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Big Sand Lk Restoration Survey and Expanded Monitoring Small Planning Grant Final report.

DNR Grant $3,000 including $1000 in local matching Big Sand Lake Restoration Survey and Monitoring.

Wild Rice

Wild rice, with nutritious seeds and palatable vegetation is a significant resource for lake fauna as well as a cultural and food resource for the Native American Community . The recent history of Wild Rice in Big Sand is one of limited production. Around 1940 it is said that about 30 pounds could be harvested in a morning. Now production is limited to less than five pounds. Other lakes such as Biggs on the Minerva chain can yield 200 pounds per trip to a single ricer. The largest beds are shown in Fig. ___ A large thin bed on the north shore was lost to weed extraction followed by wave action removing the bottom of detritus. Rushes are the only emergent macrophytes remaining. If the lake is in true balance, the weeds should just move elsewhere; thin stands are now present to the west that were formerly sand bottomed.

Red or purplish color (anthocyanin pigment) in leaves, especially undersides Day 1989

All leaf samples samples from the tropical seagrass Thalassia hemlprichii showed the capacity to take up ammonium and phosphatae. The kinetics were michaelian with variation in the ratio of fluxes between roots and leaves condition dependent. In some situations uptake by the leaves were thought to be essential (Stapel, 1996).

In one lake studied (P. F. Lee) poor production was related to low phosphorous levels, low organic content of the sediment , or high plant levels of plant competition.

Simms and Pastor 2012 reported that production is limited promarily by nitrogen, secondarily by phosphorus and light. The test involved harvesting rice plants, washing the roots, suspending them in plastic bags containing water, and adding sediment from a constant natural source. Then the plants and sediment was subjected to various combinations of conditions and amendments,

Water Chemistry: Bioassay of available nutrients.

Test 1; 2010 Seeded 4 29” diameter polycarbonate chambers with Wild Rice, in 14 inches of water in the west bay. Two were fertilized with 20/10/10 fertilizer; both produced good stands of rice, the unfertilized did not. Rice seeded in bay emerged but did not sustain.

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Seeded 4 chambers amended with, from west, N, P NP and supplement-free control at a level of 150 mg/ m^2 . Stem (tiller) diameter at the waterline was measured in early October. Results shown in Table 1.

Table 1. Effect of mineral amendments on Wild Rice growth according to stem diameter.

Nitrogen	Phosphorus	Phosphorus = + nitrogen	Unamended control
Sprouted but none emerged from the water	7.1 ± 1.3, n =7	8.2 ± 2.1, n = 7	Sprouted but none emerged from the water

Various test plots were seeded each of the following years that included addition of rice straw, stirring up sediments and spot seeding. Almost none emerged. There were a few scattered small patches, possibly associated with a fish or other carcass.

Add photographs.

Zebra mussels need sufficient calcium to establish. High calcium is associated with hard water while Big Sand is throught to be a soft water lake. The calcium threshold is around 20 mg/liters but seems to vary with location.

For example, if the
true calcium threshold is 20 mg/l rather than whichever value was used for the initial studies, then
the Manitoba study overestimated the number of vulnerable sites by 21%, the

Fish.

Those observed include bluegills, sunfish, rock bass, crappie, yellow perch, bullheads, bowfins, largemouth bass, smallmouth bass and northern pike. Creel censuses by the DMR reflect rates of growth that are slower and and body sizes that are smaller than in most area lakes. The stomachs of several bluegills were examined and several appeared to contain invertebrates. Most were decomposed and there was no further effort to identify. The stomachs of Twentyone bass were examined, mostly caught through the ice. Several were in the 12 to 14 inch range. The stomach of one contained a small bass, a second a small sunfish, and a third a small creyfish claw. The other 18 stomachs were empty.

Other verbal reports, one fisher reported finding a frog in the stomach of a bass. Another reported finding a northern pike stomach full of small bluegills.

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An excellent survey by Nick Nelson ==

A preleminary survey of fish stomach content was conducted during summer. Several bluegills showed mostly invertebrates.

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The goal of the Big Sand Lake Preservation Association is to care for the health of our lake. In accordance with this the above sum was awarded with $1,500 received together with matching funds for donated effort in the mount of 1,000. Specified was a survey to understand property owner's position on restoration implementation, as well as some related monitoring efforts on the lake.

Landowner Survey. Permanent residents include Native Americans on properties administered by the St. Croix Chippewa Indians of Wisconsin and number about 150 individuals. Other landowners include about 100 mostly cabin owners. Residency is generally limited to a few summer weekends per year. Addresses of the landowners were obtained from public records and personal contact. Individual Tribal households are less easily contacted but general positions are clear by consensus opinions. The Tribe maintains an environmental protection that facilitates sound drainage policies, collects data used for effecting some lake use policies and has helped with issues of common interest. While our survey necessarily excludes this group, we are in regular contact and cooperation has been extensive. Appreciation of lake association efforts has been expressed.in writing in the Letter of Support for this effort from the Tribes environmental group and both verbally and in writing by individual tribal members. No contentious issues emerged.

Circulation. The survey, reproduced below, was attached the *Sand Lake Observer*, Volume 2, No. 2, 2014, and sent to the approximately 100 landowners mentioned above. Scores ranked from 0 to 3 on questions ranged from a low of 2.00 on lake health monitoring to a high of 2.61 for reestablishment of wild rice. For vegetative buffers it was a very positive 2.67 ± 0.68; n = 19. Also most (16) wanted to receive association minutes by e-mail, 13 would donate funds, but only 5 had time to donate.

Written comments were exceedingly positive and generally said "we like what you are doing". One thought catch and release would not work, and one was troubled by structural problems within the organization. A later e-mail indicated that these problems had apparently been resolved. Only one respondent, a member of our sister organizaion, was negative and exceedingly so. The actual survey and statistical analysis is as follows.

Landowner Survey June 14, 2014

To be used as part of current Department of Natural Resources grant to the BSLPA)

Please indicate your level of support, little to strong: 0 , 1, 2, or 3

Instillation of fish sticks to help restore biological balance in Big Sand.
___0 ___1 ___2 ___3 **Response: Average 2.58 ± 0.71; n = 17**

Catch and release of northern pike (and walleye if established) is useful.
___0 ___1 ___2 ___3 **Response: Average Score: 2.53 ± 1.00; n = 17**

Re-establishment of wild rice in non-populated areas such as the west bay is useful.
___0 ___1 ___2 ___3 **Response: Average Score: 2.61 ± 0.61; n = 1.03**

Expanded effort to monitor the health of Big Sand including automatic lake levels, fish stomachs, fish sizes, invertebrates, phytoplankton is useful.
___0 ___1 ___2 ___3 **Response: Average Score 2.00 ± 1.03; n = 19**

Shoreline plantings friendly to wildlife and that intercept nutrients is useful.
___0 ___1 ___2 ___**3** **Response: Average Score 2.67 ± 0.68; n = 0.68**

Would like to receive board meeting minutes?
___No ___By e-mail ___By US mail __on www.bigsandlakepreservationassoc.org/

Responders preferto see minutes by e-mail 16 to 1.

Comments attached:

Six responders gave very strong support

One responder was concerned with organization structure and later gave strong support due to subsequent productivity.

One thought catch and release would not work, be mandatory or enforced.

One responder thought that most of the members should join the original lake association.

Riparian buffers around the lake were examined by aerial photography followed by lake-level photos by boat. The lake lies in a shallow basin on a plateau near the headwaters of the watershed. Iinfluent from surface water flow is therefore negligible. Most water throughput is due to groundflow from the comparatively large watershed. This has buffered changes in lake level extreams over nearly a century to only about a foot; most lakes vary much more.

Ground cover. Lake frontages were examined by air and by boat. Aerial photography was by PA-12 using a hand-held camera through an open window. Lake level images were taken by power boat. Features are identified in Fig. 1. Aerial photos begin at the northwest point off the west bay and show the north shore. .

Shoreline distances were calculated using a mean height of 60 feet for tree height. This amounts to 11658 feet as shown**,** or about 29% of the shoreline. Only lightly vegetated shoreline was photographed at lake level This amounts to a little more than two miles of the seven mile shoreline

Figure 2 shows lake frontage around the public landing by air. Figure 2 shows part of the same region from lake level. The digital record is submitted separately on disc. Sparsely vegetated shoreline as viewed from water level roughly 300 feet distant is shown in Table ___.. About 31% appeared to e was lightly vegetated, and onnly 850 feet of or 7% of the ~12,000 feet of tree and brush free beach at high water were of stone or gravel. Past erosion was evident at only two sites, both of which had been mitigated by the Tribe. One of these is shown in Fig. Figure 3 is an example of the plethora of docks that protrude from the shore. Shallow beeches surround much of Big Sand and the docks ease access to boats. Studies show that dock density correlates with reduced habitat, biodiversity and lake health.

Table ___. Length of lightly vegetated lakeshore around Big Sand Lake.

Image number	Length, feet	Image number	Length, feet	Image number	Length, feet	Image number	Length, feet
1	71.	11	82	21	81	31	220
2	117.	12	248	22	642	32	750
3	161.	13	409	23	98	33	154
4	260.	14	450	24	60	34	202
5	450	15	338	25	83	35	500
6	150.	16	128	26	642	36	642
7	150,	17	281	27	535	37	326
8	60.	18	281	28	200	38	450
9	105.	19	642	29	268		**3,244**
10	162.	20	642	30	562		
	1686		3501		3171	Total =	**11,658**

Water Chemistry. To better understand the chemistry of Big Sand water, we considered we source water and flow, fish kills, wild rice dynamics, and nutrient limitation. Big Sand was a drainage lake before about 1930 and gradually became a seepage lake due to influent blockage from Warner Lake by Highway 70, effluent blockage by Sand Lake Road, and diversion of water from the watershed to the southeast to Clam River. The water may have been enriched by flow from a cranberry marsh contained due to natural nitrogen and phosphorus, chemical fertilization, or both. For whatever reason algal blooms appear to have been slightly more intense then than at present.

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Water flow out Sand Creek has diminished by chronic blockage under Sand Lake Road. Addition of culverts last summer improved flow. However the area had become blocked by an aggressive cattail hybrid and flow was insufficient to clear a waterway. Fig. ___. The dense vegetation filtered out detritus in the flow. The deposits raised the creek bed a foot or two over the sand bottom blocking flow and breaking communication with the Yellow River system. The flow of forage fish including redhorse suckers was then blocked impacting food webs in the lake. The accumulating detritus also may have increased oxygen consumption and reduced input oxygen from the lake proper leading to the first fish kill as reported in both the TryCounty Leader and the Sand Lake Observer.

Water quality. Clear water is a hallmark of Big Sand. The main water input is indirect from precipitation over a fairly large water shed of approximately 10 square miles in the form of ground-water flow. This pure water flows into the lake from the south and out to the west has buffered seasonal changes in lake level to about a foot since the 1930's. It also favors a calcium-poor softwater lake that may resist infection by zebra mussels that need calcium for shells. There is little nutrient input from farming, surface runoff from the lakes position as a shallow depression in a headwater plateau, or nutrient seepage from surrounding cabin septic tanks due to improved design. Also the lake is covered with weed beds due to a shallow mean depth, plants that sequester most dissolved nutrients and deposit them into the sediments. The result is clear water with Secchi disc readings of about 10 feet, but rather low productivity due to populations of phytoplankton that are low.

Dissolved nutrients. The productivity of fish and other living material in lakes depends on plants at the base of the food chain, mostly phytoplankton. But plants such as wild rice depend on the same nutrition: nitrogen, phosphorus, carbon dioxide, and light. Mineral limitation is most common. Most literature identifies nitrogen as the limiting nutrient for wild rice. Wild rice is of particular importance of our Native American culture on Big Sand. However it is disappearing here as elsewhere. Although quite shallow, harvests have never been very large at least since the dust bowl years and have diminished ever since. To determine why, we fertilized test chambers with combinations of minerals. Among those that supported wild rice, only those amended with phosphate would grow.

Table __ Effect of mineral amendments on Wild Rice growth according to stem diameter.

Nitrogen	Phosphorus	Phosphorus + nitrogen	Unamended control
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Add Photos.

Preliminary analysis of Big Sand phytoplankton speciation

Date	Species	Division
1/19/13	Chlorococcum	Chlorophyta
1/19/13	Asterionella	
	Westella	Chlorophyta
	Planktolyngbya	Chlorophyta
	Gleocystus	Chlorophyta
1/12/14	Synedra	Bacillariophyta
	Asterionella	Bacillariophyta
	Celostrum	
	Closterium	Chlorophyta
	Navicula	Bacillariophyta
	Ceratium	
	Synechococcus	Cyanophyta
	Frustulia	Baccillariophyta
	Ceratium	Pyrrhophyta
1/17/14	Pandorina	
	Glenodinium	
	Nitzschia	Bacillariophyta
	Peridinium	Pyrrhophyta
211/14	Anabaena	Cyanophyta
	Aphanizomenon	Cyanophyta
	Gyrosigma	
	Tolypthrix	
3/30/14	Tribonema	Chrysophyta
	Tabellaria	Chrysophyta
	Pithophora	Chlorophyta
	Mesotaenium	
	Oophila	
	Frustulia	Bacillariophyta
	Microcystis	Cyanophyta
	Coelastrum	
7/7/14	Schenedesmus	
	Microcystis	Cyanophyta
	Rhodomonas	
	Monoraphidium	
	Synedra	
	Rhodomonas	Cryptophycophyta
7/3014	Euglena	Euglenohyta

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	Rhodomonas	Cryptophycophyta
	Merismopedia	
	Oedogonium	
	Microcystis	Cyanophyta
	Nostoc	Cyanophyta
8/5/14	Volvox	Chlorophyta
	Gonyostomum	Ochrophyta
8/10/14	Chrysophaerella	
	Gleoeocystis	
	Kirchnerilla	
	Anabaena	Cyanophyta
	Nostoc	
	Gonystomum	
	Fragilaria	Bacillariophyta
	Pandorina	Chlorophyte
8/31/14	Nistoc	
	Gonystomum	
	Fragilaria	Bacillariophyta
	Aulacoseria	Bacillariophyta
	Frystylia	Bacillariophyta
	Anabaena	Cyanophyta
	Oscillatoria	Cyanophyta
9/21/14	Chroococcus	
	Nitchia	Bacillariophyta
	Microcystis	Cyanophyta
	Cyclotella	Bacillariophyta
	Rhodomonas	Cryotophyces
	Chlamydomonas	
	Amphenozomnon	Cyanophyta
10/27/14	Volvox	Chlorophyta
	Frustucia	
	Scenedesmus	Chlorophyta
1/24/15	Chlorocluster	
	Coelastrum	
	Gomphonema	Bacillariophyta
	Coscinodiscus	
	Hemidinium	
	Chlorococcum	Chlorophyta
	Selenastrum	Chlorophyta
	Nitzschia	Frustulia
	Dinobryon	
	Nostoc	Cyanophyta

Prominent Big Sand phytoplankters provisionally identified are shown in Fig. ___. Some were collected by net. Others were bucked sampled, most through the ice, Treated with iodine, allowed to settle usually three times in succession over three days, collecting the lower fraction,

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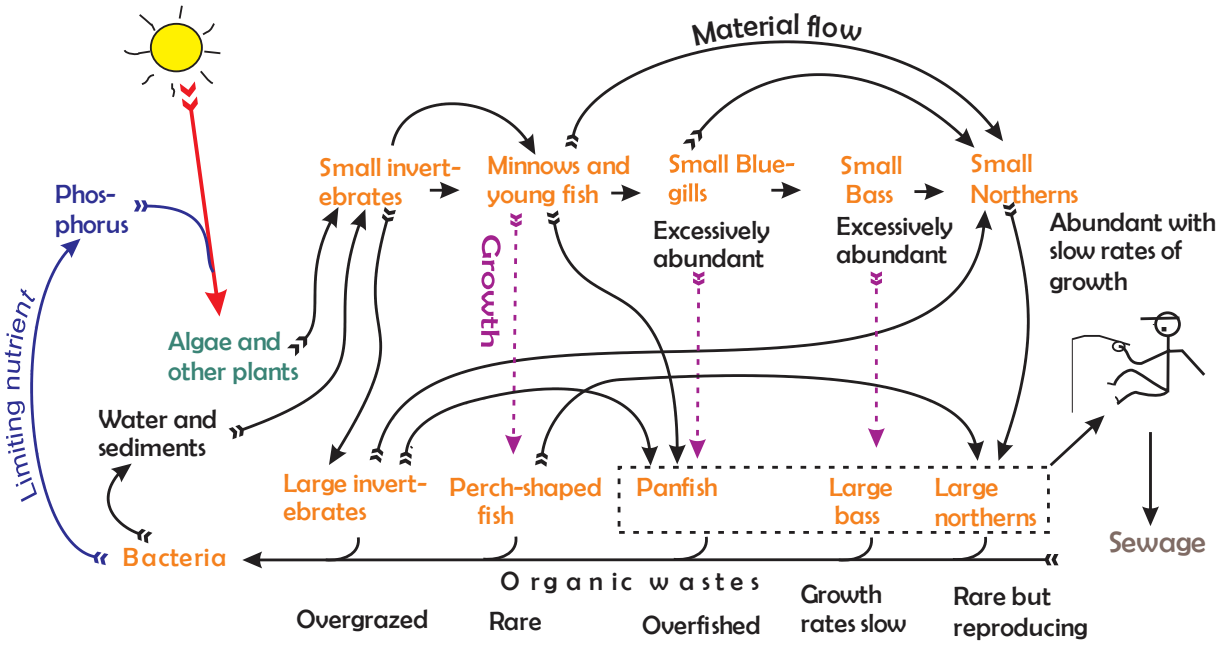
identified by microscope in wet mount, and photographed through a Leitz microscope mated to a digital recorder with a BEST custom coupler with internal vignetting-reduction lens.

Noteworthy was the significant Cyanobacterial content, even during winter. Iridescent metallic green sheen suggestive of cyanobacteria, organisms responsible for dog deaths and human problems have appeared. They were not, however positively identified.

Major flows of energy in Big Sand



Winners and loosers

Walleye	extirpated	Yellow perch	increasing	Bluegills	dwarfed	Fishers	increasing
Large northerns	threatened	Geese	increasing	Crappie	dwarfed		
Clams	threatened	Diving waterfowl	decreasing	Bass	dwarfed		
Bullheads	threatened	Chinese snails	invading	Northerns	dwarfed		
Mayfly nymphs	threatened	Wild rice	decreasing				
Invertebrates	overgrazed	Reed Canary grass	invading				

Conceptual model of energy flow in Big Sand. Beginning with algal production at the expense of sunlight, energy moves up through the food chain through various invertebrates, on to fish, and with humans as a major sink. Some of the interconnections are shown than is more accurately known as a food web. The return flow, the waste products of digestion are harvested by bacteria and returned to the water as minerals to be used by phytoplankton and other photosynthetic organisms including macrophytes (sea weeds) and cyanobacteria. As the lake

evolves under pressures, particularly human kind, there are some that increase and others that decrease shown as winners and losers. One surprising newcomer is yellow perch. These were always present but their particularly large size is new.

Date	Activity	Name	Time	Rate	Total
8/10/15	Aerial Survey	Button	0:45	200/hr	150
8/10/15	Boat Survey	Button/Putnoc	0;45	200/hr	150
Table ____	Phtoplankton analysis	Button	14 samples X 10 hrs	$50/hr with Labatatory	700
And much more					1,000

Key Findings:

1) The Big Sand Lake Landowner survey showed near unanimous support for efforts of the Big Sand Lake Preservation Association's Efforts to maintain the health of Big Sand including lakeshore restoration.

2) Images showed that some lake-fronts might be improved by vegetative restorations but they were limited, and only 7% of those were mineral surfaced. Main improvements would be a stronger riparian connection and shoreline erosion.

3) Bioassays showed the lake to be phosphorus limited so that runoff abatement is paradoxical. Increased density of littoral vegetation would reduce shoreline erosion, strengthen the terrestrial link to the aquatic community, and improve biodiversity. Conversely the trophic status tends toward oligotrophic so that greater water transparent might improve some visual properties, productivity of the already under-fed fishery might be further decreased.

4) Invasion by foreign species often appears to depend on lake properties such as distribution and water chemistry. Big Sand, if it is a soft water lake low in calcium, may resist invasion by zebra mussels.

5) A series of impediments to water flow due from road and other projects has converted Big Sand from a drainage lake to a seepage lake which has decreased productivity.

6) Morphology is diverse with deep refuges extensive shallow weed beds improving attractiveness to fish and wildlife.

7) Anthropogenic overfishing has led to dwarfing, extinctions, threatened populations including the top piscivore (northern pike) and reduced opportunities to catch large

Fish.

Increased corn crops has bolstered geese populations that use Big Sand as a migratory respite damaging rice beds and, as carriers of schistosomes, increasing the presence of swimmers itch.

8) Invasion by alien species is comparatively limited. Largemouth ball and black crappie were introduced as sport fish, reed canary grass was introduced as cattle feed, and a few large snails have appeared.

9) Cyanobacteria are surprisingly abundant and persist throughout the year.

10) Big Sand appears to be striving for new equilibria in response to these various insults. Over the years excess populations have shifted from small northern pike to small sunfish, and then to small bass. Reed canary grass and hybrid cattails are gaining. And a good population of large yellow perch is becoming established. Mayflies, once numerous, along with their larva as a major food stock along with frogs and clams and wild rice are in decline.

11) Climate change and associated warming could impact Big Sand with Northern pike near its upper temperature limit and dense Cyanobacterial blooms, along with associated toxins could become problematic leading to possible ecological upsets such as can be initiated by infestation by common carp.

Strategy going forward. Following are plans based on results from the planning grant. The common thread is that the main threats to the health of Big Sand, invasion by alien species, habit destruction, and selective removal of the most robust individuals of various species are mostly man made.

Species invasion. Although interlake transfer by bait or boat is likely, few new fully aquatic species are apparent. The main resistance may be a healthy lake with insufficient empty niches and suitable chemical and physical properties for easy invasion. For example common carp, long established in Yellow River a couple miles down stream, have failed to establish p population of breeding fish. New evidence suggests that mineral concentrations, sediment content, and turbidity can all affect invasions. Thus understanding invasive threats requires some new measurements such as the levels of calcium, iron, and algal toxins, the properties of sediments, and deep water turbidity.

Secondly species is not necessarily all that bad; new DNA is added which may simply speed evolution toward a new maximum in total biomass. Also a new species can add to species diversity, the hallmark of a healthy ecosystem. So the invasion could be more of a short term problem and the new species may fit in better in time as it becomes prey for a new predator perhaps normally present in the invaders original home.

Shoreline restoration. Most of the shoreline of Big Sand is vegetated by native species, and nutrient runoff appears not to be problematic. However there is room for improvements and financial support to do so for part of the waterfront. Some shoreline is eroded, some has little vegetative buffer to limit erosion and support ecological exchanges, and some might profit by replacing mineral waterfronts with some firmly rooted plants. The density of docks is high and evidence indicates a negative impact on lake ecology. In many cases a the gently sloping beach makes a somewhat lengthy dock convenient, even for craft of modest draft.

Understanding Big Sand. With foreign authorship in the lead American *Limnology and Oceanography* at 62% and government funding for understanding our lakes somewhere well below 0.1% of that for human health, It is not surprising that basic concepts in how our lakes function lags. Interactions among aquatic organisms can be likened to those among the organs of the human body. Both are complex, but only those of the human body have enjoy detailed descriptions.

Most useful for understanding lake is a measurement based mathematical model of the biological organisms contained. A conceptual model based on synoptic observations of Big Sand (Fig. __) attempted to show energy flows and feeding responses. More useful are models that reflect actual flows. Recent advances in the construction of such models have been pioneered in Europe. We are making certain contributions to the modeling of competition for nutrients as well. One goal is to utilize this new knowledge in a way that helps generate better management decisions for the lake.

Fishery improvement. A significant immediate problem is selective removal of the largest members of the several fished species. It has led to dwarfing, slow rates of growth, and ecological imbalances. We therefore propose to encourage a culture of catch and release modeled around some of the successes experienced in Minnesota and particularly in Canada.

Historical changes. Niow with experience in identifying trends in the populations of phytoplankton, we plan to examine the record of diatom sizes left in the sediments. The main goal is to help correlate lake health with the rather recent increases in human populations over the last two centuries.

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