THE SEASONAL AND LINEAR DISTRIBUTION OF BENTHIC ALGAL COMMUNITIES IN A NORTH CAROLINA MOUNTAIN STREAM

A Thesis

by

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Submitted to the Graduate Faculty of

Appalachian State University in

partial fulfillment of the requirements

for the degree

MASTER OF ARTS

in

Biology

May, 1981

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ABSTRACT

The Seasonal and Linear Distribution of Benthic Algal Communities of a North Carolina Mountain Stream

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Investigations of a mountain stream, Boone Fork Stream, in Watauga County, North Carolina were made to determine the seasonal and linear distribution of benthic algal communities. In addition, data on nutrient concentration of nitrate nitrogen, ammonium nitrogen, and orthophosphate phosphorus were gathered to ascertain the effects of nutrient fluctuations on relative biomass and species periodicity.

Data collected on physical and nutrient parameters indicates that Boone Fork Stream remains relatively unpolluted. It was evident that nutrient concentration had little effect on species periodicity. The algae instead demonstrated marked seasonal periodicity. Chlorophycophyta and Chrysophycophyta (particularly diatoms) were the predominant species of Boone Fork Stream preferring the spring and fall months. Seasonal periodicity was attributed to changes in light intensities and fluctuations in temperatures. *Bactracospermum macrosporum* favored low light intensities and high water temperatures. A strong correlation was found to exist between orthophosphate levels and subsequent changes in relative biomass at the head waters of Boone Fork Stream. A very rare species, *Hammatoidea normanii*, was also found in the head waters.

ACKNOWLEDGEMENTS

I wish to express my thanks and deep appreciation to my advisor Dr. Mary Ursula Connell for her help and guidance during the course of this study.

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INTRODUCTION

According to Blum (1957), and Whitford and Shumacher (1963) little attention has been given to benthic stream algae of the United States. However, Dillard (1956) states that Europeans such as Fritsch and Butcher have done much to accumulate information on lotic benthic algae in that region. More recent studies in Europe have been carried out by Marker (1976a, 1976b), Moore (1977), and Jones (1978) who have added to the collections of Fritsch and Butcher.

Phycologists have long been aware that some algae are restricted to lotic habitats, including *Batrachospermum* spp., *Lemanea* spp. (Rhodophyceae), *Hydrurus foetidus* (Vill.) Trev. (Chrysophyceae), *Cladophora* spp., *Spirogyra* spp., and *Oedogonium* spp. (Chlorophyceae) (Dillard, 1969). The restrictive habitat of these algae, and apparent preference of these algae to the running water habitats, has received little attention. This is probably because of the many variables that may affect the growth of lotic algae including current velocity, oxygen levels, temperature, and nutrient concentrations.

Apparently the first in the United States to describe the benthic algae of a stream was Brown (1908), who studied a small stream in Indiana. The Cyanophycophyta of the Concesoga River in Pennsylvania was described by Roddy (1915). Norrington (1927) studied the algae occurring in the mountain lakes and streams of Utah.

Studies of benthic algae in flowing water environments have become more numerous within the last 20 years. A very recent collection of algae from the littorial zones of 21 lakes and streams in the Northwest Territories (Canada) found *Tabellaria flocculosa* (Bacillariophyceae) to be the dominant species in the epilithon and epipelon (Moore 1979). Algal genera from 21 Illinois streams were recovered by Lin and Beustcher (1978) from 1971 through 1976. Diatom communities in White Clay Creek, Pennsylvania were described by Patrick (1978) who noted that naturally increasing daylength was more beneficial for community growth than increasing daylength by artificial light.

The first list of fresh-water algae for North Carolina was compiled by Whitford (1943) and added to by a number of workers (Phillips and Whitford, 1958; Shumacher and Whitford, 1959a, 1959b, 1961; and Shumacher et al. 1966) bringing the state list to a total of 1,840 taxa. Communities of algae in a North Carolina coastal plain stream along with seasonal distribution were described by Whitford and Shumacher (1963). A study of macroscopic communities in a small brown water stream in the high sandhill region of North Carolina by Dillard (1966) showed *Batrachospermum macrosporum* Mont. dominated the algal community in the summer while *Audouinella violacea* (Kuetz.) Ham. dominated the community in the winter. Dillard (1969) further described communities of benthic algae in a small North Carolina piedmont stream. According to Dillard no successional phenomena took place among the benthic algal communities however water temperature seemed to cause the greatest change in seasonal dominance. Communities of algae in a North Carolina mountain stream and seasonal relationships have yet to be studied.

The objective of this study was to do a seasonal and linear comparison of benthic algal communities of a lotic habitat. Collections of algae attached to rocks (epilithon), sediments (epipelon), and plants (epiphyton) were made from different stations along Boone Fork, a mountain stream in Watauga County, North Carolina. Some environmental factors, including temperature, dissolved oxygen, nitrate nitrogen, ammonia nitrogen, and orthophosphate were also monitored during the course of this study.

MATERIALS AND METHODS

Samples of benthic algae were collected biweekly from March 15, 1980 through November 22, 1980 from Boone Fork, a small mountain stream system located in Watauga County, North Carolina. A total of 18 sampling trips were made during the course of this study. The stream originates approximately one km northeast of Grandfather Mountain at an elevation of approximately 4800 feet. The stream flows northeast into Price Lake approximately 5.3 km east of Blowing Rock, North Carolina. Boone Fork flows from Price Lake north into the Watauga River approximately 3.7 km below the lake. After leaving Price Lake, the stream has several feeder brooks along its course. The watershed is mostly woodland with occasional pastures (Fig. 1).

Collections were made at four stations (Fig. 1). Station 1 was located 4.6 km south of Price Lake. The stream was narrow, consisting of many pools and large boulders. The bottom consisted of large gravel and sand. Upstream the watershed was wooded (Table 1). The collecting site was well lighted year round. Station 2 was located 0.7 km south of Price Lake. The stream was shallow with a sluggish current. The bottom consisted of rocks and silt.

A large lake bed just above the collecting site may have contributed to silting (Fig. 1) (Table 1). Upstream the watershed was mostly pasture. The collecting site was well lighted in the fall but quite shaded in the spring and summer months. Station three was located 0.2 km north of Price Lake. The lake was the source of water for this portion of the stream. Rocks and sand made up the bottom strata. The collecting site was well shaded in all seasons. Station four was located 0.3 km south of Watauga River. Several feeder streams contributed to the stream's swift current and wide banks (Table 1). The bottom consisted of large rocks and gravel. The collecting site was moderately shaded in all months.

Collections of epilithic algae at each station were made by scraping attached material from five square meters of rock surface using a scalpal blade. A square meter was determined using a square constructed of wood nailed together to form four corners. The samples were washed into a plastic container with stream water. In the laboratory identifications were made under a Swift binocular phase contrast scope (maximum magnification 100X) and the keys by Smith (1950), Prescott (1970, 1973), and Whitford and Schumacher (1973).

The frequency of algae was determined by the observation of visible benthic algae in each meter square measured. The visual sighting was recorded in field notes onto a grid representing each square meter. Biomass was calculated by determining what percent of each square meter was darkened.

Epipelic algae was collected from the sediments of each station using an aspirator and were analyzed as outlined for the epilithic. Any higher plants suspected of having attached algae were brought into the laboratory for closer examination.

Water temperature was taken at each station with a standard centigrade thermometer. The hour and sky conditions were recorded. The term clear, partly cloudy, or overcast was used to express the condition of the sky. Dissolved oxygen was determined by the azide modification of the Winkler Method (Standard Methods for the Examination of Water and Wastewater, A.P.H.A., Twelfth edition, 1965). All oxygen samples were collected and chemically fixed in standard 300 ml B.O.D. bottles. In the laboratory sulfamic acid was added to the sample bottle and 200 ml were titrated with PAO for water and sewage (Strickland and Parsons, 1969; Standard Methods, 1965).

Approximately 300 ml of water from each station was taken to the laboratory and used to determine the concentrations of the following dissolved inorganic chemicals: orthophosphate phosphorus, ammonia nitrogen, and nitrate nitrogen. Chemical analysis was performed colorimetrically using Hach reagents and procedures (Hach Chemical Company, Ames, Iowa) and a Bausch and Lomb Spectronic 20 spectrophotometer. These determinations and procedures are based on those in Standard Methods for the Examination of Water and Wastewater (A.P.H.A. publication, 12th edition, 1965). All chemical analyses were performed immediately upon returning from the field.

FIGURE 1. The Boone Fork Stream Area, Watauga County, North Carolina. Elevations are in feet. Watershed is wooded unless otherwise indicated.

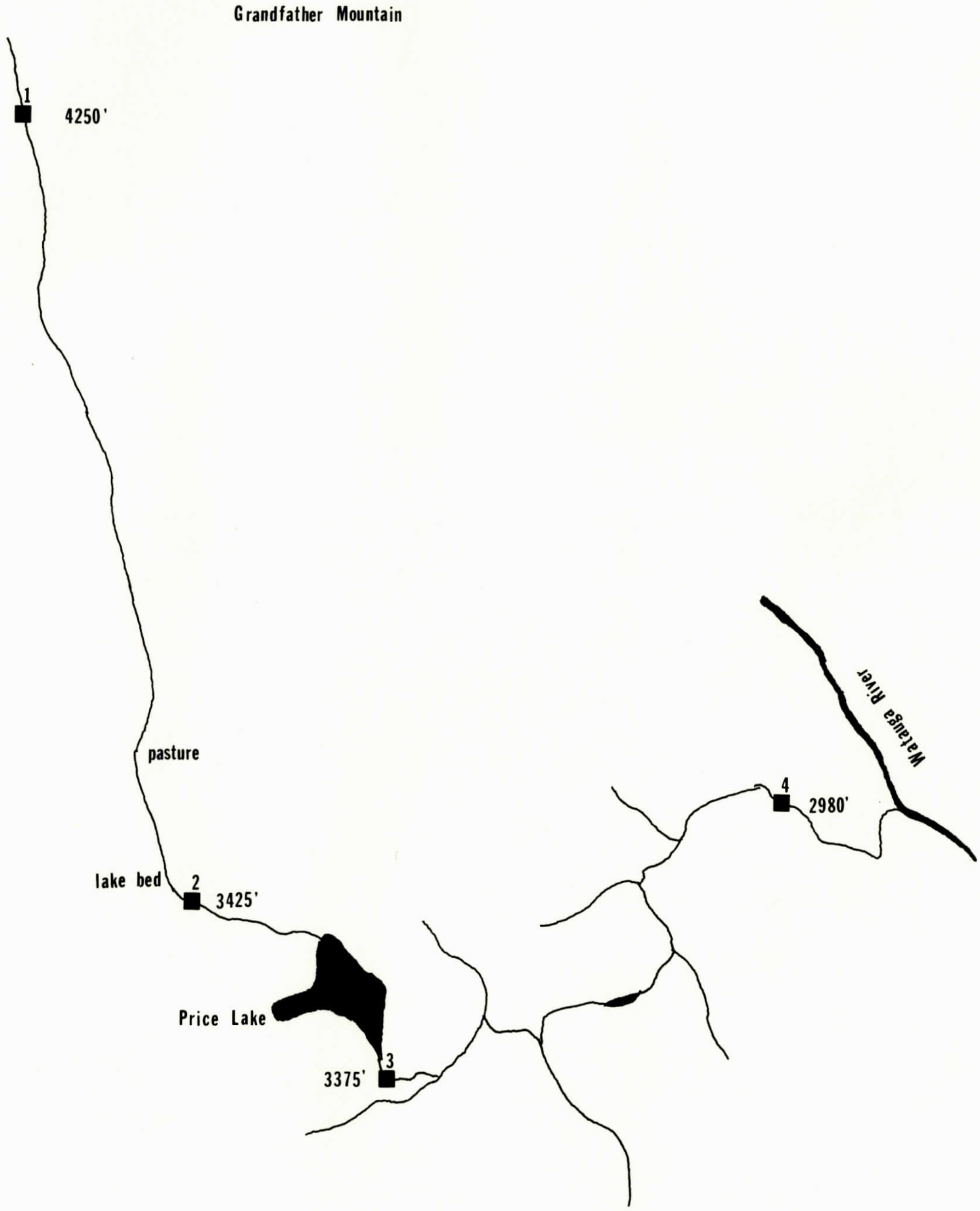

Grandfather Mountain
1
4250'
pasture
lake bed
2
3425'
Price Lake
3
3375'
4
2980'
Watauga River

TABLE 1

Stream Description

Station	Average Width	Average Depth	Current Velocity
One	2.98 m	.25 m	*
Two	5.26 m	.142 m	1.55 m/sec
Three	8.16 m	.267 m	2.45 m/sec
Four	13.2 m	.313 m	3 m/sec

*Stream velocity could not be determined because of many pools and eddys.

RESULTS

Seasonal fluctuations of temperature and dissolved oxygen in Boone Fork were recorded from March, 1980 through November, 1980 (Fig. 2). An inverse relationship between temperature and dissolved oxygen was seen. Temperature rose steadily from mid-March to mid-September then dropped sharply through November, while the amount of dissolved oxygen dropped steadily from mid-March to mid-September then rose sharply through November. This fluctuation was sharpest at station 3 where the temperature rose from 4.5°C in mid-March to 24.5°C in July, while the amount of dissolved oxygen fell from a high of 11.0 ppm in mid-March to 6.7 ppm in July. Temperature and dissolved oxygen concentration fluctuated the least at station 1 where temperature warmed from 3.0°C in mid-March to only 18°C in August, while the amount of dissolved oxygen fell from a high of 11.5 ppm in March to 7.8 ppm in August.

The concentration of nitrate nitrogen, orthophosphate, and ammonia in Boone Fork fluctuated markedly during the course of this study (Fig. 3). Fluctuations in the concentration of nitrate nitrogen, orthophosphate, and ammonia were greatest during the spring and decreased during the summer and fall. This spring fluctuation was greatest at station 2 where the concentration of nitrate nitrogen dropped to 0.00 ppm on May 9 and then rose to 0.12 ppm only two weeks later. Nutrient concentrations were generally lowest at station 1 where the concentration of nitrate nitrogen, orthophosphate, and ammonia increased in April to a maximum of 0.11 ppm, 0.06 ppm, and 0.64 ppm respectively and then gradually decreased over the summer months to a minimum of 0.025 ppm, 0.02 ppm, and 0.0275 ppm respectively. The concentration of these nutrients then began to rise again at the end of September. Orthophosphate concentration remained more stable than the other two nutrients but exhibited a sharp rise on October 10 to 0.13 ppm. It is interesting to note that the levels of concentration of nitrate nitrogen and ammonia remained unchanged or nearly so for long periods of time at station 3, where nitrate nitrogen concentration remained at 0.1 ppm from March 29 through April 25, and 0.09 ppm from May 22 through June 28. Ammonia remained at about 0.45 ppm from June 28 through September 21.

Fifty species of algae from four separate divisions were identified in Boone Fork Stream (Table 2). The most representative division was the Chlorophycophyta (green algae) with 26 of the species belonging to it. Fourteen species belonged to the Chrysophycophyta (golden brown, including diatoms) division, 6 to the Cyanophycophyta (blue-green) and 2 to the Rhodophycophyta (red) division.

Representatives of the four algal divisions demonstrated a seasonal periodicity. At station 1 the greens were dominant in the early spring and again in mid summer through late fall (Fig. 4). The blue-greens co-dominated with the reds in mid-spring then took over dominance in early and mid-summer. The diatoms dominated in the late summer flora. At station 2 the greens and the diatoms dominated each season (Fig. 5). The blue-greens were apparent in early spring through mid-summer with a brief reappearance in early fall. At station 3, the greens, diatoms, and reds were seen each season (Fig. 6). Blue-greens never made up a major portion of the flora. The diatoms were dominant in early spring through mid-spring and again mid-summer through late fall. The greens dominated from late spring through early summer, while the reds dominated late summer and mid-fall. The greens and reds co-dominated the early fall flora. The greens and diatoms co-dominated at station 4 in early spring and mid-fall, with blue-greens dominant in mid-spring through mid-fall, and diatoms dominant in late fall (Fig. 7).

Algae from the four represented divisions not only demonstrated seasonal preferences but families within each division occurred seasonally. Members of the family Chaetophoraceae (Table 2) preferred the spring and late fall months (Mar. 15 - Mar. 29, Fig. 8; Mar. 15 - June 9, Fig. 13 and 14; Nov. 22, Fig. 17; Mar. 15 - June 9, Fig. 18 and 19; Nov. 11 - Nov. 22, Fig. 22; and Mar. 15, Fig. 23). Members of the family Dictyosphaeriaceae preferred early spring at station 4 (Mar. 15 - Mar. 29, Fig. 23) while members of the family Ulotrichaceae preferred early summer at station 3 (June 28, Fig. 19). Members of the families Zygnemataceae and Desmidiaceae (Table 2) did not occur at any station in early spring through mid-spring but did occur in late spring through late fall (July 26 - Nov. 22, Fig. 10, 11, and 12; May 22 - Nov. 22, Fig. 14, 15, 16, and 17; July 26 - Nov. 22, Fig. 20, 21, 22; and Oct. 10 - Nov. 22, Fig. 26 and 27). Members of the family Oedogoniaceae did not occur in early spring through mid-spring but did occur in late spring through late fall (June 9 - Nov. 11, Fig. 14, 15, 16, and 17; and Oct. 10 - Nov. 22, Fig. 11 and 12). Members of the family Fragilariaceae preferred the spring and fall months (Mar. 15 - June 9, Fig. 18 and 19; Nov. 11 - Nov. 22, Fig. 22; Mar. 15, Fig. 23; and Nov. 22, Fig. 27).

Many individuals (genera, species) demonstrated seasonal periodicity as well. At station 1 *Palmella mucosa* dominated in the early spring (Mar. 15, Fig. 8) and again in the mid-fall (Oct. 26, Fig. 11). *Oscillatoria* dominated in mid-spring through early summer joined briefly by *Stigeoclonium lubricum* June 9 (Mar. 29 - June 28, Fig. 8 and 9). *Spirogyra* dominated the mid-summer and late summer months (July 26, Fig. 10; and Aug. 22, Fig. 10) interrupted briefly by *Navicula* on August 6 (Fig. 10). Dominance was shared equally among *Desmidium, Cosmarium circulare, Mougeotia, Spirogyra,* and *Stigeoclonium lubricum* in the early fall months (Sept. 6 - Sept. 21, Fig. 11) while *Oedogonium* and *Mougeotia* co-dominate in the late fall (Nov. 22, Fig. 12). At station 2 *Oscillatoria, Navicula,* and *Chaetophora elegans* co-dominated in the early spring (Mar. 15, Fig. 13). *Navicula* and *C. elegans* remained dominant through March while *Oscillatoria* dominance diminished (Mar. 29, Fig. 13). *Stigeoclonium lubricum* dominated in mid-spring (May 9 - June 9, Fig. 14) but yielded dominance to *Cosmarium, Closterium rostratum, Oscillatoria,* and *Oedogonium* in the early summer (June 28, Fig. 14). By mid-summer *Mougeotia* dominated (July 26 - Aug. 6, Fig. 15) and was joined by

Zygnema and *Oedogonium* in the late summer (Aug. 22, Fig. 15). *Zygnema* and *Oedogonium* quickly disappeared leaving *Mougeotia* again as the dominant genera through the fall (Sept. 21 - Nov. 21, Fig. 16 and 17). *Mougeotia* was joined briefly by *Synedra* (October 10) and *Oedogonium* and *Navicula* (October 26). *Spirogyra* replaced *Mougeotia* as the dominant genera in the late fall (Nov. 22, Fig. 17). During the early spring *Tabellaria flocculosa, Stigeoclonium flagelliferum,* and *Navicula* dominated the flora at station 3 (Mar. 15, Fig. 18). These are quickly replaced by *Microspora floccosa.* After the flood on April 14 *T. flocculosa* reappeared with *T. fenestrata,* and *Stigeoclonium lubricum* (Apr. 25 - May 9, Fig. 18 and 19). A very high species diversity occurred in the late spring but gave way to *Hormidium* in the early summer (May 22 - June 28, Fig. 19). *Hormidium* in turn was replaced by *Gomphonema, Navicula, Audouinella violaceae,* and *Oscillatoria* in early July. *Gomphonema* and *Navicula* were subsequently replaced by *Closterium* and *Pinnularia* (July 14 - July 26, Fig. 20). By mid-summer dominance was established by *A. violacea* and *Mougeotia.* They remained very much the dominant species until late fall when *Synedra* and *Navicula* dominated (Aug. 6 - Nov. 22, Fig. 20, 21, and 22). At station 4 the flora of the early spring was dominated by

Dictyosphaerium pulchellum and *Navicula* (Mar. 15, Fig. 23). *Navicula* quickly disappeared leaving *D. pulchellum* as the dominating species (Mar. 19, Fig. 23). After the flood of April 14 the dominant species became *Oscillatoria* which remained a dominating genera through mid-fall (June 22 - Oct. 26, Fig. 24, 25, and 26). *Oscillatoria*'s dominance was interrupted briefly by *Palmella mucosa* May 9. *Spirogyra* co-dominated with *Oscillatoria* on July 14 while *Mougeotia* joined *Oscillatoria* as co-dominant in the mid-fall (Oct. 10 - Oct. 26, Fig. 26). *Mougeotia* briefly dominated on Nov. 11 but gave way quickly to *Synedra* and *Navicula* in the late fall (Nov. 11 - Nov. 22, Fig. 27).

A linear pattern of distribution was exhibited by the benthic algal communities. Out of the 50 species identified only 12 appeared at all stations at some time during the course of this study: *Mougeotia* sp., *Spirogyra* sp., *Closterium* sp., *Cosmarium* sp., *H. dissiliens, Oedogonium* sp., *Oscillatoria* sp., *Synedra* sp., *T. flocculosa, Gomphonema* sp., *Navicula* sp., and *A. violacea* (Table 3). *Netrium* sp., *T. fenestrata,* and *Cymbella* sp. occurred at all stations except station 1. *Stigeoclonium tenue* and *Desmidium* sp. occurred at all stations except station 2, while *Stigeoclonium lubricum* occurred at all stations except station 4. There were several species unique to only one station (Tables 4, 5, and 6). All species unique to station 1 are blue-green (Table 4) and included a very rare species, *Hammatoidea normanii*. A red alga, *Batrachospermum macrosporum*, was unique to station 3 (Table 6).

The families Zygnemataceae, Oedogoniaceae, and Desmidiaceae (particularly *Cosmarium* sp.) demonstrated a successive linear pattern as well. Members of the families Zygnemataceae and Desmidiaceae (Table 2) occurred in late spring at station 2 (May 22, Fig. 14), mid-summer at station 3 (July 26, Fig. 20), and early fall at station 4 (Oct. 10, Fig. 26). Members of the family Oedogoniaceae occurred in late spring at station 2 (June 9, Fig. 14) and in early fall at station 1 (Oct. 10, Fig. 11). No members of the family occurred at stations 3 and 4.

One genera, *Synedra*, of the family Fragilariaceae demonstrated a successive linear pattern. *Synedra* dominated the flora at station 2 from Sept. 21 - Nov. 10 (Fig. 16 and 17) then occurred at station 3 from Nov. 10 - Nov. 22 (Fig. 22).

Species diversity varied between the four collecting sites on Boone Fork. Station 3 had the highest diversity with 33 species represented, while station 1 had the lowest diversity with only 21 species recorded (Table 3).

The fluctuation of relative biomass of algae varied seasonally and differed linearly also (Fig. 28). At station 1, the fluctuation of relative biomass was erratic changing abruptly during all seasons. After a sharp drop (from 100% to 0%) in biomass in the early spring, there was a gradual increase in biomass in the early summer (61%) at station 2, followed by another sharp drop during the mid-summer. A significant rise in biomass occurred at this station in the late summer (100%) but after Aug. 22 relative biomass gradually decreased through Oct. 10 leveling off at about 15% in the fall. Station 3 demonstrated a gradual increase in biomass through each season, averaging 13% biomass through June 9. Two abrupt fluctuations occurred in mid and late summer with biomass leveling off at about 60% through Oct. 26, then dropping steadily through Nov. 22. The fluctuation in biomass at station 4 was extreme from early spring to early summer but then average biomass remained relatively constant (about 58%) through late fall.

A strong correlation existed between orthophosphate levels and relative biomass (Fig. 13). This correlation was most prominent at station 1 where variation in orthophosphate level resulted in a delayed but similar deviation in relative biomass. There was not a strong correlation between relative biomass and the concentration of the other major nutrients.

FIGURE 2. The seasonal fluctuations of temperature (▮▮▮▮▮▮▮▮▮▮▮▮) and dissolved oxygen (————) in Boone Fork Stream, March 1980 through November 1980.

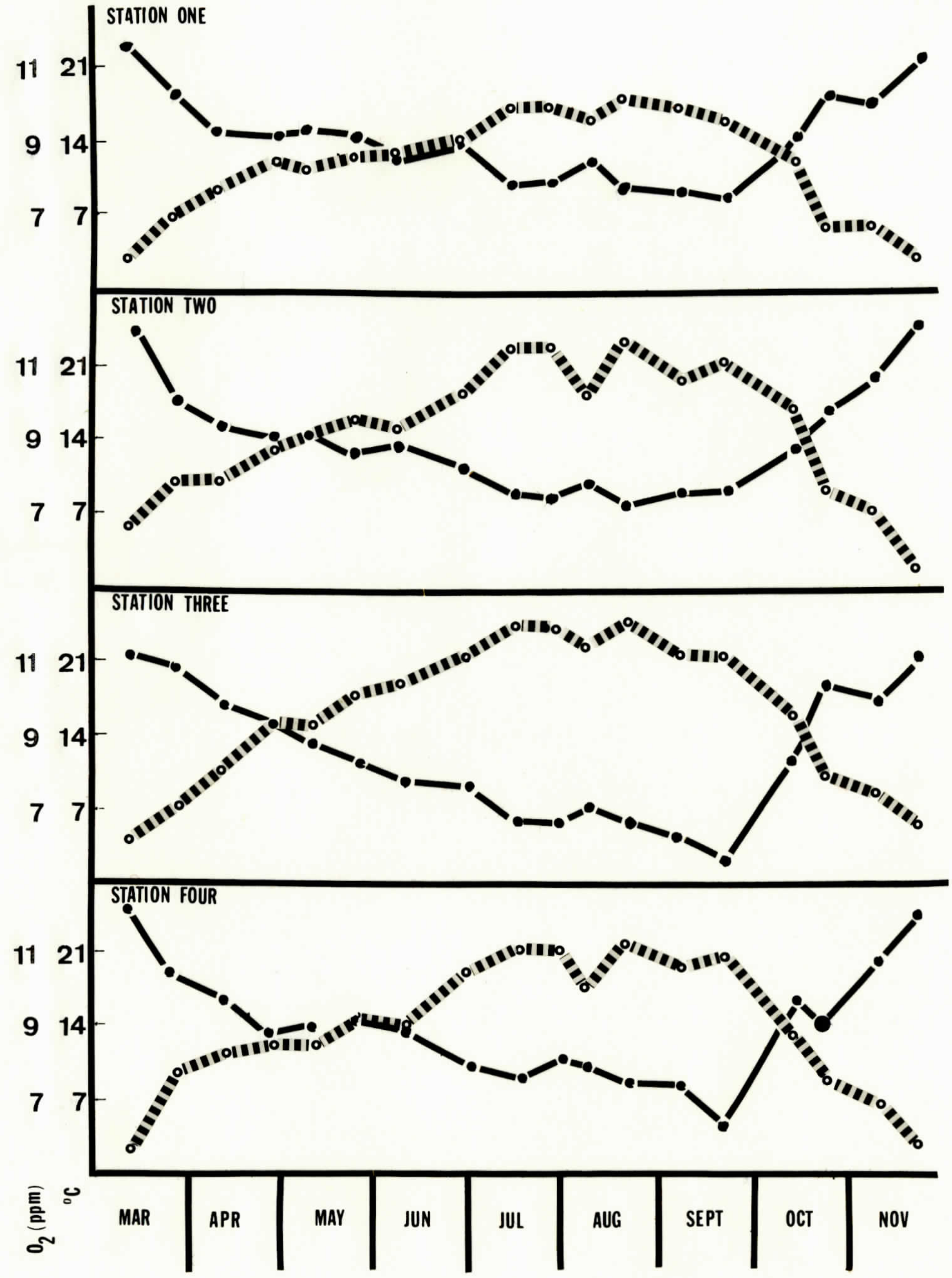

STATION ONE
STATION TWO
STATION THREE
STATION FOUR
11 21
9 14
7 7
O_2 (ppm)
°C
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV

FIGURE 3. The seasonal fluctuations of nitrate nitrogen (▬ ▪ ▬ ▪ ▪), ammonia nitrogen (▪▪▪▪▪▪▪▪▪▪▪▪), and orthophosphate phosphorous (———) in Boone Fork Stream, March 1980 through November 1980.

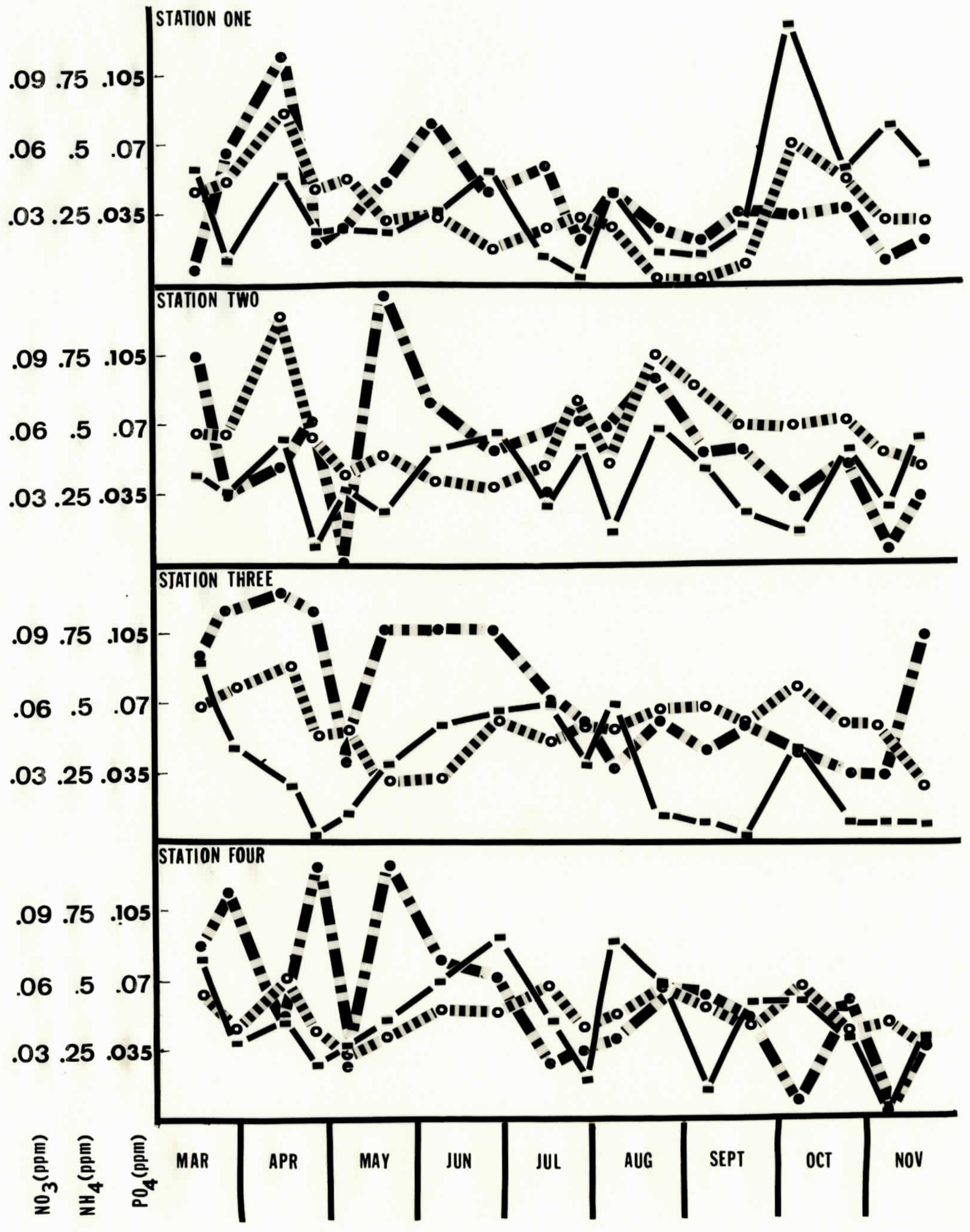

STATION ONE
STATION TWO
STATION THREE
STATION FOUR
.09 .75 .105
.06 .5 .07
.03 .25 .035
NO3(ppm)
NH4(ppm)
PO4(ppm)
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV

TABLE 2

Algae Occurring in Boone Fork Stream
from March 1980 through November 1980

Taxonomic Classification	
Division Chlorophycophyta	
Family Chlorococcaceae	*Chlorococcum* sp.
Family Dictyosphaeriaceae	*Dictyosphaerium pulchellum*
Family Ulotrichaceae	*Hormidium* sp. *Ulothrix subtilissima* *Ulothrix tenerrema*
Family Chaetophoraceae	*Chaetophora elegans* *Draparnaldia acuta* *Draparnaldia glomerata* *Stigeoclonium flagelliferum* *Stigeoclonium lubricum* *Stigeoclonium tenue*
Family Microsporaceae	*Microspora amoena* *Microspora floccosa*
Family Zygnemataceae	*Mougeotia* sp. *Spirogyra* sp. *Zygnema* sp.
Family Desmidiaceae	*Closterium* sp. *Cosmarium* sp. *Desmidium* sp. *Hyalothica dissiliens* *Micrasterias* sp. *Netrium* sp. *Phymatodocis nordestedtiana*

TABLE 2 (cont.)

Taxonomic Classification	
Division Chlorophycophyta	
Family Oedogoniaceae	*Bulbochaete* sp. *Oedogonium* sp.
Family Palmellaceae	*Palmella mucosa*
Division Cyanophycophyta	
Family Chroococcaceae	*Aphanocapsa delicatissima* *Gloethece linearis* *Synechococcus aeruginosa*
Family Oscillatoriaceae	*Oscillatoria* sp.
Family Rivulariaceae	*Calothrix juliana* *Hammatoidea normanii*
Division Chryosophycophyta	
Family Fragilariaceae	*Asteronella formosa* *Fragilaria* sp. *Synedra* sp.
Family Meridionaceae	*Meridion circulare*
Family Tabellariaceae	*Tabellaria fenestrata* *Tabellaria flocculosa*
Family Cymbellaceae	*Cymbella* sp.
Family Naviculaceae	*Gomphonema acuminatum* *Navicula* sp. *Pinnularia* sp.
Family Eunotiaceae	*Eunotia* sp.
Family Coscinodiscaceae	*Melosira varians*
Family Surirellaceae	*Surirella* sp.
Family Vaucheriaceae	*Vaucheria* sp.

TABLE 2 (cont.)

Taxonomic Classification	
Division Rhodophycophyta	
Family Acrochaetiaceae	*Audouinella violaceae*
Family Batrachospermaceae	*Batrachospermum macrosporum*

TABLE 3

Linear Distribution of Algae
in Boone Fork Stream

Taxonomic Classification	Station 1	2	3	4
Chlorophycophyta				
Chlorococcum sp.			*	
Dictyophaerium pulchellum				*
Hormidium sp.			*	
Ulothrix subtilissima			*	
Ulothrix tenerrema	*		*	
Ulothrix sp.		*		
Chaetophora elegans		*		
Draparnaldia acuta				*
Draparnaldia glomerata	*		*	*
Stigeoclonium flagelliferum		*	*	
Stigeoclonium lubricum	*	*	*	
Stigeoclonium tenue	*		*	*
Microspora amoena			*	
Microspora floccosa			*	
Mougeotia sp.	*	*	*	*
Spirogyra sp.	*	*	*	*
Zygnema sp.		*		

TABLE 3 (cont.)

Taxonomic Classification	Station 1	2	3	4
Closterium sp.	*	*	*	*
Cosmarium sp.	*	*	*	*
Desmidium sp.	*		*	*
Hyalothica dissiliens	*	*	*	*
Micrasterias sp.		*		
Netrium sp.		*	*	*
Phymatodocis nordestedtiana		*		
Bulbochaete sp.		*		
Oedogonium sp.	*	*	*	*
Palmella mucosa	*			*
Cyanophycophyta				
Aphanocapsa delicatissima	*			
Gloeotheca linearis	*			
Synechococcus aeruginosa				*
Oscillatoria sp.	*	*	*	*
Calothrix juliana			*	
Hammatoidea normanii	*			
Chrysophycophyta				
Asteronella formosa			*	
Fragilaria sp.				*
Synedra sp.	*	*	*	*

TABLE 3 (cont.)

Taxonomic Classification	Station 1	2	3	4
Meridion circulare		*		
Tabellaria fenestrata		*	*	*
Tabellaria flocculosa	*	*	*	*
Cymbella		*	*	*
Gomphonema acuminatum			*	
Gomphonema	*	*	*	*
Navicula	*	*	*	*
Pinnularia		*	*	
Eunotia			*	
Melosira varians				*
Surirella		*		
Vaucheria			*	
Rhodophycophyta				
Audouinella violacea	*	*	*	*
Batrachospermum macrosporum			*	

TABLE 4

Algae Occurring at Station One Only

Cyanophycophyta

Aphanocapsa delicatissima

Gloeotheca linearis

Hammatoidea normanii

TABLE 5

Algae Occurring at Station Two Only

Chlorophycophyta

Bulbochaete sp.

Chaetophora elegans

Micrasterias sp.

Phymatodocis nordestediana

Zygnema sp.

Chrysophycophyta

Meridian circulare

Surirella sp.

TABLE 6

Algae Occurring at Station Three Only

Chlorophycophyta

Chlorococcum sp.

Hormidium sp.

Microspora amoena

Microspora floccosa

Cyanophycophyta

Calothrix juliana

Chrysophycophyta

Asterionella formosa

Eunotia sp.

Vaucheria sp.

Rhodophycophyta

Batrachopermum macrosporum

TABLE 7

Algae Occurring at Station Four Only

Chlorophycophyta

Dichtyosphaerium pulchellum

Draparnaldia acuta

Cyanophycophyta

Synechococcus aeruginosa

Chrysopycophyta

Fragilaria sp.

Melosira varians

FIGURE 4. Seasonal periodicity of greens (G), blue-greens (BG), diatoms (D), and reds (R) in Boone Fork Stream from early spring through late fall at station 1.

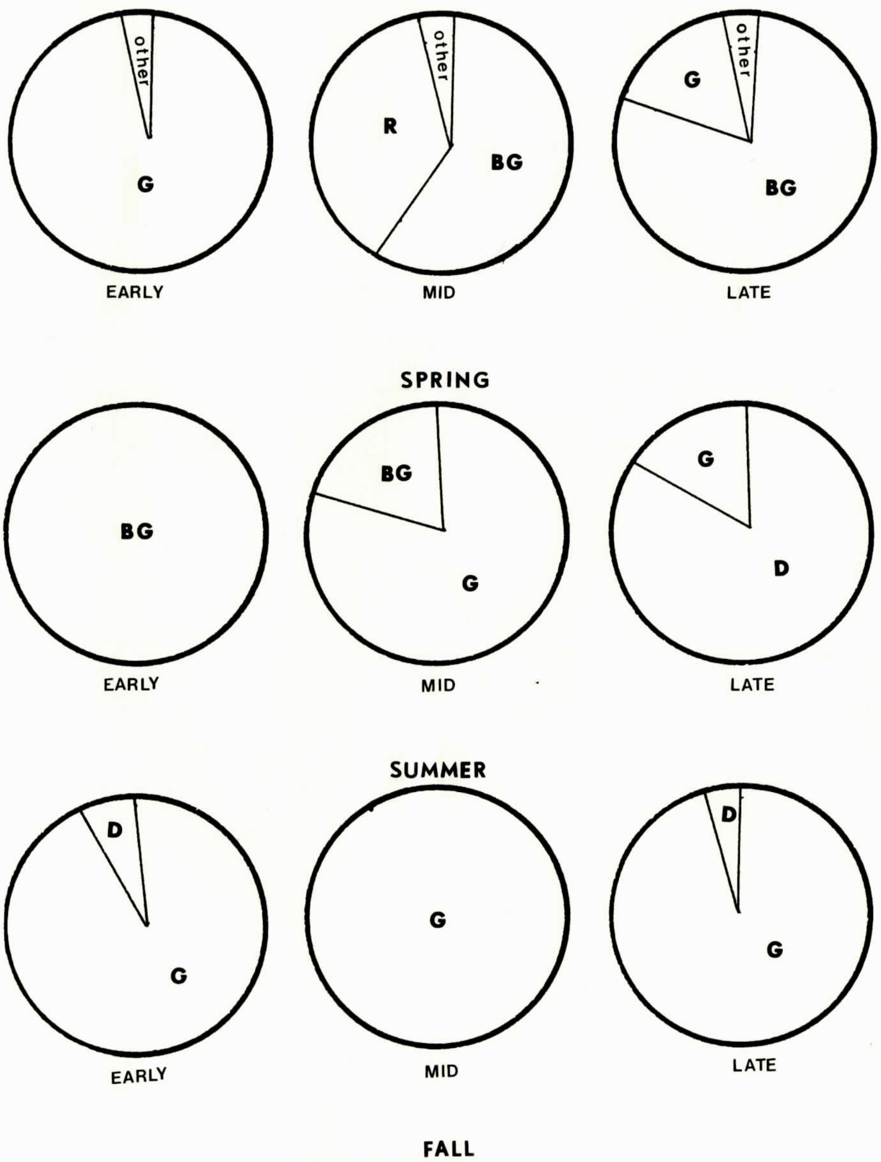

other
G
other
R
BG
other
G
BG
EARLY
MID
LATE
SPRING
BG
BG
G
G
D
EARLY
MID
LATE
SUMMER
D
G
G
D
G
EARLY
MID
LATE
FALL

FIGURE 5. Seasonal periodicity of greens (G), blue-greens (BG), diatoms (D), and reds (R) in Boone Fork Stream from early spring through late fall at station 2.

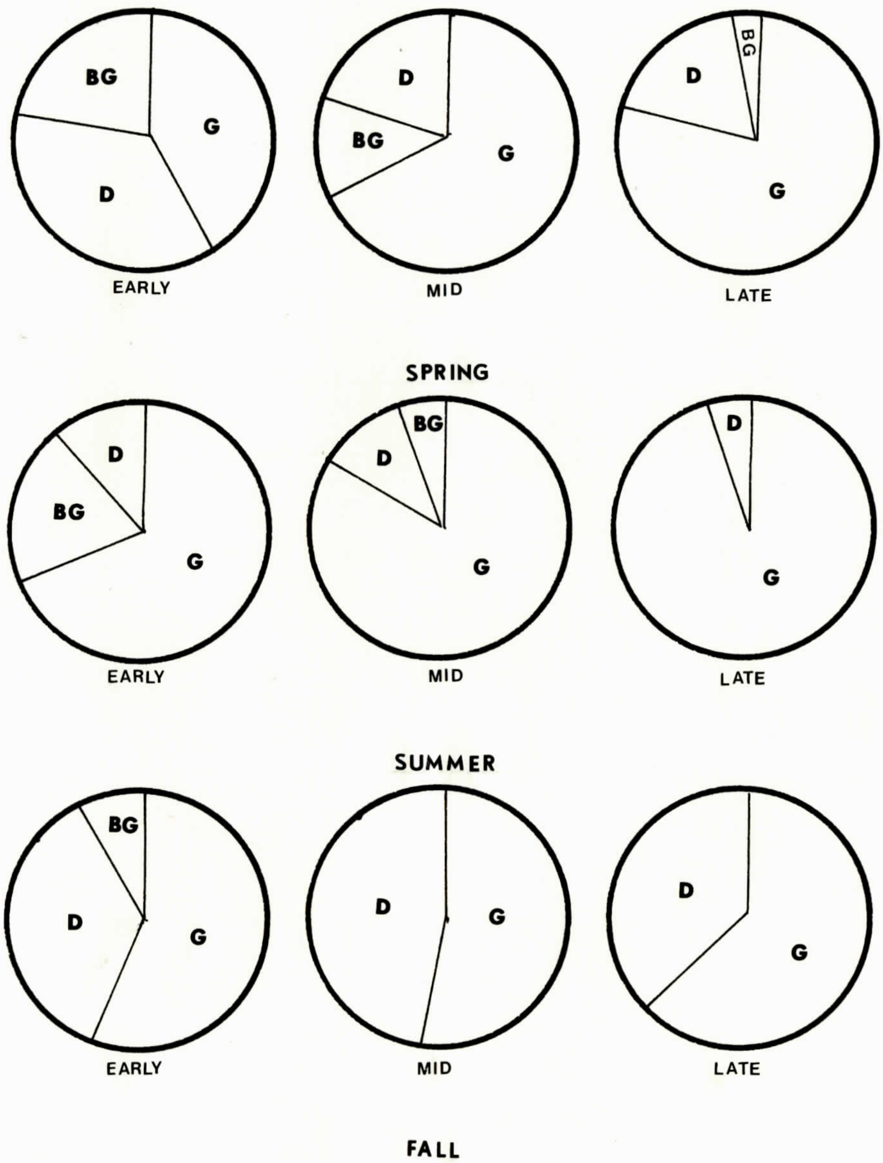

BG
G
D
EARLY
D
BG
G
MID
BG
D
G
LATE
SPRING
D
BG
G
EARLY
BG
D
G
MID
D
G
LATE
SUMMER
BG
D
G
EARLY
D
G
MID
D
G
LATE
FALL

FIGURE 6. Seasonal periodicity of greens (G), blue-greens (BG), diatoms (D), and reds (R) in Boone Fork Stream from early spring through late fall at station 3.

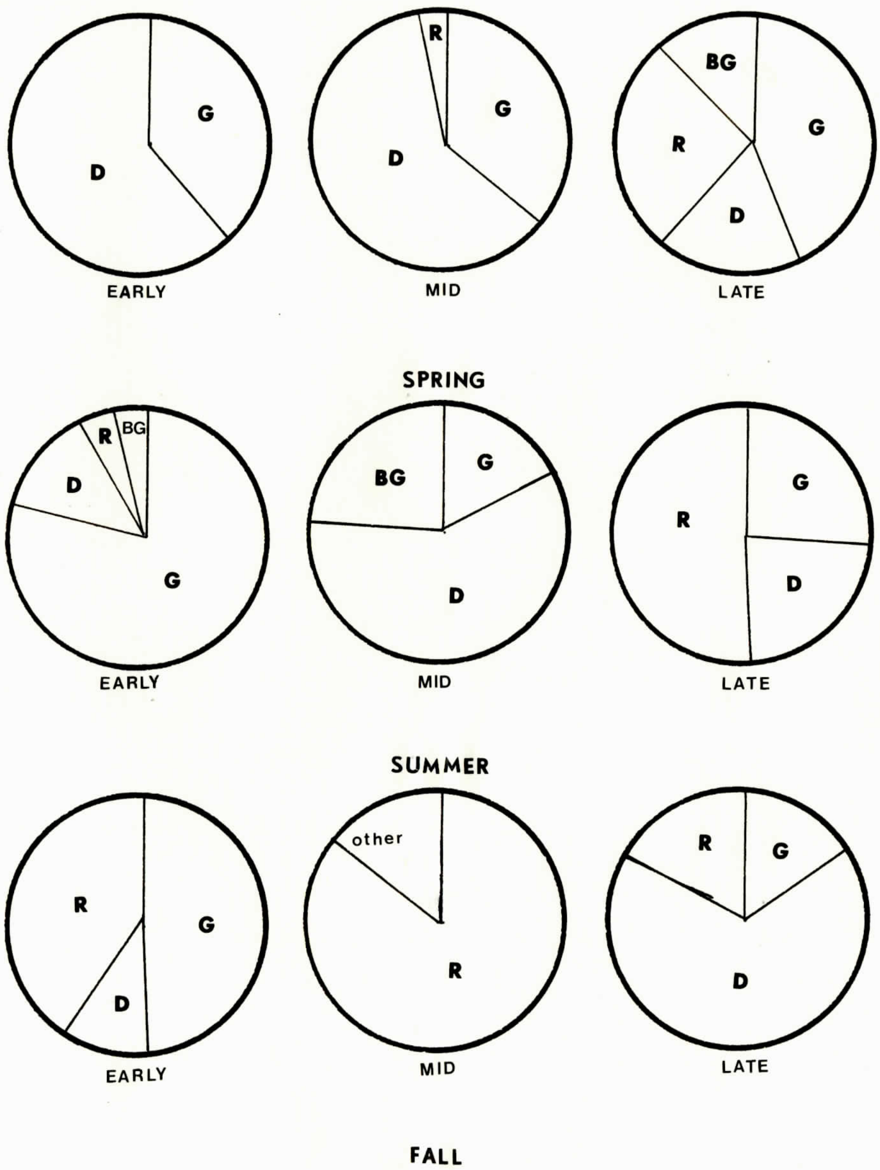

G
D
R
G
D
BG
G
R
D
EARLY
MID
LATE
SPRING
R
BG
D
G
BG
G
D
G
R
D
EARLY
MID
LATE
SUMMER
R
G
D
other
R
R
G
D
EARLY
MID
LATE
FALL

FIGURE 7. Seasonal periodicity of greens (G), blue-greens (BG), diatoms (D), and reds (R) in Boone Fork Stream from early spring through late fall at station 4.

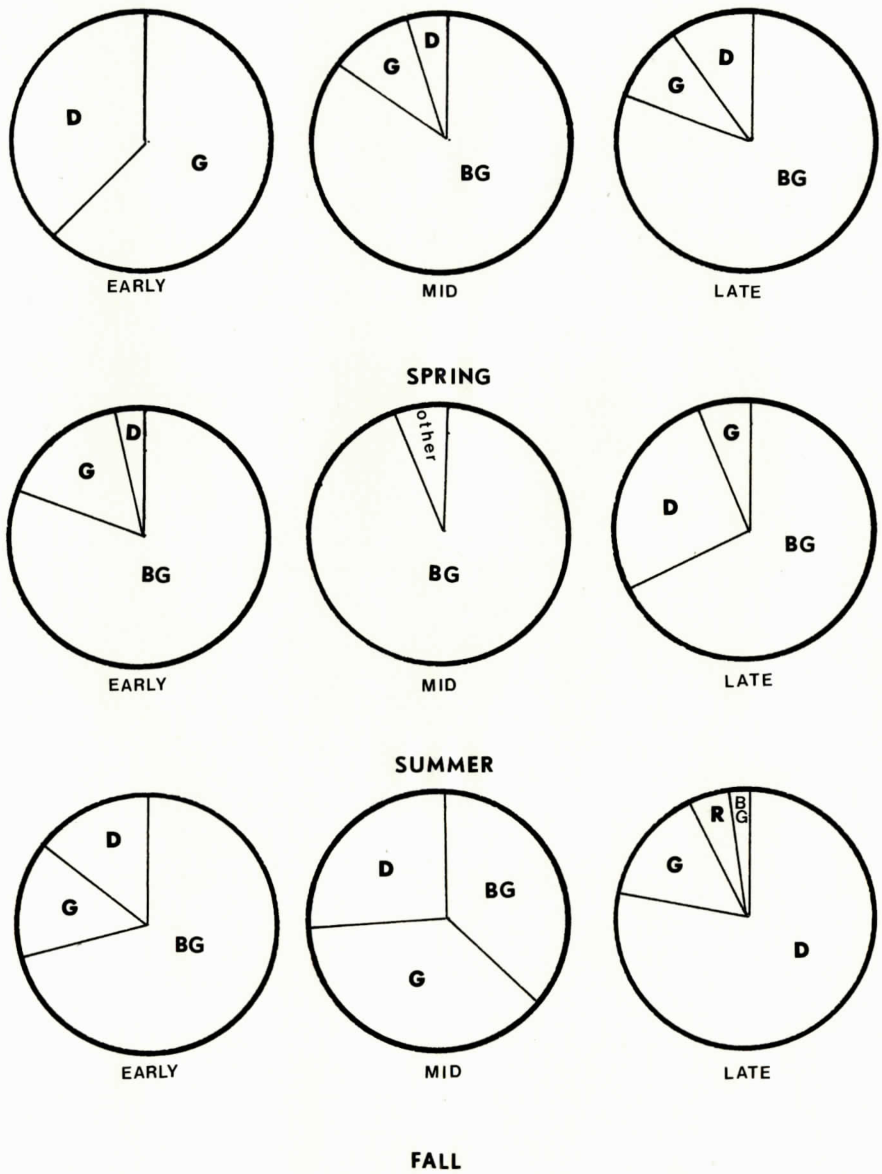
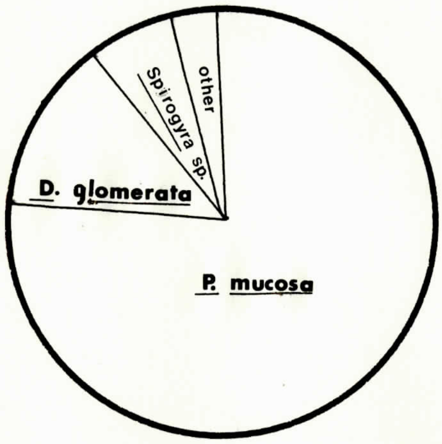
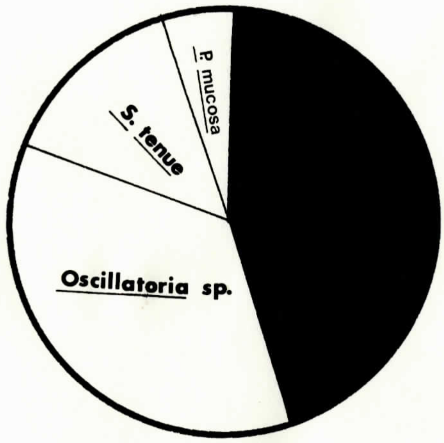

D
G
EARLY
D
G
BG
MID
D
G
BG
LATE
SPRING
D
G
BG
EARLY
other
BG
MID
G
D
BG
LATE
SUMMER
D
G
BG
EARLY
D
BG
G
MID
BG
R
G
D
LATE
FALL

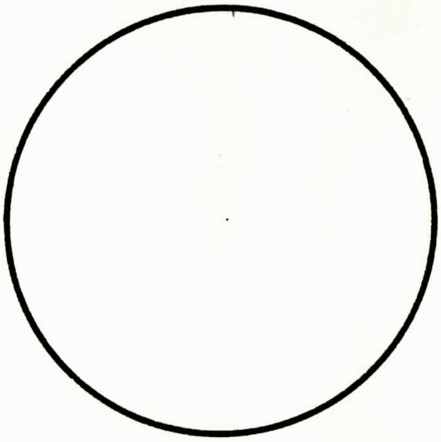
FIGURE 8. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from March 15, 1980 through April 25, 1980 at station 1. Genera include *Palmella mucosa*, *Draparnaldia glomerata*, *Stigeoclonium tenue*, and *Audouinella violacea*.



MAR 15

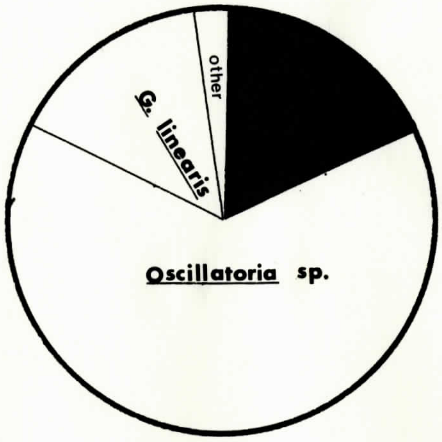


MAR 29

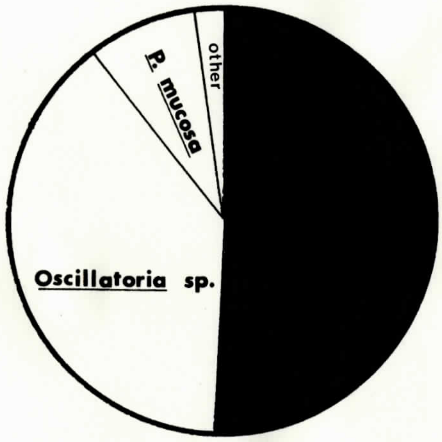

APR 14

APR 25

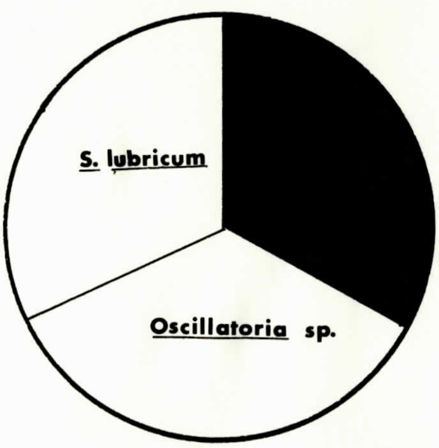
FIGURE 9. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from May 9, 1980 through June 28, 1980 at station 1. Genera include *Gloethece linearis*, *Palmella mucosa*, and *Stigeoclonium lubricum*.



MAY 9



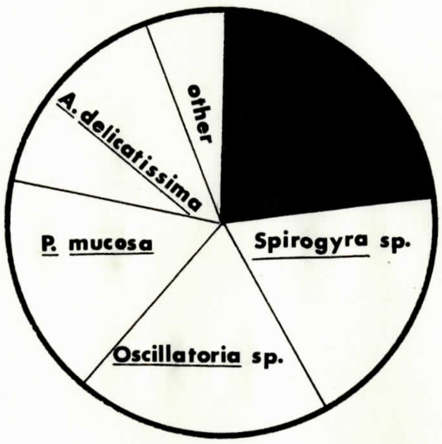
MAY 22



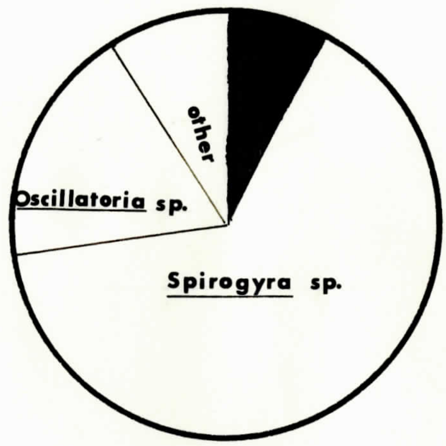
JUN 9

JUN 28

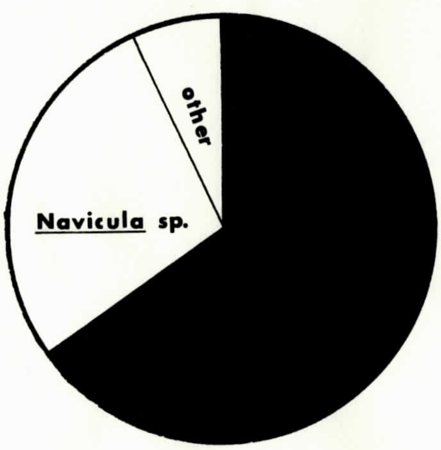
FIGURE 10. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from July 14, 1980 through August 22, 1980 at station 1. Genera include *Aphanocapsa delicatissima* and *Palmella mucosa*.



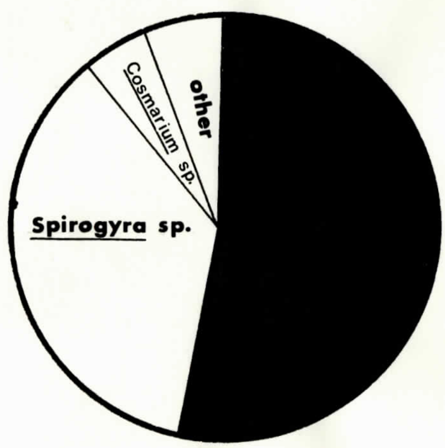
JUL 14



JUL 26

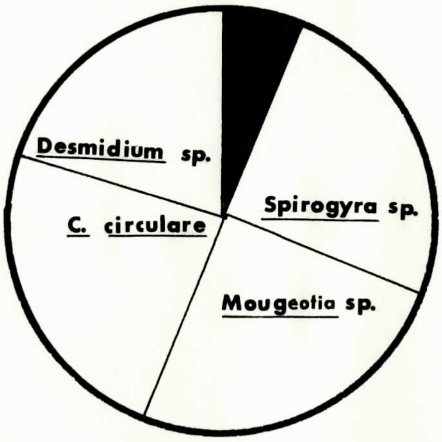


AUG 6

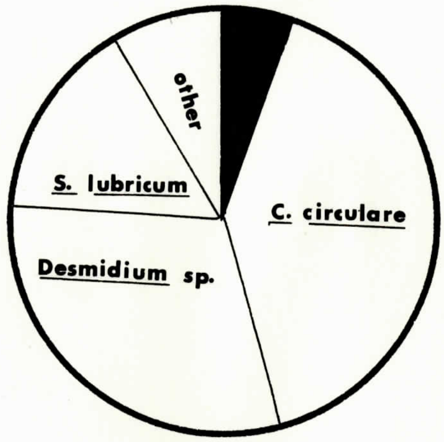


AUG 22

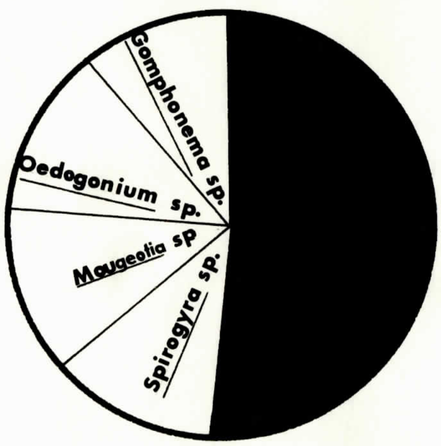
FIGURE 11. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from September 6, 1980 through October 26, 1980 at station 1. Genera include *Cosmarium circulare*, *Stigeoclonium lubricum*, and *Palmella mucosa*.



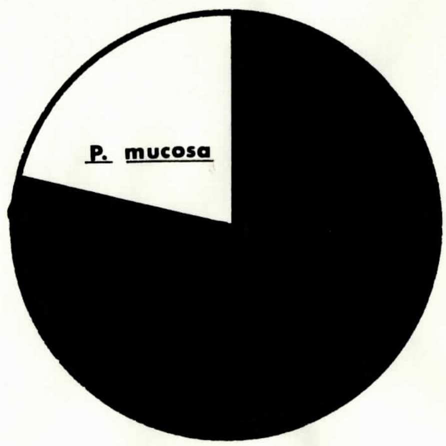
SEPT 6



SEPT 21

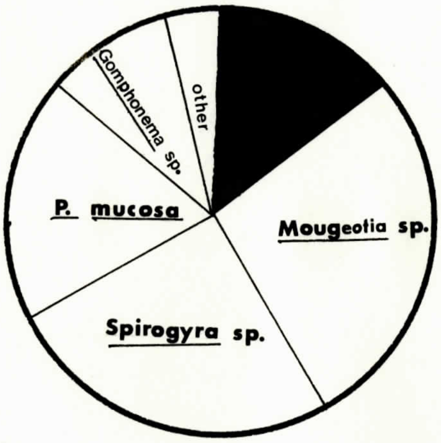


OCT 10



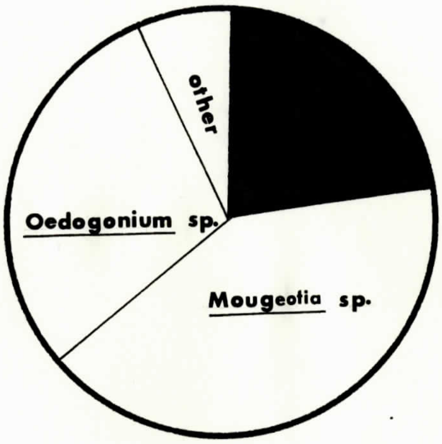
OCT 26

FIGURE 12. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from November 11, 1980 through November 22, 1980 at station 1. Genera include *Palmella mucosa*.



Gomphonema sp.
other
P. mucosa
Mougeotia sp.
Spirogyra sp.

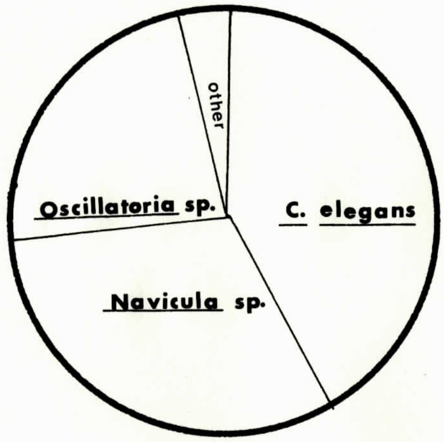
NOV 11



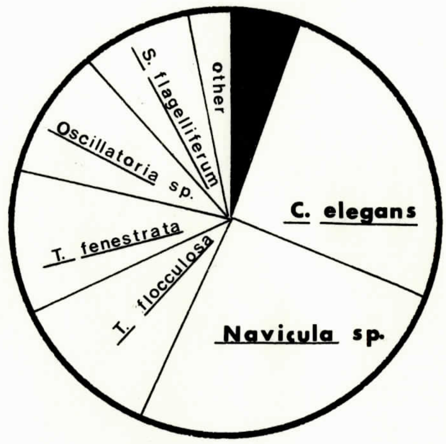
other
Oedogonium sp.
Mougeotia sp.

NOV 22

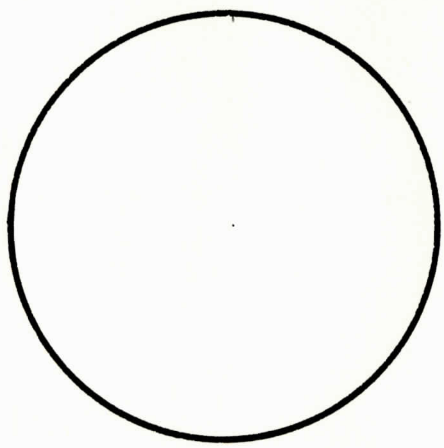
FIGURE 13. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from March 15, 1980 through April 25, 1980 at station 2. Genera include *Chaetophora elegans*, *Stigeoclonium flagelliferum*, *Tabellaria fenestrata*, *Tabellaria flocculosa*, and *Stigeoclonium lubricum*.



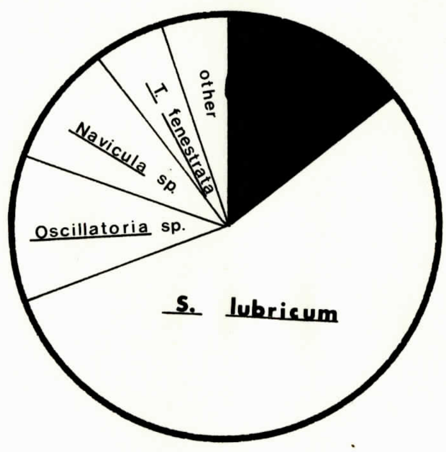
MAR 15



MAR 29

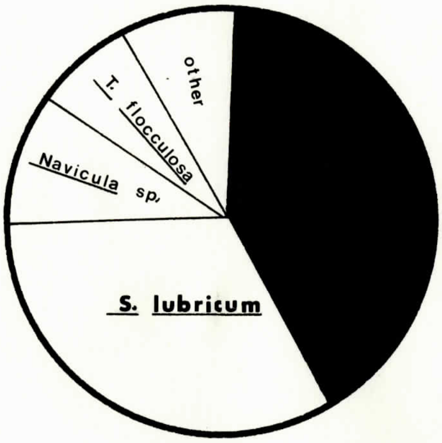


APR 14

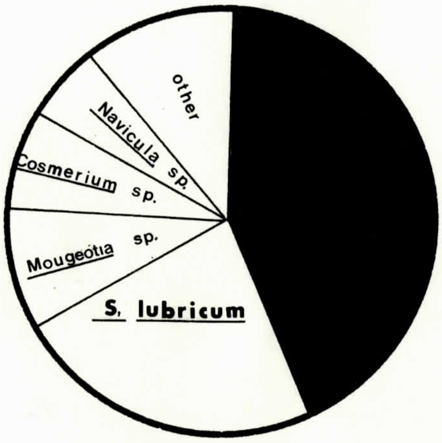


APR 25

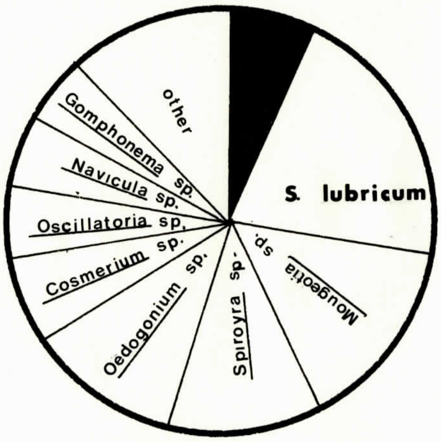
FIGURE 14. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from May 9, 1980 through June 28, 1980 at station 2. Genera include *Tabellaria flocculosa* and *Stigeoclonium lubricum*.



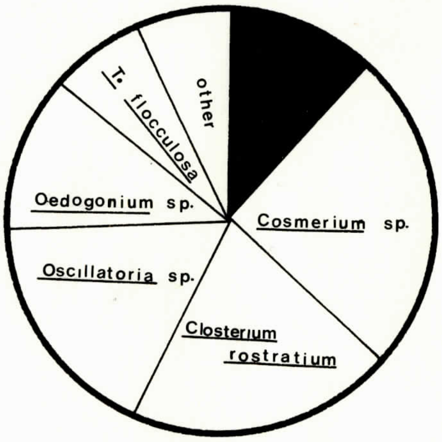
MAY 9



MAY 22

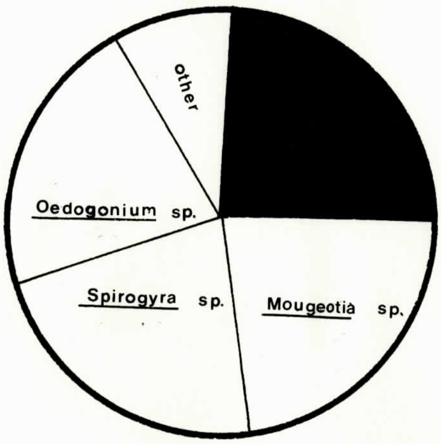


JUN 9

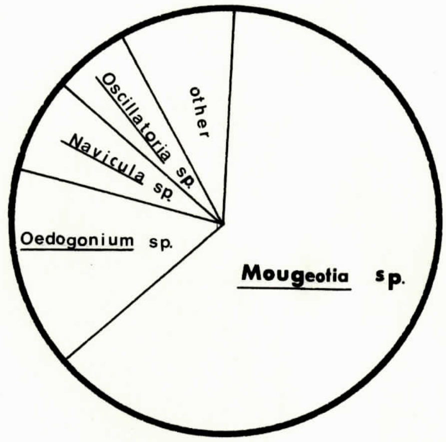


JUN 28

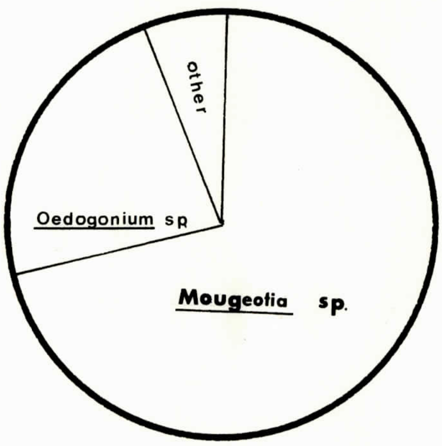
FIGURE 15. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from July 14, 1980 through August 22, 1980 at station 2.



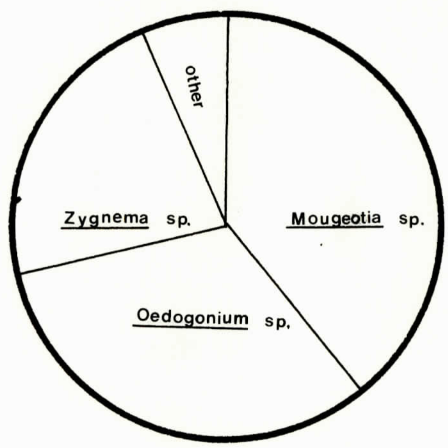
JUL 14



JUL 26

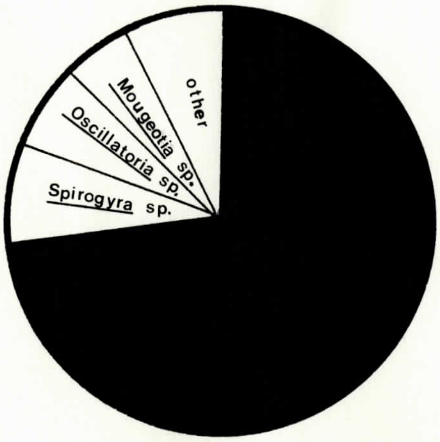


AUG 6

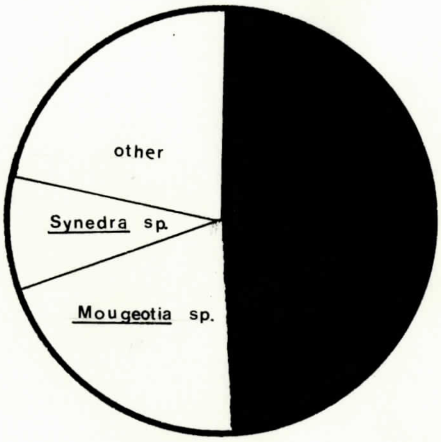


AUG 22

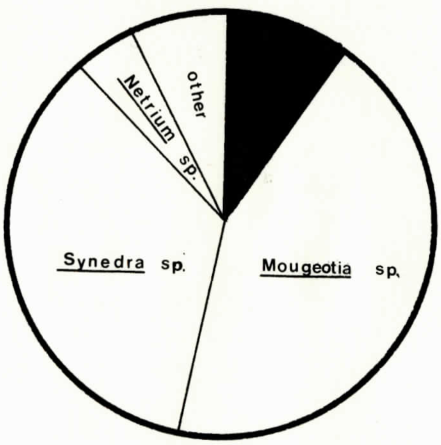
FIGURE 16. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from September 6, 1980 through October 26, 1980 at station 2.



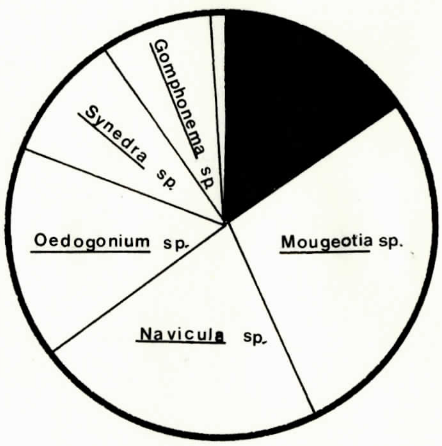
SEPT 6



SEPT 21

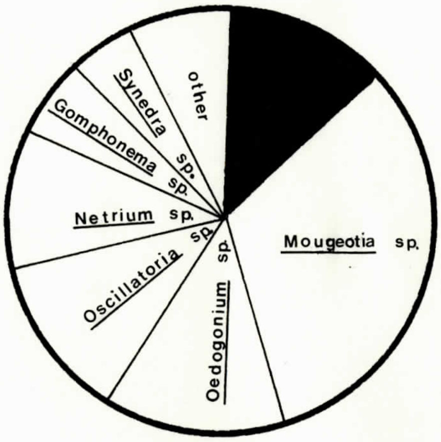


OCT 10

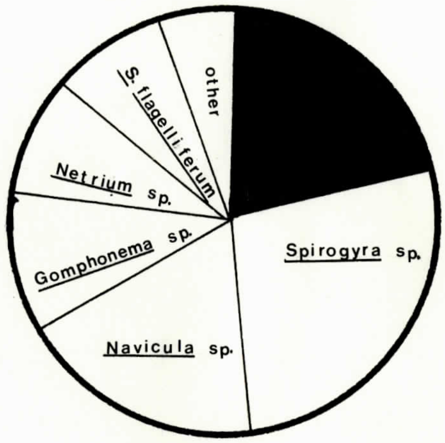


OCT 26

FIGURE 17. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from November 11, 1980 through November 22, 1980 at station 2. Genera include *Stigeoclonium flagelleferum*.

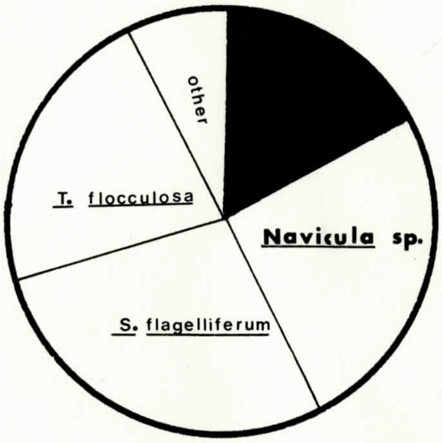

other
Synedra sp.
Gomphonema sp.
Netrium sp.
Oscillatoria sp.
Oedogonium sp.
Mougeotia sp.

NOV 11

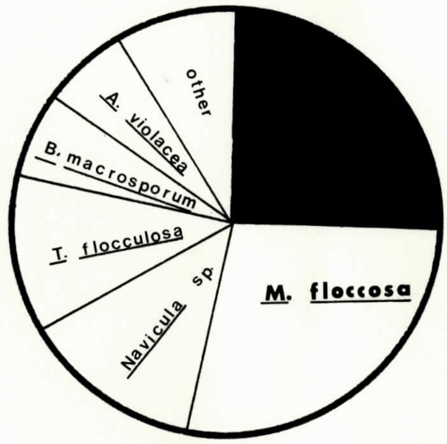

other
S. flagelliferum
Netrium sp.
Gomphonema sp.
Navicula sp.
Spirogyra sp.

NOV 22

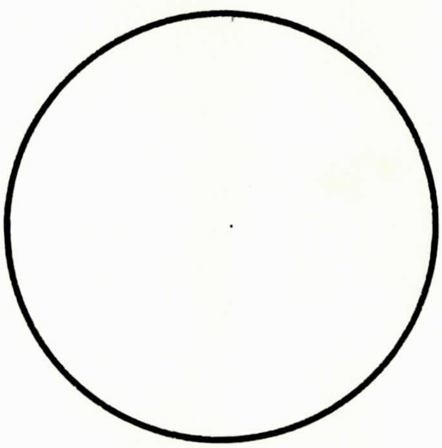
FIGURE 18. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from March 15, 1980 through April 25, 1980 at station 3. Genera include *Tabellaria flocculosa, Stigeoclonium flagelliferum, Audouinella violacea, Batrachospermum macrosporum, Microspora floccosa, Tabellaria fenestrata,* and *Stigeoclonium lubricum.*



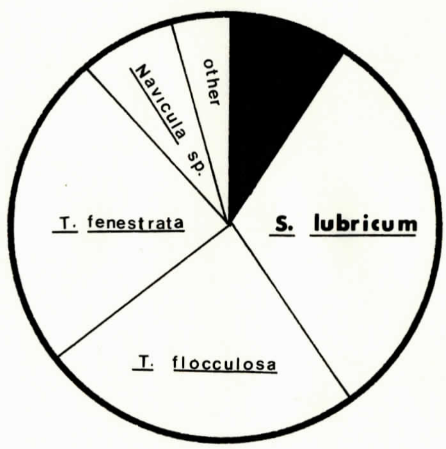
MAR 15



MAR 29

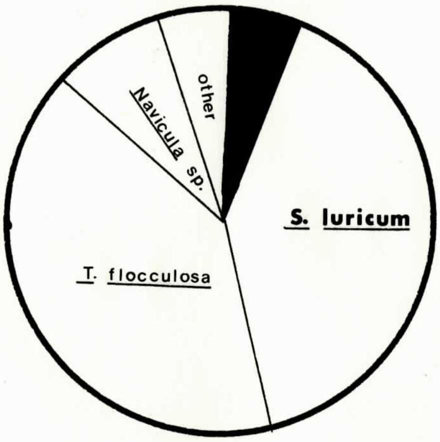


APR 14

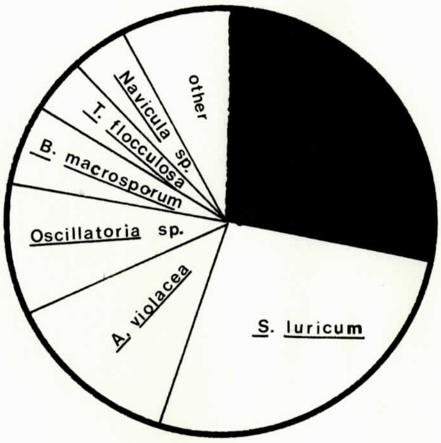


APR 25

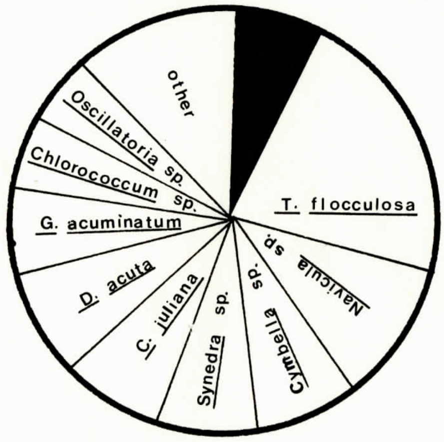
FIGURE 19. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from May 9, 1980 through June 28, 1980 at station 3. Genera include *Tabellaria flocculosa*, *Stigeoclonium lubricum*, *Batrachospermum macrosporum*, *Audouinella violacea*, *Calothrix juliana*, *Draparnaldia acuta*, and *Gomphonema acuminatum*.



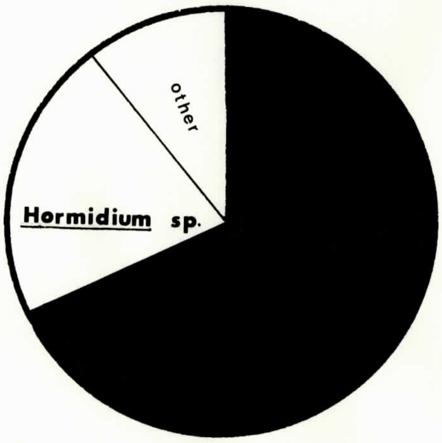
MAY 9



MAY 22

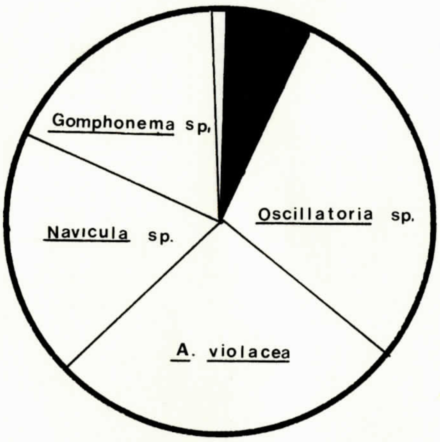


JUN 9

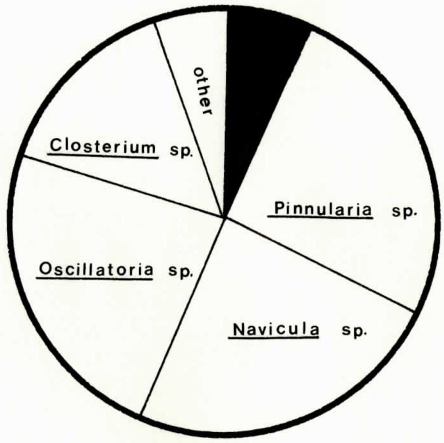


JUN 28

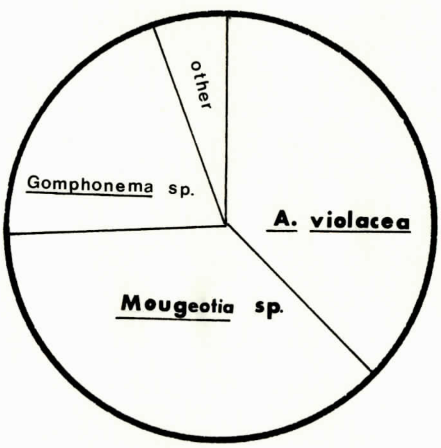
FIGURE 20. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from July 14, 1980 through August 22, 1980 at station 3. Genera include *Audouinella violacea*.



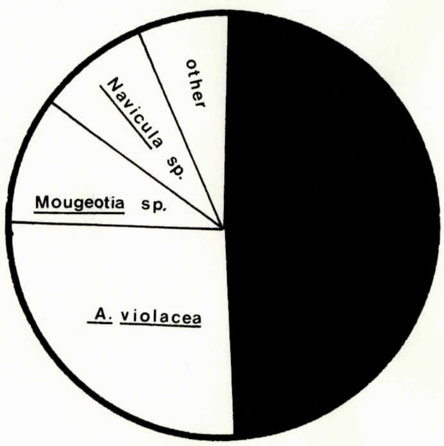
JUL 14



JUL 26



AUG 6



AUG 22

FIGURE 21. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from September 6, 1980 through October 26, 1980 at station 3. Genera include *Audouinella violacea*.

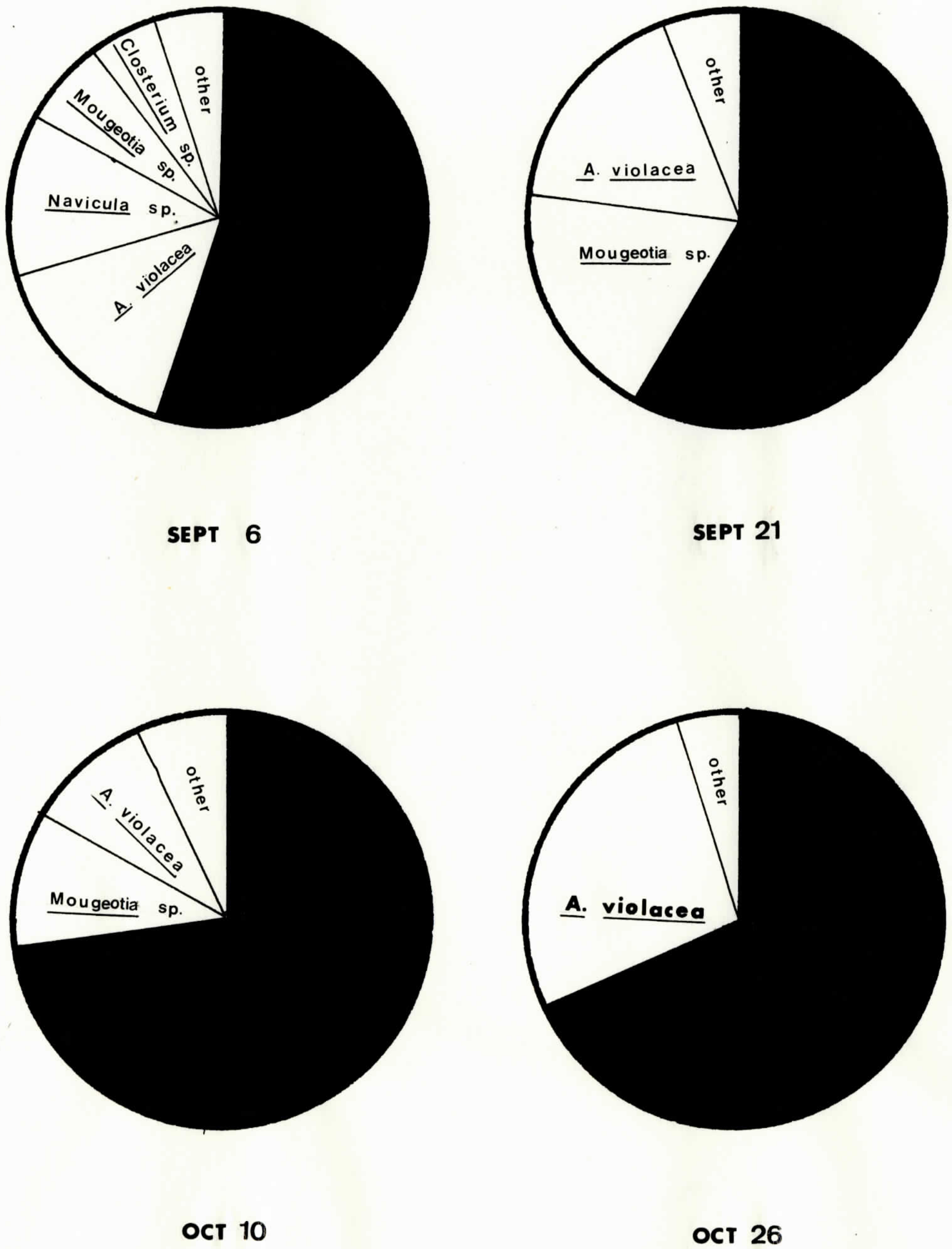
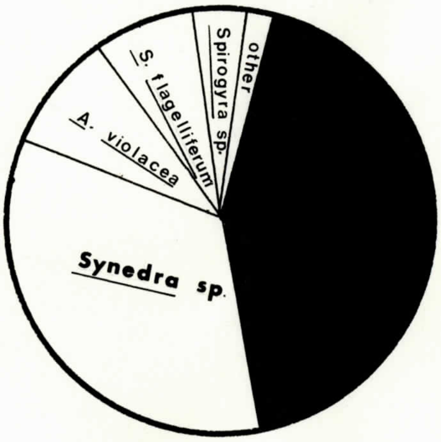
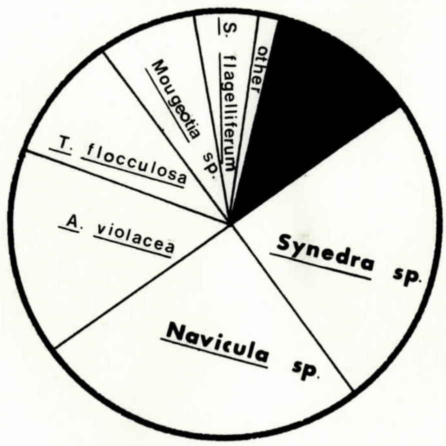

other
Closterium sp.
Mougeotia sp.
Navicula sp.
A. violacea
SEPT 6
other
A. violacea
Mougeotia sp.
SEPT 21
other
A. violacea
Mougeotia sp.
OCT 10
other
A. violacea
OCT 26

FIGURE 22. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from November 11, 1980 through November 22, 1980 at station 3. Genera include *Stigeoclonium flagelliferum*, *Audouinella violacea*, and *Tabellaria flocculosa*.

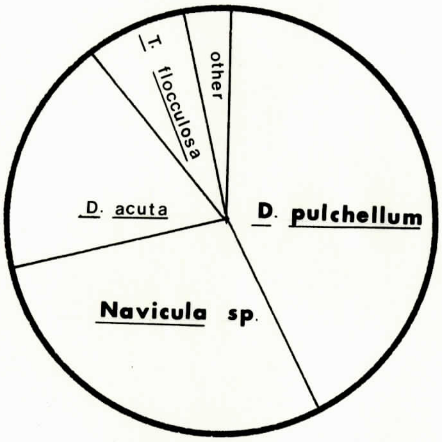

other
Spirogyra sp.
S. flagelliferum
A. violacea
Synedra sp.

NOV 11

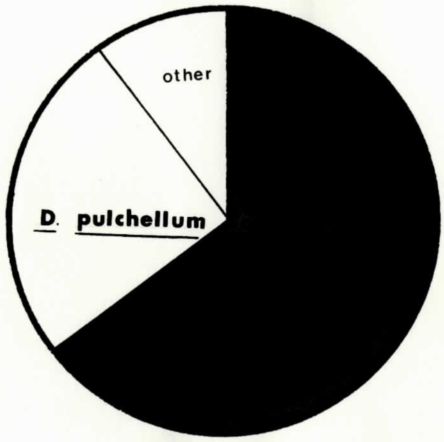

S. flagelliferum
other
Mougeotia sp.
T. flocculosa
A. violacea
Synedra sp.
Navicula sp.

NOV 22

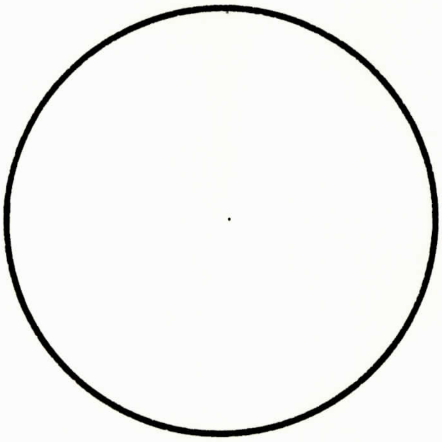
FIGURE 23. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from March 15, 1980 through April 25, 1980 at station 4. Genera include *Tabellaria flocculosa*, *Draparnaldia acuta*, and *Dictyophaerium pulchellum*.



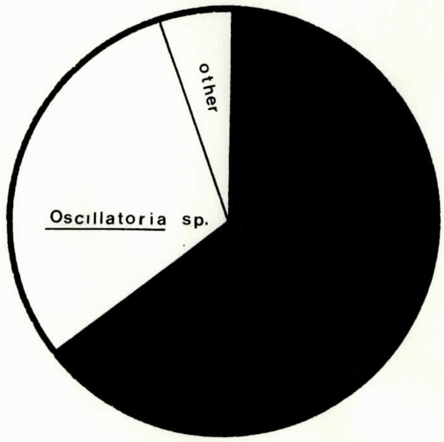
MAR 15



MAR 29

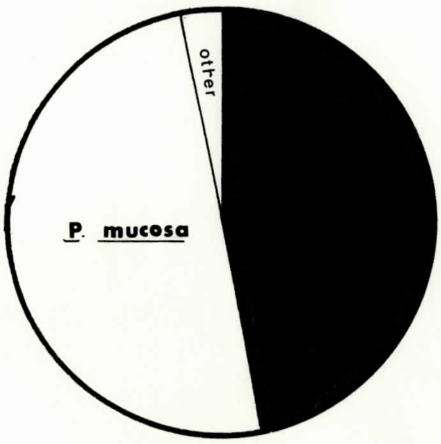


APR 14

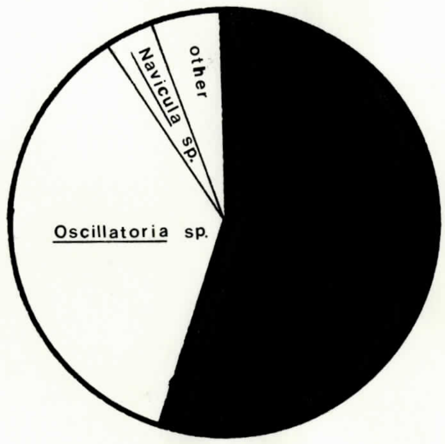


APR 25

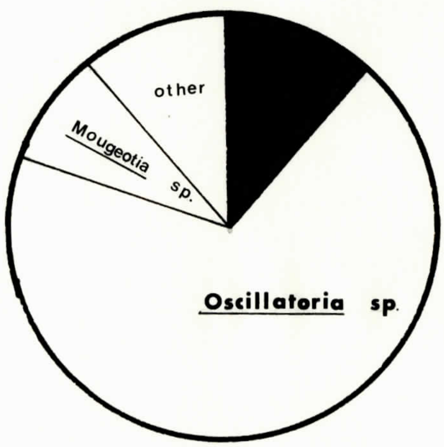
FIGURE 24. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from May 9, 1980 through June 22, 1980 at station 4. Genera include *Palmella mucosa*.



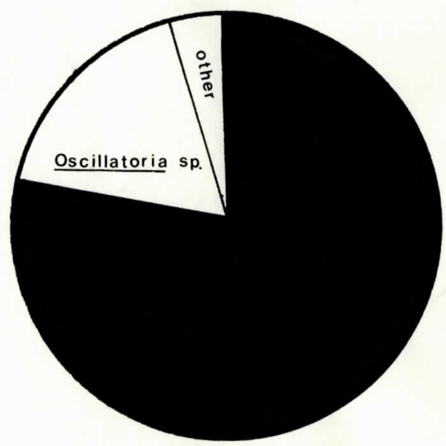
MAY 9



MAY 22

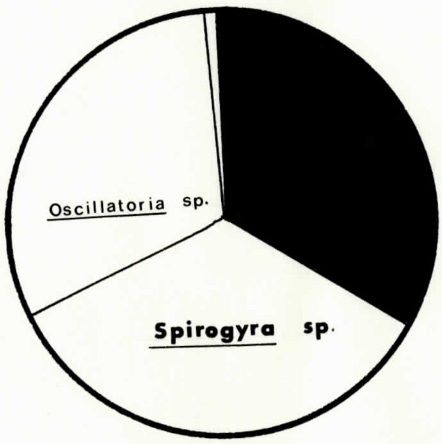


JUN 9

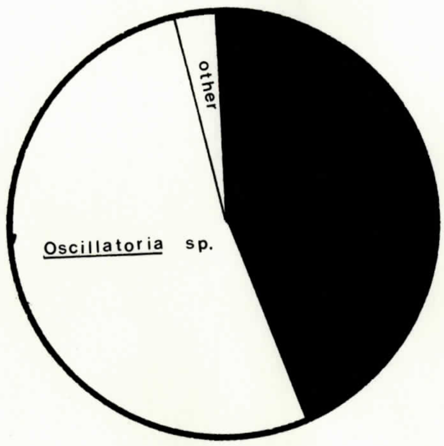


JUN 22

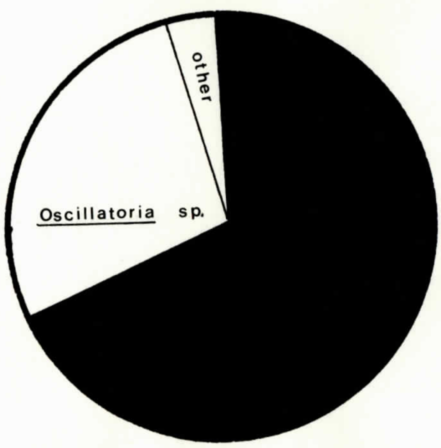
FIGURE 25. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from July 14, 1980 through August 22, 1980 at station 4.



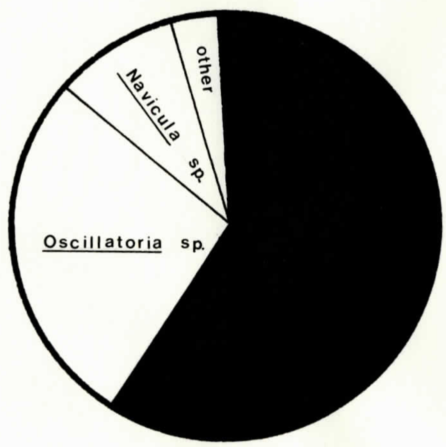
JUL 14



JUL 26

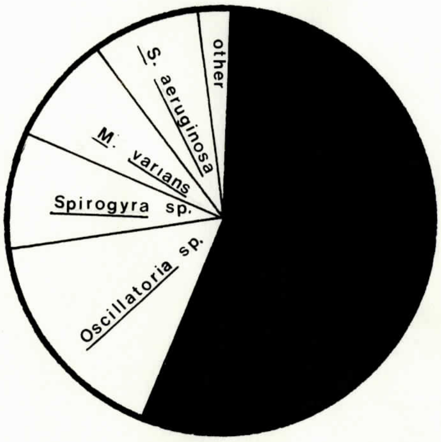


AUG 6

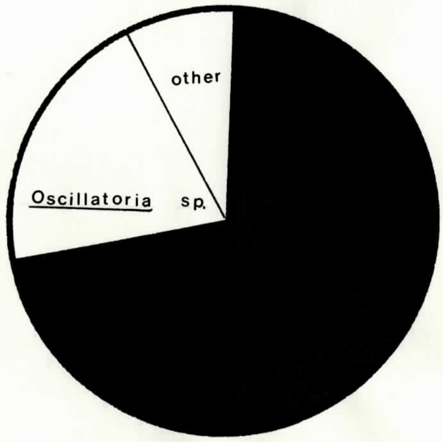


AUG 22

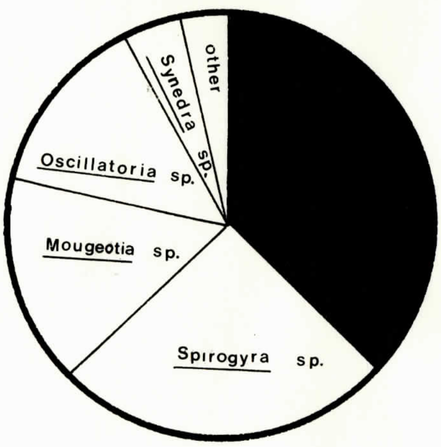
FIGURE 26. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from September 6, 1980 through October 26, 1980 at station 4. Genera include *Synechococcus aeruginosa* and *Melosira varians*.



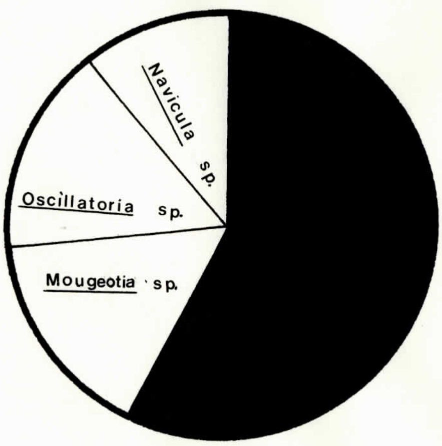
SEPT 6



SEPT 21

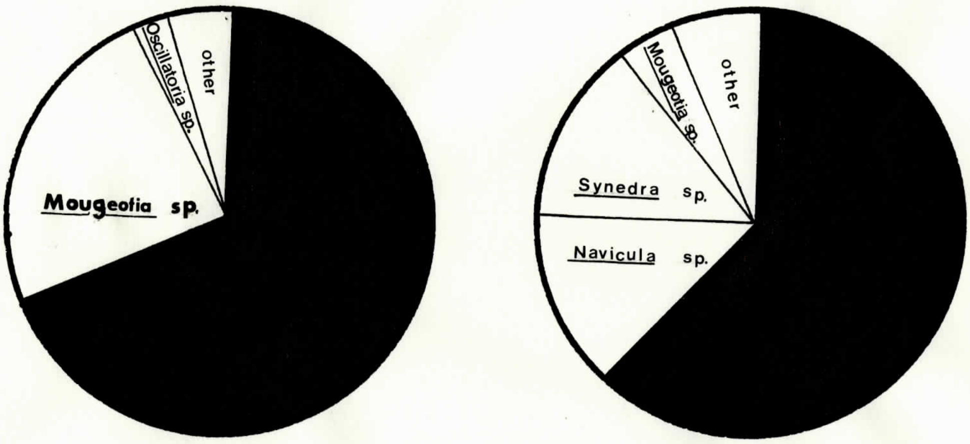


OCT 10



OCT 26

FIGURE 27. The seasonal periodicity and relative biomass of algal species in Boone Fork Stream from November 11, 1980 through November 22, 1980 at station 4.


other
Oscillatoria sp.
Mougeotia sp.
other
Mougeotia sp.
Synedra sp.
Navicula sp.

NOV 11

NOV 22

FIGURE 28. The seasonal fluctuations in relative biomass of benthic algae in Boone Fork Stream, March 1980 through November 1980.

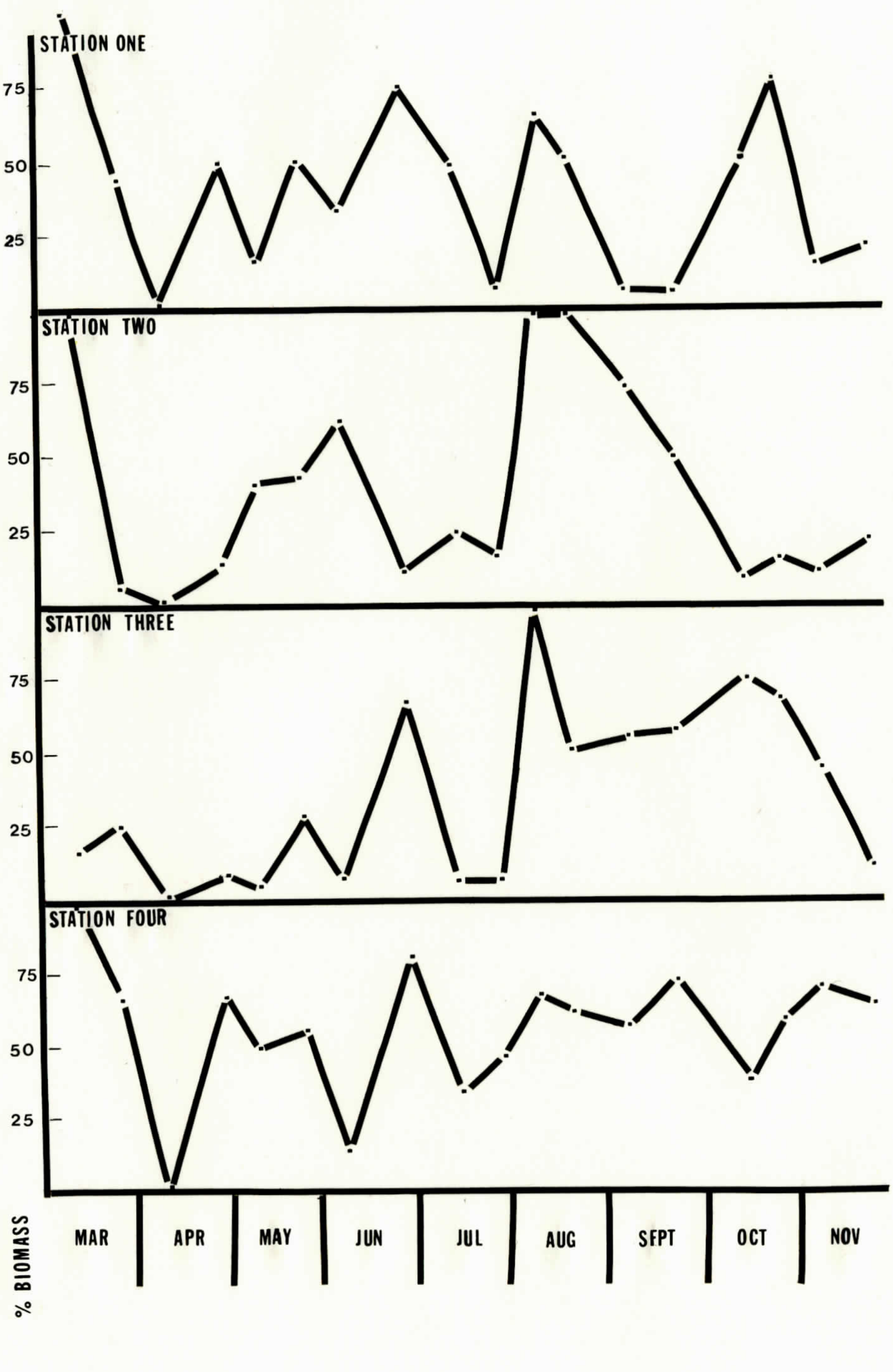
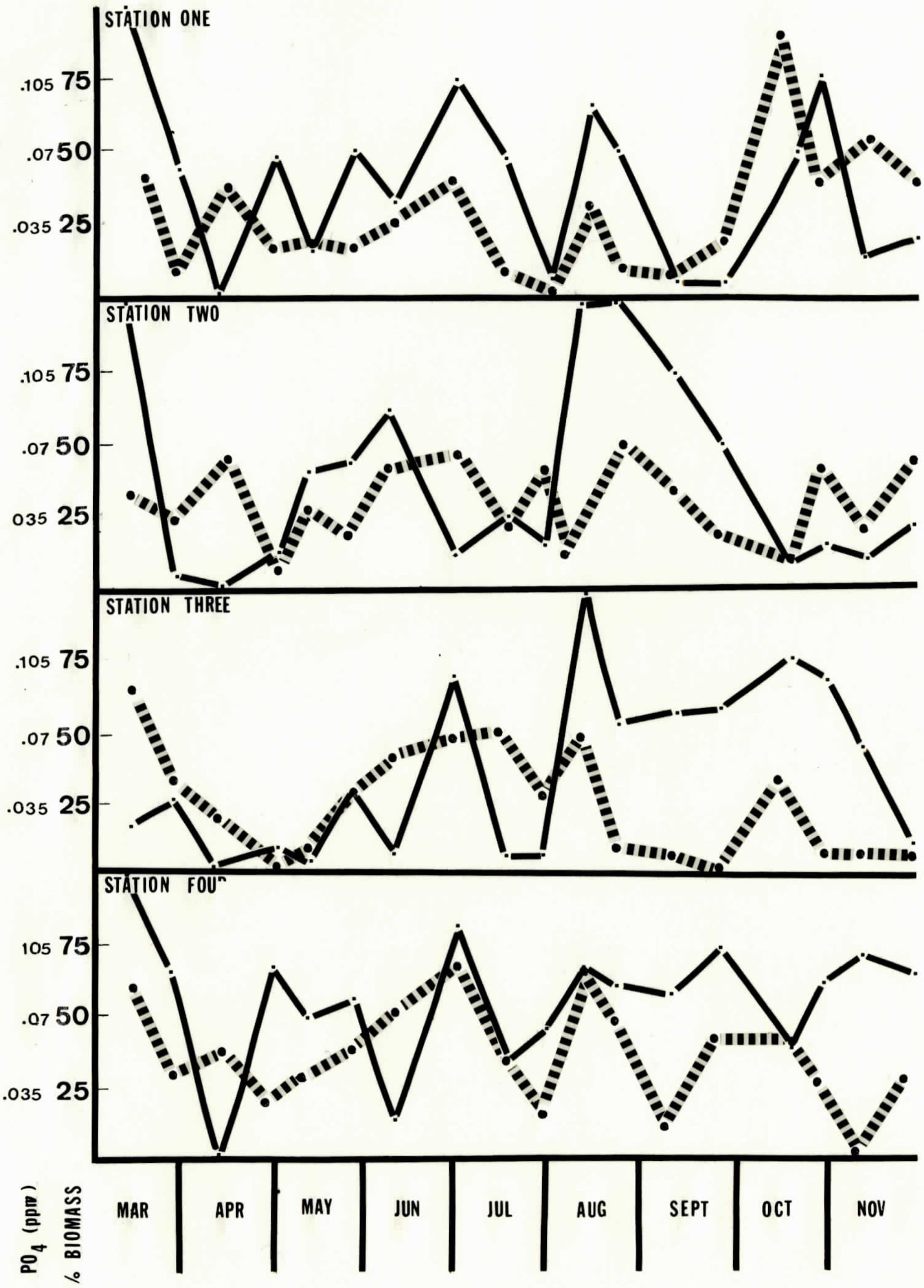

STATION ONE
STATION TWO
STATION THREE
STATION FOUR
75
50
25
% BIOMASS
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV

FIGURE 29. The seasonal fluctuations of orthophosphate phosphorous (dashed line) and relative biomass (solid line) of benthic algae in Boone Fork Stream, March 1980 through November 1980.


STATION ONE
STATION TWO
STATION THREE
STATION FOUR
.105 75
.07 50
.035 25
PO4 (ppm)
% BIOMASS
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV

DISCUSSION

Boone Fork is one of the feeder streams located at the head waters of Watauga River. Results of this study have shown that although nutrient levels fluctuated in this stream over a season the total concentration of nutrients was low at all stations. Low nutrient concentration is a characteristic of relatively unpolluted waters (Hutchinson, 1957; Reid, 1961; Ruttner, 1963). Reid (1961) reports that an ammonia nitrogen concentration on the order of 1 mg/1 or less is an especially good indicator of an unpolluted system. The maximum level of ammonia nitrogen recorded for Boone Fork was only 0.905 ppm indicating that this stream remains relatively unpolluted. A further indication of this was the very low orthophosphate levels that were recorded. Phosphate concentration even fell below detectable levels on Boone Fork at station 3 on September 21 and at station 4 on November 11.

A seasonal fluctuation of nutrient levels is common to most aquatic systems (Hutchinson, 1957; Reid, 1961; Ruttner, 1963). This study has found such a seasonal fluctuation in the nutrient concentration of Boone Fork. Sharpest fluctuations were seen at station 2. Above station 2 the stream system was interrupted by a dried lake-bed surrounded by a large cleared area of pasture land. Silting and nutrient run-off from this area could have contributed to the sharp nutrient fluctuation at station 2.

The temperature of a stream tends to follow atmospheric temperatures and the response of a small stream to temperature variations is more rapid (Reid, 1961). This study found that the average temperature of Boone Fork Stream increased as seasonal atmospheric temperatures increased and decreased as atmospheric temperatures decreased. Reid (1961) further suggests that the annual cycle of oxygen of a stream is closely correlated with temperature conditions. Oxygen is moderately soluble in water and decreases in concentration with increasing temperatures (Hutchinson, 1957; Reid, 1961; Ruttner, 1963). Just such a relationship between temperature and dissolved oxygen was found during this study. There was no evidence that oxygen content had any direct affect on the species of algae or relative biomass in Boone Fork Stream.

Streams are subject to changes along their length, associated with depth, rate of flow, turbidity, geology of the land surface and geology of the stream bed (Reid, 1961; Round, 1973). This study found as expected that current velocity increased upstream. Therefore only algae capable of holding fast to the substrate should endure here. All forms found at upstream stations were tightly bound to the substrate.

Seasonal temperature changes tend to increase in a downstream fashion (Reid, 1961; Hynes, 1969). Expected trends in temperature increases for downstream stations did not hold true for Boone Fork Stream. Temperature was generally higher at station 3 than at station 4. The influx of warm, surface waters from Price Lake likely affected the water temperature at station 3. The temperature at station 2 was about the same as the temperature at station 4, but station 2 and the length of the stream above it was not shaded as it was at station 4. Often the ecological characteristics of a downstream station is moved upstream by mans interference with the watershed (Hynes, 1969). The Boone Fork Stream system is interrupted by a dried lake-bed, pastures, and by the presence of Price Lake between station 2 and station 3.

The concentration of dissolved substances can also be expected to increase downstream (Reid, 1961; Hynes, 1969). Such an increase was seen in nutrient levels of Boone Fork. The orthophosphate levels remained relatively higher at station 4 from mid-summer through mid-fall. During the same time orthophosphate concentration was lower at upstream stations. Reid (1961) maintains that increased surface run-off contributes to the phosphorus content of a stream. It should be noted there are several feeder streams between station 3 and station 4 which could account for the increased level of orthophosphate at station 4. At station 3 nitrate nitrogen remained relatively high at about 0.1 ppm for two periods each lasting approximately one month.

It is evident from this study that nutrient concentration had little affect on species periodicity. The algae instead demonstrated marked seasonal periodicity. Such periodicity has been described by Whitford and Shumacher (1963) and by Dillard (1963, 1966). A study of macroscopic communities in a small brown water stream in the high sandhill region of North Carolina by Dillard (1966) found *Batrachospermum macrosporum* dominated the algal community in the summer while *Audouinella violacea* dominated in the winter. In this study it was found that not only individual genera demonstrated a seasonal preference but that entire families and indeed many families of a single division showed seasonal preference. It may be possible to use seasonal periodicity as a taxonomic characterization of a species as well as physical and evolutionary criteria.

The various factors influencing seasonal periodicity are so complex that to describe the specific action of one is not practical. Agencies which may effect the seasonal periodicity of algae might include annual intensity and duration of sunlight, change of temperature, and fluctuation of nutrient concentrations (Smith, 1950). Chlorophycophyta and Chrysophycophyta (particularly diatoms) were the predominant species of Boone Fork Stream. Many families of these divisions preferred the spring and fall months. This would indicate that these algal groups prefer cooler waters. Members of the family Oedogoniaceae demonstrated marked preference for warmer water occurring at station 2 in the late spring and then in the early fall at station 1. Greens and diatoms also seemed to prefer higher light intensities and were predominant in the early spring and fall months at stations 3 and 4, and dominant all seasons at station 2.

Changes in temperature affected linear distribution as well as seasonal periodicity. The appearance of *Bactracospermum macrosporum* at only station 3 is a good example. Dillard (1969) concluded that *B. macrosporum* requires low light intensity and high water temperatures.

Fritch (1959) adds that species of *Batrachospermum* favor well-aerated water of slow-moving streams. All of these conditions were characteristic of station 3.

A very rare species, *Hammatoidia normanii*, was found at station 1. *Hammatoidia normanii* has been recorded only from one locality in this country by Smith, (1950). Cocke (1967) reports finding *H. normanii* only once in a shallow pool at the base of a drinking fountain in Mt. Morrow State Park, Stanley County, North Carolina. This species was found at station 1 only on two occasions and was represented by a very few individuals. It is possible that this species is more widely distributed but due to its low individual numbers is rarely collected and identified.

Biomass varied from season to season and from station to station but the fluctuations in orthophosphate concentration and successive similar fluctuation in relative biomass at station 1 is well worth noting. Some studies attempt to link orthophosphate fluctuations with biomass production (Hutchinson, 1957). Phosphorous is probably the most important element ecologically because it is the least abundant in our waters (Ruttner, 1963) and therefore is often the limiting factor in the amount of biomass produced. This would be especially true at upstream stations that are not receiving as much of nutrient load compared to downstream stations.

Based on this study several additional investigations can be suggested. An investigation should be made of the algal communities appearing further downstream in the Watauga River system, to assess the changes that occur in species composition. In addition a seasonal and linear study of algal communities in other mountain streams within the same watershed would provide a more complete picture of the Watauga River system. Relatively little progress has been made in developing simple, reliable techniques for evaluating nutrient supplies to aquatic plants growing in natural environments (Gerloff, 1969). Indeed this study limited itself to monitoring only three nutrients. According to Reid (1961) and Smith (1950) there appears to be a correlation in streams between quality and quantity of algae, and calcium carbonate concentration. This suggests that a comparative study should be made between two streams differing in calcium bicarbonate concentration. Based on the geology of this area such a study could compare mountain streams in North Carolina with those in adjacent counties of Tennessee where limestone rock is present. Additional studies should also be made with *Batrachospermum macrosporum* and the effect of light intensity and water temperature on its occurrence and distribution. Finally, each single characteristic of a lotic system and its influence on the periodicity of algal species and single families should be analyzed further.

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APPENDIX I.

Temperature for each station of Boone Fork Stream for each sampling date, March 15 to November 22, 1980

TEMPERATURE (°C)

Date:	Station 1	Station 2	Station 3	Station 4
15 Mar	3.0	5.5	4.5	2.7
29 Mar	6.5	10.0	7.5	9.0
4 Apr	9.5	10.0	11.0	11.0
25 Apr	12.0	13.0	15.0	12.5
9 May	11.0	14.0	15.0	12.5
22 May	12.5	16.0	17.5	14.5
9 Jun	13.0	15.0	18.0	14.0
28 Jun	14.0	18.0	21.0	19.2
14 Jul	17.0	22.0	24.5	23.0
26 Jul	17.0	22.5	24.0	20.5
6 Aug	16.0	18.0	22.0	18.0
22 Aug	18.0	23.5	25.0	22.0
6 Sept	17.0	19.5	21.5	19.0
21 Sept	16.0	21.0	21.5	20.0
10 Oct	11.5	17.0	16.0	13.0
26 Oct	6.0	9.0	10.0	9.0
11 Nov	6.0	6.0	8.5	6.0
22 Nov	3.0	2.0	5.5	3.0

APPENDIX II.

Dissolved oxygen for each station of Boone Fork Stream for each sampling date, March 15 to November 22, 1980

OXYGEN (ppm)

Date:	Station 1	Station 2	Station 3	Station 4
15 Mar	11.5	11.8	11.0	12.2
29 Mar	10.3	10.0	10.5	10.2
4 Apr	9.3	9.4	9.5	9.5
25 Apr	9.2	9.0	9.2	8.6
9 May	9.4	9.1	8.6	8.9
22 May	9.2	8.7	8.2	9.0
9 Jun	8.6	8.8	7.7	8.8
28 Jun	9.0	8.3	7.6	7.9
14 Jul	7.9	7.5	6.7	7.5
26 Jul	7.9	7.3	6.5	8.0
6 Aug	8.5	7.8	7.0	7.8
22 Aug	7.8	7.2	6.5	7.4
6 Sept	7.8	7.6	6.2	7.3
21 Sept	7.6	7.6	5.5	6.1
10 Oct	9.1	8.7	8.3	9.6
26 Oct	10.3	9.8	10.2	9.1
11 Nov	10.1	10.7	9.8	10.6
22 Nov	11.2	12.0	11.0	12.0

APPENDIX III.

Orthophosphate for each station of Boone Fork Stream for each sampling date, March 15 to November 22, 1980

ORTHOPHOSPHATE (ppm)

Date:	Station 1	Station 2	Station 3	Station 4
15 Mar	0.06	0.05	0.09	0.08
29 Mar	0.015	0.04	0.05	0.04
4 Apr	0.06	0.065	0.03	0.05
25 Apr	0.03	0.015	0.005	0.03
9 May	0.03	0.04	0.015	0.04
22 May	0.03	0.03	0.04	0.05
9 Jun	0.04	0.06	0.06	0.07
28 Jun	0.06	0.07	0.07	0.09
14 Jul	0.015	0.03	0.07	0.05
26 Jul	0.005	0.06	0.04	0.02
6 Aug	0.05	0.02	0.07	0.09
22 Aug	0.02	0.07	0.015	0.07
6 Sept	0.015	0.05	0.01	0.015
21 Sept	0.03	0.03	0.00	0.06
10 Oct	0.13	0.02	0.05	0.06
26 Oct	0.06	0.06	0.01	0.04
11 Nov	0.08	0.03	0.01	0.00
22 Nov	0.06	0.065	0.01	0.04

APPENDIX IV.

Nitrate nitrogen for each station of Boone Fork Stream for each sampling date, March 15 to November 22, 1980

NITRATE NITROGEN (ppm)

Date:	Station 1	Station 2	Station 3	Station 4
15 Mar	0.01	0.09	0.08	0.075
29 Mar	0.06	0.03	0.1	0.1
4 Apr	0.11	0.06	0.11	0.03
25 Apr	0.02	0.065	0.1	0.11
9 May	0.025	0.00	0.035	0.025
22 May	0.045	0.12	0.09	0.11
9 Jun	0.07	0.07	0.09	0.07
28 Jun	0.04	0.05	0.09	0.06
14 Jul	0.05	0.03	0.06	0.025
26 Jul	0.02	0.065	0.035	0.03
6 Aug	0.04	0.06	0.03	0.035
22 Aug	0.025	0.08	0.05	0.055
6 Sept	0.02	0.05	0.04	0.05
21 Sept	0.03	0.05	0.05	0.04
10 Oct	0.03	0.03	0.04	0.01
26 Oct	0.03	0.045	0.03	0.05
11 Nov	0.01	0.01	0.03	0.00
22 Nov	0.02	0.03	0.085	0.03

APPENDIX V.

Ammonia nitrogen for each station of Boone Fork Stream for each sampling date, March 15 to November 22, 1980

AMMONIA NITROGEN (ppm)

Date:	Station 1	Station 2	Station 3	Station 4
15 Mar	0.36	0.49	0.5	0.44
29 Mar	0.4	0.49	0.545	0.325
4 Apr	0.64	0.905	0.65	0.515
25 Apr	0.36	0.48	0.385	0.3
9 May	0.4	0.35	0.43	0.25
22 May	0.25	0.415	0.25	0.3
9 Jun	0.25	0.3	0.25	0.4
28 Jun	0.15	0.3	0.48	0.37
14 Jul	0.23	0.36	0.37	0.48
26 Jul	0.25	0.595	0.415	0.325
6 Aug	0.21	0.37	0.45	0.37
22 Aug	0.0275	0.75	0.5	0.48
6 Sept	0.0275	0.65	0.5	0.4
21 Sept	0.075	0.5	0.45	0.325
10 Oct	0.5	0.5	0.56	0.45
26 Oct	0.37	0.515	0.45	0.415
11 Nov	0.21	0.385	0.43	0.35
22 Nov	0.21	0.325	0.23	0.25

APPENDIX VI.

Relative biomass for each station of Boone Fork Stream for each sampling date, March 15 to November 22, 1980

RELATIVE BIOMASS (%)

Date:	Station 1	Station 2	Station 3	Station 4
15 Mar	100	100	16	100
29 Mar	44	5	25	65
4 Apr	0	0	0	0
25 Apr	51	14	8	64
9 May	17	41	5	48
22 May	51	43	28	54
9 Jun	33	61	6	12
28 Jun	76	11	68	79
14 Jul	23	24	6	34
26 Jul	7	16	6	45
6 Aug	65	100	100	67
22 Aug	52	100	49	60
6 Sept	6	73	54	55
21 Sept	5	49	58	71
10 Oct	51	9	73	37
26 Oct	79	15	68	58
11 Nov	14	12	43	68
22 Nov	22	21	11	62

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Brevard High School, Brevard, N. C.... 1976-1979