RESULTS OF SEDIMENT CORE TAKEN FROM SNIPE LAKE, VILAS 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.

Figure 1. Photomicrographs of the diatoms *Navicula submuralis* (A) and *Staurosira pinnata* (B, C). These were common diatoms found in the core. Both of these diatoms are found growing attached to substrates, especially submerged aquatic plants.

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 concentrations, water clarity, and pH conditions as well as alterations in the aquatic plant (macrophyte) community.

On 1 September 2009 a sediment core were taken from near the deep area (N45° 56.414 W89° 21.932) of Snipe Lake in about 12 feet of water using a gravity corer. Samples from the top of the core (0-1 cm) and a section (55-57 cm) deeper in the core were kept for analysis. It is assumed that the upper sample represents present conditions while the deeper sample is indicative of water quality conditions at least 100 years ago.

Results

In order to determine if the bottom sample of the core was deposited at least 130 years ago the sample was analyzed for the radionuclides lead-210 (^{210}Pb), radium-226 (^{226}Ra), and cesium-137 (^{137}Cs). Lead-210 and ^{226}Ra are naturally occurring radionuclides while ^{137}Cs is a byproduct of atmospheric nuclear testing that was conducted by the USA and USSR from 1954-1963. Lead-210 has a half life of 22.26 years which means it can be detected after deposition for about 130-150 years. Radium-226 is used to measure background concentrations of ^{210}Pb since values of ^{210}Pb and ^{226}Ra are similar when the lead isotope is around 130 years old.

No ^{137}Cs was detected in the sample (Table 1), indicating that the bottom sample was deposited before 1954. The ^{210}Pb concentration was higher than the concentration of ^{226}Ra indicating that the bottom sample probably was deposited within the last 130 years but the low concentration indicates it likely was deposited around 100 years ago. The radiochemical analysis suggests that the bottom sample is sufficiently old enough to use the diatom community to estimate water quality conditions prior the establishment of shoreline development.

Table 1. Amount of ^{210}Pb, ^{226}Ra, and ^{137}Cs found in the bottom core sample. Units are pCi g^{-1}.

	Lead-210	**Radium-226**	**Cesium-137**
Bottom	1.7490	1.0053	0

Most of the diatom community, in both the top and the bottom segments of the core, is composed of species that grow attached to substrates, e.g. macrophytes. This is not surprising since Snipe Lake is a shallow lake with clear water. There is a decline in planktonic diatoms, those that grow in the open water, from the bottom to the top of the core. This likely indicates an increase in the growth of macrophytes. The change in the macrophyte community likely does not mean a greater coverage of the lake bottom by macrophytes but instead a shift in macrophyte species. A study by Dr. Susan Borman in lakes in northwestern Wisconsin found that with increased shoreline development, there was a shift in the macrophyte community from small low growing species to larger taller species. The diatoms indicate that this may have occurred in Snipe Lake over the last 100 years.

The dominant benthic diatoms were benthic *Fragilaria* such as *Staurosira pinnata* var. *pinnata* (Figure 2), *S. pinnata* var. *lancettula*, and *Staurosira construens* var*. venter*. These

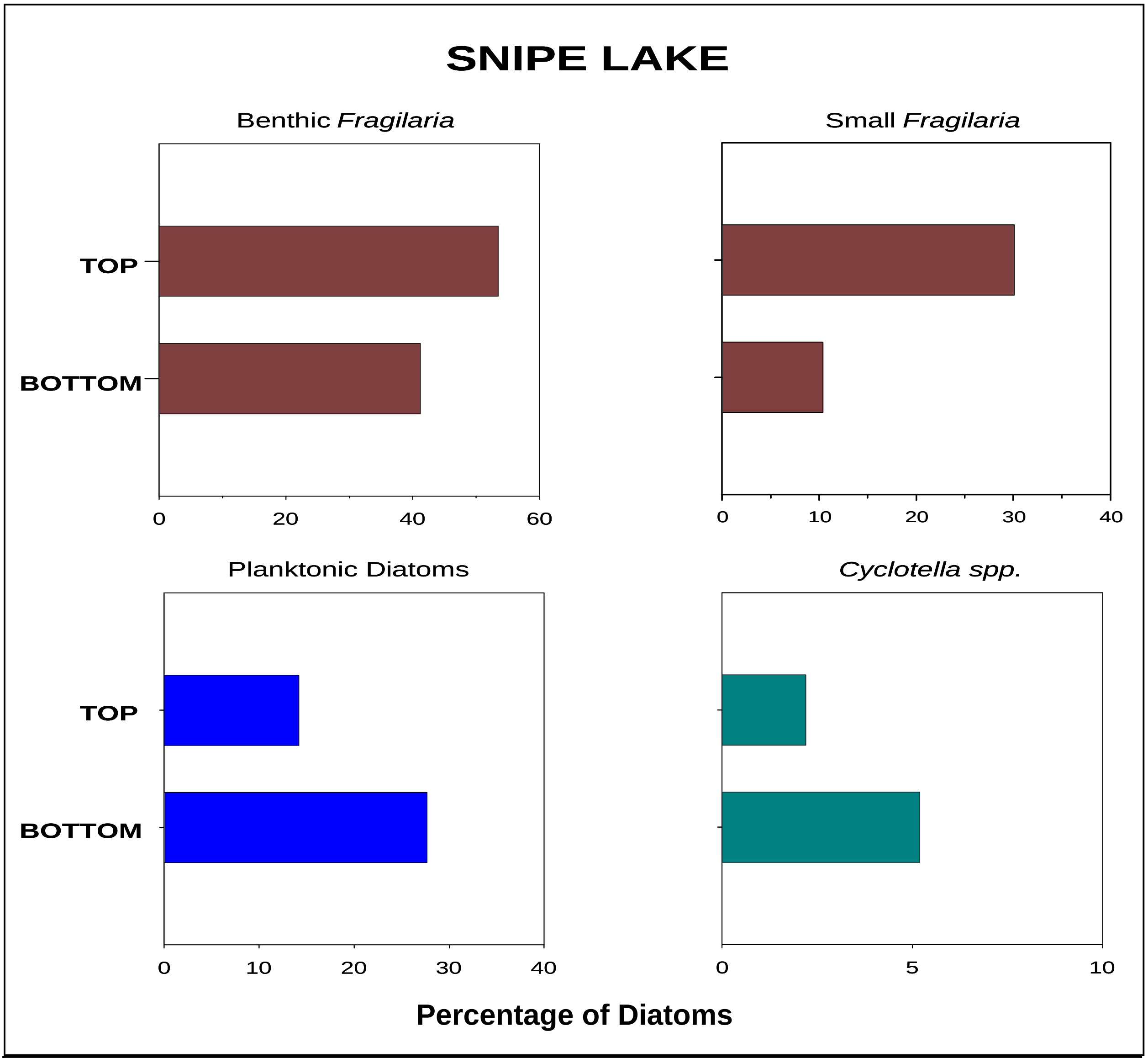

Figure 2. Changes in the abundance of important diatoms found at the top and bottom of the Snipe Lake sediment core. The increase in benthic *Fragilaria* indicates an increase in submerged aquatic vegetation and the increase in the small *Fragilaria* indicates an increase in phosphorus levels. *Cyclotella* spp. is a planktonic diatom and its decline reflects and increase in macrophytes.

taxa increased from the bottom of the core to the top consistent with an increase in the macrophyte community. The increase in small *Fragilaria* likely indicates an increase in phosphorus levels. The presence of these attached diatoms reduces the amount of phosphorus that is available for others types of algae and thus reduce algal blooms.

A comparison was made of the diatom communities at the top and bottom of cores from shallow, softwater lakes similar to Snipe Lake. This comparison was made using detrended correspondence analysis (DCA). This is a multivariate statistical analysis that determines relative differences in the diatom community between different samples. The farther apart the top/bottom samples plot on the graph, the greater the differences in the diatom com-

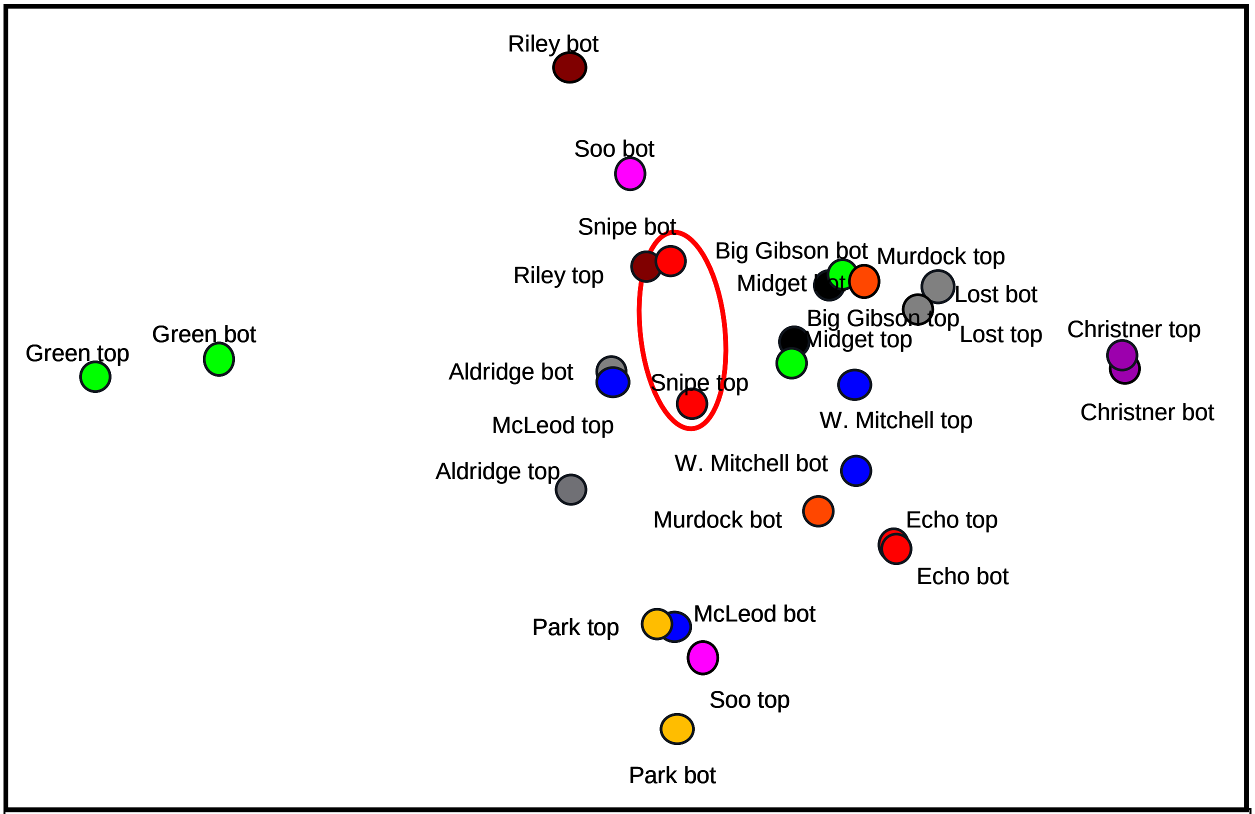

Figure 3. A DCA analysis of top/bottom cores in shallow, softwater lakes similar to Snipe Lake. This analysis is based upon the diatom community. The closer the samples are, the less change that has occurred in the diatom community. Examples of lakes that show little change are Echo and Christner. The diatom communities of other lakes exhibit greater differences between the top and bottom of the core. Examples of these lakes are Riley and Murdock. Snipe Lake is intermediate but this analysis indicates that the ecology of Snipe Lake has changed during the last 100 years.

munities. This analysis is shown in Figure 3. Some lakes show little difference in the diatom communities between the top and bottom of the cores, e.g. Echo, Christner, while others exhibit larger differences, e.g. Riley, Murdock. The differences in Snipe Lake are intermediate but demonstrate that the diatom community has changed during the last 100 years.

Another indication that Snipe Lake has changed in the last 100 years is that there were 15 more species in the sample from the bottom of the core. At the top of the core the diatom community was not as diverse.

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 a model was applied to the diatom community in the core from Snipe Lake. The model indicates there has been an increase in phosphorus. The model indicates that phosphorus concentrations are higher at the top of the core compared with the bottom of the core. The increase in phosphorus is about 2-4 µg L^{-1}.

In summary, Snipe Lake has experienced an increase in macrophytes as well as phosphorus from the time period represented by the bottom of the core. The change in the macrophyte community is consistent to what has happened in many other northern Wisconsin lakes as a result of shoreline development. Even though the present phosphorus concentrations in the lake are low, they are higher than concentrations were historically.

When taking the core it was apparent that the lake is in good overall condition. The core indicates that the lake has changed during the last 100 years. It is not likely that it will be possible to reverse the change. Instead it is important to not let the lake degrade further. This can be done by reducing sediment and nutrient input from homes on the shoreline by reducing the application of lawn fertilizers and minimizing runoff from the lawns and structures. One of the best ways to do this maintaining a natural buffer vegetation along the lake shore and minimize runoff from impervious surfaces.

SNIPE LAKE

Vilas County

Top

	COUNT TOTAL	
	Number	Prop.
TAXA		
Achnanthes biasolettiana (Kützing) Grunow	1	0.002
Achnanthes spp.	3	0.007
Achnanthidium minutissimum (Kützing) Czarnecki	8	0.020
Achnanthidium minutissimum var. scotica (Carter) Lange-Bertalot	4	0.010
Asterionella formosa Hassal	7	0.017
Aulacoseira ambigua (Grunow) Simonsen	3	0.007
Aulacoseira italica (Ehrenberg) Simonsen	2	0.005
Aulacoseira perglabra var. florinae (Camburn) Haworth	13	0.032
Brachysira vitrea (Grunow) Ross	1	0.002
Cyclotella bodanica var. affinis (Grunow) Cleve-Euler	1	0.002
Cyclotella bodanica var. lemanica Müller	2	0.005
Cyclotella spp.	2	0.005
Cymbella spp.	1	0.002
Discotella stelligera (Hustedt) Houk et Klee	4	0.010
Encyonema lunatum (Smith) Van Heurck	1	0.002
Eolimna minima (Grunow) Lange-Bertalot	3	0.007
Eolimna subminuscula Manguin	14	0.034
Eunotia incisa Smith ex Gregory	1	0.002
Fragilaria capucina var. gracilis (Østrup) Hustedt	1	0.002
Fragilaria sepes Ehrenberg	10	0.024
Mayamaea atomus var. permitis (Hustedt) Lange-Bertalot	3	0.007
Navicula lanceolata (Agardh) Ehrenberg	6	0.015
Navicula radiosa Kützing	8	0.020
Navicula submuralis Hustedt	15	0.037
Navicula small	8	0.020
Navicula spp.	4	0.010
Neidium affine (Ehrenberg) Pfitzer	1	0.002
Nitzschia amphibia Grunow	4	0.010
Nitzschia perminuta (Grunow) Peragallo	10	0.024
Pinnularia spp.	4	0.010
Sellaphora pupula (Kützing) Meresckowsky	2	0.005
Sellaphora seminulum (Grunow) Mann	2	0.005
Stauroneis phoenicenteron (Nitzsch) Ehrenberg	2	0.005
Staurosira construens var. venter (Ehrenberg) Hamilton	79	0.193
Staurosirella pinnata (Ehrenberg) Williams et Round	44	0.108
Staurosirella pinnata var. lancettula (Schumann) Siver et Hamilton	96	0.235
Synedra rumpens Kützing	5	0.012
Synedra subrhombica Nygaard	8	0.020
Synedra sp.	4	0.010
Tabellaria flocculosa (strain III) sensu Koppen	4	0.010
Tabellaria flocculosa (strain IIIp) sensu Koppen	6	0.015
Tabellaria spp.	9	0.022
unknown pennate	3	0.007
TOTAL	409	1.000
Planktonic diatoms		0.142
Nonplanktonic diatoms		0.858
Chrysophyte scale	6	
Chrysophyte cyst	20	
Scenedesmus coenubia	1	

SNIPE LAKE		
Vilas County		
Bottom		
	COUNT TOTAL	
	Number	Prop.
TAXA		
Achnanthes biasolettiana (Kützing) Grunow	2	0.005
Achnanthes rupestoides Hohn	6	0.015
Achnanthidium minutissimum (Kützing) Czarnecki	2	0.005
Asterionella formosa Hassal	2	0.005
Asterionella ralfsii var. americana Körner	1	0.002
Aulacoseira ambigua (Grunow) Simonsen	4	0.010
Aulacoseira nygaardii Camburn	2	0.005
Aulacoseira perglabra var. florinae (Camburn) Haworth	8	0.020
Aulacoseira subborealis Denys, Muylaert, Krammer, Joosten, Reid et Rioual	4	0.010
Aulacoseira tenella (Nygaard) Simonsen	2	0.005
Aulacoseira (VV)	2	0.005
Brachysira vitrea (Grunow) Ross	2	0.005
Cyclotella bodanica var. affinis (Grunow) Cleve-Euler	7	0.017
Cymbella angustata (Smith) Cleve	2	0.005
Cymbella gaeumannii Meister	1	0.002
Cymbella spp.	1	0.002
Discotella glomerata (Hustedt) Houk et Klee	13	0.032
Discotella stelligera (Hustedt) Houk et Klee	1	0.002
Encyonema lunatum (Smith) Van Heurck	3	0.007
Eunotia flexuosa Brébisson ex Kützing	2	0.005
Eunotia incisa Smith ex Gregory	1	0.002
Eunotia pirla Carter et Flower	1	0.002
Eunotia rhomboidea Hustedt	1	0.002
Eunotia spp.	3	0.007
Fragilaria capucina var. gracilis (Østrup) Hustedt	5	0.012
Fragilaria capucina var. mesolepta Rabenhorst	2	0.005
Fragilaria crotonensis Kitton	6	0.015
Fragilariforma constricta (Ehrenberg) Williams et Round	1	0.002
Gomphonema angustum Agardh	3	0.007
Gomphonema gracile Ehrenberg emend Van Heurck	2	0.005
Mayamaea atomus var. permitis (Hustedt) Lange-Bertalot	2	0.005
Navicula lanceolata (Agardh) Ehrenberg	1	0.002
Navicula leptostriata Jörgansen	4	0.010
Navicula radiosa Kützing	2	0.005
Navicula small	4	0.010
Navicula spp.	5	0.012
Navicula submuralis Hustedt	4	0.010
Neidium affine (Ehrenberg) Pfitzer	1	0.002
Neidium ampliatum (Ehrenberg) Krammer	3	0.007
Neidium spp.	3	0.007
Nitzschia acicularis (Kützing) Smith	1	0.002
Nitzschia gracilis Hantzsch ex Rabenhorst	3	0.007
Nitzschia perminuta (Grunow) Peragallo	2	0.005
Pinnularia abaujensis var. linearis (Hustedt) Patrick	9	0.022
Pinnularia dactylus Ehrenberg	1	0.002
Pinnularia pogoii Scherer	1	0.002
Pinnularia spp.	1	0.002
Psammothidium ventralis (Krasske) Bukhtiyarova et Round	1	0.002
Pseudostaurosira brevistriata (Grunow) Williams et Round	2	0.005
Rossithidium linearis (Smith) Round et Bukhtiyarova	2	0.005
Sellaphora laevissima (Kützing) Mann	1	0.002
Stauroneis phoenicenteron (Nitzsch) Ehrenberg	2	0.005
Stauroneis spp.	2	0.005
Staurosira construens var. venter (Ehrenberg) Hamilton	2	0.005
Staurosira elliptica (Schumann) Williams et Round	3	0.007
Staurosirella pinnata (Ehrenberg) Williams et Round	37	0.091
Staurosirella pinnata var. lancettula (Schumann) Siver et Hamilton	122	0.301
Stenopterobia curvula (Smith) Krammer	1	0.002
Surirella linearis var. constricta Grunow	1	0.002
Synedra delicatissima Smith	16	0.040
Synedra radians Kützing	1	0.002
Synedra rumpens Kützing	1	0.002
Synedra subrhombica Nygaard	6	0.015
Synedra sp.	1	0.002
Tabellaria flocculosa (strain III) sensu Koppen	6	0.015
Tabellaria flocculosa (strain IIIp) sensu Koppen	37	0.091
Tabellaria flocculosa (strain IV) sensu Koppen	3	0.007
Tabellaria spp.	16	0.040
unknown pennate	3	0.007
TOTAL	405	1.000
Planktonic diatoms		0.277
Nonplanktonic diatoms		0.723
Chrysophyte scale	9	
Chrysophyte cyst	144	
Scenedesmus coenubia	19	
Pediastrum coenubia	1	