORES TAKEN FROM LAKE DESAIR, BARRON COUNTY, WISCONSIN

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Aquatic organisms are good indicators of a lake's water quality because they are in direct contact with the water and are strongly affected by the chemical composition of their surroundings. Most indicator groups grow rapidly and are short lived so the community composition responds rapidly to changing environmental conditions. One of the most useful organisms for paleolimnological analysis are diatoms. These are a type of algae which possess siliceous cell walls, which enables them to be highly resistant to degradation and are usually abundant, diverse, and well-preserved in sediments. They are especially useful, as they are ecologically diverse. Diatom species have unique features as shown in Figure 1, which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to objects such as aquatic plants or the lake bottom.

By determining changes in the diatom community it is possible to determine water quality changes that have occurred in the lake. The diatom community provides information about changes in nutrient, water color, and pH conditions as well as alterations in the aquatic plant (macrophyte) community.

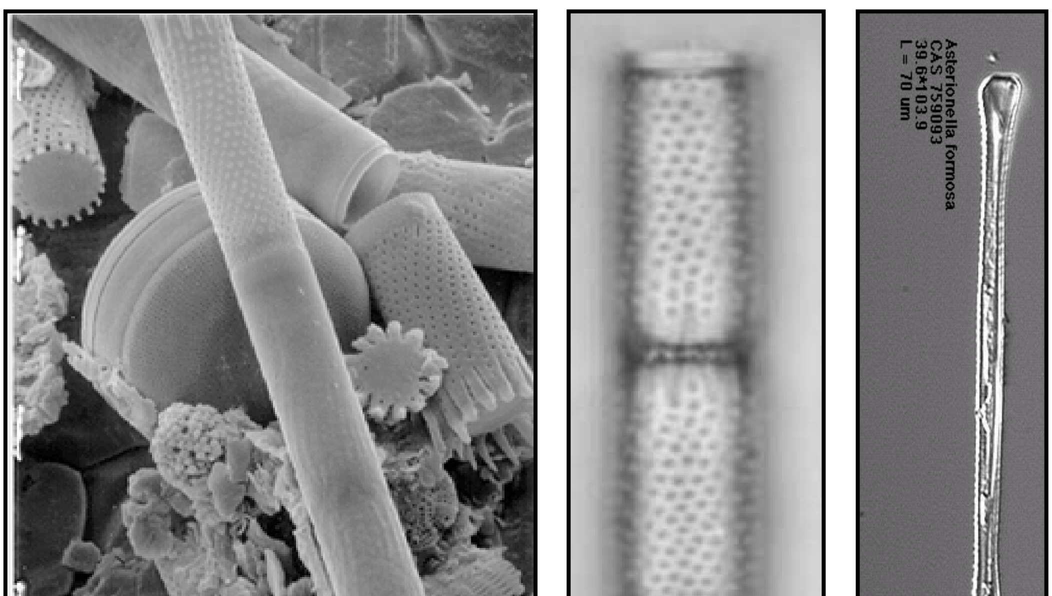

Figure 1. Photomicrographs of diatoms *Aulacoseira subarctica* (left), *Aulacoseira granulata* (middle), and *Asterionella formosa* (right). *A. subarctica* is found in low nutrient lakes while *A. granulata* occurs in higher nutrient environments. *A. formosa* typically is found in lakes with moderate nutrient levels.

On 8 July 2004 cores were taken from three locations in Magnor Lake (Figure 2). Near Site DS-1 a core was extracted to determine water quality changes in the lake during the last 150 years. This core was 60 cm long. The top 2 cm and bottom 2 cm were kept for analysis. It is assumed that the upper sample represents present conditions while the deeper sample is indicative of historical water quality conditions. At this and 2 other sites cores (Table 1) were extracted and the top 10 cm kept. These samples were used to determine the density of the upper sediment in order to estimate the depth to which alum would settle if it were applied to the lake.

Table 1. Location of coring sites.

Coring Site	**Latitude**	**Longitude**	**Water Depth** (ft)
DS-1	N 45º 32.775'	W 091º 46.645'	28
DS-2	N 45º 32.682'	W 091º 46.766'	25
DS-3	N 45º 32.410'	W 091º 46.936'	15

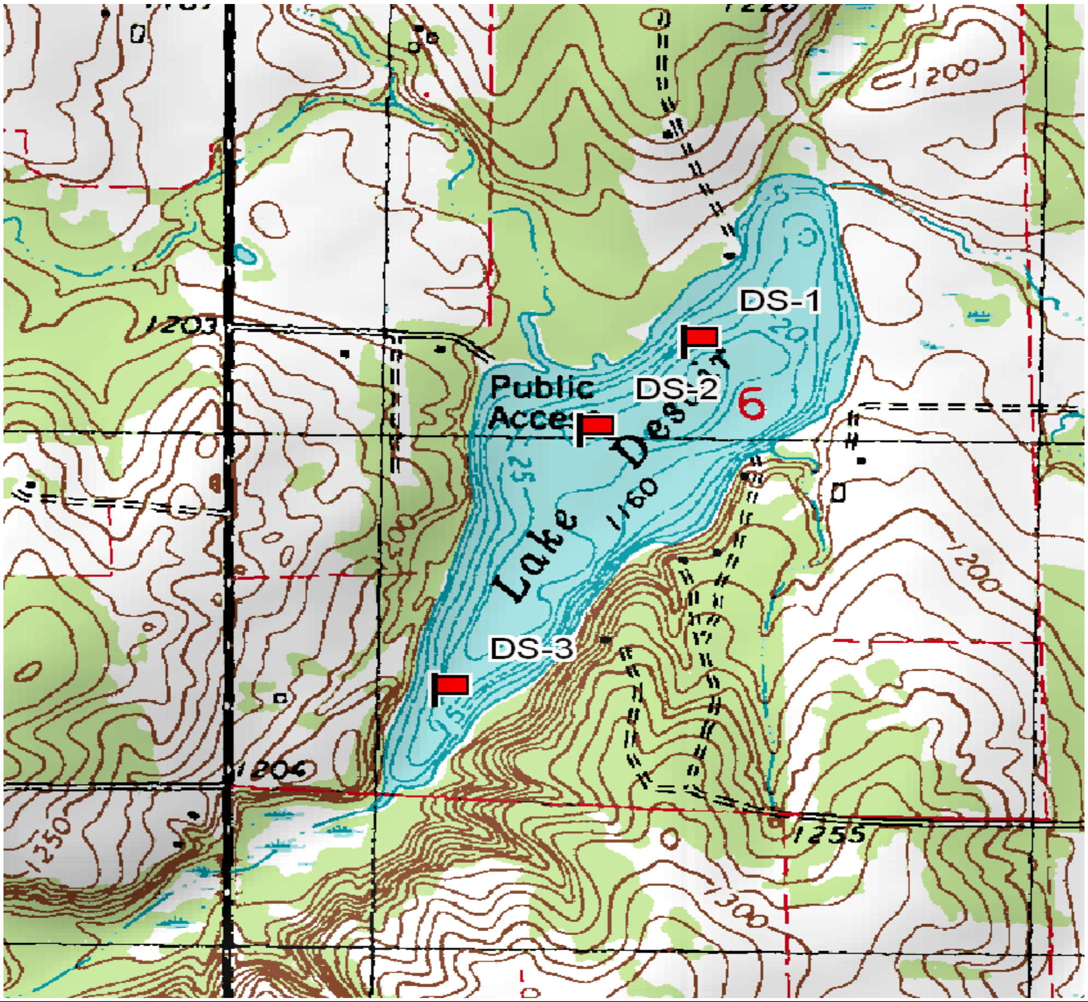

Figure 2. Location of sampling sites of cores collected on 8 July 2004. The top/bottom core was collected near Site DS-1 in about 30 feet of water.

Water Quality Changes

The diatom community at the bottom of the core is much different than the one at the top. In fact the difference is greater than I have observed in any other lake. The difference is so great than none of the common species at the bottom are common at the top of the core. Although the percentage of planktonic diatoms (those that typically are found floating in the open water) at the top of the core is less than at the bottom by about 10% (Figure 3), the biggest difference is in species composition. Historically, the dominant diatom was *Aulacoseira subarctica*. This species is found in low nutrient conditions and often very softwater. This species was absent from the top of the core and was replaced by other *Aulacoseira*, e.g. *A. granulata* and *A. ambigua* (Figure 3). These species are typically found at higher nutrient levels, especially *A. granulata*. Other species which were common at the top of the core were *Fragilaria vaucheriae* and *F. capucina* var. *mesolepta* which also are found under elevated nutrient levels. The abundance of *Asterionella formosa* is more common at the bottom of the core. Its decline is also an indication of higher nutrient levels since it prefers moderate nutrient levels.

The diatom community indicates that changes other than increased nutrients have occurred in the lake. The community indicates that historically, there was more color (brown color) in the water and the alkalinity (pH) was lower than it is at the present time. These changes, along with higher nutrients, are likely the result of large changes in landuse in the lake's watershed. These changes are likely associated with agricultural activities.

Diatom assemblages historically have been used as indicators of nutrient changes in a qualitative way. In recent years, ecologically relevant statistical methods have been developed to infer environmental conditions from diatom assemblages. These methods are based on multivariate ordination and weighted averaging regression and calibration. Ecological preferences of diatom species are determined by relating modern limnological variables to surface sediment diatom assemblages. The species-environment relationships are then used to infer environmental conditions from fossil diatom assemblages found in the sediment core.

Such models were applied to the diatom community in the core from Lake Desair. The models indicated that historical phosphorus levels were around 10 $\mu g\ L^{-1}$ while current phosphorus levels are about 35-40 $\mu g\ L^{-1}$ (Table 2). The estimated present day concentrations are lower than values measured in 2003 (50-70 $\mu g\ L^{-1}$) but the model does indicate a significant increase in phosphorus during the last 100 years. The models also indicate a decline in water color from 29 to 13 units and an increase in alkalinity from 11 to 84 mg L^{-1} (Table 2).

In summary, the diatom community indicates that Lake Desair has undergone a large change in water quality during the last 100 years. There has been a large increase in nutrients, especially phosphorus, a decline in water color, and an increase in alkalinity. These changes are likely the result of agricultural activities in the watershed. These changes resulted in the increased delivery of phosphorus and sediment from the watershed which caused higher nutrient levels and more solids (alkalinity) in the lake.

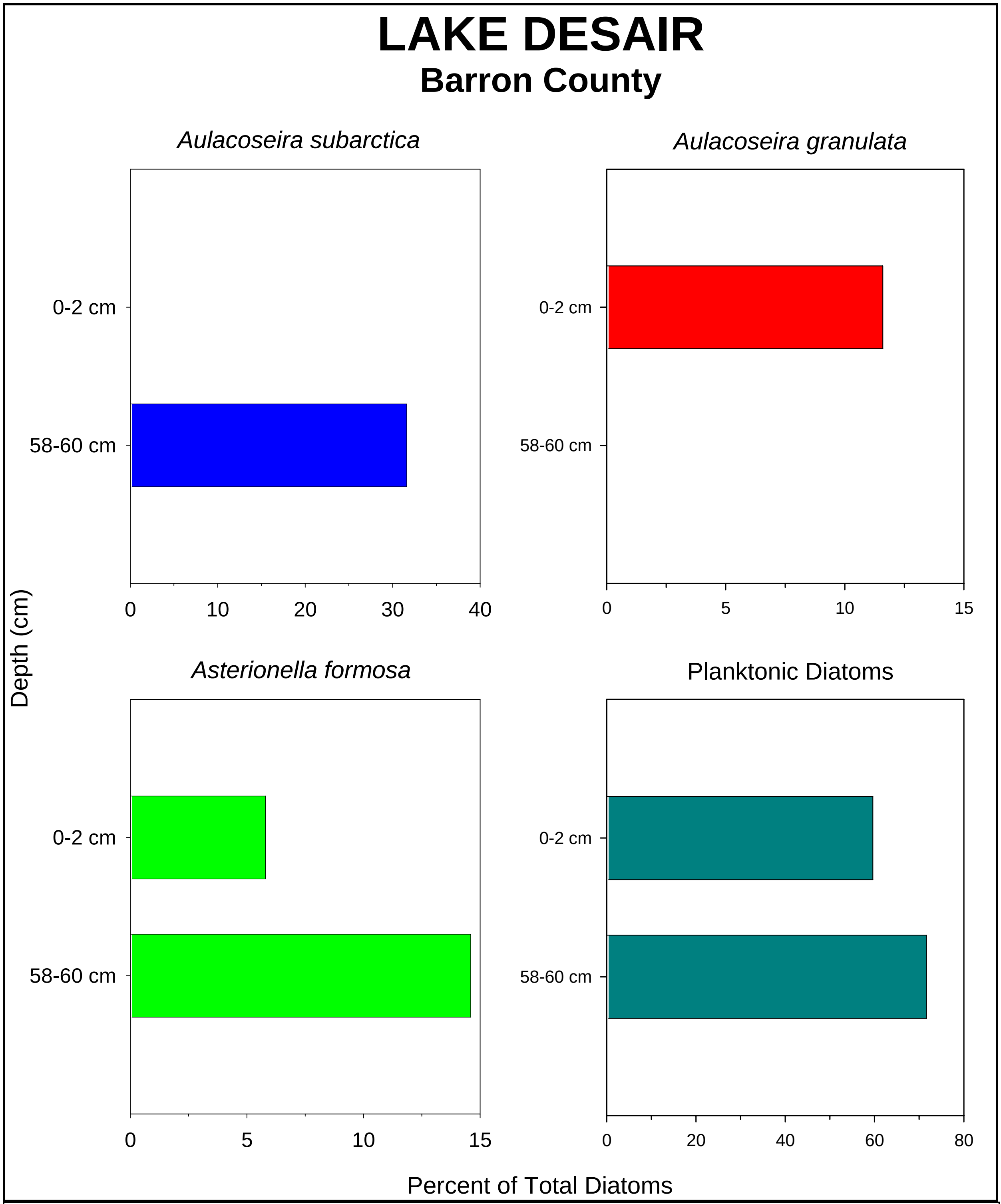

Figure 3. Changes in abundance of common diatoms found at present and presettlement times. *A. subarctica* is a planktonic diatom that is found under low nutrient levels. *A. granulata* indicates eutrophic phosphorus levels while *A. formosa* if found under moderate nutrient conditions.

Table 2. Estimated values of water quality variables. Values were inferred from the diatom community using multivariate statistical models.

Core Depth	**Summer Phosphorus** (µg L^{-1})	**Color**	**Alkalinity** (mg L^{-1})
Top	35	13	84
Bottom	10	29	11

Sediment density

The density of the top 10 cm of sediment was measured at 3 locations in the lake. The purpose of this measurement was to estimate how deep alum (aluminum sulfate) might penetrate the sediments. Alum treatments have been used successfully to significantly reduce internal phosphorus loading from bottom sediments. Phosphorus is released when water overlying these sediments is devoid of oxygen. The lack of oxygen results in the form of iron changing from ferric (+3) to ferrous (+2). When this happens phosphorus that was bound to the iron is solubilized and moves from the sediments to the overlying water. Aluminum bound phosphorus does not become soluble in the absence of oxygen and thus stays in the sediment. Alum often is denser than lake sediments and when this is the case, alum will settle into the sediments until is reaches a depth where its density is equal to, or less than the sediments.

In all of the samples from Lake Desair the percentage of water was less than 90% (Table 3). Other studies have found that this can be a reasonable estimate of the depth alum will settle. This analysis indicates that an alum treatment would likely remain on top of the sediment and therefore alum may be appropriate for this lake. A more accurate test of the effectiveness of alum would be to extract cores from the lake and treat them with sequential amounts of alum. This analysis will better estimate the amount of alum necessary to bind the sediment phosphorus. This analysis will also give a better estimate of the cost of an effective alum treatment.

Table 3. Percent water in the top 10 cm of sediments at 3 locations in Lake Desair. Refer to Figure 1 for locations.

DS-1

Depth (cm)	**Water** (%)
0-2	84.3
2-4	81.9
4-6	82.7
6-8	83.5
8-10	76.2

DS-2

Depth (cm)	**Water** (%)
0-2	69.8
2-4	67.7
4-6	53.9
6-8	47.9
6-8 rep	49.0

DS-3

Depth (cm)	**Water** (%)
0-2	89.1
2-4	84.7
4-6	81.5
6-8	80.9
8-10	83.3

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Core Top (0-2 cm)

TAXA	COUNT TOTAL Number	Prop.
Achnanthidium linearis	5	0.016
Achnanthidium minutissima	6	0.019
Asterionella formosa	18	0.058
Aulacoseira ambigua	14	0.045
Aulacoseira granulata	35	0.113
Aulacoseira italica	8	0.026
Aulacoseira (VV)	1	0.003
Cocconeis placentula var. linearis	4	0.013
Cyclostephanos sp.	2	0.006
Cyclotella atomus	11	0.036
Cyclotella distinguenda	15	0.049
Cyclotella pseudostelligera	6	0.019
Cyclotella sp.	6	0.019
Cymbella sp.	2	0.006
Eucocconeis flexella	1	0.003
Eunotia bilunaris	0.5	0.002
Eunotia incisa	0.5	0.002
Eunotia sp.	1	0.003
Fragilaria crotonensis	22	0.071
Fragilaria crotonensis var. oregona	2	0.006
Fragilaria vaucheriae	27	0.088
Fragilaria (GV) (14-15/10u) (central area)	38	0.123
Gomphonema truncatum	1	0.003
Hantzschia amphioxys	0.5	0.002
Luticola goeppertiana	1	0.003
Navicula cincta	1	0.003
Navicula lanceolata	6	0.019
Navicula minima	20	0.065
Navicula (GV) (short)	2	0.006
Nitzschia acicularis	0.5	0.002
Nitzschia amphibia	1	0.003
Nitzschia gracilis	1	0.003
Nitzschia palea	3.5	0.011
Nitzschia pusilla	3	0.010
Nitzschia sp.	1	0.003
Pseudostaurosira brevistrata	2	0.006
Sellaphora pupula	3	0.010
Staurosira construens var. venter	4	0.013
Staurosirella pinnata	1	0.003
Stephanodiscus sp.	6	0.019
Synedra acus	3	0.010
Synedra minuscula	3	0.010
Synedra rumpens var. familaris	15	0.049
Synedra sp.	6	0.019
Surirella angusta	1	0.003
Unknown	2	0.006
Unknown (raphid)	1	0.003
TOTAL	308.5	1.000
Chrysophyte scales	1	
Chrysophyte cysts	25	
Planktonic taxa		0.596
Nonplanktonic taxa		0.394

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Core Bottom (58-60 cm)

TAXA	COUNT TOTAL Number	Prop.
Achnanthes lacus-vulcani	6	0.018
Achnanthidium exiguum	1	0.003
Achnanthidium minutissima	4	0.012
Achnanthidium sp.	3	0.009
Asterionella formosa	49	0.146
Aulacoseira distans var. tenella	15	0.045
Aulacoseira perglabra var. floriniae	1	0.003
Aulacoseira ambigua	29	0.087
Aulacoseira subarctica	71	0.212
Aulacoseira VV	35	0.104
Cyclotella atomus	2	0.006
Cyclotella glomerata	4	0.012
Cyclotella pseudostelligera	2	0.006
Cyclotella stelligera	8	0.024
Diatoma vulgare	2	0.006
Encyonema silesiacum	2	0.006
Eunotia bilunaris	1	0.003
Eunotia incisa	0.5	0.001
Eunotia praerupta	1	0.003
Eunotia sp.	2.5	0.007
Fistulifera pelliculosa	2	0.006
Fragilaria crotonensis	5	0.015
Fragilaria vaucheriae	3	0.009
Fragilaria (GV) (14-15/10u) (central area)	2	0.006
Gomphonema minutum	2	0.006
Gomphonema sp.	2	0.006
Meridion circulare	2	0.006
Navicula agretis	2	0.006
Navicula difficillima	2	0.006
Navicula lanceolata	1	0.003
Navicula minima	4	0.012
Navicula (GV) (short)	5	0.015
Navicula sp.	2	0.006
Nitzschia acicularis	1.5	0.004
Nitzschia palea	2	0.006
Nitzschia pusilla	1	0.003
Nitzschia sp.	2.5	0.007
Pseudostaurosira brevistrata	4	0.012
Sellaphora pupula	1	0.003
Staurosirella pinnata	4	0.012
Synedra minuscula	1	0.003
Synedra radians	2	0.006
Synedra rumpens	11	0.033
Synedra rumpens var. familaris	6	0.018
Synedra tenera	4	0.012
Synedra sp.	3	0.009
Tabellaria flocculosa str. III	8	0.024
Tabellaria flocculosa str. IIIp	15	0.045
Tabellaria flocculosa str. IV	1	0.003
Unknown	1	0.003
Unknown (raphid)	0	0.000
TOTAL	335	1.000
Chrysophyte scales	10	
Chrysophyte cysts	35	
Planktonic taxa		0.716
Nonplanktonic taxa		0.281