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Determination of the Seasonal Changes in Nitrate and Phosphate Concentration and Phytoplankton Composition Within Selected Fertilized Lakes

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DETERMINATION OF THE SEASONAL CHANGES IN NITRATE AND PHOSPHATE CONCENTRATION AND PHYTOPLANKTON COMPOSITION WITHIN SELECTED FERTILIZED LAKES

for the

Arkansas Game and Fish Commission
Fisheries Division
Little Rock, Arkansas

by
Richard L. Meyer
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Final Report
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Acknowledgments

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Introduction

The two year study conducted by Meyer and Trost (1993) on Bob Kid Lake, a Arkansas Game and Fish Commission (AG&FC) Lake, has clearly indicated that this lake is nitrate-nitrogen (NO_3-N) limited. A cooperative detailed study of phytoplankton and zooplankton response to traditional fertilization practices was conducted on this lake in 1993 (Meyer, 1993). The latter study demonstrated that the applied 4 tons of fertilizer at three selected sites in Bob Kidd Lake had little or no influence on the quantity and quality of phytoplankton and/or zooplankton. Combined, these studies estimated the limiting factor and tested the efficacy of standard fertilizer composition, application rate and time of fertilization. Ongoing analysis of a modified strategy instituted by the AG&FC with a nitrogen only fertilizer has demonstrated desired results of increasing the preferred food source, chlorophycean phytoplankton, and assimilation of the nitrogen addition.

The standard strategy for fertilization of lakes is to use varying quantities of a commercial fertilizer of fixed composition; e.g., 18-46-0 NPK @ n tons per acre. This a strategy assumes that all lakes have the same chemical composition, follow the same nutrient cycling, and are phosphorus limited.

This strategy is challengable since Arkansas has a diversity of ecological regions and climatic conditions. The Boston Mountain and Ozark Plateau of northwest Arkansas are primarily under lain with limestone and sandstone substrate with oak-hickory forest and prairie while the southwestern Ouachita Mountain region has a granitic substrate and supports a pine forest. The southern gulf coastal plain is composed of marine deposits and covered with a pine forest. The central Arkansas River Valley contains alluvial deposits and is extensively farmed but contains scattered wood lots. The eastern delta region is composed of alluvial deposits from the Mississippi River. It is extensively farmed with minimal native vegetation remaining. Within the eastern delta is an island of the eastern deciduous forest, Crowley Ridge. This diversity of geological history, topography, vegetation and land use practice strongly suggests that AG&FC lakes are integrators of the local conditions and are not of identical physical, chemical and biological characteristics. The managed lakes, however, may share characteristics which allow them to be clustered into strategic management groups.

The objectives of this study were to determine the monthly and annual concentration of nitrate-nitrogen (NO_3-N) and soluble reactive phosphate-phosphorus (SRP-P) as well as the composition of the phytoplankton population. Also the lakes were characterized by measuring annual epilimnetic temperature and light penetration by Secchi disc depth measurements. Biodiversity of the phytoplankton and seasonal succession of dominate taxa provide insight into the response of the basic trophic level in the lake ecosystem.

Site Descriptions

The lakes selected for analysis were determined by the AG&FC staff. The included :

Lake Atkins; 752 acres, 37 years old, Arkansas River Valley, Pope Co.
Lake Avalon; Ouachita Mountains, Garland Co.
Lake Balboa; Boston Mountains/Ozark Plateau, Benton Co.
Lake Bob Kidd; 200 acres, 18 years old, Boston Mountains/Ozark Plateau, Washington Co.
Lake Charles; 650 acres, 30 years old, Boston Mountains/Ozark Plateau foothills, Lawrence Co.
Lake DesArc; 350 acres, 27 years old, Delta & Arkansas River Valley, Prairie Co.
Harris-Brake Lake; 1300 acres, 39 years old, Ouachita Mountain foothills, Perry Co.
Lake Overcup; 1025 acres, 31 years old, Arkansas River Valley, Conway Co.
Lake Poinsett; 600 acres, 32 years old, Crowley Ridge, Poinsett Co.
White Oak Lakes; 2667 acres (upper lake 1031 acres, lower lake 2645 acres), Gulf Coastal Plain, Nevada Co.

Protocols and Methods

Field measurements and samples were provided by AG&FC personnel on a monthly basis. Field measurements included temperature and Secchi disc depth. An epilimnetic chemical sample and a M_3 preserved phytoplankton sample were mailed to the Arkansas Water Resources Center, Water Quality Laboratory for nutrient analysis. Analysis was conducted with ion chromatographic standard methods. All nutrient analysis included approved quality assurance and quality control protocols. Microscopic examination of the phytoplankton was conducted by the author.

Results and Interpretation

Certain generalized geographic trends are evident. For example the thermal regimes of the lakes vary by latitude. The northern lakes tend to have a thermal maximum near 30°C while the southern lakes peak at 35°C or greater. The northern lakes tend to have a broad maximum (July & August) with gradual increase in spring and a less dramatic decline during the fall. The southern lakes experience rapid warming during May through July, a single peak (August) with rapid cooling during September and October. A comparison of Bob Kidd Lake or Lake Balboa versus Lake Poinsett or White Oak Lakes clearly demonstrate these differences.

Secchi disc readings are variable and inconclusive. These readings are influenced not only by the presence of phytoplankton but beach erosion and resuspension of silt from the lake bottom. More useful readings would be those taken from the open lake rather than near the shore.

Two general nutrient dynamics patterns emerge from the analysis. Five lakes, Lakes Avalon, Bob Kidd, Charles, DesArc and Poinsett, each have their high concentrations of NO_3-N and SRP-P during the winter with a precipitous decline in the spring. The concentrations remain at minimal level until fall turnover. At that time nutrients in the hypolimnion are added to the surficial waters. In contrast three lakes, Lake Balboa and upper and lower White Oak Lake, are more dynamic. The spring decline leads to a minimal concentration in May with a recovery to near maximum concentration in June with a secondary

minimum in late summer. Fall turnover may result in increased nutrients but these are quickly utilized and then become available a second time.

The constant feature of all lakes is that nutrients are at the there maximum or elevated during the winter and there is a rapid uptake of nutrients in the spring. This implies that light is limiting growth of phytoplankton. Insolation is increased during the spring-to-summer transition because on extending day length and greater sun angle.

The annualized pattern of dominant phytoplankton taxa in temperate mesotrophic lakes is as follows. The diatoms dominate in the winter and early spring phytoplankton assemblage. This assemblage may include golden brown flagellates. During the spring cryptomonads and green algae are the most common phytoplankters with a small representation of bluegreen taxa. With an adequate nitrogen source the desirable green algae extend into the early summer. If, however, nitrogen is limiting bluegreen algae tend to dominate. The late summer assemblage includes taxa which are tolerant to elevated temperatures, typically selected bluegreen algae. Following fall turnover a wide diversity of algae are present with rapid succession bluegreens, greens and flagellates. During late fall, as light and temperature become limiting, flagellates continue in importance and are accompanied by an increase in diatom abundance.

The lakes included in this research demonstrated a typical fall-winter-spring cycle. Differences were noted in the dynamics of nutrient concentrations and phytoplankton composition in the spring and early summer.

The five lakes which have precipitous declines of NO_3-N of zero or trace concentration are dominated by nitrogen fixing bluegreen algae during the summer period. These algae are capable of expending energy to pump SRP-P into the cells. The phosphate is stored as phosphate bodies and can be used as a resource during periods of stress. Also, these algae are capable of nitrogen fixation. Thus when nitrogen and phosphorus are limiting to other algae they can utilize stored phosphate and fix atmospheric nitrogen for continued growth. This competitive advantage is expressed by their dominance during periods of nutrient stress. The presence of these bluegreen algae does not necessarily imply eutrophic conditions but survival of the best adapted.

The three lakes, Lake Balboa and upper and lower White Oak Lake, displayed a recovery of the green algae during June. Interestingly, nitrogen concentrations increased in both White Oak Lakes while the SRP-P only increased in Upper White Oak Lake. In each instance desirable taxa increased in importance. The populations shifts were observable in June or a delayed response was observed in July. This difference could be associated with the time of sampling relative to the availability of nutrients and the growth rate of the algae. Following the growth of this temporary assemblage the nutrients decline to near undetectable levels and the "stress" assemblage is re-established.

The most critical period for providing food for the larval fish and zooplankton is during the spring. The desirable food sources are flagellates and green algae. These phytoplankton organisms maintain their maximum growth rate and assemblage dominance when NO_3-N is readily available. This pattern was observed in the eight lakes during the spring and also in early summer when nitrogen was available in Lake Balboa and the White Oak Lakes. These observations strong support the need to maintain the NO_3-N concentrations in these lakes if the maximum desirable phytoplankton quantity is to be available for the young of the year fish population.

Each of the lakes surveyed appeared to be NO_3-N limited and not SRP-P limited. With the addition of NO_3-N fertilizer phosphate may become restrictive. The addition phosphate, however, may result in accelerating eutrophic conditions and producing conditions which cause an undesirable shift in the fish population. The data suggest that continued use of the present practice of low N:P ratio fertilizer will, in the long term, produce undesirable results.

Lakes Balboa and Overcup and Harris-Brake Lakes are not included in the foregoing analysis because of interrupted and/or insufficient data.

Recommendations

Each of the lakes examined indicate that the spring phytoplankton bloom quickly utilizes all of the available NO_3-N and most or all of the SRP-P. When nitrate become limiting the populations shift from the desirable green to less desirable bluegreen algae. In order to maintain the growth rate of the green

algae and to extend their availability as food sources for the zooplankton and larval fish additional NO_3-N is required.

In those lakes in which the NO_3-N concentration declines and remains low, successive applications of *high nitrogen* fertilizers would be most desirable, i.e., two, three or more applications. In those lakes with available SRP-P during the summer, Lakes Avalon, DesArc and Poinsett, a *nitrogen only* based fertilizer would be the most desirable. If enhanced overall phytoplankton production is desirable, a high nitrogen and low phosphorus fertilizer could increase the standing crop of phytoplankton, eg., Bob Kidd Lake and Lake Charles. This enhancement should be approached with caution since the addition of phosphate could result in undesirable eutophic conditions. Initial trial applications of fertilizer should have a N:P ratio greater than 10:1.

In those lakes with an additional early summer maxima of nutrients a single application of nitrate only fertilizer would be necessary. The addition of this fertilizer in late March should provide the nitrate necessary to extend the abundance of green phytoplankton assemblage into the normal summer bloom.

In summary, a fertilization strategy should be developed to maintain NO_3-N availability from early March through June or early July. This is best accomplished by multiple lower quantity applications. A single large quantity application **does not** produce th desired results or is cost/time effective.

The critical periods of the year are early spring through early summer and again in late fall. A modified sampling regime is recommended. Samples should

be taken at two-week intervals from early March through June or early July and in late October or early November. This sampling protocol will provide greater detail into nutrient and phytoplankton dynamics during the critical spring/early summer growth period as well as an indication of the lake trophic status. The latter can be estimated via the late fall samples. If the lake is fertilized, samples should be collected immediately before and after fertilization, i.e., the same day. The sampling should extend for two sampling periods, four weeks, after fertilization in order to measure the efficacy of the application.

Fertilizers should be applied only to the epilimnetic littoral zone in order to expand the desirable phytoplankton in the feeding range of the juvenile fish. This restricted application will avoid the problems associated with increasing eutrophication.

Literature Cited

Meyer, R. L. 1993. Determination of the Efficacy of Fertilization Practices on Bob Kidd Lake. Arkansas Water Resources Center, University of Arkansas. 38 p.

Meyer, R. L. and Trost, G. K., 1993. The Influence of Reservoir Basin Morphometey on Phytoplankton Community Structure. Arkansas Water Resources Center Publ. No. 163. University of Arkansas. 40 p.

Cyanophyta												
Anabaena	1	1	1	1		1		1				
Aphanothece			1	1								
Coleosphaerium			1									
Eucapsis		1	1									
Gloeocapsa		1		1								
Lyngbya			1	1								
Merismopedia				1				1				
Microcystis			1	1		1		1	1			
Oscillatoria	1	1	1	1		1			1			
Diversity (n)	14	13	22	20	*ns*	17	*ns*	7	10	*ns*	12	0

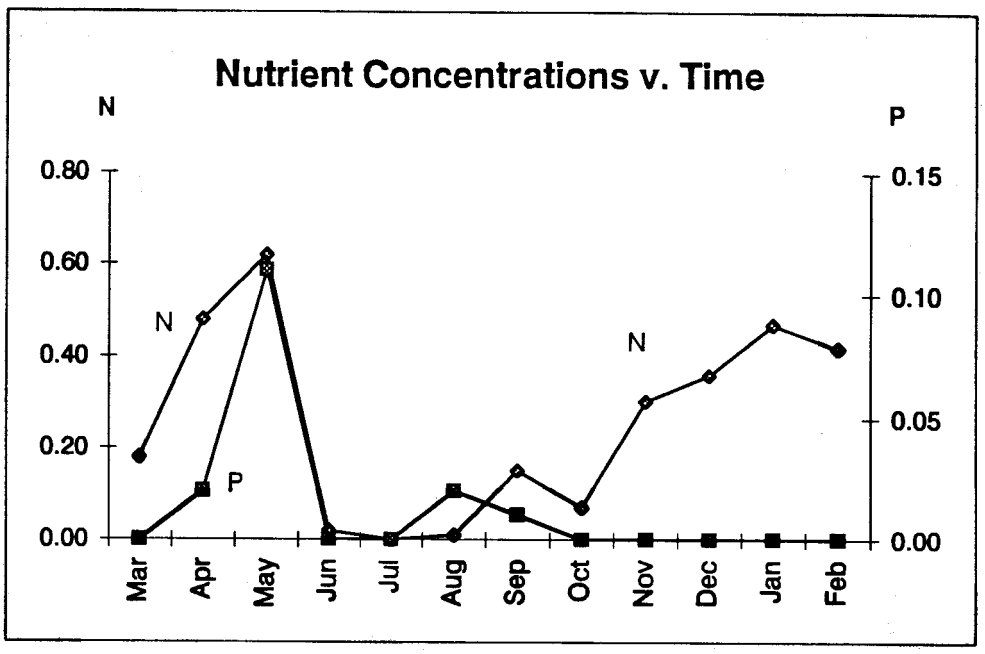
Dominant Algae	
March	Cyclotella, Ankistrodesmus & Nitzschia
April	Anabaena & Gloeocapsa
May	Microcystis(>70%) , Aphanothece , Anabaena & Aknistrodesmus
June	Microcystis (>70%), Ankistrodesmus & Merismopedia
July	*No Sample*
August	Oscillatoria, Mictrocystis & Anabaena
September	*No Sample*
October	Microcystis, Merismopedia & Ankistrodesmus
November	Oscillatoria, Ankistrodesmus & Melosira
December	*No Sample*
January	Cyclotella, Synedra, Nitzschia & Mallomonas
February	

Arkansas Game & Fish Commission---Lake Survey

Lake Avalon

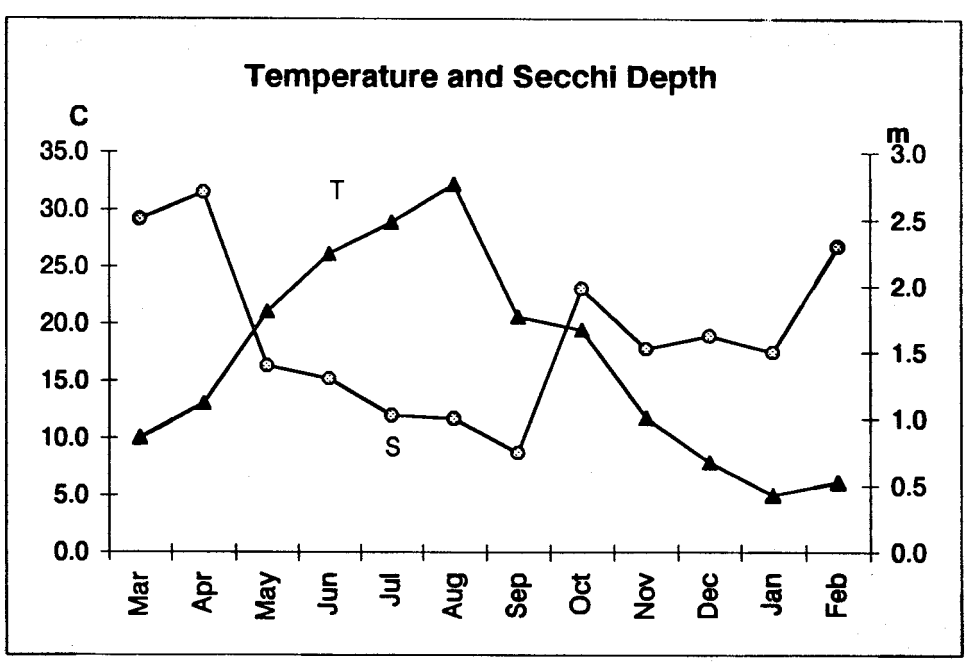
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N	0.18	0.48	0.62	0.02	0.00	0.01	0.15	0.07	0.30	0.36	0.47	0.42
Phosphate-P	0.00	0.02	0.11	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00



Temperature & Secchi Depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)	10.0	13.0	21.1	26.1	28.9	32.2	20.6	19.4	11.7	7.8	5.0	6.1
Secchi depth (m)	2.5	2.7	1.4	1.3	1.0	1.0	0.7	2.0	1.5	1.6	1.5	2.3



Arkansas Game & Fish Commission---Lake Survey

Lake Avalon

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Chlorophyta	15	15	14	15	15	17	17	13	15	16	14	16
Ankistrodesmus	1	1	1				1					1
Asterococcus				1								
Chlamydomonas	1		1		1	1	1					
Coelastrum										1		
Cosmarium						1						
Crucigenia					1			1				
Diaspora												
Dictyosphaerium					1							
Eudorina	1											
Gloeocystis					1						1	
Kirchneriella						1						
Micractinium											1	
Oocystis	1											
Pandorina					1	1						
Phacotus	1											
Planktosphaeria				1	1		1					
Scendesmus			1				1					
Tetraedron	1											
Treubaria												1
Bacillariophyta												
Cyclotella	1	1	1				1		1	1		
Melosira	1								1	1		
Achnanthes	1		1									
Asterionella			1	1							1	
Cymbella	1											
Nitzschia					1							
Surirella												
Synedra		1	1	1					1	1		1
Chrysophyta												
Dinobryon					1		1		1			
Ochromonas								1			1	
Uroglena			1						1			
Synurophyta												
Mallomonas	1		1		1			1	1	1	1	
Cryptophyta												
Chroomonas	1				1						1	
Cryptomonas									1	1	1	
Pyrrhophyta												
Amphidinium	1											
Ceratium									1			
Peridinium	1											
Euglenophyta												
Lepocinclis									1			
Phacus	1											

Cyanophyta												
Anabaena				1	1	1			1			
Aphanothece			1									
Coleosphaerium			1									
Eucapsis							1					
Lyngbya						1						
Microcyctis				1		1	1	1				
Oscillatoria	1			1	1	1	1	1		1		1
Raphidiopsis						1	1					
Diversity (n)	17	4	12	8	13	10	11	6	11	8	8	5

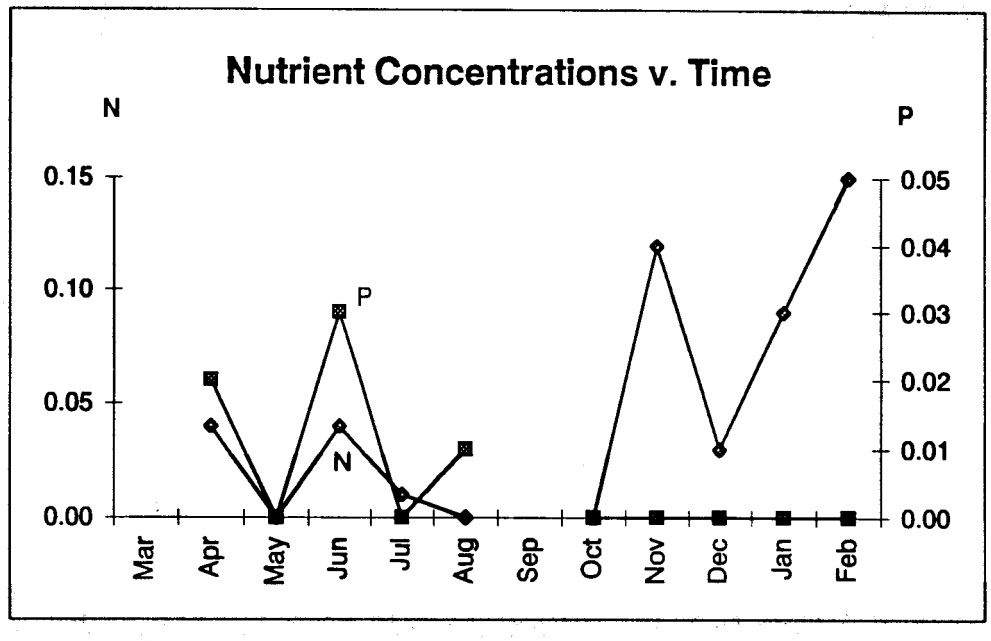
Dominant Algae	
March	Mallomonas & Chroomonas
April	Cyclotella (>80%) & Ankistrodesmus
May	Coleosphaerium (>95%)
June	Oscillatoria, Planktosphaeria, Synedra & Asterionella
July	Dictyosphaeridium, Dinobryon, Gloeocystis 7 Oscillatoria
August	Raphidiopsis (50%), Lyngbya & Anabaena
September	Dinobryon, Microcystis & Eucapsa
October	Mallomonas (>90%), Ochromonas & Microcystis
November	Mallomonas (>95%), Ceratium & Cryptomonas
December	Mallomonas (>95%), & Cryptomonas
January	Mallomonas (>95%), Golenkinia & Micractinium
February	Oscillatoria, Synedra & Ankistrodesmus

Arkansas Game & Fish Commission---Lake Survey

Lake Balboa

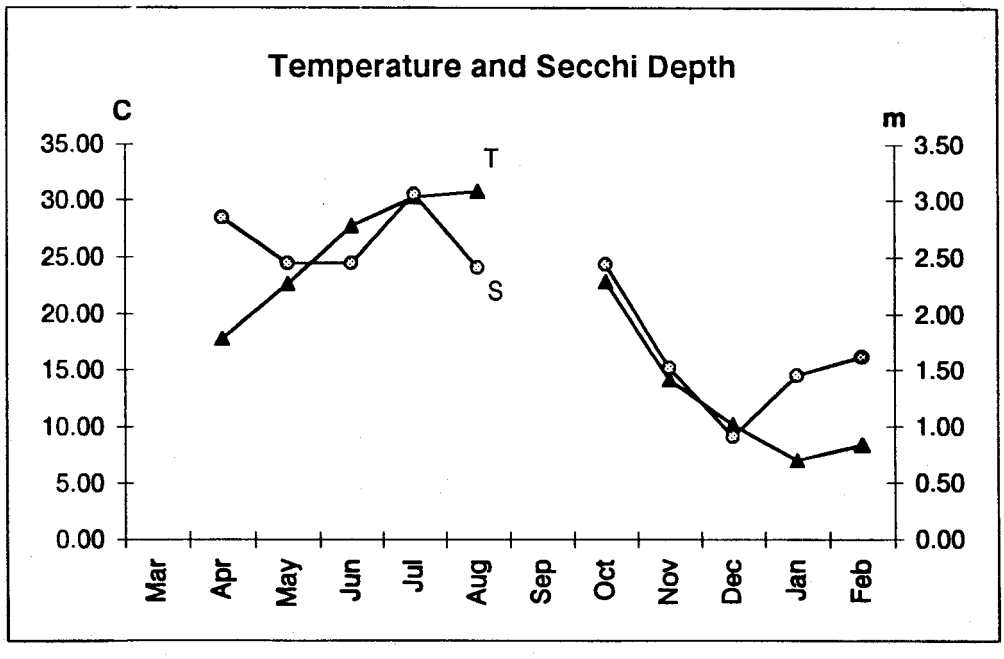
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N		0.04	0.00	0.04	0.01	0.00		0.00	0.12	0.03	0.09	0.15
Phosphate-P		0.02	0.00	0.03	0.00	0.01		0.00	0.00	0.00	0.00	0.00



Temperature & Secchi depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)		17.8	22.6	27.7	30.2	30.7		22.8	14.1	10.2	7.0	8.3
Secchi depth (m)		2.8	2.4	2.4	3.1	2.4		2.4	1.5	0.9	1.5	1.6



Arkansas Game & Fish Commission---Lake Survey

Lake Balboa

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	*ns*	30	28	25	14	31	*ns*	##	1	7	12/30	1/28	Day
Ankistrodesmus			1										
Arthrodesmus						1							
Chlamydomonas										1			
Cosmarium			1			1							
Gloeocystis			1		1	1				1			
Golenkinia						1							
Oocystis					1								
Planktosphaeria			1										
Pediastrum						1							
Scendesmus			1			1							
Staurasturm						1							
Tetraedron					1								
Bacillariophyta													
Cyclotella		1	1		1	1					1	1	
Cymbella								1					
Fragilaria											1		
Navicula					1								
Synedra											1	1	
Chrysophyta													
Ochromonas						1							
Cryptophyta													
Chroomonas												1	
Pyrrhophyta													
Gymnodinium						1							
Peridinium					1								
Cyanophyta													
Aphanothece			1										
Lyngbya						1							
Microcystis			1					1					
Oscillatoria				1	1								
Diversity (n)	*ns*	1	8	1	7	11	*ns*	2	0	2	3	3	

ns = no sample

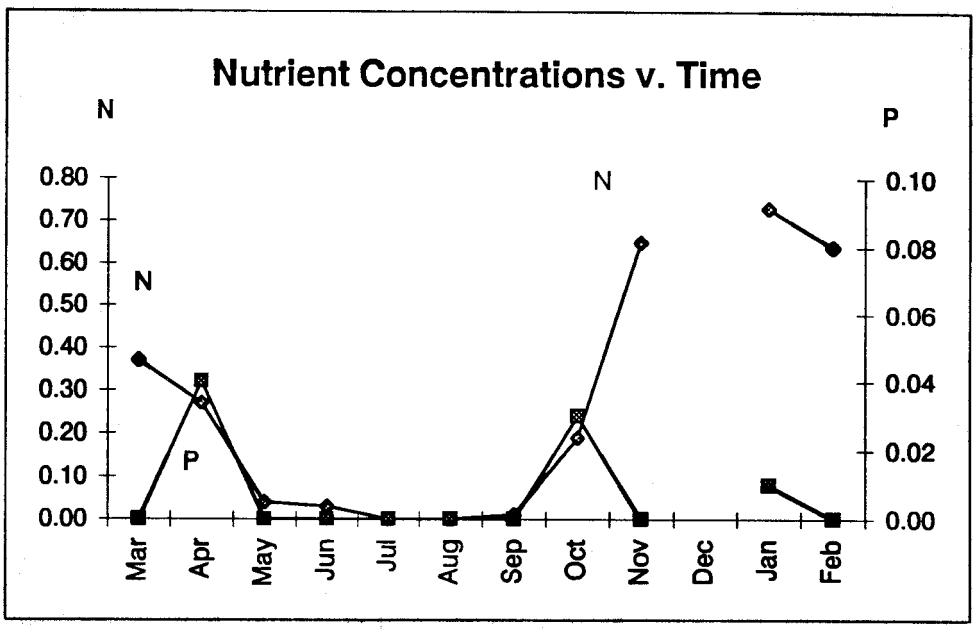
Dominant Algae	
March	*No Sample*
April	Cyclotella only; with numerous rotifers
May	Microsystis, Gloeocystis & Cosmarium
June	Microcystis
July	Microcystis (90%), Gloeocystis & Micractinium
August	Staurasturm, Arthrodesmus & Gloeocystis
September	*No Sample*
October	Microcystis
November	*No living phytoplankton observed.*
December	Chlamydomonas & Gloeocystis (Sparse)
January	Cyclotella, Fragilaria & Synedra (Sparse)
February	Cyclotella, Chroomonas & Synedra (Sparse)

Arkansas Game & Fish Commission---Lake Survey

Lake Bob Kidd

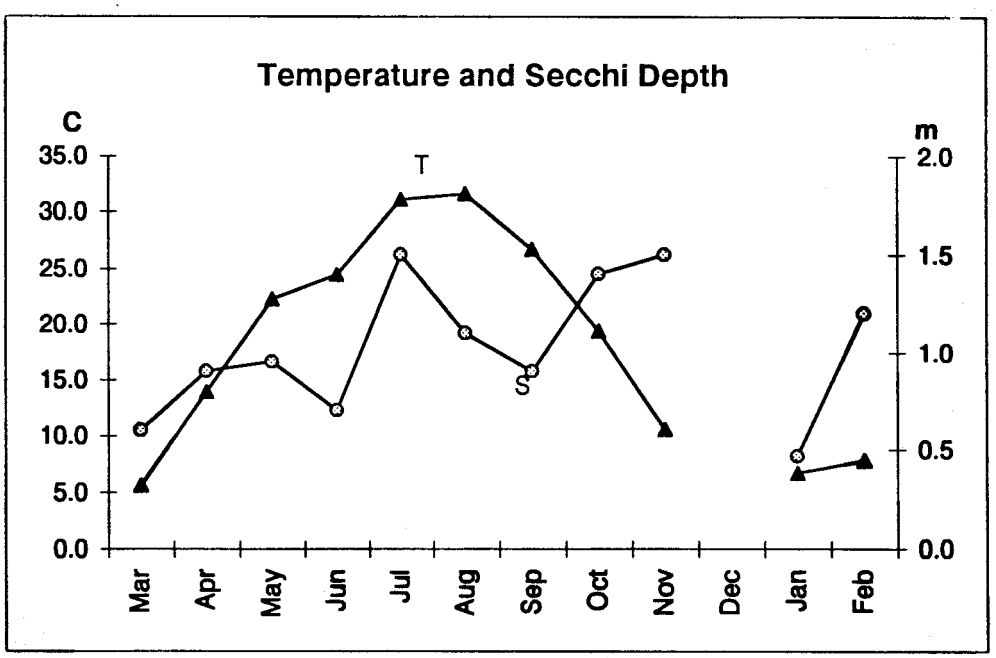
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N	0.37	0.27	0.04	0.03	0.00	0.00	0.01	0.19	0.65		0.73	0.64
Phosphate-P	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.03	0.00		0.01	0.00



Temperature & Secchi depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)	5.6	13.9	22.2	24.4	31.1	31.6	26.7	19.4	10.6		6.7	7.8
Secchi depth (m)	0.6	0.9	1.0	0.7	1.5	1.1	0.9	1.4	1.5		0.5	1.2



Arkansas Game & Fish Commission---Lake Survey

Lake Bob Kidd

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	15	13	17	8	19	27	22	8	22	*ns*	27	22	Day
Actinasturm		1											
Ankistrodesmus	1	1	1		1	1	1	1	1		1	1	
Arthrodesmus				1									
Carteria			1										
Chlamydomonas	1		1										
Closteriopsis	1												
Coelastrum											1		
Crucigenia		1											
Dactylococcopsis		1											
Dictyosphaeridium	1	1	1								1	1	
Elakatothrix		1											
Euastrum							1						
Eudorina			1										
Gloeocystis				1		1	1		1				
Golenkinia			1										
Kirchneriella		1		1									
Micractinium	1								1				
Oocystis						1							
Pediastrum				1									
Phacotus		1											
Planktosphaeria				1	1						1		
Scendesmus	1	1	1	1	1		1		1		1		
Staurasturm						1							
Tetraedron							1						
Westella									1				
Bacillariophyta													
Cyclotella	1	1	1	1			1	1	1		1		
Melosira	1			1					1		1		
Stephanodiscus	1	1											
Achnanthes	1												
Asterionella	1												
Cymbella	1												
Fragilaria	1							1	1				
Gomphonema	1												
Gyrosigma											1		
Navicula	1	1	1	1	1								
Nitzschia	1	1	1	1	1			1	1		1		
Surirella													
Synedra	1			1							1		
Synurophyta													
Mallomonas									1				
Cryptophyta													
Chroomonas	1		1								1		
Cryptomonas				1	1	1			1				

Pyrrhophyta												
Gymnodinium	1	1										
Peridinium				1		1	1					
Euglenophyta												
Euglena	1					1						
Cyanophyta												
Anabaena		1	1	1		1	1					
Aphanizomenon				1	1							
Aphanothece					1						1	
Chroococcus			1				1		1			
Dactylococcopsis						1						
Eucapsis								1				
Gomphosphaeria							1					
Lyngbya				1	1		1					
Merismopedia						1	1					
Microcyctis			1	1	1	1	1	1			1	
Oscillatoria			1	1	1	1	1	1			1	
Raphidiopsis					1	1	1					
Diversity (n)	20	15	15	18	12	13	15	7	12	*ns*	14	2

ns = no sample

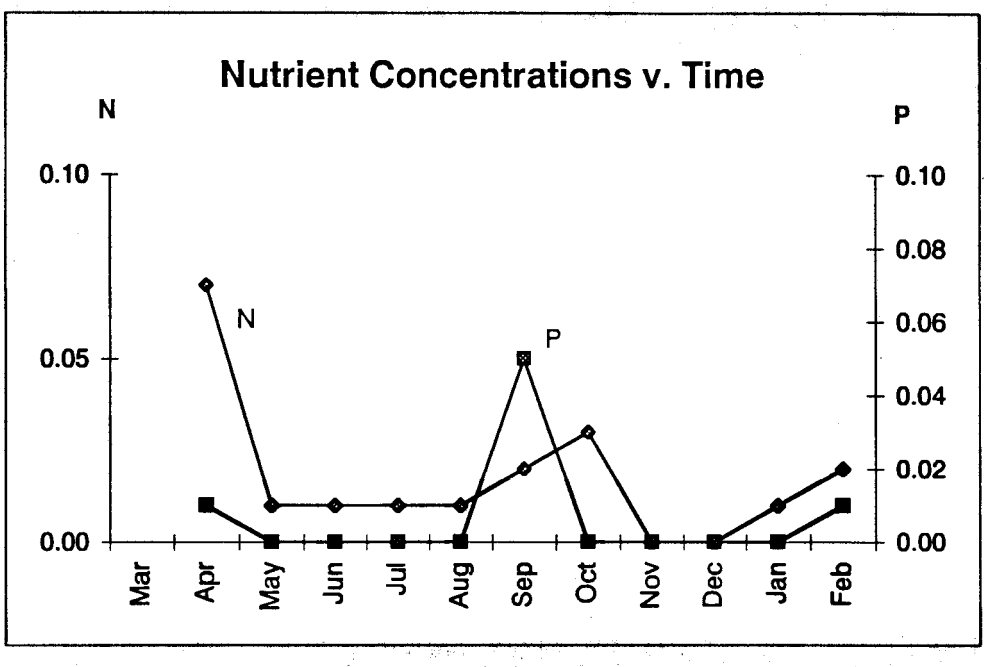
Dominant Algae	
March	Cyclotella (>95%)
April	Elakatothrix, Cyclotella & Actinasturm (Coccoid Chlorophytes)
May	Scendesmus, Chroococcus & Dictyosphaeridium
June	Oscillatoria, Microcystis, Peridinium & Synedra
July	Oscillatoria (45%), Microsystis (40%) & Nitzschia
August	Oscillatoria, Dactylococcopsis, Microcystis & Anabaena
September	Oscillatoria, Microcystis, Raphidiopsis & Merismopedia
October	Oscillatoria, Microcystis & Ankistrodesmus
November	Melosira (>90%) & Ankistrodesmus
December	*No sample*
January	Nitzschia, Melosira & Cyclotella
February	Dictyosphaeridium & Ankistrodesmus

Arkansas Game & Fish Commission---Lake Survey

Lake Charles

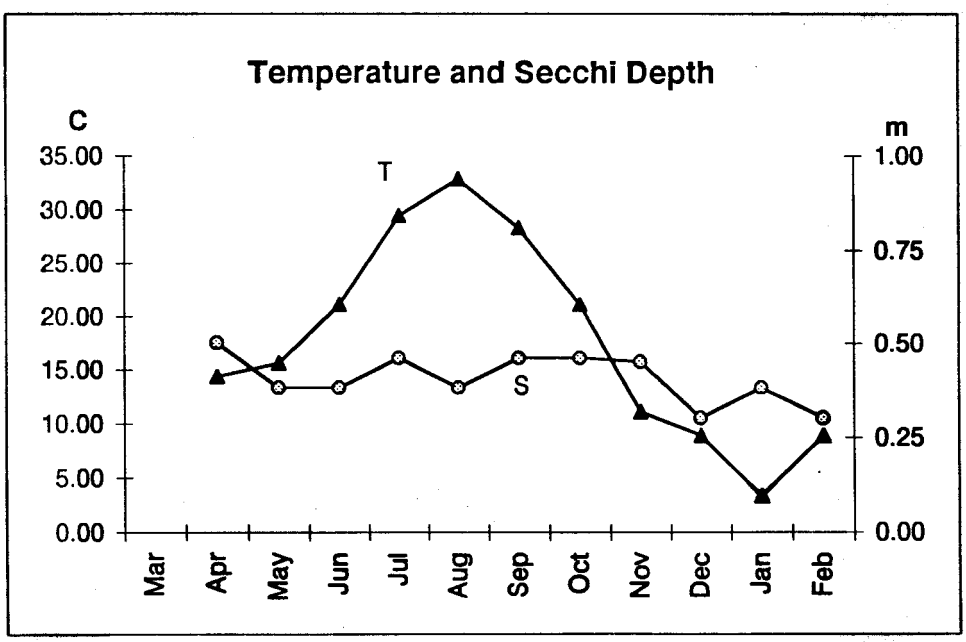
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N		0.07	0.01	0.01	0.01	0.01	0.02	0.03	0.00	0.00	0.01	0.02
Phosphate-P		0.01	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.01



Temperature & Secchi depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)		14.4	15.6	21.1	29.4	32.8	28.3	21.1	11.1	8.9	3.3	8.9
Secchi depth (m)		0.5	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.3	0.4	0.3



Arkansas Game & Fish Commission---Lake Survey

Lake Charles

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	*ns*	3	4	2	6/3	2	2	4	1	2	4	23	Day
Ankistrodesmus		1			1		1		1	1			
Carteria											1		
Chlamydomonas				1							1		
Chodatella											1		
Closterium									1				
Coelastrum													
Cosmarium					1								
Disctyosphaeridium												1	
Eudorina					1								
Gloeocystis				1	1			1	1				
Golenkinia										1			
Kirchneriella									1				
Micractinium		1							1				
Pandorina					1								
Planktosphaeia								1					
Spondylosium				1									
Staurastrum				1									
Scendesmus			1					1					
Tetraedron		1											
Bacillariophyta													
Cyclotella		1	1	1			1		1	1	1		
Melosira		1							1	1		1	
Cymbella												1	
Fragilaria		1	1										
Gomphonema													
Navicula			1	1		1		1				1	
Nitzschia		1				1	1	1	1				
Pleurosigma												1	
Surirella													
Synedra		1										1	
Chrysophyta													
Dinobryon		1	1										
Synurophyta													
Mallomonas			1										
Cryptophyta													
Chroomonas		1		1				1	1				
Cryptomonas		1	1						1	1	1		
Pyrrhophyta													
Gymnodinium					1				1		1		
Peridinium				1									

Euglenophyta												
Euglena		1										
Phacus				1								
Trachelomonas			1								1	
Cyanophyta												
Anabaena				1	1				1			
Aphanothece		1										
Chroococcus		1								1		
Dactylococcopsis							1					
Eucapsis							1					
Merismopedia		1				1	1		1			
Microcyctis						1		1	1	1		
Oscillatoria						1	1	1	1	1		1
Raphidiopsis					1	1	1	1				
Diversity (n)	*ns*	16	9	11	8	7	9	10	16	9	8	8

ns = no sample

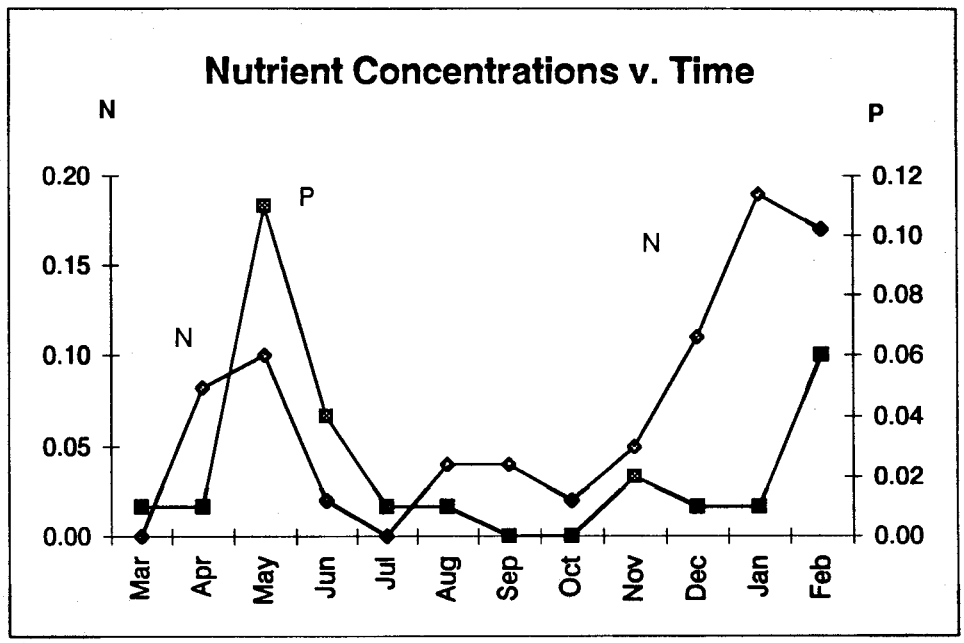
Dominant Algae	
March	*No sample*
April	Cyclotella & Nitzschia/Fragilaria
May	Cryptomonas, Scenedesmus & Dinobryon
June	Anabaena (>955)
July	Pandorina & Gloeocystis
August	Raphidiopsis (85%) & Oscillatoria
September	Raphidiopsis (95)%), Merismopedia & Oscillatoria
October	Oscillatoria, Microcystis & Nitzschia
November	Cyclotella (>85%), Merismopedia & Microcystis
December	Cyclotella (>95%), Melosira & Ankistrodesmus
January	Cyclotella (>95%) & Chlamydomonas
February	Melosira, Dictyosphaeridium & Synedra

Arkansas Game & Fish Commission---Lake Survey

Lake DesArc

Nitrate-N and Phosphate-P Data (mg/l)

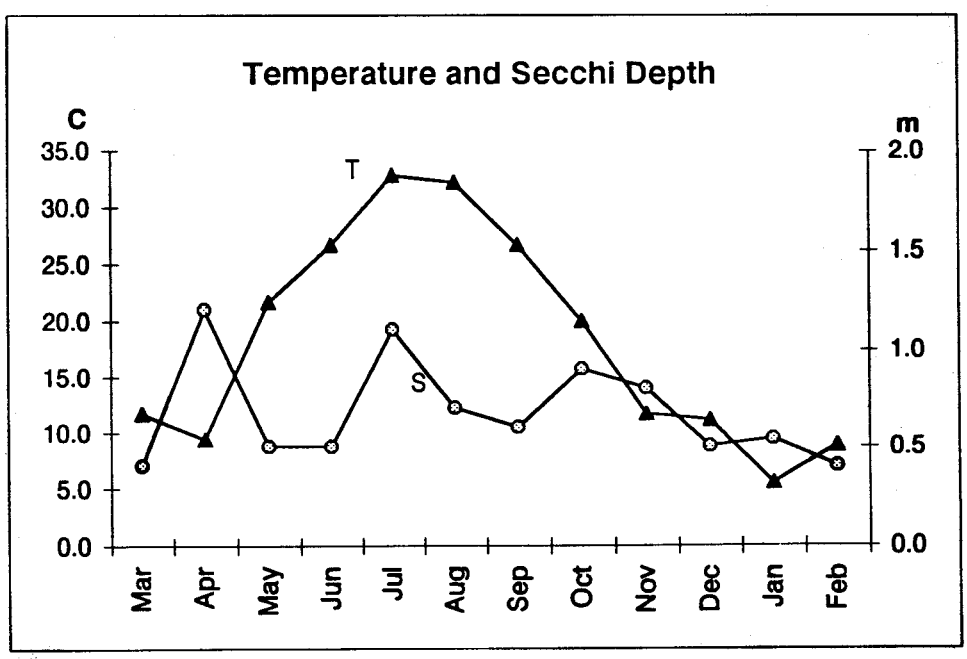
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N	0.00	0.08	0.10	0.02	0.00	0.04	0.04	0.02	0.05	0.11	0.19	0.17
Phosphate-P	0.01	0.01	0.11	0.04	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.06



Note: Lake fertilized on April 14, 1993

Temperature & Secchi depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)	11.7	9.4	21.7	26.7	32.8	32.2	26.7	20.0	11.7	11.1	5.5	8.9
Secchi depth (m)	0.4	1.2	0.5	0.5	1.1	0.7	0.6	0.9	0.8	0.5	0.5	0.4



Lake DesArc

Arkansas Game & Fish Commission---Lake Survey

Lake DesArc

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	11	6	13	8	9	3	3	6	12	10	10	14	Day
Ankistrodesmus	1	1	1	1		1	1	1	1	1	1	1	
Carteria										1			
Chlamydomonas	1	1	1			1			1			1	
Chlorogonium	1			1									
Chodatella	1												
Closterium							1						
Coelastrum	1		1		1						1		
Cosmarium			1				1	1					
Crucigenia	1	1	1	1	1			1	1	1			
Diaspora	1												
Dictyosphaerium	1	1	1							1		1	
Euastrum			1										
Gloeocystis				1	1	1				1		1	
Kirchneriella	1	1	1			1		1	1				
Micractinium	1												
Nephrocytium											1		
Oocystis	1		1	1			1						
Pediastrum			1										
Planktosphaeria								1					
Scendesmus	1	1	1	1	1			1	1	1		1	
Bacillariophyta													
Cyclotella	1	1	1		1	1		1	1	1	1	1	
Melosira		1	1	1	1			1					
Cymbella		1											
Fragilaria	1												
Gomphonema				1									
Gyrosigma				1									
Navicula		1	1	1							1		
Nitzschia	1	1	1		1		1	1				1	
Surirella							1						
Synedra			1									1	
Chrysophyta													
Ochromonas	1											1	
Synurophyta													
Mallomonas	1											1	
Synura												1	
Cryptophyta													
Chroomonas	1	1			1			1			1		
Cryptomonas		1	1						1			1	
Pyrrhophyta													
Ceratium				1									
Peridiniopsis										1			

Peridinium	1											
Euglenophyta												
Euglena	1			1							1	
Lepocinclis						1				1		
Trachelomonas						1				1		
Cyanophyta												
Anabaena			1	1		1		1				
Aphanothece		1	1								1	
Chroococcus	1		1								1	
Cyanarcus											1	
Eucapsis						1					1	1
Gloeocapsa						1						
Lyngbya			1				1					
Merismopedia	1		1		1			1	1			
Microcyctis		1	1		1			1	1	1	1	1
Oscillatoria	1		1	1	1	1	1	1			1	
Raphidiopsis				1								
Diversity (n)	23	15	24	15	11	11	8	14	9	11	13	14

Note: Lake fertilized April 14, 1993

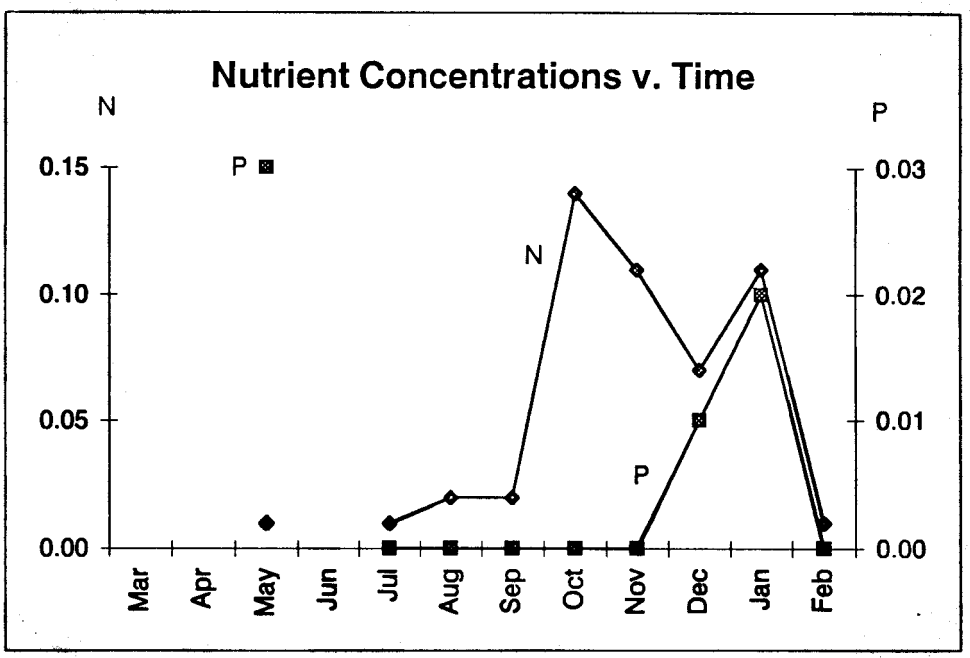
Dominant Algae	
March	Dictyosphaeridium, Chroomonas, Cyclotella & Nitzschia
April	Dictyosphaeridium, Crucigenia & Ankistrodesmus
May	Microcystis, Merismopedia, Dictyosphaeridium & Scenedesmus
June	Oscillatoria, Anabaena & Navicula
July	Merismopedia & Microcystis (>90%)
August	Oscillatoria (80%), Anabaena (10%) & Ankistrodesmus
September	Lyngbya, Oscillatoria & Ankistrodesmus
October	Microcystis, Ankistrodesmus, Merismopedia & Cyclotella
November	Cyclotella, Microcystis, Merismopedia & Ankistrodesmus
December	Cyclotella, Microcystis & Ankistrodesmus
January	Microcystis, Aphanothece, Cyanarcus & Ankistrodesmus
February	Ankistrodesmus, Cyclotella & Gloeocystis

Arkansas Game & Fish Commission---Lake Survey

Harris-Brake Lake

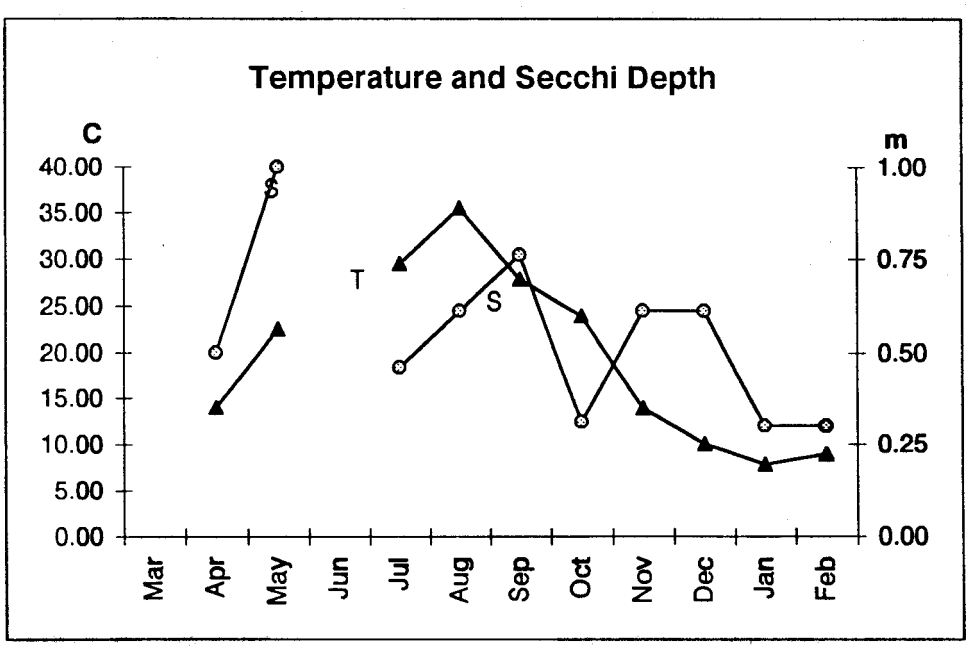
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N			0.01		0.01	0.02	0.02	0.14	0.11	0.07	0.11	0.01
Phosphate-P			0.03		0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00



Temperature & Secchi Depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)		14.0	22.5		29.4	35.5	27.8	23.9	13.9	10.0	7.8	8.9
Secchi depth (m)		0.5	1.0		0.5	0.6	0.8	0.3	0.6	0.6	0.3	0.3



Arkansas Game & Fish Commission---Lake Survey

Harris-Brake Lake

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	*ns*	15	21	*ns*	14	16	13	11	17	7	10	7	Day
Ankistrodesmus		1	1		1		1	1	1	1	1		
Chlamydomonas					1			1			1		
Coelastrum								1					
Cosmarium								1					
Crucigenia								1					
Golenkinia						1							
Planktosphaeria											1		
Scendesmus			1								1		
Staurasturm		1				1	1						
Volvox			1										
Bacillariophyta													
Cyclotella		1	1					1	1	1	1	1	
Melosira		1	1					1					
Asterionella		1	1										
Navicula			1		1						1		
Nitzschia										1			
Pinnularia		1											
Synurophyta													
Mallomonas		1						1	1	1	1	1	
Cryptophyta													
Chroomonas								1					
Cryptomonas		1					1		1	1	1		
Pyrrhophyta													
Ceratium			1										
Peridiniopsis											1		
Euglenophyta													
Trachelomonas					1	1							
Raphidiophyta													
Gonyostomum								1	1	1	1		
Cyanophyta													
Anabaena			1		1	1	1	1					
Aphanocapsa		1											
Aphanothece											1	1	
Chroococcus										1			
Dactylococcopsis					1	1						1	
Lyngbya					1	1	1						
Merismopedia								1					
Microcyctis		1	1		1		1	1	1			1	
Oscillatoria		1	1		1		1						
Raphidiopsis							1						

Diversity (n)	ns	11	11	0	9	6	8	13	6	7	11	5

ns = no sample

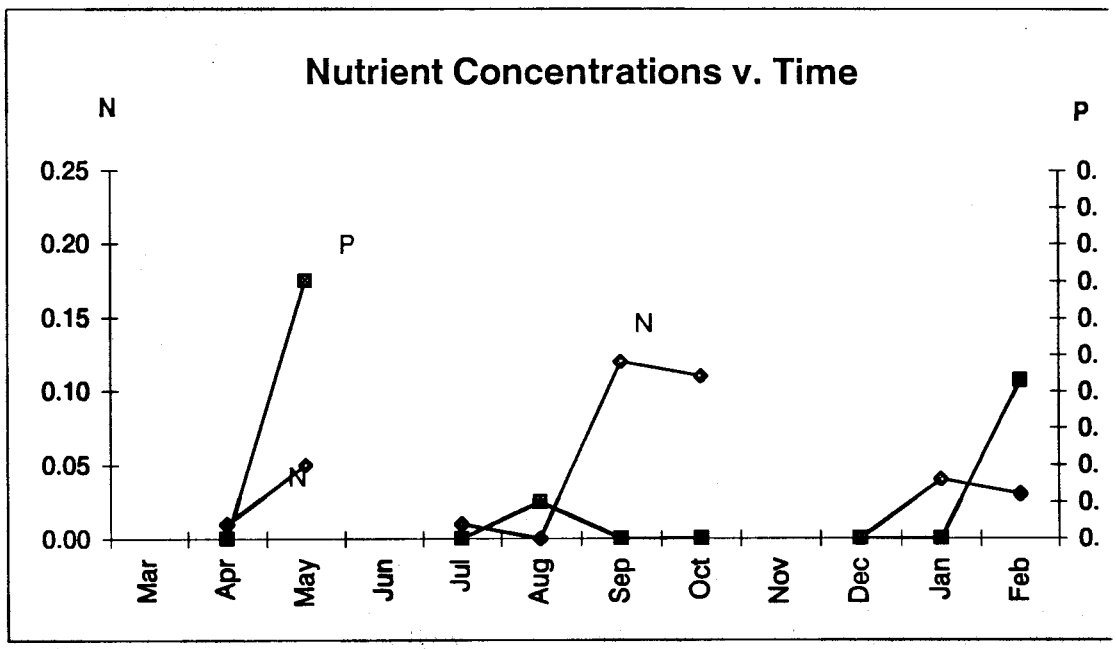
Dominant Algae	
March	*No sample*
April	Cyclotella, Ankistrodesmus & Melosira
May	Cyclotella (90%), Ankistrodesmus, Anabaena
June	*No sample*
July	Lyngbya, Oscillatoria & Dactylococcopsis
August	Dactylococcopsis, Lyngbya & Anabaena
September	Raphidiopsis & Anabaena
October	Microcystis, Merismopedia & Ankistrodesmus
November	Gonyostomum (>90%), Cyclotella & Microcystis
December	Cyclotella, Gonyostomum, Mallomonas & Cryptomonas
January	Ankistrodesmus, Scenedesmus, Gonyostomum & Mallomonas
February	Dactylococcopsis (80%) & Microcystis (15%)

Arkansas Game & Fish Commission---Lake Survey

Overcup Lake

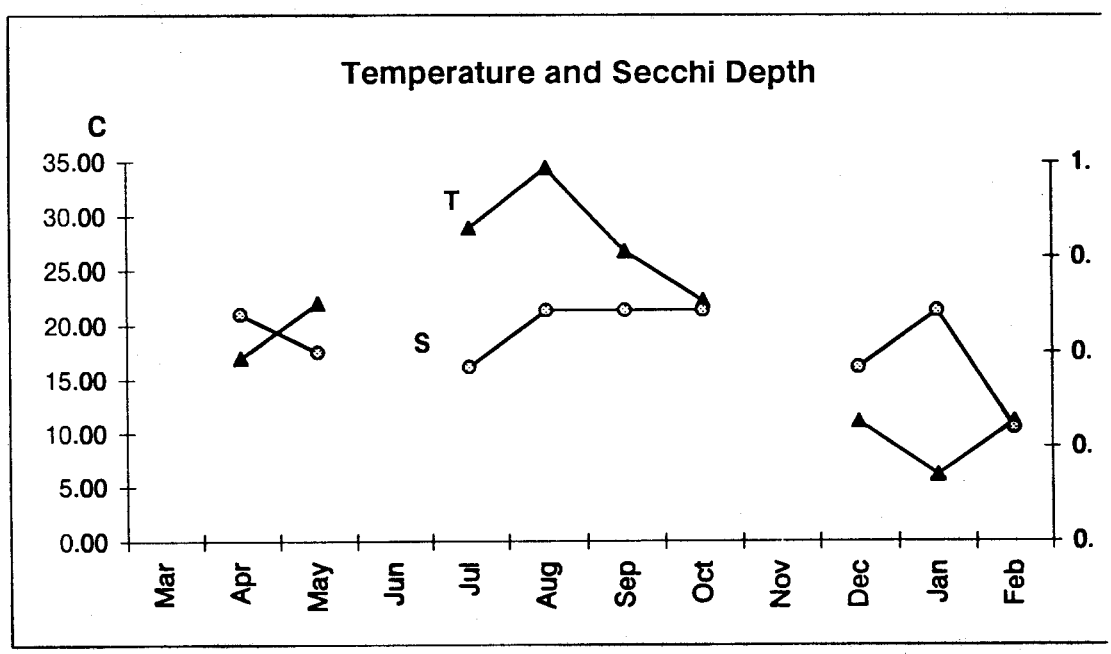
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N		0.01	0.05		0.01	0.00	0.12	0.11		0.00	0.04	0.03
Phosphate-P		0.00	0.07		0.00	0.01	0.00	0.00		0.00	0.00	0.04



Temperature & Secchi Depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)		17.0	22.0		28.9	34.4	26.7	22.2		11.1	6.1	11.1
Secchi depth (m)		0.6	0.5		0.5	0.6	0.6	0.6		0.5	0.6	0.3



Arkansas Game & Fish Commission---Lake Survey

Overcup Lake

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Chlorophyta	*ns*	13	13	*ns*	14	16	3	14	17	7	10	7
Ankistrodesmus		1	1		1	1		1	1	1	1	1
Carteria									1			
Chlamydomonas		1			1	1		1	1	1	1	1
Chodatella		1										
Closterium									1			
Closteriopsis		1										
Coelastrum			1					1		1		
Cosmarium					1							
Crucigenia		1	1						1	1	1	1
Dictyosphaerium		1								1	1	1
Elakatothrix										1		
Gloeocystis					1		1	1			1	1
Golenkinia					1						1	1
Gonium			1			1				1		1
Kirchneriella								1		1		1
Oocystis		1										1
Planktosphaeria		1									1	1
Pediastrum			1		1							
Scendesmus		1	1		1	1		1	1	1	1	1
Staurastrum			1				1	1	1	1		
Tetraedron			1						1		1	
Tetrastrum											1	
Bacillariophyta												
Cyclotella		1	1						1	1	1	1
Melosira		1	1		1			1	1	1	1	1
Asterionella		1	1									1
Cymbella									1			
Fragilaria									1			
Navicula			1									
Nitzschia		1					1		1	1		
Surirella										1		
Synedra			1							1		1
Chrysophyceae												
Dinobryon									1			
Ochromonas											1	
Synurophyta												
Mallomonas								1		1		1
Cryptophyta												
Chroomonas								1	1	1		1
Cryptomonas					1	1		1	1			1

Pyrrhophyta												
Gymnodinium								1			1	
Peridiniopsis						1						
Peridinium					1	1					1	
Euglenophyta												
Euglena					1	1		1			1	
Lepocinclis										1		
Trachelomonas							1			1	1	1
Cyanophyta												
Anabaena			1		1	1	1	1				
Chroococcus		1								1	1	
Dactylococcopsis						1			1			
Eucapsis							1					
Gomphosphaeria										1		
Lyngbya					1							
Merismopedia		1	1			1		1	1			
Microcyctis		1	1		1	1	1	1	1	1		
Oscillatoria		1			1	1	1	1		1	1	
Raphidiopsis							1	1				
Diversity (n)	*ns*	17	16	*ns*	15	13	9	18	19	23	19	19

ns = no sample

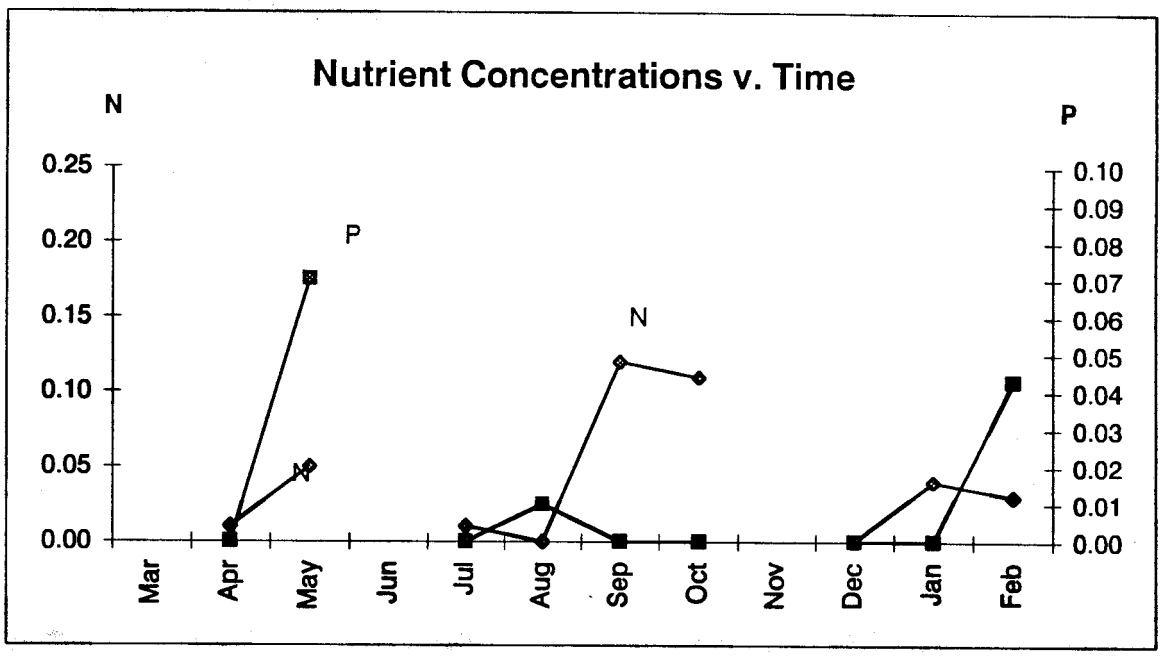
Dominant Algae	
March	*No sample*
April	Planktosphaeria, Ankistrodesmus & Scenedusmus
May	Microcystis, Crucigenia/Scenedesmus & Pediastrum
June	*No sample*
July	Oscillatoria, Microcystis & Ankistrodesmus
August	Dactylococcopsis, Oscillatoria & Microcystis
September	Raphidiopsis (80%) & Microcystis
October	Raphidiopsis, Oscillatoria, Merismopedia & Microcystis
November	Melosira (90%) & Microcystis
December	Melosira (80%), Ankistrodesmus & Chroomonas
January	Ankistrodesmus, Dicytosphaeridium, Cyclotella & Melosira
February	Melosira, Dictyosphaeridium, Ankistrodesmus & coccoid g

Arkansas Game & Fish Commission---Lake Survey

Overcup Lake

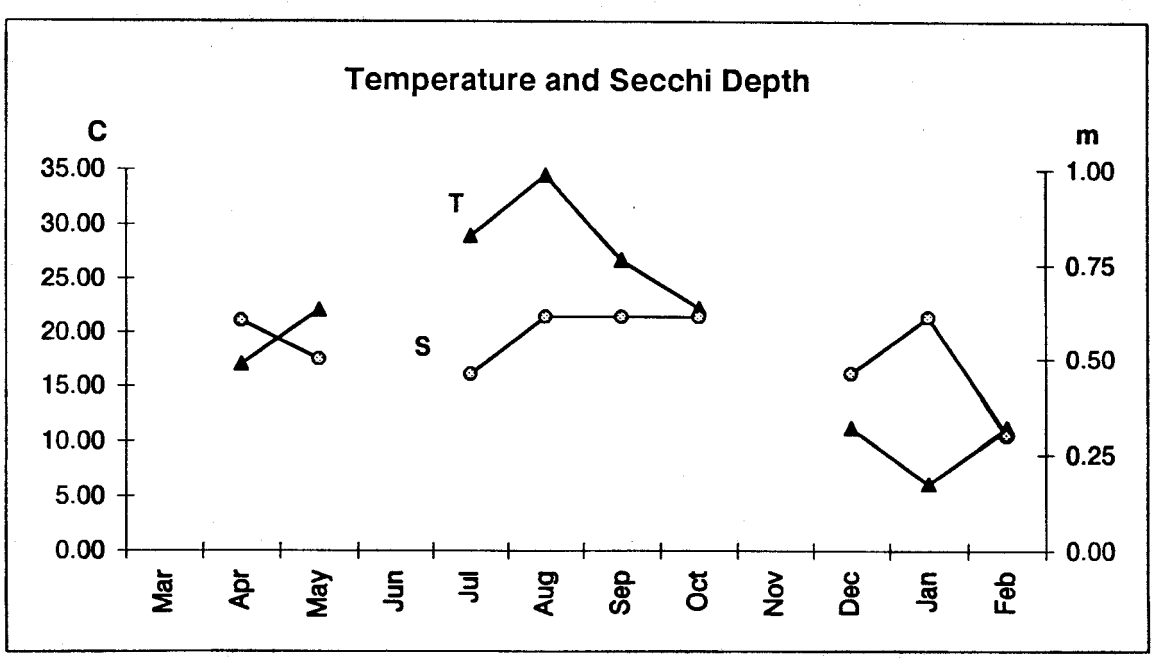
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N		0.01	0.05		0.01	0.00	0.12	0.11		0.00	0.04	0.03
Phosphate-P		0.00	0.07		0.00	0.01	0.00	0.00		0.00	0.00	0.04



Temperature & Secchi Depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)		17.0	22.0		28.9	34.4	26.7	22.2		11.1	6.1	11.1
Secchi depth (m)		0.6	0.5		0.5	0.6	0.6	0.6		0.5	0.6	0.3



Arkansas Game & Fish Commission---Lake Survey

Overcup Lake

Phytoplankton Qualitative Data

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	*ns*	13	13	*ns*	14	16	3	14	17	7	10	7	Day
Ankistrodesmus		1	1		1	1		1	1	1	1	1	
Carteria									1				
Chlamydomonas		1			1	1		1	1	1	1	1	
Chodatella		1											
Closterium									1				
Closteriopsis		1											
Coelastrum			1					1		1			
Cosmarium					1								
Crucigenia		1	1						1	1	1	1	
Dictyosphaerium		1								1	1	1	
Elakatothrix										1			
Gloeocystis					1		1	1			1	1	
Golenkinia					1						1	1	
Gonium			1			1				1		1	
Kirchneriella								1		1		1	
Oocystis		1										1	
Planktosphaeria		1									1	1	
Pediastrum			1		1								
Scendesmus		1	1		1	1		1	1	1	1	1	
Staurastrum			1				1	1	1	1			
Tetraedron			1						1		1		
Tetrastrum											1		
Bacillariophyta													
Cyclotella		1	1						1	1	1	1	
Melosira		1	1		1			1	1	1	1	1	
Asterionella		1	1									1	
Cymbella									1				
Fragilaria									1				
Navicula			1										
Nitzschia		1					1		1	1			
Surirella										1			
Synedra			1							1		1	
Chrysophyceae													
Dinobryon									1				
Ochromonas											1		
Synurophyta													
Mallomonas								1		1		1	
Cryptophyta													
Chroomonas								1	1	1		1	
Cryptomonas					1	1		1	1			1	

Pyrrhophyta												
Gymnodinium								1			1	
Peridiniopsis						1						
Peridinium					1	1					1	
Euglenophyta												
Euglena					1	1		1			1	
Lepocinclis										1		
Trachelomonas							1			1	1	1
Cyanophyta												
Anabaena			1		1	1	1	1				
Chroococcus		1								1	1	
Dactylococcopsis						1			1			
Eucapsis							1					
Gomphosphaeria										1		
Lyngbya					1							
Merismopedia		1	1			1		1	1			
Microcyctis		1	1		1	1	1	1	1	1		
Oscillatoria		1			1	1	1	1		1	1	
Raphidiopsis							1	1				
Diversity (n)	*ns*	17	16	*ns*	15	13	9	18	19	23	19	19

ns = no sample

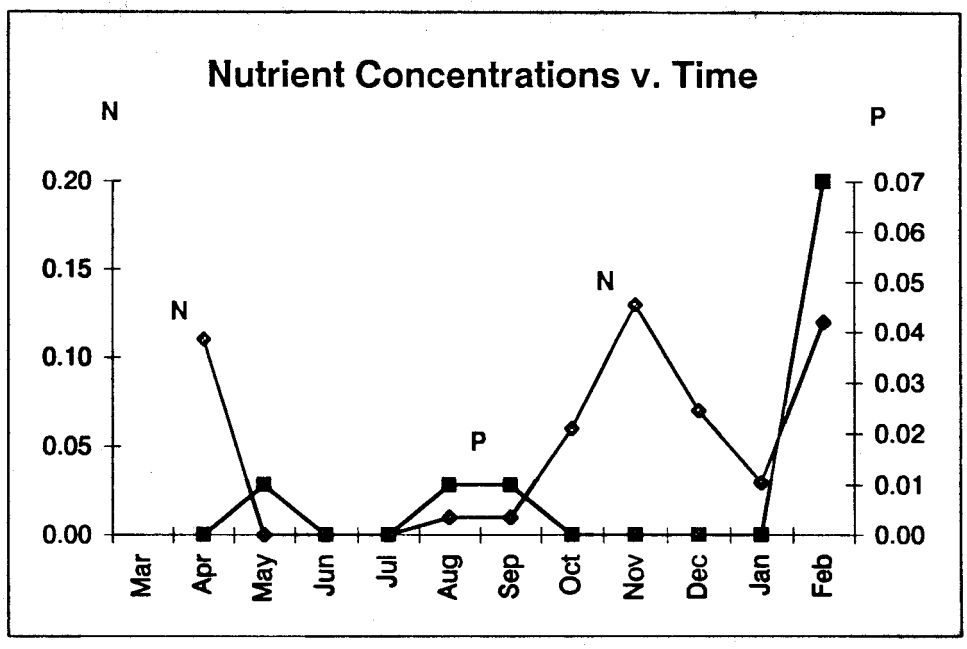
Dominant Algae	
March	*No sample*
April	Planktosphaeria, Ankistrodesmus & Scenedusmus
May	Microcystis, Crucigenia/Scenedesmus & Pediastrum
June	*No sample*
July	Oscillatoria, Microcystis & Ankistrodesmus
August	Dactylococcopsis, Oscillatoria & Microcystis
September	Raphidiopsis (80%) & Microcystis
October	Raphidiopsis, Oscillatoria, Merismopedia & Microcystis
November	Melosira (90%) & Microcystis
December	Melosira (80%), Ankistrodesmus & Chroomonas
January	Ankistrodesmus, Dicytosphaeridium, Cyclotella & Melosira
February	Melosira, Dictyosphaeridium, Ankistrodesmus & coccoid greens

Arkansas Game & Fish Commission---Lake Survey

Lake Poinsett

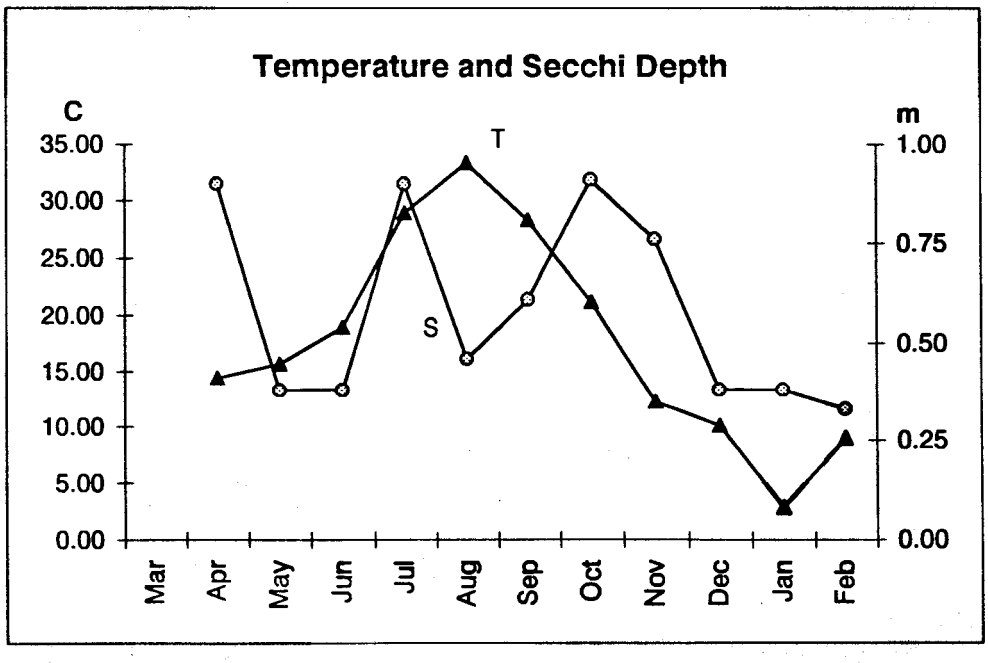
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N		0.11	0.00	0.00	0.00	0.01	0.01	0.06	0.13	0.07	0.03	0.12
Phosphate-P		0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.07



Temperature & Secchi Depth

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)		14.4	15.6	18.9	28.9	33.3	28.3	21.1	12.2	10.0	2.8	8.9
Secchi depth (m)		0.9	0.4	0.4	0.9	0.5	0.6	0.9	0.8	0.4	0.4	0.3



Arkansas Game & Fish Commission---Lake Survey

Lake Pointsett

Phytoplankton Qualitative Data

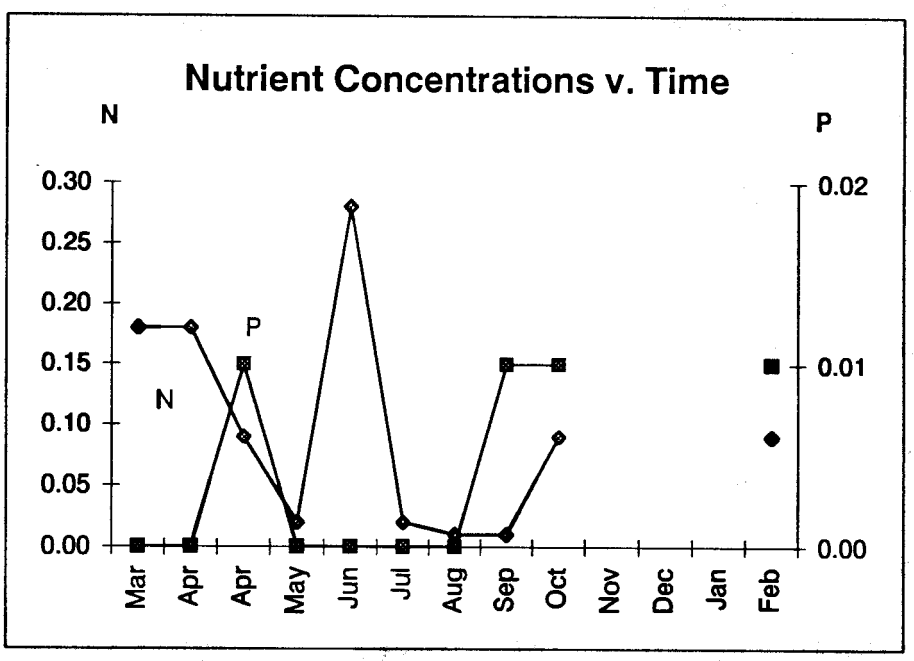
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	*ns*	3	3	2	6/3	##	1	##	1	6	4	27	Day
Actinastrum						1							
Ankistrodesmus		1	1			1		1		1			
Chlamydomonas		1			1	1		1		1			
Closterium				1						1			
Coelastrum										1			
Cosmarium					1								
Crucigenia			1		1	1							
Dictyosphaerium			1										
Eudorina		1			1								
Gloeocystis						1					1		
Golenkinia							1	1					
Kirchneriella		1	1			1							
Micractinium						1							
Oocystis			1				1						
Pediastrum			1										
Planktosphaeia			1			1				1			
Pleurotaenium				1									
Scendesmus			1	1	1	1	1						
Spermatozoopsis										1			
Staurasturm				1									
Tetraedron							1						
Bacillariophyta													
Cyclotella			1	1				1	1	1	1		
Melosira			1	1			1						
Achnanthes		1											
Cymbella		1											
Fragilaria			1										
Gomphonema		1											
Navicula							1					1	
Nitzschia					1		1	1					
Synedra			1									1	
Chrysophyta													
Dinobryon													
Ochromonas		1											
Synurophyta													
Mallomonas		1			1				1	1	1		
Synura													
Cryptophyta													
Chroomonas		1				1				1	1		
Cryptomonas		1								1			

Arkansas Game & Fish Commission---Lake Survey

Lower White Oak Lake

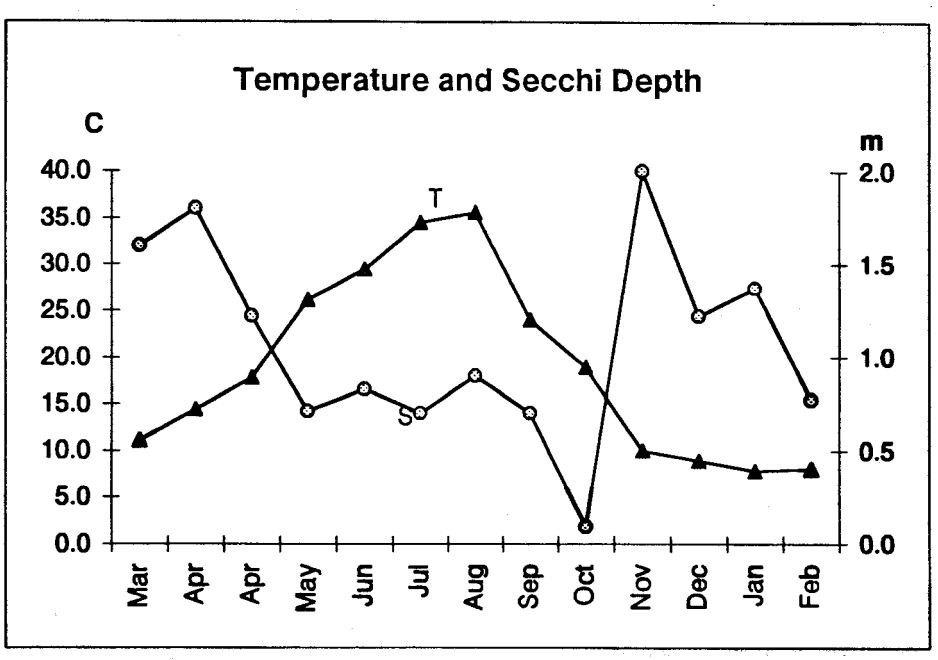
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N	0.18	0.18	0.09	0.02	0.28	0.02	0.01	0.01	0.09				0.09
Phosphate-P	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01				0.01



Temperature & Secchi Depth

	Mar	Apr	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)	11.1	14.4	17.8	26.1	29.4	34.4	35.5	24.0	18.9	10.0	8.9	7.8	8
Secchi depth (m)	1.6	1.8	1.2	0.7	0.8	0.7	0.9	0.7	0.1	2.0	1.2	1.4	0.8



Lower White Oak Lake

Arkansas Game & Fish Commission---Lake Survey

Lower White Oak Lake

Phytoplankton Qualitative Data

	Mar	Apr	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Chlorophyta	17	6	16	17	17	15	17	16	20	28	17	24	17
Ankistrodesmus				1	1	1		1	1	1	1		1
Chlamydomonas	1		1		1	1			1	1			
Closterium													1
Crucigenia									1				
Dactylococcopsis													
Dictyosphaerium				1	1	1		1					1
Ducellaria			1										
Eudorina			1										
Gloeocystis	1				1		1	1	1				
Golenkinia						1	1		1				
Kirchneriella									1				
Oocystis	1											1	
Pandorina					1								
Planktosphaeria		1	1						1			1	
Scendesmus				1	1				1				
Staurastrum						1		1	1				
Tetrastrum				1	1								
Treubaria									1				
Bacillariophyta													
Cyclotella				1		1	1						
Melosira			1		1								1
Asterionella				1									
Cymbella													1
Fragilaria									1		1	1	1
Navicula						1							
Nitzschia									1				1
Surirella												1	
Synedra				1								1	1
Chrysophyta													
Dinobryon			1										1
Ochromonas													1
Rhizochrysis										1			
Synurophyta													
Mallomonas	1		1					1	1	1		1	1
Synura	1											1	1
Cryptophyta													
Chroomonas			1								1		1
Cryptomonas		1			1		1	1			1	1	1
Pyrrhophyta													
Gymnodinium									1			1	
Peridinium					1	1	1	1	1			1	
Euglenophyta													

Pyrrhophyta												
Ceratium					1							
Gymnodinium							1					
Peridinium						1						
Euglenophyta												
Euglena					1					1		
Lepocinclis												
Phacus					1							
Trachelomonas												
Raphidiophyta												
Gonyostomum					1							
Cyanophyta												
Anabaena		1	1	1		1		1	1	1		
Aphanothece		1					1					
Chroococcus												
Coleosphaerium		1										
Eucapsis						1						
Lyngbya							1					
Merismopedia		1	1				1					
Microcyctis		1	1	1	1		1					
Oscillatoria			1	1	1	1	1					1
Diversity (n)	*ns*	11	17	10	14	14	12	8	3	12	5	3

ns = no sample

Dominant Algae	
March	*No sample*
April	Eudorina, Ankistrodesmus & Chroomonas/Cryptomonas
May	Microcystis, Cyclotella & Ankistrodesmus/Dictyosphaeridium
June	Melosira, Microcystis & Merismopedia
July	Gonyostomum, Oscillatoria, Microcystis & Ceratium
August	Oscillatoria (80%), Kirchneriella & Scenedesmus
September	Lyngbya & Oscillatoria
October	Microcystis, Ankistrodesmus & Cyclotella
November	Anabaena, Cyclotella & Mallomonas
December	Anabaena (>95%), Cyclotella & Ankistrodesmus
January	Anabaena (>95%) & Cyclotella
February	Navicula, Oscillatoria & Synedra

Euglena	1				1								
Phacus							1						
Trachelomonas							1	1	1				
Raphidiophyta													
Gonyostomum	1		1							1		1	
Merotrichia			1										
Cyanophyta													
Anabaena				1	1	1			1				
Aphanizomenon								1					
Aphanothece						1							
Lyngbya							1		1				
Merismopedia					1	1							
Microcyctis				1	1	1	1		1	1			
Oscillatoria				1		1	1	1	1				1
Diversity (n)	7	2	10	10	14	13	10	10	20	6	4	11	15

Dominant Algae	
March	Gonyostomum, Mallomonas & Synura
April	Planktosphaeria
April	Gonyostomum & Eudorina
May	Anabaena (90%) & Ankistrodesmus
June	Microcystis (75%), Anabaena & Flagellates
July	Microcystis (75%), Oscillatoria (10%) & Anabaena
August	Lyngbya & Peridinium
September	Oscillatoria & Cryptomonas
October	Ankistrodesmus, Crucigenia & Staurastrum
November	Mallomonas, Ankistrodesmus & Microcystis
December	Cryptomonas, Chroomonas & Ankistrodesmus
January	Mallomonas, Fragilaria, Cryptomonas & Synedra
February	Fragilaria, Cryptomonas & Synedra

Arkansas Game & Fish Commission---Lake Survey

Upper White Oak Lake

Phytoplankton Qualitative Data

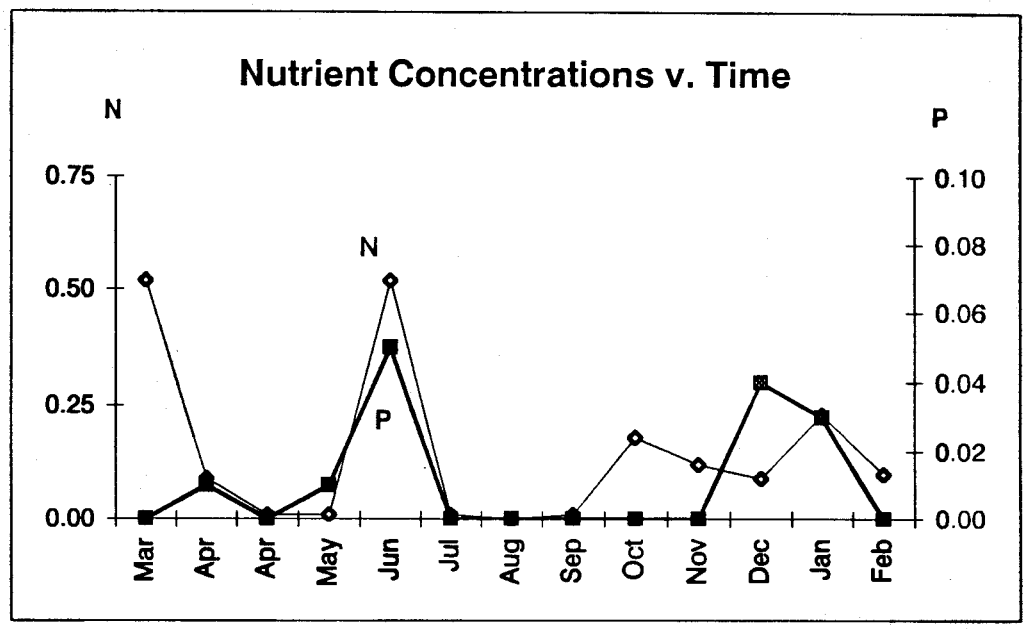
	Mar	Apr	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Chlorophyta	17	6	16	17	17	15	12	16	20	28	17	24	17	Day
Actinasturm					1	1								
Ankistrodesmus	1	1			1	1	1		1	1	1	1		
Arthrodesmus								1						
Botryococcus			1								1			
Chlamydomonas							1					1	1	
Chlorogonium			1											
Closterium							1						1	
Coelastrum						1								
Crucigenia							1							
Dictyosphaerium				1	1		1							
Ducellaria			1											
Elakatothrix	1				1									
Euastrum						1								
Eudorina			1				1					1		
Gloeocystis						1	1							
Golenkinia									1					
Hyalotheca													1	
Kirchneriella				1		1								
Micrasterias					1									
Nephrocytium											1			
Oocystis		1												
Pediastrum					1	1								
Planktosphaeria					1			1	1					
Quadrigula								1						
Scendesmus		1		1			1	1	1					
Schroderia											1			
Staurastrum				1	1	1	1	1	1					
Staurodesmus						1								
Tetrastrum										1				
Treubaria							1							
Volvox			1											
Bacillariophyta														
Cyclotella	1	1		1					1		1			
Melosira					1	1		1			1	1		
Rhizosolenia											1			
Achnanthes													1	
Asterionella		1	1											
Cymbella											1	1		
Eunotia			1										1	
Fragilaria			1								1	1	1	
Nitzschia					1						1		1	

Arkansas Game & Fish Commission---Lake Survey

Upper White Oak Lake

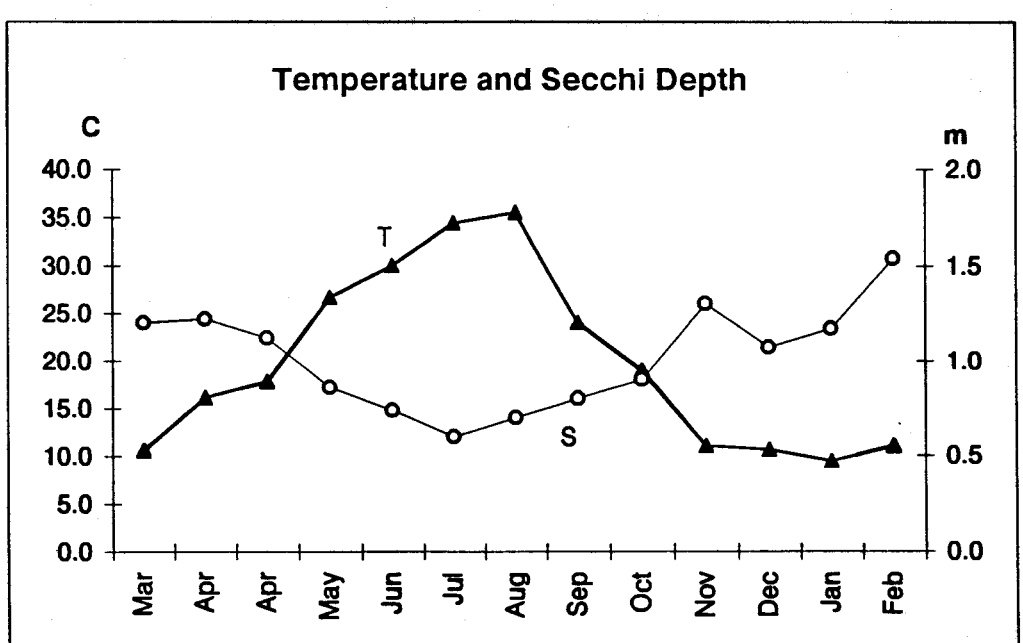
Nitrate-N and Phosphate-P Data (mg/l)

	Mar	Apr	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Nitrate-N	0.52	0.09	0.01	0.01	0.52	0.01	0.00	0.01	0.18	0.12	0.09	0.23	0.10
Phosphate-P	0.00	0.01	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.00



Temperature & Secchi Depth

	Mar	Apr	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C)	10.6	16.1	17.8	26.7	30.0	34.4	35.5	24.0	18.9	11.0	10.6	9.4	11.0
Secchi depth (m)	1.2	1.2	1.1	0.9	0.7	0.6	0.7	0.8	0.9	1.3	1.1	1.2	1.5



Synedra							1	1		1		1	
Tabellaria							1						
Chrysophyta													
Dinobryon								1					
Ochromonas								1	1		1		
Uroglena		1									1	1	
Synurophyta													
Mallomonas		1						1	1	1	1	1	
Synura											1		
Cryptophyta													
Chroomonas	1									1	1		
Cryptomonas	1	1	1							1	1	1	
Pyrrhophyta													
Gymnodinium										1			
Euglenophyta													
Lepocinclis						1							
Trachelomonas		1		1	1		1	1					
Raphidophyta													
Gonyostomum		1					1				1		
Cyanophyta													
Anabaena			1	1	1	1	1	1					
Aphanizomenon					1								
Aphanothece	1												
Borzia		1											
Chroococcus		1					1						
Coleosphaerium								1					
Eucapsis							1	1					
Lyngbya						1							
Merismopedia			1		1	1	1	1					
Microcyctis			1	1	1	1	1	1	1	1			
Oscillatoria				1		1	1	1				1	1
Raphidiopsis								1					
Diversity (n)	3	8	15	9	14	15	16	16	18	5	16	14	12

Dominant Algae	
March	Cyclotella (>95%)
April	Cyclotella (>80%), Cryptomonas & Chroomonas
April	Gonyostomum, Eudorina & Mallomonas
May	Anabaena (90%), Merismopedia (10%) & Dictyosphaeridium
June	Planktosphaeria (80%), Dictyosphaeridium & Pediastrum
July	Anabaena, Microcystis & aphanizomenon
August	Lyngbya, Oscillatoria & Anabaena
September	Microcystis &Oscillatoria
October	Microcystis, Merismopedia & Oscillatoria
November	Mallomonas, Ankistrodesmus & Microcystis
December	Cryptomonas, Chroomonad, Mallomonas & Ankisstrodesmus
January	Synura, Mallomonas, Fragilaria & Chroomonas
February	Fragilaria (80%), Uroglena & Synedra

Upper White Oak Lake