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Undated

TITLE

Fish Distributions, Species Diversity, and Physiochemical Conditions Related to Stream Order in a Central Pennsylvania River Basin.

BYLINE

J.R. Kremmel, S.F. Krotowski, Jr., S.R. Salvatore, and L.A. Williams

Department of Biology, Juniata College, Huntingdon, PA 16652

ABSTRACT

A total of 21 first, second, and third order streams in the lower drainage basin of the Raystown Branch of the Juniata River were studied from October through November of 1981. Fishes were sampled quantitatively and the corresponding physiochemical conditions were recorded. Physiochemical conditions were relatively homogeneous in the area studied. The number of fish species and families increased from first to third order streams, possibly due to increased habitat variability and decreased environmental fluctuation. Fish species diversity increased from first to third order streams.

INTRODUCTION

Relationships between stream order and stream fishes have been the subject of many studies. Several studies have suggested that the species number and diversity of stream fishes increases with longitudinal distance from stream source (Odum, 1; Kuehne, 2; Harrel et al, 3; Sheldon, 4; Whiteside and McNatt, 5; Platts, 6; Evans and Noble, 7; and Barila et al, 8). Stream classification may be accomplished using several different methods. Criteria for classification have been water velocity and nature of substrate (Pearse, 9), stream slope and velocity (Huet, 10), habitat (Odum, 11), and stream branching (Horton, 12 and Strahler, 13).

The purpose of this study is to compare the diversity and distribution of fishes and also physiochemical conditions with stream order. This study is limited to first, second, and third order streams in the lower drainage basin of the Raystown Branch of the Juniata River, which is part of the Susquehanna River System (Figure I).

STUDY AREA

The lower watershed of the Raystown Branch of the Juniata River, was the target area of this study. The southern boundary of this area is delineated by the point at which Brush Creek enters into the Raystown branch north of Mench, PA. The northern boundary of the area is the point where the the Raystown Branch enters the main branch of the Juniata

River near Huntingdon, PA. The basin extends through Bedford and Huntingdon counties, and is part of the Susquehanna River System. The streams in this area drain various limestone, dolomite, conglomerate, sandstone, and shale substrata of the Appalachian Valley and Ridge Province. These substrata have been greatly disturbed by folding and faulting. Specific geological data can be obtained from the Geological Atlas of the U.S., Hollidaysburg-Huntingdon Folio (14).

METHODS

Fish samples were collected from October through November of 1981 with a 110 volt AC electrofishing unit. A random sampling scheme was devised to sample the streams in the study area. The Horton-Strahler method of stream order classification was used to divide the streams into first, second, and third order catagories (Horton, 12 and Strahler, 13). By this method a headwater tributary is designated as a first order stream. When two first order streams combine, they form a second order stream. Two second order streams combine to form a third order stream, and so on (Wetzel and Likens, 15). Streams were located on 7.5 minute Geological Survey maps, numbered, and then measured with a cartometer (Appendix I). Ten streams from each order were selected randomly using a Radio Shack Level II Basic statistical package. Since there were only seven third order streams, Great Trough Creek was subdivided into 4 third order stations because of its length (Table I).

At each station, approximately 30 meter sections of stream were isolated with block seines. Special effort was made to include both pools and riffles in each sample. Fish were collected and then preserved on location in 10% formalin (See Appendix II for original data sheets). Game fishes were cataloged and released. Identification of fishes followed Trautman (16) and Eddy & Underhill (17).

Physiochemical data was collected at each sampling station in order to determine correlations between the physiological environment and stream order. Dissolved oxygen and temperature readings were measured with a YSI Model 57 dissolved oxygen meter, and conductivity was measured with a YSI Model 33 conductivity meter. The pH was measured with a Corning Model 16 portable pH meter.

RESULTS AND DISCUSSION

Fish and physiochemical samples were obtained from 21 of the 30 randomly selected streams. Stations 10 and 11 showed indications of severe pollution by acid mine drainage. The effects of acid mine drainage on stream ecology is discussed by Letterman and Mitsch (18). Seven other streams remained unsampled due to equipment failure, dried-up streams, and property owners denying stream access.

Fish Distributions

A total of 3,344 fish were collected during the study. Thirty-two species of fish representing eight families were

present in the drainage area. Thirteen species representing six families were present in first order streams, 22 species representing seven families were present in second order streams, and 27 species representing eight families were present in third order streams (Table II). Eleven species representing five families occurred in all three stream orders (Distributions of individual species are shown in Appendix III). This distribution is similiar to that found by Sheldon (4), and shows a pattern of progressive addition of species from lower to higher order streams.

Barila, et al, (1981) found 44 species of fish in the entire Raystown Branch of the Juniata River drainage basin. All of the species collected in the present study were collected in the Barila, et al, (1981) study except Lepomis cyanellus. In addition, two species of sculpins, Cottus cognatus and Cottus bairdi, were identified in the present study. Barila, et al, (1981) collected a total of 12 species which were not collected in the present study. Of these 12 species, Anguilla rostrata and Fundulus diaphanus were found only in fourth and fifth order streams. Ericymba buccata, Lepomis megalotis, and Poxomis annularis were found only in samples taken outside the present study area, which suggests that these species might be more common in the upper drainage of the Raystown Branch. The remaining seven species, Exoglossum maxillingua, Notropis cornutus, Notropis hudsonius, Notropis rubellus, Lepomis auritus, Poxomis annularis, and Perca flavescens were collected at stations within the present study area.in the previous but not the present study. This difference can possibly be accounted for by considering the sampling designs used in each study. The Barilla, et al, (1981) study focused its sampling on obtaining

as many different species as possible with no constant sampling size. The present study, however, uses a constant sample size at each station (approximately 30 meters of stream), in order to determine not only the number of species present, but also the relative number of fish present in each sample. These seven species could thus represent rarer species not picked up in the sample size utilized in the present study. A complete listing of the fishes present in the Susquehanna River System above Conowingo Dam is presented by Denoncourt (1975). Recent additions to this system are presented by Denoncourt, et al, (1975).

Fish Species Diversity

In order to correlate species diversity to stream order, indices were calculated for the overall number of species found in each of the three orders. The margalef (19) index was selected in order to compare the calculated indices with those found by Harrel et al, (3). It is represented by:

$$d = \frac{S - 1}{\ln X}$$

where S = total number of species, and X = the total number of individuals collected in the sampling. The calculated indices show that species diversity increases as stream order increases (Table III). This same trend has been found by various other authors (Odum, 1; Kuehne, 2; Harrel et al, 3; Sheldon, 4; Whiteside and McNatt, 5; Platts, 6; Evans and Noble, 7; and Barila et al, 8). When species diversity was plotted against stream order, the correlation coefficient for

the resulting regression was r = 0.94 (Figure II). Since there were only three data points, however, the correlation is not statistically significant. Harrel et al, (3) suggested that the increasing species diversity in higher order streams could be due to the increase in the available habitat, and a decrease in environmental fluctuations.

Physiochemical Conditions

The mean values of physiochemical conditions are presented in Table IV. A one-way ANOVA was performed for each measurement value comparing the data from each of the three orders. None of the physiochemical conditions varied significantly ($P > 0.05$ in all cases). This suggests the physiochemical environment is relatively homogeneous throughout the study area. The mean temperature did decrease, however, from first to third order stations due to the seasonal sequence of sampling. Lower order streams were sampled in the early fall and higher order streams in the later fall. The rise in dissolved oxygen levels is expected with this drop in temperature. The percent saturation of dissolved oxygen was near or above 100% in all cases, and can also be attributed to falling water temperature. The pH values were relatively constant at all of the stations sampled. Mean conductivity increased from first to second order, but then decreased in the third order. This is due to the artificial bias imposed on the data by the subdivision of Great Trough Creek into four sections. Great Trough Creek is considerably lower in conductivity than any of the other

third order streams sampled. One would expect a constant rise in conductivity from lower to upper order streams, due to increased leaching of soluble ions in larger streams (Whiteside and McNatt, 5).

These results suggest a positive correlation between fish species diversity and distribution with stream order. Physiochemical characters do not appear to have a significant impact on distribution or diversity, but may be more influential in other seasons of the year. A more extensive sampling program, conducted throughout the year, might yield more significant correlations regarding species diversity and distributional patterns in this geographical area.

ACKNOWLEDGEMENTS

We would like to thank Dr. Robert Fisher of Juniata College for his constant support throughout this study. We would also like to thank Dr. James Gooch and Dr. Todd Gustafson of Juniata College for their professional advice, and reviews of our manuscript. Finally, Dr. Edward Cooper of the Pennsylvania State University provided invaluable assistance in identifying a number of the more difficult species of fish.

TITLE

Fish Distributions, Species Diversity, and Physiochemical Conditions Related to the the Stream Order in the Blacklog Creek System

BYLINE

J.D. Moseman and B.W. Neiswender

Department of Biology, Juniata College, Huntingdon, PA 16652

ABSTRACT

A survey was made of distribution and diversity of fish in the Blacklog Creek, Huntingdon County, Pennsylvania. A total of 74.79 km of streams were sampled which included 18 first, second, and third order streams. Physiochemical data was consistent throughout the study area. Thirty species of fish were collected in sample sites and the number of fish species increased from first to third order streams. Variation in habitats probably accounts for this gradient.

INTRODUCTION

There have been many studies to show the relationships between stream order and stream fishes. Several studies have shown that the number of species and the species diversity increases proportionately with increasing distance from the stream source (Odum, 1; Kuehne, 2; Harrel et al, 3; Sheldon, 4; Whiteside and McNatt, 5; Platts, 6; Evans and Noble, 7; and Barila et al, 8). Several methods to determine a stream ordering system have been developed to classify streams (Pearse, 9; Huet, 10; Odum, 11; Horton, 12; and Strahler, 13).

The purpose of this study is to survey the Blacklog Creek System to determine the distribution, relative population size, and diversity of fishes in first, second, and third order streams. Some physiochemical conditions and stream parameters were also measured for further understanding of the streams environment. The Blacklog Creek system is limited to only first, second, and third order streams; it is a tributary of Aughwick Creek which drains into the Juniata River of the Susquehanna River Drainage Basin (Figure I).

STUDY AREA

The Blacklog stream system was chosen for this study since there is no previous published record. The Blacklog

constitutes a first order stream as a headwater tributary. When two first order streams combine, a secondary stream is formed. When two secondary streams combine, a third order stream is formed. Streams indicated as intermittent were not considered in stream ordering. There were a total of 1,496 sample sites in the Blacklog system composed of 524 in first order, 652 in second order, and 310 in third order streams. Sample stations were randomly selected from each stream order. Two percent of the total sample sites were sampled. A sample site consisted of a 50 meter segment of stream length. First order streams contained 34.5% of the samples sites (10 stations), second order streams 44.8% (13 stations), and third order streams contributed 20.7% (6 stations). Stations can be located on Figure III. Additional sites were chosen to substitute for unaccessible stations.

At the sample station a 50 meter area was isolated with block seines. Fish were collected and immediately preserved in 10% formalin. These fish were later counted and identified (see Appendix II for sample data). Game fishes and larger individuals were identified, measured and released back to the stream (i.e. Trout & large Suckers). Identification of fishes followed Whitaker (14), Thompson (15) and Eddy & Underhill (16). Temperature and ph measurements were made at the sampling stations.

third order diversity was due to less efficient sampling technique.

PHYSIOCHEMICAL DATA

The pH levels showed little variation between sample stations. Temperature variations reflected normal change due to seasonal fluctuations. Temperature and pH averages can be found on Table IV.

RESULTS AND DISCUSSION

Sampling of fish and physiochemical data were taken from 29 sampling sites. Stations 31 and 32 had to be substituted due to dried up streams. While in station 15, access was denied by property owners.

A total of 3,458 fish representing thirty species from eight families were collected from the Blacklog Creek system. Eight species existed in all three stream orders, they were: *Salvelinus fontinalis* (Brook Trout), *Catostomus commersoni* (White Sucker), *Semotilus atromaculatus* (Creek Chub), *Rhinichthys atratulus* (Blacknose Dace), *Rhinichthys cataractae* (Longnose Dace), *Notropis rubellus* (Rosy-face Shiner), *Notropis cornutus* (Common Shiner), *Notropis hudsonius* (Spot Tailed Shiner), *Campostoma anomalum* (Stoneroller), *Ambloplites rupestris* (Rock Bass), and *Cottus bairdi* (Mottled Sculpin). Minnows (Cyprinidae) and sunfish (Centrarchidae) were the most dominant families with twelve and six species collected respectively(List IV). The three most abundant species were *Rhinichthys atratulus* (Blacknose Dace), *Cottus bairdi* (Mottled Sculpin), and *Semotilus atromaculatus* (Creek Chub). *Rhinichthys atratulus* (Blacknose Dace) was the most widely occuring species in each of the three orders (1627 collected in all). First order streams contained 12 species, second order 27 species, and third order 23 species (Chart 1). Species lists for

coresponding stream order can be found in List I, II, and III, respectively. The qualitative distribution of fish species by stream order and species number by stream order is illustrated in tables II and III, respectively.

FISH SPECIES DIVERSITY

In order to correlate the species diversity to stream order indices were calculated for the overall number of species found in each of the three stream orders. The Margelef index was selected to allow comparison to previous studies. It is represented by: d=s-1/ln X , where s=the total number of species and X=the total number of individuals collected. The calculated diversity index was expected to show that species diversity increases as stream order increases. This trend is found by various other authors (Odum,1; Kuehne,2; Parrel et al, 3; Sheldon, 4; Whiteside and Mcnatt, 5; Platts, 6; evans and Noble, 7; and Barila et al, 8). Our diversity index supported this trend and increased from first to third order. However a drop in value from 3.69 to 3.14 occured from second to third order streams. Whiteside & McNatt (5) reported a decrease in diversity in fifth order streams, and suggested migration of fishes into lower order streams for spawning purposes, escape from high waters, or reduced seining efficiency due to increasing depth and obstacles, as possible causes for the decrease. We feel that the reason for the decrease in

LEGENDS

Figure I — The Blacklog Creek system, a tributary of Aughwick Creek which drains into the Juniata River. Study area is outlined.

Figure II — Study area. The Blacklog Creek system. Numbers designate individual sampling stations.

Figure III — Streams selected and stations sampled according to stream order.

List I — Family and species names for first order streams. General information for first order streams.

List II — Family and species names for second order streams. General information for second order streams.

List III — Family and species names for third order streams. General information for third order streams.

List IV — Total family and species names. Total general information for streams.

Table I — Species diversity by stream order.

Table II — Distribution of fish species by stream order.

Table III — Species number by stream order.

Table IV — Averages of physiochemical data and stream parameters of stream order.

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We would like to thank Dr. Robert Fisher of Juniata College for his constant support throughout this study. We would also like to thank Dr. Todd Gustafson for his professional advice.

FIGURE I

The Aughwick Creek System

Blacklog Creek Basin- outlined

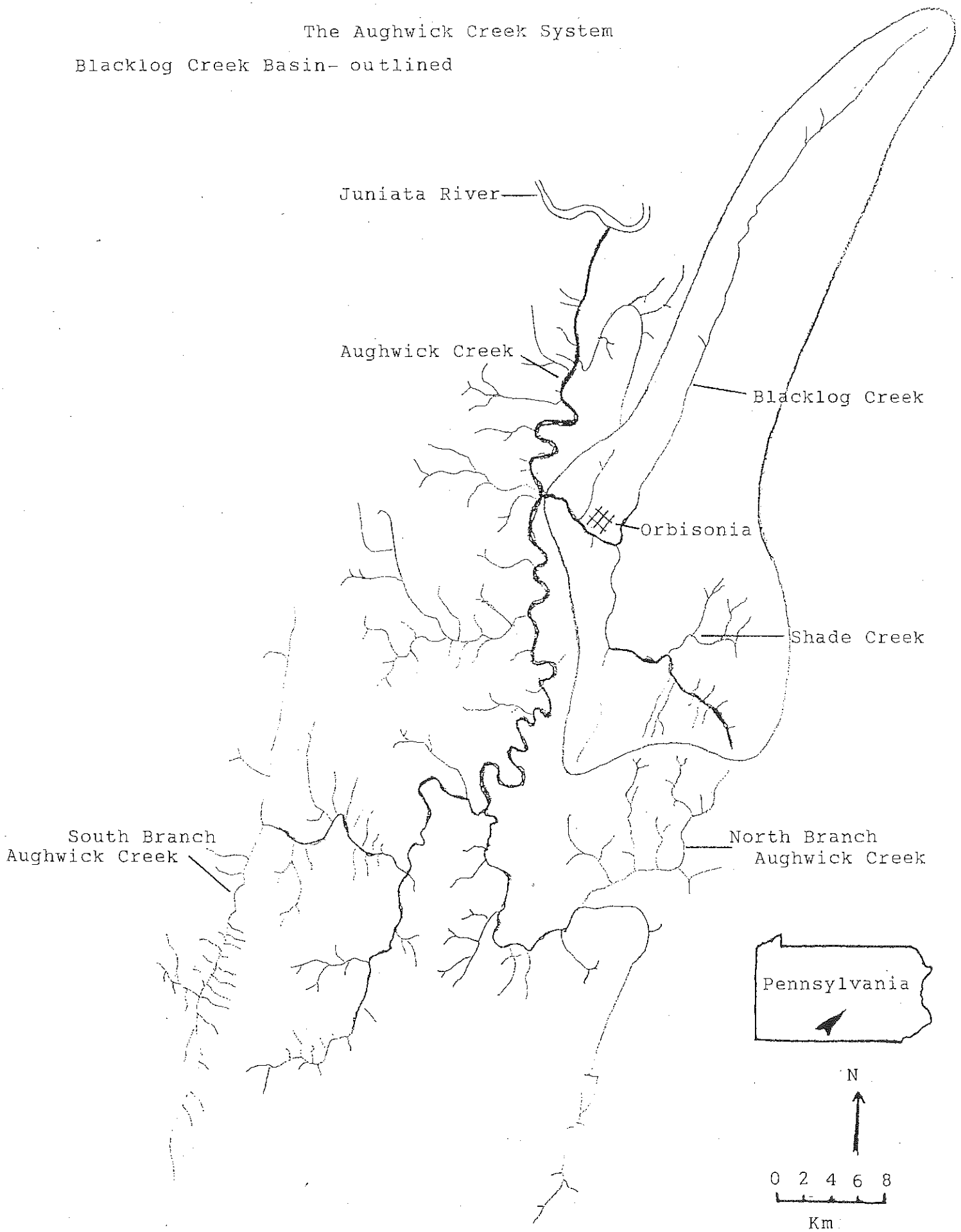


FIGURE II

STUDY AREA

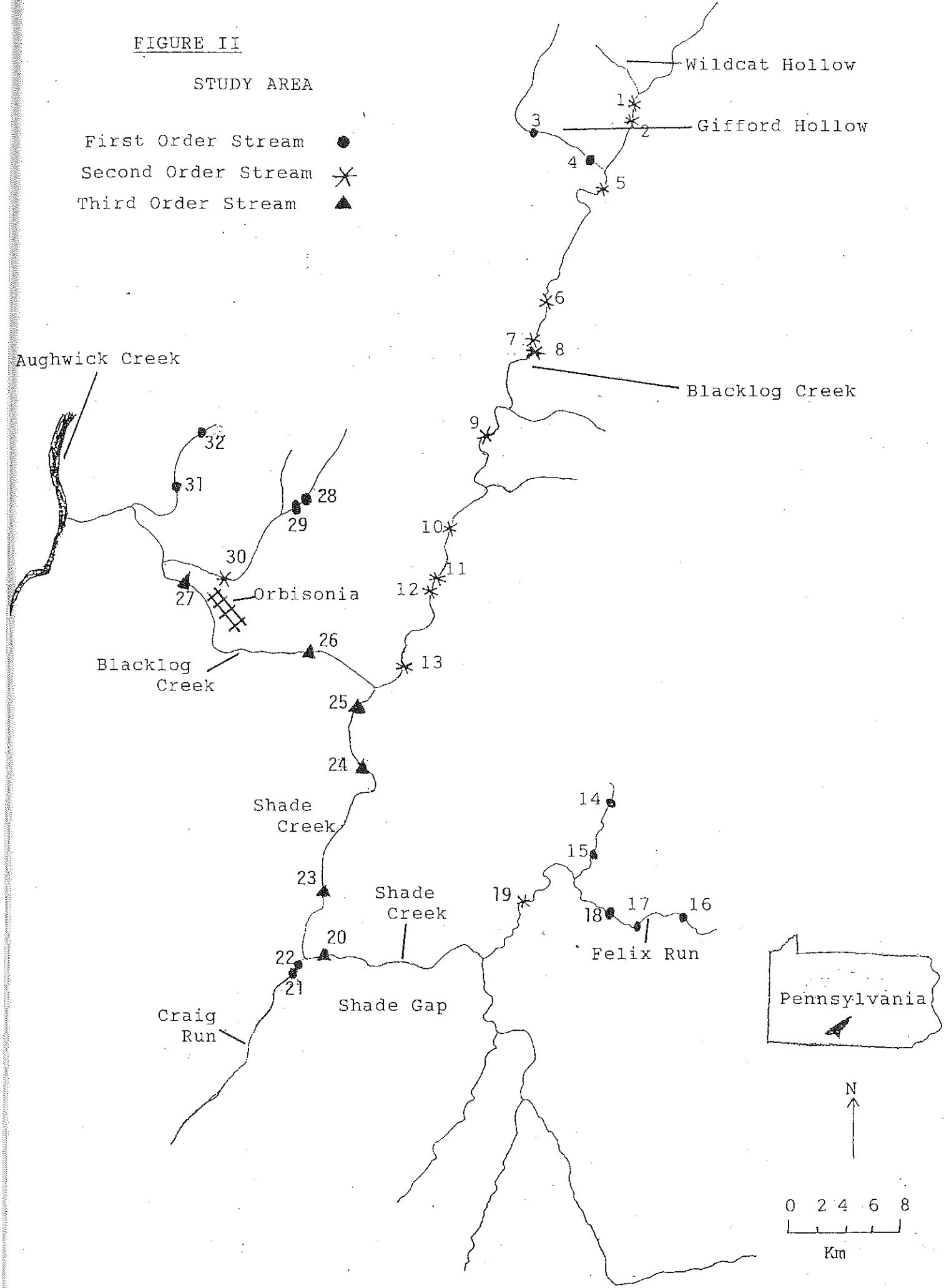


Figure III

Streams selected and stations sampled according to stream order

STREAM ORDER	TOTAL No. of STREAMS	TOTAL LENGTH (km)	STREAMS SELECTED RANDOMLY	STATIONS SAMPLED
I	13	26.2	5	10
II	4	33.1	3	13
III	1	15.5	1	6

LIST I

Species List For First Order Streams

Catostomidae
- Catostomus commersoni
- Erimyzom oblongus

Centrarchidae
- Ambloplites rupestris

Cottidae
- Cottus bairdi

Cyprinidae
- Campostoma anomalum
- Notropis cornutus
- Notropis hudsonius
- Notropis rubellus
- Rhinichthys atratulus
- Rhinichthys cataractae
- Semotilus atromaculatus

Salmonidae
- Salvelinus fontinalis

First Order General Information

13 streams
26.22 KM
524-50 Meter sampling sites
10 sampling stations
5 of 13 streams surveyed
500 M sampled
1.9% of stream sampled
1,222 fish collected
Size range 2.5cm-19.3cm
12 species
d=1.55

LIST II

Species List For Second Order Streams

Catostomidae
- Catostomus commersoni
- Erimyzom oblongus
- Hypentelium nigricans

Centrarchidae
- Ambloplites rupestris
- Lepomis auritus
- Lepomis gibbosus
- Lepomis macrochirus
- Micropterus dolomieui
- Micropterus salmoides

Cottidae
- Cottus bairdi

Cyprinidae
- Campostoma anomalum
- Exoglossum maxillingua
- Nocomis micropogon
- Notropis cornutus
- Notropis hudsonius
- Notropis rubellus
- Notropis spilopterus
- Pimephales notatus
- Rhinichthys atratulus
- Rhinichthys cataractae
- Semotilus atromaculatus
- Semotilus corporalis

Ictaluridae
- Noturus insignis

Percidae
- Etheostoma nigrum
- Percina peltata

Salmonidae
- Salmo trutta
- Salmo gairdneri
- Salvelinus fontinalis

Second Order General Information

4 streams
13.11 KM
652-50 Meter sampling sites
13 sampling stations
3 of 4 streams surveyed
650 M sampled
2.0% of stream sampled
1,143 fish collected
Size Range 2.9cm-36.5cm
27 species
d=3.69

LIST III

Species List For Third Order Streams

Catostomidae
- Catostomus commersoni
- Erimyzom oblongus
- Hypentelium nigricans

Centrarchidae
- Ambloplites rupestris
- Lepomis gibbosus
- Lepomis macrochirus
- Micropterus dolomieui

Cottidae
- Cottus bairdi

Cyprinidae
- Campostoma anomalum
- Exoglossum maxillingua
- Nocomis micropogon
- Notropis cornutus
- Notropis hudsonius
- Notropis rubellus
- Rhinichthys atratulus
- Rhinichthys cataractae
- Semotilus atromaculatus
- Semotilus corporalis

Esocidae
- Esox americanus

Ictaluridae
- Noturus insignis

Percidae
- Etheostoma nigrum
- Etheostoma blennioides
- Percina peltata

Third Order General Information

1 streams
15.46 KM
310-50 Meter sampling sites
6 sampling stations
1 of 1 streams surveyed
300 M sampled
1.9% of stream sampled
1,093 fish collected
Size range 3.0cm-37.0cm
23 species
d=3.14

LIST IV

Total Species List For Blacklog Stream

- Catostomidae
  - Catostomus commersoni
  - Erimyzom oblongus
  - Hypentelium nigricans
- Centrarchidae
  - Ambloplites rupestris
  - Lepomis auritus
  - Lepomis gibbosus
  - Lepomis macrochirus
  - Micropterus dolomieui
  - Micropterus salmoides
- Cottidae
  - Cottus bairdi
- Cyprinidae
  - Campostoma anomalum
  - Exoglossum maxillingua
  - Nocomis micropogon
  - Notropis cornutus
  - Notropis hudsonius
  - Notropis rubellus
  - Notropis spilopterus
  - Pimephales notatus
  - Rhinichthys atratulus
  - Rhinichthys cataractae
  - Semotilus atromaculatus
  - Semotilus corporalis
- Esocidae
  - Esox americanus
- Ictaluridae
  - Noturus insignis
- Percidae
  - Etheostoma nigrum
  - Percina peltata
  - Etheostoma blennioides
- Salmonidae
  - Salmo trutta
  - Salmo gairdneri
  - Salvelinus fontinalis

Total Blacklog General Information

18 streams
74.79 KM
32 sampling stations
9 of 18 streams surveyed
1,450 M sampled
2.0% of stream sampled
3,458 fish collected
Size range 2.5cm-37.0cm
30 species
d=3.56

TABLE I

Species Diversity by Stream Order

Stream Order	Number of Species	Number of Fish	d
First	12	1,222	1.55
Second	27	1,143	3.69
Third	23	1,093	3.14

TABLE II

Distribution of Fish Species by Stream Order

STREAM ORDER	I	II	III
Salvelinus fontinalis	x	x	x
Catostomus commersoni	x	x	x
Erimyzom oblongus	x		x
Semotilus atromaculatus	x	x	x
Rhinichthys atratulus	x	x	x
Rhinichthys cataractae	x	x	x
Notropis rubellus	x	x	x
Notropis cornutus	x	x	x
Notropis hudsonius	x	x	x
Campostoma anomalum	x	x	x
Ambloplites rupestris	x	x	x
Cottus bairdi	x	x	x
Salmo trutta		x	
Salmo gairdneri		x	
Hypentelium nigricans		x	x
Semotilus corporalis		x	x
Nocomis micropogon		x	x
Exoglossum maxillingua		x	x
Notropis spilopterus		x	
Pimephales notatus		x	
Noturus insignis		x	x
Micropterus dolomieui		x	x
Micropterus salmoides		x	
Lepomis macrochirus		x	x
Lepomis auritus		x	
Lepomis gibbosus		x	x
Etheostoma nigrum		x	x
Percina peltata		x	x
Esox americanus			x
Etheostoma blennioides			x
Total No. of Species	12	27	23
Total No. of Families	5	7	7

TABLE III

Species number by Stream Order

STREAM ORDER	I	II	III
Salvelinus fontinalis	19	6	
Catostomus commersoni	12	66	28
Erimyzom oblongus	1		1
Semotilus atromaculatus	128	75	11
Rhinichthys atratulus	911	323	403
Rhinichthys cataractae	2	13	42
Notropis rubellus	3	22	5
Notropis cornutus	8	86	53
Notropis hudsonius	11	9	17
Campostoma anomalum	23	83	63
Ambloplites rupestris	1	33	29
Cottus bairdi	98	134	206
Salmo trutta		1	
Salmo gairdneri		1	
Hypentelium nigricans		13	24
Semotilus corporalis		24	28
Nocomis micropogon		51	63
Exoglossum maxillingua		46	13
Notropis spilopterus		48	
Pimephales notatus		14	
Noturus insignis		22	6
Micropterus dolomieui		10	7
Micropterus salmoides		2	
Lepomis macrochirus		1	3
Lepomis auritus		1	
Lepomis gibbosus		1	5
Etheostoma nigrum		29	3
Percina peltata		2	21
Esox americanus			1
Etheostoma blennioides			48
Total No. of Species	12	27	23
Total No. of Fish	1,222	1,143	1,093

TABLE IV

Averages of Physiochemical Data and stream Parameters of Stream Order

	STREAM LENGTH (km)	pH	AIR TEMP. C	WATER TEMP. C	WATER DEPTH (m)	STREAM WIDTH (m)
I	2.02	7.32	9.15	7.95	0.09	0.38-1.23
II	8.26	7.43	14.9	10.4	0.81	3.86-5.27
III	15.5	7.9	14.5	9.47	0.76	3.43-5.11

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APPENDIX I

NUMBER	STREAM NUMBER	LENGTH (km)	QUAD MAP
1	101	2.10	Butler Knob
2	102	0.93	" "
3	103	2.60	Butler Knob and Aughwick
4	104	1.36	Aughwick
5	105	1.00	" "
6	106	3.36	" "
7	107	4.70	" "
8	108	5.20	Orbisonia
9	109	2.00	Shade Gap
10	110	2.36	" "
11	111	2.03	" "
12	112	1.36	" "
13	113	2.03	" "

NUMBER	STREAM NUMBER	LENGTH (km)	QUAD MAP
1	201	2.33	Butler Knob and Orbisonia
2	202	26.76	Blairs Mills, Aughwick, Shade
3	203	2.56	Shade Gap
4	204	1.66	" "

NUMBER	STREAM NUMBER	LENGTH (km)	QUAD MAP
1	301	15.46	Shade Gap, Orbisonia, Butler

APPENDIX II

STREAM NUMBER	SAMPLE NUMBER	STATION NUMBER
202	2-502	1
202	2-476	2
106	1-178	3
106	1-175	4
202	2-416	5
202	2-348	6
202	2-321	7
202	2-316	8
202	2-231	9
202	2-164	10
202	2-135	11
202	2-130	12
202	2-054	13
109	1-372	14
109	1-349	15
110	1-412	16
110	1-400	17
110	1-389	18
203	2-616	19
301	3-259	20
108	1-239	21
108	1-238	22
301	3-243	23
301	3-166	24

STREAM NUMBER	SAMPLE NUMBER	STATION NUMBER
301	3-147	25
301	3-099	26
301	3-047	27
103	1-063	28
103	1-062	29
201	2-023	30
101	1-015	31
101	1-039	32

APPENDIX III

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Sandy Ridge Date: 10-28-89 Time: 4:55

Approx. Location: North Of Orbisonia, Rt. 522

Quadrangle Map: Butler Knob

Stream Number: 101 Sample Number: 1-015

Chemical/Physical Data

Temperature: Air: _____

Water: _____

pH: _____

Stream Characteristics:

Vegetation:

Bottom Characteristics:

Current:

Depth:

Width:

Shore Characteristics:

Weather:

Additional Notes:

Stream bed was dry. No data was collected.

Fish Species: (Scientific Name) (Common Name)

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Sandy Ridge Date: 10-28-89 Time: 4:55

Approx. Location: North of Orbisonia along Rt. 522

Quadrangle Map: Butler Knob

Stream Number: 101 Sample Number: 1-039

Chemical/Physical Data

Temperature: Air:_____

Water:_____

pH:____

Stream Characteristics:

Vegetation:

Bottom Characteristics:

Current:

Depth:

Width:

Shore Characteristics:

Weather:

Additional Notes:

Stream beds were dry at time of sampling.

Fish Species:(Scientific Name) (Common Name)

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Sandy Ridge Date: 11-4-89 Time: 11:00

Approx. Location: Orbisonia Rockhill Sportsman Assoc. Co-operate Nursery

Quadrangle Map: Butler Knob

Stream Number: 103 Sample Number: 1-062

Chemical/Physical Data

Temperature: Air: 9 C

Water: 8.5 C

pH: 7.87

Stream Characteristics:

Vegetation: Some on stream edges (nostoc)

Bottom Characteristics: stones/with sand

Current: moderate to fast

Depth: to 60 cm

Width: 30-125 cm

Shore Characteristics: Cow pasture, grass field, Pines, Birch

Weather: sunny

Additional Notes:
The trout filtered down from the nursery.
Many riffles between 0-9 cm

Fish Species: (Scientific Name)	(Common Name)	
Erimyzom oblongus	Creek Chubsucker	1
Rhinichthys atratulus	Blacknose Dace	7
Salmo gairdneri	Rainbow trout	12
Salvelinus fontinalis	Brook trout	10
Semotilus atromaculatus	Creek Chub	2

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Sandy Ridge Date: 11-4-89 Time: 12:47

Approx. Location: Orbisonia Rockhill Sportsman Assoc. Nursury

Quadrangle Map: Butler Knob

Stream Number: 103 Sample Number: 1-063

Chemical/Physical Data

Temperature: Air: 17.5 C

Water: 9 C

pH: 6.70

Stream Characteristics:

Vegetation: Some Algae around edge of stream

Bottom Characteristics: Rocky with sand

Current: moderate

Depth: to 60 cm

Width: 30-92 cm

Shore Characteristics: Same as 1-062

Weather: sunny

Additional Notes:

Trout may have come from the hatchery upstream.

Fish Species: (Scientific Name)	(Common Name)	
Notropis cornutus	Common shiner	1
Rhinichthys atratulus	Blacknose Dace	31
Salvelinus fontinalis	Brook trout	6
Semotilus atromaculatus	Creek Chub	3

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Gifford Hollow Date: 10-24-89 Time: 1:30 pm

Approx. Location: Blacklog Sportsman Club

Quadrangle Map: Aughwick

Stream Number: 106 Sample Number: 1-175

Chemical/Physical Data

Temperature: Air: 17 C

Water: 9 C

pH: 7.65

Stream Characteristics:

Vegetation: none

Bottom Characteristics: rocky

Current: fast w/ pools

Depth: to 45 cm

Width: 30-75 cm

Shore Characteristics: Hemlock, Red Maple, Oak

Weather: sunny

Additional Notes: Few days of heavy rain previous to sampling. Wooded area, lots of leaves in the stream.

Fish Species: (Scientific Name)	(Common Name)	
Salvelinus fontinalis	Brook Trout	1
Rhinichythys atratulus	Blacknose Dace	40

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Gifford Hollow Date: 10-24-89 Time: 1;40

Approx. Location: Blacklog Sportsman Club

Quadrangle Map: Aughwick

Stream Number: 106 Sample Number: 1-178

Chemical/Physical Data

Temperature: Air: 17 C

Water: 9 C

pH: 7.66

Stream Characteristics:

Vegetation: none

Bottom Characteristics: rocky

Current: fast w/ pools

Depth: to 45 cm

Width: 30-60 cm

Shore Characteristics: Hemlock, Red Maple, Oak

Weather: sunny

Additional Notes: Sample collected few days after heavy rain wooded area/ many leaves in the water

Fish Species: (Scientific Name)	(Common Name)	
Rhinichythys atratulus	Blacknose Dace	3
Salvelinus fontinalis	Brook Trout	2

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Craig Run Date: 11-4-89 Time: 2:19

Approx. Location: Abandoned road south of roadside park substation

Quadrangle Map: Orbisonia

Stream Number: 1Q8 Sample Number: 1-238

Chemical/Physical Data

Temperature: Air: 8 C

Water: 9 C

pH: 7.76

Stream Characteristics:

Vegetation: none

Bottom Characteristics: sandstone rocky

Current: slow

Depth: to 30 cm

Width: 30-213cm

Shore Characteristics: Pines, Hickory, maple, Oaks, shrubs

Weather: sunny

Additional Notes:

Fish Species: (Scientific Name)	(Common Name)	
Campostoma anomalum	Stoneroller	4
Cottus Bairdi	Mottled Sculpin	4
Rhinichthys atratulus	Blacknose Dace	181
Rhinichthys cataractae	Longnose Dace	2
Semotilus atromaculatus	Creek Chub	7

Blacklog Drainage Fish Distribution Data

Huntingdon/Juniata County, PA

Stream Name: Craig Run Date: 11-13-89 Time: 2:30

Approx. Location: Bridge at Shade Gap substation

Quadrangle Map: Orbisonia

Stream Number: 108 Sample Number: 1-239

Chemical/Physical Data

Temperature: Air: 13 C

Water: 10 C

pH: 7.1

Stream Characteristics:

Vegetation: none

Bottom Characteristics: sandstone with some silt

Current: slow to moderate

Depth: to 30 cm

Width: 30-75 cm

Shore Characteristics: Pines, Hardwoods, brushes

Weather: sunny with few clouds

Additional Notes:

Sample site was partly under bridge.

Fish Species: (Scientific Name)	(Common Name)	
Campostoma anomalum	Stoneroller	8
Cottus bairdi	Mottled Sculpin	11
Notropis hudsonius	Spot-tailed shiner	11
Notropis rubellus	Rosey-face shiner	1
Rhinichthys atratulus	Blacknose Dace	566
Semotilus atromaculatus	Creek Chub	16

RAYSTOWN FIELD STATION
JUNIATA COLLEGE

Program Review :

A Preliminary Study of the Plankton of Raystown Lake.

Advisors:

Robert L. Fisher
Paul M. Heberling

Lorraine Widdowson

The Plankton of Raystown Lake

The minute organisms constituting the plankton of Raystown Lake have not, to my knowledge, been previously studied. If a study has been performed in the past, it has not been published. The Environmental Impact Statement of Raystown Lake, Raystown Branch of the Juniata River compiled by the U.S. Army Corps of Engineers reveals a survey-type study of the macro-flora and -fauna of Raystown Lake and surrounding land; but, no research was made of the microscopic aquatic invertebrate life. I am interested in freshwater biology and am curious about the types of plankton, both plant and animal, which inhabit the lake. I chose to sample at various depths and at three different locations within the lake in order to see what plankton exist. The three sampling locations were arbitrarily chosen, they are: James Creek, Nancy's Camp, and Trough Creek. These three areas are within easy access from the Juniata Biological Field Station's cove and are not too distant from one another. The specific locations of these sampling sites can be determined from a coordinate map of Raystown Lake.

In sampling plankton, one must first determine what group of organisms (size-selected) are desired and from what portion of the aquatic system they are to come. I chose to sample the net plankton of the limnetic zone of the lake, more specifically, the trophogenic zone (Fig.1).

Plankton sampling techniques are size-selected. A convenient size differentiation of the plankton is "net plankton" and "nannoplankton." The distinction is based on the passage of organisms through a No.25 mesh plankton net (which means that there are 200 meshes per inch). The organisms retained by the net are considered "net plankton," regardless of their taxonomic position.

Nannoplankton are those organisms that pass through a No.25 mesh net. To collect these organisms, it is obvious that water must also be passed through such a net and then collected. The tiny organisms must later be separated from the water by either settling, filtration, or centrifugation, all of which are done in the laboratory.

The "limnetic zone" of a lake refers to that region of open water (devoid of vegetation), the horizontal extent of which is bounded peripherally by the zone of emergent vegetation.[1.] Of specific concern in this study is the vertical extent of the zonation. Vertically, the limnetic zone extends from the surface of the water to the bottom of the lake and includes both the trophogenic and tropholytic zones. The upper, trophogenic zone, in which I am interested, corresponds to the lighted zone (the depth depending upon sunlight penetration) which serves as an environment for the photosynthetic phytoplankton and the zooplankton (Fig.1).

To carry out this study, both field work and laboratory work are necassary. The field work involves the actual collection of the plankton from the lake and the laboratory work involves qualitative analysis of the plankton, as well as quantitative analysis. Unfortunately, the quantitative analysis procedure is very lengthy and involved; threfore, I performed quantitative analysis on one sample only. This analysis, however, will establish a basis upon which future quantitative plankton work can be made. The methods involved in both qualitative (identification) and quantitative (enumeration) analyses will be discussed next.

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1. Reid, G.K. 1961 p.293.

Methods & Materials

The data for the present paper were obtained from two series of collections made from Raystown Lake in May 1976. Previous collections in April 1976 resulted in a scanty representation of phytoplankton (e.g. Asterionella, Tabellaria, etc.) with no zooplankton present in any of the samples. The plankton samples taken in May, however, revealed a varied community of phytoplankton and zooplankton. The field work of this study involved the use of the following equipment:

No. 25 Birge closing net
8 oz. plastic collecting bottles
10 oz. polyethylene squeeze bottles

Reagents:

Supply of neutral formalin (to make a 5 percent formalin solution).

Procedure:

Before going to the lake, the selection of three sampling sites was made. These sites were: the area of open water between the island marked J2 and the bank of the lake (James Creek location); the area of open water off of Nancy's Camp; and the area of open water adjacent to the entrance of Trough Creek into Raystown Lake. I chose to sample vertically at depths of one meter: 1m. to surface, 2m. to 1m., 3m. to 2m., etc. down to 4m. depth. At Nancy's Camp and Trough Creek, a 4m.-5m. sample was made to see what might be at this depth. The collecting bottles were labeled prior to collecting.

On the lake, once the sampling site was reached, the boat was anchored and the wind direction noted so that sampling could be done on the lee side of the boat without interference from the wind. The Birge net was assembled by attaching the plankton bucket securely onto the headpiece at the lower end of the straining sleeve (Fig.2). The main draw line was held high enough in the air so that the net was suspended vertically. The canvas sleeve was lifted into vertical position and the plunger of the trip was pushed down in order to lock the suspension ring into the tripping mechanism.

By means of a graduated (meters) main draw line, the net was lowered promptly until the top of the canvas sleeve was at the lowermost depth level of the horizontal stratum through which the sample was to be taken. The net was then drawn slowly but steadily upward until the top of the stratum was reached. For samples other than one meter to surface, the messenger was sent down, which upon striking the plunger of the trip, releases the suspension ring in the top of the net, allowing the entire canvas sleeve to fall over and assume a reverse position. The weight of the whole net is transferred to the lowermost end of the main draw line causing the supporting ring at the top of the straining sleeve (lower ring on the diagram) to take on an edgewise position. Thus, the net is effectively closed.[2.]

The closed net was then brought to the surface where the water trapped within the bucket was allowed to drain out. The plankton bucket was detached and its lower end placed in the neck of the collecting bottle into which the contents were delivered by removing the plunger of the bucket. The plankton adhering to the sides of the bucket were washed down into the collecting (concentrate) bottle by squirting water from the squeeze bottle onto thesides. The bucket plunger was replaced and the bucket securely reattached to the headpiece for the next sampling operation.

The palnkton samples (concentrates) were preserved with a five percent formalin solution. This step was performed incorrectly in that formalin (greater than five percent) could have been placed in the collecting bottles prior to going to the lake for the actual collecting. Once the plankton catch was delivered into the collecting bottle, the resulting dilution would produce a four or five percent solution.

After completion of the sampling, the concentrates of plankton (in the collecting bottles) were taken to the laboratory for identification and enumeration purposes.

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2. Welch, Paul S. 1948 p.246-248.

Laboratory Work

Qualitative Analysis: This involved the identification of the plankton in the preserved samples(refer to Tables I. and II., also Plankton Data Sheets). The following equipment was used for identification of the net plankton:

Compound microscope equipped with high-power dry objective (45x) and oil immersion (100x)
Immersion oil
Glass microscope slides & cover slips

The preserved samples were mixed well, from which enough of the concentrate was withdrawn to cover the glass slide. The cover slip was placed over the drops and was viewed with low power and then high power. In many cases the use of oil immersion was necessary to obtain greater clarity of the transparent loricas (the hard, protective shells of zooplankton) or algal sheaths. For each of the twelve samples and the two taken at 5meters from Nancy's Camp and Trough Creek, I went through this procedure of viewing at least five times or more until I found two consecutive slides that revealed no new organisms for that particular sample. The samples and depths follow:

Sample site:	Depths:
James Creek	1m, 2m, 3m, 4m.
Nancy's Camp	1m, 2m, 3m, 4m, 5m.
Trough Creek	1m, 2m, 3m, 4m, 5m.

Because of the tremendous diversity of organisms composing plankton of inland waters, the difficulties of identification tax severely the taxonomic skill of even the most experienced worker. Ideally, and often practically, it is just as important to the limnologist as to the taxonomist to identify planktens to species. But with the exception of a certain number of well- marked forms, identification to species must be restricted to those particular groups among the plankters in which the limnologist may have taxonomic command through long experience. Beyond this limitation he must count on securing the aid of experts in the other groups involved. Commonly, in general plankton study (which is being dealt with here), strict practicality precludes identification of

plankters to species.[3.] I have had some experience in identification of plankton at the University of Montana's Biological Field Station at Flathead Lake and am therefore familiar with the difficulties involved with taxonomic identification among plankters, as well as the need for meticulous checking of extended descriptions and other sources of information when taking them to species (no two identification keys are alike). As this is a general plankton study, I have identified the plankters to genus and in one case to species, e.g. Kellicottia longispina. I was able to take this rotifer, Phylum Rotatoria, to species simply because there are only two limnetic species known - Kellicottia bostoniensis and K. longispina. Kellicottia longispina is different from K. bostoniensis, in that the latter has a posterior spine much much shorter than K. longispina; otherwise, the two species are quite similar.

I have made two composite lists of the organisms found in the samples with respect to their taxonomic position, one list for phytoplankton and the other list for zooplankton (Tables I. & II.).

Quantitative Analysis: Before beginning enumeration of the plankton, I calculated the volume of lake water filtered (i.e. sampled) by using the following formula: (Lind, O.T., 1974 p.84)

$$\text{Volume sampled} = \text{length of tow} \times \pi \times (\text{radius of net opening})^2$$

For example: For James Creek at 1 meter depth, the volume of lake water sampled was:

$$\text{Volume sampled} = 100 \text{ cm.} \times 3.14 \times (6 \text{ cm.})^2$$

$$= 100 \text{ cm.} \times 3.14 \times 36 \text{ cm.}^2$$

$$= 8{,}304 \text{ cm.}^3 \qquad 8.3\ \ell$$

To obtain the answer in liters (the standard expression for this type of work):

Conversion factor for cubic centimeters to gallons is 2.642×10^{-4}:

$$8{,}304 \text{ cm.}^3 \left(2.6 \times 10^{-4}\right) \frac{\text{gallons}}{\text{cm}^3} = 2.1590 \text{ gallons}$$

3. Welch, P.S. 1948 p. 268.

Conversion factor for gallons to liters is 3.785 : (4.)

$$2.159 \text{ gallons} \times 3.785 \frac{\text{liters}}{\text{gallon}} = 8.2 \text{ liters of lake water filtered}$$

The counting method used for the enumeration of the net plankton was the aliquot method. This method is used for rotifers, colonial diatoms, filamentous green & blue-green algae; as well as larger forms, such as copepods and cladocerans. The materials used for aliquot enumeration are as follows:

Compound microscope
Whipple eyepiece disk
Sedgewick-Rafter counting cell with cover slip
Large bore pipette with 1-2ml. capacity

The Whipple micrometer has rulings engraved on a disk of thin clear glass the diameter of which is such that it will just fit into the interior of an ocular. The dimensions of one large square are such that with a certain combination of objective, ocular, and draw-tube length, the area enclosed on the microscope stage is exactly 1 sq.mm. The Sedgewick-Rafter counting cell has a capacity of exactly 1 cc.

Procedure:

The preserved sample was mixed well and aliquot was withdrawn with the pipette. One ml. of this sample was introduced into the Sedgewick-Rafter cell. The cover slip is placed diagonally across the top of the counting cell so that when the sample is introduced into one or both corners, a surface film of water raises the cover slip from the ground glass edges and allows it to swing about to cover and seal the cell. Careful attention must be paid to avoid formation of air bubbles underneath the cell where they can become trapped.

4. Lind, O.T. 1974 p.145

The slide was placed on the microscope stage and field strip counts were taken. To make these counts I used an objective of 10x with 10x oculars, so that 100 x magnification was obtained. The width of a strip is approximately 1mm. With these dimensions, one can calculate the total number of each species or genus in the 1ml. of water contained by the Sedgewick-Rafter counting cell. The determination of the number of organisms of each genus per liter of lake water is as follows:

$$\text{Organisms per liter of lake water} = \frac{\text{organisms per ml. of concentrate} \times 1{,}000}{\text{concentration factor}}$$

where $$\text{Concentration factor} = \frac{\text{volume of water filtered (ml)}}{\text{volume of concentrate (ml)}}$$

For example: At James Creek at 1 meter depth:

$$\text{Organisms per liter of lake water} = \frac{6 \times 1{,}000}{328} = 18.3$$

$$\text{Concentration factor } \frac{8.2 \text{ liters}}{25\text{ml}} = \frac{8{,}200 \text{ ml.}}{25 \text{ ml.}} = 328$$

All of this data is recorded on Plankton Enumeration Sheets so that a permanent record is kept (see Plankton Enumeration Sheet Sample). The enumeration of plankton was performed on the one meter sample collected at James Creek. The strip to be used for counting plankters is obtained by use of the Whipple eyepiece disk. The upper and lower parallel sides of the Whipple micrometer are used to limit the width of the counted strip and organisms falling on the upper line are included in the count, whereas those falling on the lower line are excluded.

Discussion of Phytoplankton

Chlorophyta (green algae)

The green algae were never conspicuously abundant in the plankton samples. Ususally they turned up in small numbers. From James Creek samples, Ulothrix occurred only in the four meter sample. At 1m., 2m., and 3m. depths there was no Ulothrix algae found. From Trough Creek, the samples seemed to contain more algae than either James Creek or Nancy's Camp. The explanation may be that due to the recent rainfall, algae was being brought into the lake by means of Trough Creek and had not had a chance to distribute itself into the lake waters. At the time that this sample was taken, it had rained less than three hours ago and quite heavily. Overall, however, algae was not commonly occurring in the samples.

Chrysophyta (including Bacilliophyceae, diatoms)

The yellow-green algae and diatoms were represented in every one of the fourteen samples. The most usual genera seen in large numbers were Dinobryon, Fragilaria, and Tabellaria. From looking at the Plankton lists for each locality, it can be seen that only from Trough Creek at 4 meters was Synedra found. Asterionella made its appearance in each of the samples with Navicula being quite uncommon.

Cyanophyta (blue-green algae)

The only genus of this phylum was Oscillatoria, which is often considered to be an "indicator" of pollution, although not necessarily. It was, however, not found in many of the samples - only those depths taken at Trough Creek. From this discussion it can be seen that algae was quite a common plankton component of these lake waters at Trough Creek, perhaps due to the recent heavy rainfall washing them into the lake.

Discussion of Zooplankton

Protozoa

The only genus of protozoa observed in the samples was Ceratium , which occurred throughout each of the samples, i.e. at all depths and locations. It did not appear to be restricted to any particular depth or location but was found randomly in all of the fourteen samples. I would label it a common genus, but not an abundant one since it was not observed in great numbers in any one sample.

Rotatoria

There were four genera represented in each of the fourteen samples. Polyarthra appeared to be quite common, for it was conspicuously present on every slide I viewed. Asplancha was another common plankter and appeared in every slide also. Kellicottia longispina turned up in only two samples above 4 meters - at Nancy's Camp at 1 meter and at Trough Creek at 1 and at 3 meter depths. This species of rotifer seemed to prefer depths of 4m. or greater since it was observed in all samples at 4 meters and in the two 5 meter samples. Keratella was very common from samples at James Creek and was missing only at 4 meter depth in Nancy's Camp samples. From Trough Creek samples , either due to the current or the prevailing bad weather conditions (of strong gusty winds), Keratella turned up sporactically at 2 meters and five meters. This rotifer was not found at one meter, three meters, or four meters.

Cladocera

The cladocerans were by far the most common plankters, for they turned up in every sample examined in usual abundance. Daphnia were quite abundant at all depths and localities. However, Bosmina appeared only in samples taken from Nancy's Camp and Trough Creek at five meters, as well as the regular 4m, 3m, 2m, and 1m. depths. The most highly interesting observation was made

in this Order. In some of the samples, there were female Daphnia with their parthenogenetic eggs in their brood chamber. An even more interesting occurrence was to find female Daphnia carrying the hatched young in their brood chambers. The young look like miniature replicas of the adult.

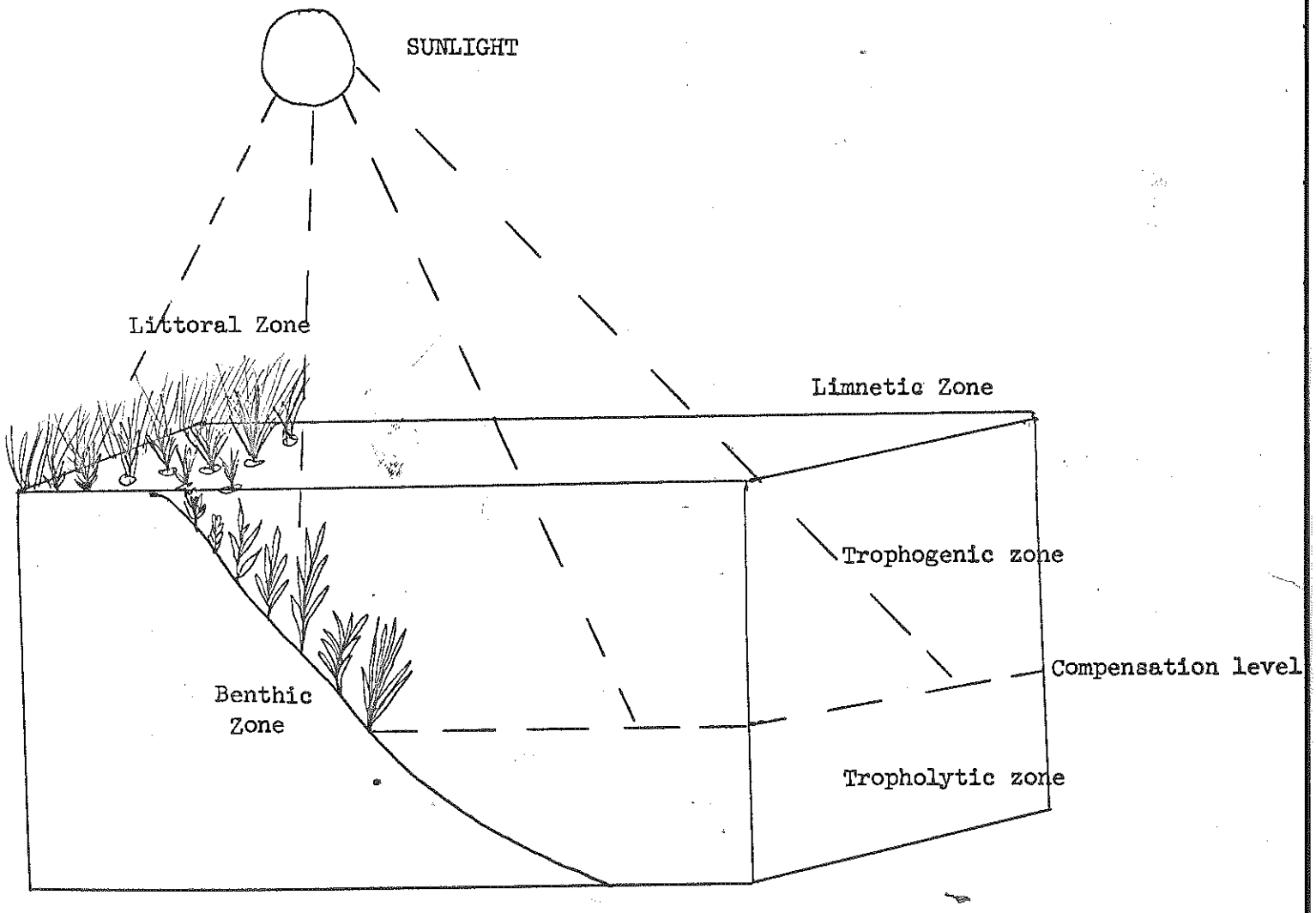
Copepoda

As was the case with the cladocerans, the copepods were found in all fourteen samples and in common occurrence. The truly interesting slides of this crustecean Order were the ones that revealed female Cyclops or occasionally Diaptomus with egg clusters in the ovisacs. The nauplius copepod larvae were seen in all of the fourteen samples and appearred to be quite common. Both copepod genera were evidently in a reproductive cycle since both the nauplius and eggs were seen in almost every slide. The differeniation between copepod eggs and cladoceran eggs is very easy and readily observable. Cladoceran eggs , when not seen in the brood chamber, occur outside of the cladoceran female singly and are of a light greenish-yellow color with a granular texture. Copepod eggs, on the other hand, are dark brown due to the dense fliud inside the egg and occur in clusters, when not attached ot the female. Copepod eggs are somewhat smaller than cladoceran eggs in size and differ in shape in that cladoceran eggs are oval, while copepod eggs are spheres.

All in all I really enjoyed this study very much and have hopes that plankton sampling will be done throughout the summer by other biology students. This is only a preliminary study to obtain an overall view of what organisms exist in the waters of Raystown Lake and many studies as to correlations of the plankton supply with changes in fish (population) numbers could be made in the future. A study could also be made on the diurnal changes in plankton in the lake as well as seasonal plankton compostion changes.

Fig. 1 The Major Horizontal and Vertical Life Zones of a Lake.

The area of interest in this study is the open water "limnetic zone," more specifically, the trophogenic zone which receives sunlight and serves as an environment for a community of microscopic photosynthetic plants (phytoplankton) and a plant-based animal community (especially zooplankton).

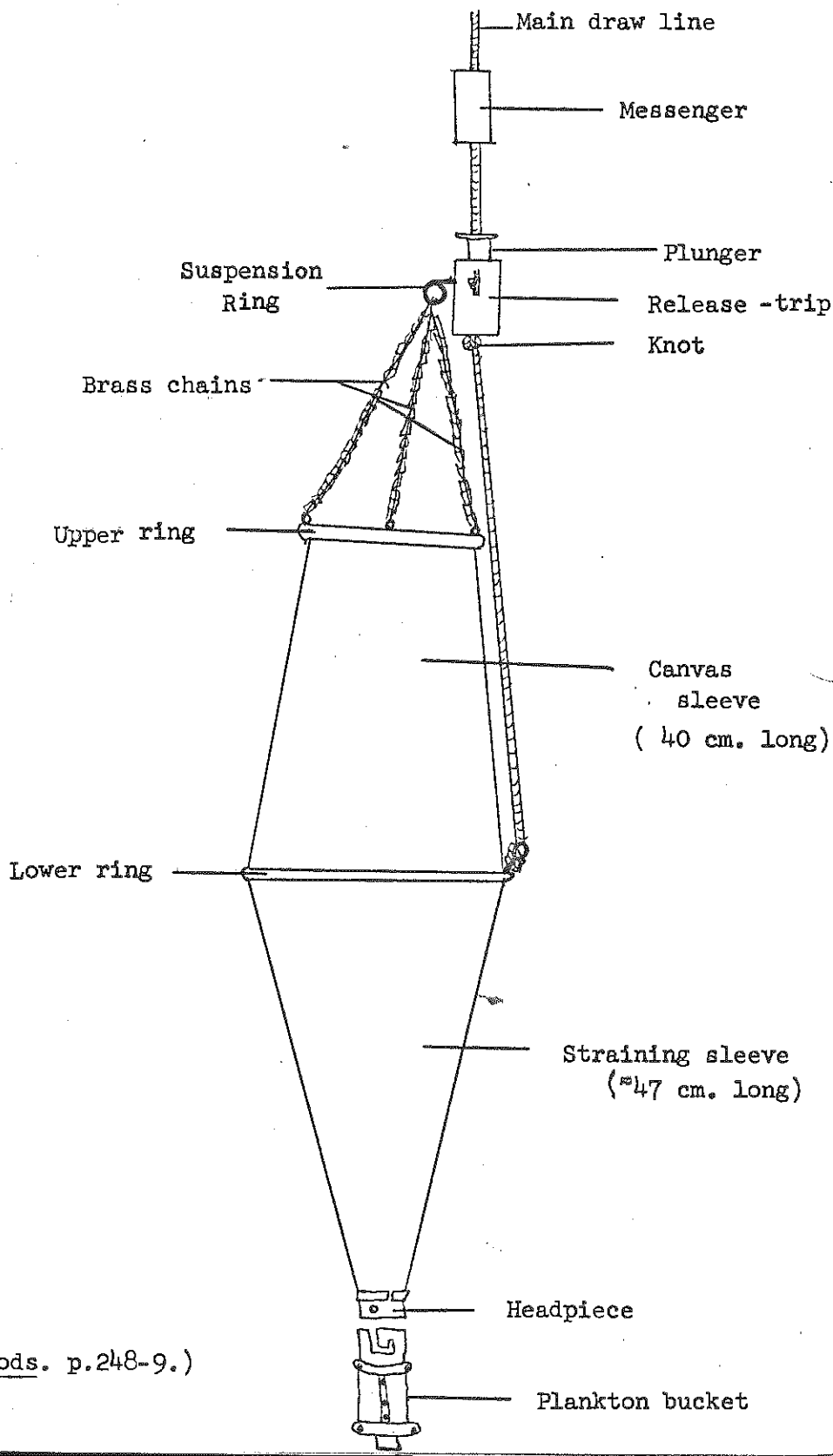


(This diagram is adapted from: Reid, G.K., Ecology of Inland Waters and Estuaries. D. Van Nostrand Company: New York, P.292.)

Fig. 2 The Principal Features of the Closing Net

Theoretically, and under ideal conditions of operation, thisclosing net strains a column of water with a diameter of that of the upper ring of the canvas sleeve and a length equal to the distance through which the net was pulled prior to closing. Much depends upon the speed of the pull. Excessive speed results in overspill at the receiving end of the net; undue slowness also gives uncertain results. An approach to the optimum speed depends upon a combination of good judgment by the operator and some test trials made before the work is begun. Closing nets of this type are designed primarily for vertical sampling and are ideal for such purposes.

When wet, the canvas sleeve becomes watertight and allows no net plankters to enter through its sides. If properly done, the necessary lowering of the net open involves no entry of plankters from strata other than the selected one.*



(*Welch, Paul S. Limnological Methods. p.248-9.)

Table I. Composite List of Phytoplankton

Phylum: Chlorophyta (green algae)

Genera: *Eudorina*

Spirogyra

Ulothrix

Phylum: Chrysophyta (yellow-green algae, including Bacilliophyceae)

Genera: *Asterionella*

Dinobryon

Fragilaria

Navicula

Synedra

Tabellaria

Phylum: Cyanophyta (blue-green algae)

Genus: *Oscillatoria*

(Classified according to terms in : Needham & Needham, 1962)

Table II. Composite List of Zooplankton

Phylum: Protozoa

Genus: *Ceratium*

Phylum: Rotatoria

Genera: *Asplancha*

Kellicottia longispina

Keratella

Polyarthra

Phylum: Arthropoda

Class: Crustacea

Order: Cladocera

Genera: *Daphnia*

Bosmina

Phylum: Arthropoda

Subclass: Copepoda

Order: Eucopepoda (copepods)

Genera: *Cyclops*

Diaptomus

Nauplius larvae of copepods *Cyclops* & *Diaptomus*.

(Taxonomic classification terms adapted from: Pennak, R.W. 1953)

Sample Sheet:

Plankton Enumeration

Water Clear, green Station James Creek (J2) Date May 16, 1976

Hour collected 2:00 pm Wind Moderate; steady (5mph) Sky Overcast; occasional sunshine

Depth 1 meter Net size No.25 Volume filtered 8.2 liters Collect.by lw

Volume concentrate 25 ml. Counting method Aliquot Count by lw

Organisms	Field Strip Counts: 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	TOTAL	Average number per ml concentrate	Number per l. original water
Asterionella	2	3	7	8	9	10	6	7	5	3		60	6	18.3
nobryon	5													
agilaria	3													
vicula														
bellaria	4													
Ceratium	10													
Asplancha	9													
olyrathra	13													
eratella	11													
aphnia	15													
[illegible]	9													
OTALS :	120													

EMARKS:

yclops 12
iaptomus 9
auplius 18

James Creek

Plankton Data :

Water Clear, green color

Water temperature 17° at 1.m.

Sky Heavy overcast

Wind Moderate

Date May 16, 1976

Net size No.25

	Depth:			
Phytoplankton	1 m.	2 m.	3 m.	4 m.
Eudorina				
Spirogyra				
Ulothrix				X
Asterionella	X	X	X	X
Dinobryon	X	X	X	X
Fragilaria	X		X	
Navicula		X		
Synedra				
Tabellaria	X	X	X	
Oscillatoria				
zooplankton				
Ceratium	X	X	X	X
Asplancha	X	X	X	X
Polyarthra	X	X	X	X
Kellicottia lonispina				X
Keratella	X	X	X	X
Daphnia	X	X	X	X
Bosmina				
Cyclops	X	X	X	X
Diaptomus	X	X	X	X
Nauplius	X	X	X	X

Nancy's Camp

Plankton Data :

Water Clear; green

Sky Heavily overcast

Wind Steady; gusty (up to 30 mph)

Date May 19, 19, 1976

Net size No. 25

Phytoplankton	Depth: 1m.	2m.	3m.	4m.	5m.
Eudorina					
Spirogyra	X				
Ulothrix					
Asterionella	X	X	X	X	X
Dinobryon	X	X	X	X	X
Fragilaria					
Navicula	X		X		
Synedra					
Tabellaria		X		X	
Oscillatoria					
Zooplankton					
Ceratium	X	X	X	X	X
Asplancha	X	X	X	X	X
Polyarthra	X	X	X	X	X
Kellicottia longispina	X			X	X
Keratella	X	X	X		X
Daphnia	X	X	X	X	X
Bosmina	X	X	X	X	X
Cyclops	X	X	X	X	X
Diaptomus	X	X	X	X	X
Nauplius	X	X	X	X	X

Trough Creek

Plankton Data:

Water Muddy (rainfall recent)

Date May 19 ,1976

Sky Heavily overcast

Net size No.25

Wind Steady; gusty (30 mph at times)

	Depth: 1m.	2m.	3m.	4m.	5m.
Phytoplankton					
Eudorina		X		X	
Spirogyra	X				
Ulothrix			X	X	X
Asterionella	X	X	X	X	X
Dinobryon	X	X	X	X	X
Fragilaria		X	X		
Navicula					
Synedra				X	
Tabellaria	X			X	X
Oscillatoria			X	X	
Zooplankton					
Ceratium	X	X	X	X	X
Asplancha	X	X	X	X	X
Polyarthra	X	X	X	X	X
Kellicottia longispina	X		X	X	X
Keratella		X			X
Daphnia	X	X	X	X	X
Bosmina	X	X	X	X	X
Cyclops	X	X	X	X	X
Diaptomus	X	X	X	X	X
Nauplius	X	X	X	X	X

1973

THE ESTABLISHMENT OF INVERTEBRATE COMMUNITIES ON GRAVEL SUBSTRATES IN JAMES CREEK, PA.

Todd Beck

Independent Study

Juniata College, Fall 1973

ABSTRACT

Development of invertebrate communities on gravel substrates of three types was investigated. The study revealed species characteristic of gravel communities. It was not possible to establish, for any species, a preference for a particular gravel type. For all gravel types, the chironomids colonized most rapidly along with the oligochaetes, Ancylus, and Psephenus. Hydropsychids and Acroneuria did not appear in any great numbers until the fourth week. The Ephemeroptera, Amphipods, and Philopotamids were found evenly throughout the experimental period. Copepods did not appear in the latter half of the period.

Quantitative sampling of gravel substrate areas of James Creek showed that the average production was 1584 invertebrates per square foot or 32.862 grams per square foot (wet weight).

Correlation studies using Forbe's and Cole's formulas were not successful in establishing any interspecific associations between any invertebrate types appearing in the samples. Variance between mean numbers of organisms appearing in the samples each week was found to be too great to apply the student's t- test.

Diversity indices were calculated using data obtained by Surber sampling. The species richness or variety index d = 10.93; the Shannon-Weaver function for mean diversity $\bar{d}$ = 3.583; the index of general diversity $\bar{H}$ = 1.037; and the evenness index e = 0.666 (see RESULTS and Table 7).

INTRODUCTION

Substrate is one of the most important factors controlling the characteristics of the community of aquatic invertebrates. Percival and Whitehead (29), Gaufin (49), Needham (34), Ricker (34), and Sprules (47) were among the earliest investigators of factors determining the quantity of bottom organisms. Although there seems to be some disagreement as to which factors are most important, it can be assumed that volume of flow and temperature are primary characters, current velocity and bottom composition are secondary characters and dissolved solids are tertiary characters determining production in streams. Mackay and Kalff (1969) showed that density (in numbers of organisms) per unit area increased through the following substrates: sand < gravel < stones < leaves < detritus. Biomass per unit area increased in the pattern: gravel < detritus < sand < leaves < stones. Wene and Wickliff (1940) found productivity greatest in large rubble and lowest in small rubble in the three grades of substrates they studied.

Even though gravel may not be the most productive type of substrate, it was selected for the James Creek study because natural areas of gravel bottom occur in the stream and gravel is well suited for small sample units as it provides a maximum of cover for bottom fauna in a compact area. Although gravel areas are not very stable substrates as they exist naturally, they would be relatively stable in the sampling units for the short duration of the experiment.

The study was initiated to learn something of the composition and production of invertebrate communities on gravel substrates as well as to determine physical and chemical properties of the

stream. In some ways, James Creek is typical of other streams in the area that drain cultivated areas and will empty into the newly-forming Lake Raystown. The productivity and physical nature of streams feeding into the lake will obviously affect the nature of the lake itself. How?

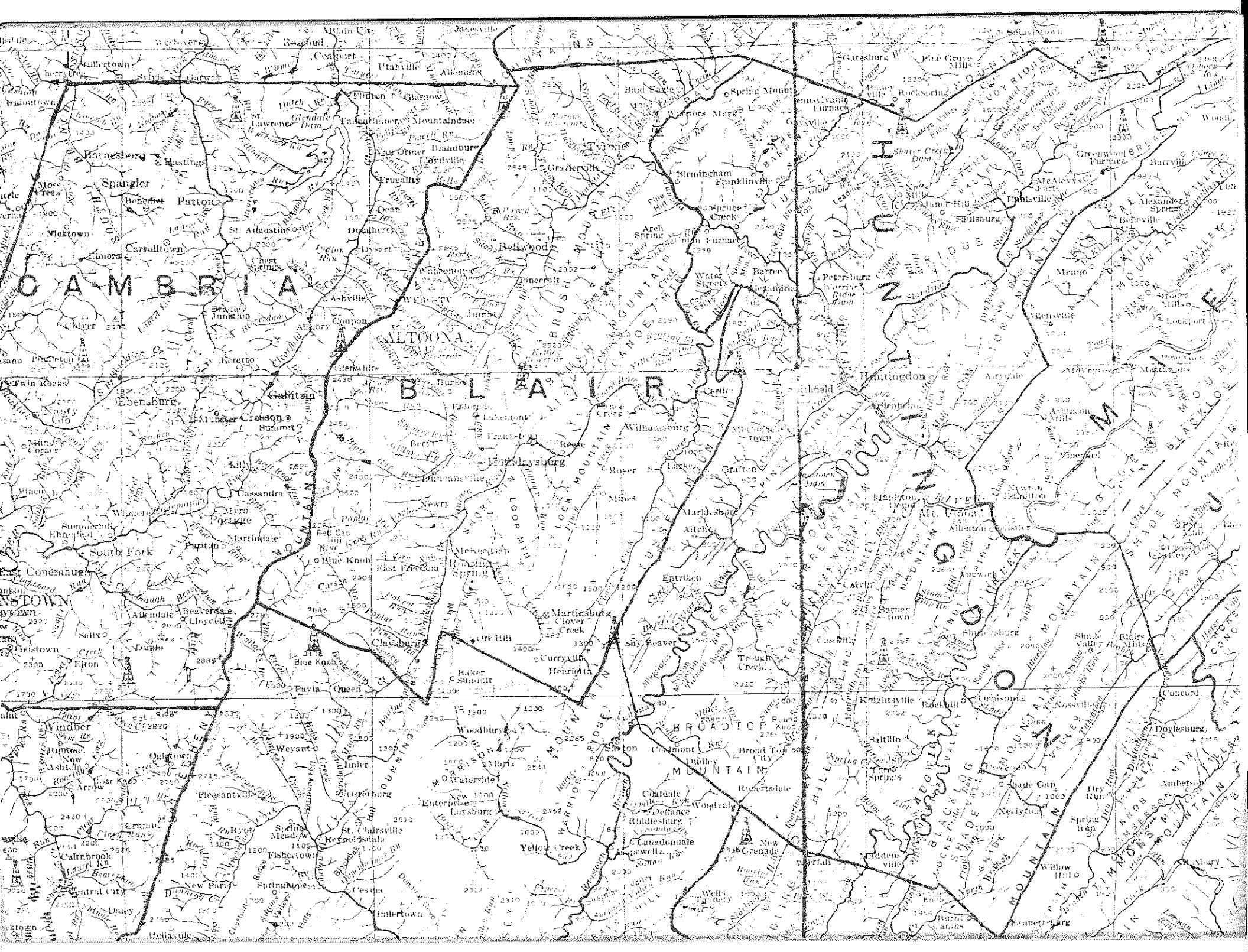
THE STUDY AREA

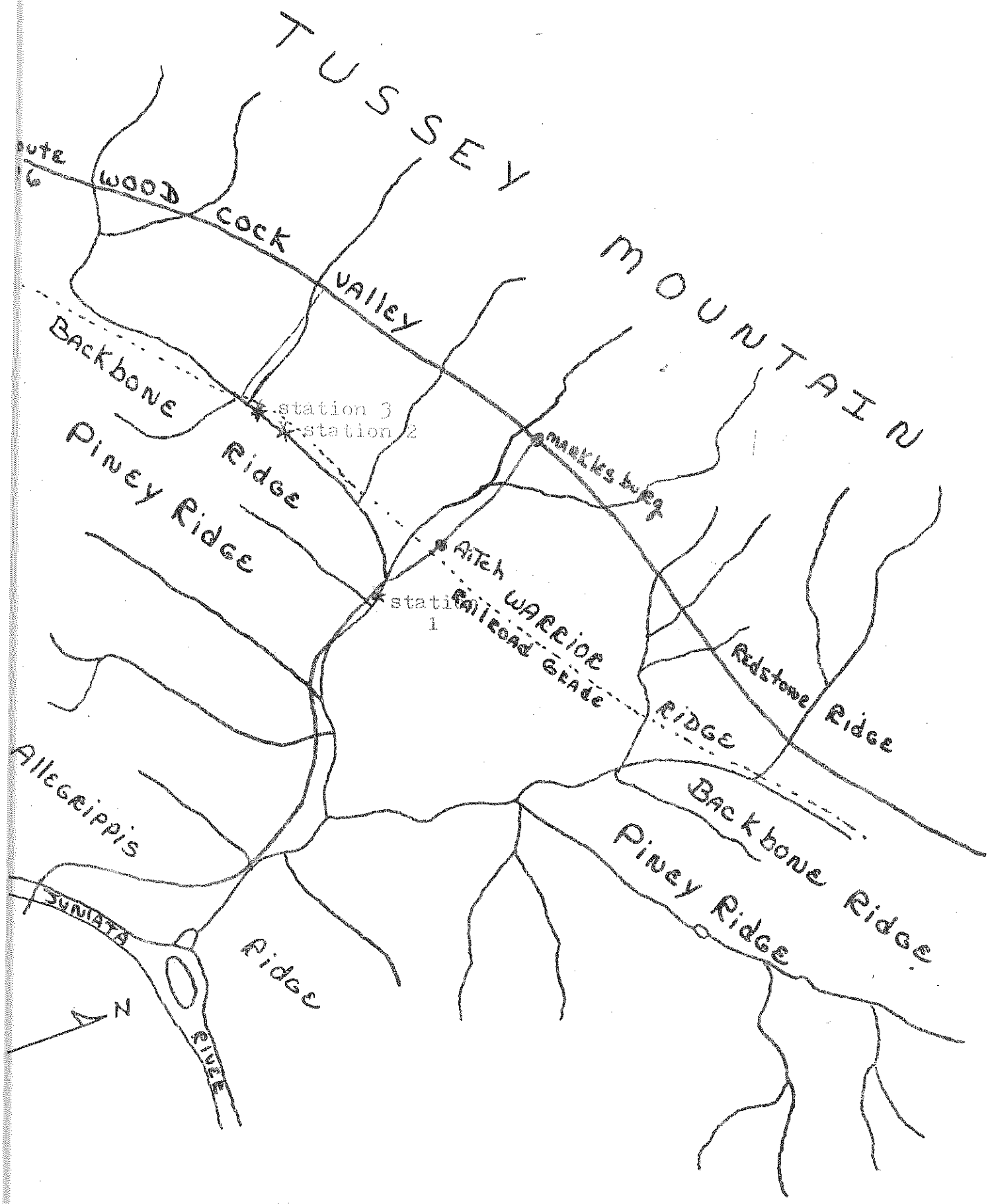
James Creek drains a 20.38 square mile area* of Penn Township in Huntingdon County. This portion of the state has a very productive limestone soil, most of which is in a high state of cultivation and has been since the late 1700's. There are rich iron ore deposits in the area; extraction of which occurred mostly between 1850 and 1890. Hematite can be found in the trough formed by Mulberry Ridge and Warrior's Ridge and scant lead ore deposits have been reported on sections of the latter. Volume measurements taken at the stream's mouth from October 1972 to Febuary 1973 indicate the stream's contribution to the Raystown branch amounted to an average of 0.972 cubic meters per second* (low of 0.178 in Oct.; high of 2.07 m^3/sec.).

The study was conducted at three stations on the section of James Creek that drains the area north and west of Backbone Ridge just south southwest of the village of Aitch. Stations 1 and 3 are separated by a distance of one mile. Station 1 was located 100 yards downstream from the bridge of legislative route 31079 and stations 2 and 3 are 500 and 300 yards (respectively) downstream of the township route T405 bridge.

The section of the stream between stations was found to be homogeneous throughout, in terms of water chemistry and species diversity. To the northwest, the study area was bordered by old field, pasture and cultivated areas while Backbone Ridge with its forested slope, rose abruptly from the southeast stream bank.

* before inundation


CAMBRIA
BLAIR
ALTOONA
Ebensburg
Gallitzin
Hollidaysburg
Martinsburg
Windber
Patton
Spangler
Carrolltown
Cassandra
Portage
Williamsburg
Huntingdon
Mount Union
Petersburg
Birmingham
Tyrone
Bellwood
Roaring Spring
Blue Knob
Clearfield
Curryville
Claysburg
Queen
Pavia
Baker Summit
Woodbury
Loysburg
Yellow Creek
Riddlesburg
Coaldale
Saxton
Broad Top City
Robertsdale
Three Springs
Shade Gap
Orbisonia
Mapleton
Entriken
Alexandria
Barree
Spruce Creek
Warriors Mark
Bald Eagle
Spring Mount
Pennsylvania Furnace
Gatesburg
Pine Grove Mills
Rockspring
Greenwood Furnace
Burrville
Tuscarora Mountain
Canoe Mountain
Brush Mountain
Allegheny Mountains
Sinking Valley
Morrison Cove
Broad Top Mountain
Shade Gap Valley
Aughwick Creek
Juniata River
Frankstown Branch
Little Juniata River
Raystown Branch
Clover Creek
Beaverdam Creek
Shoup Run
Poplar Run
Laurel Run
Dutch Run
Glendale Dam
Lake Roaring Spring
Lake Koon
Lake Sherman
Lake Canyon
Lake Lorraine
Lake Rodgers
Lake Gwynedd
Lake Penn
Lake Meadow
Lake Lauralyn
Lake Lloyd
Lake Rowena
Lake Roland
Lake Glen Hazel
Lake Lenape
Lake Lenwood
Lake Lenhaven
Lake Lenwell
Lake Lenwood
Lake Lenhaven
Lake Lenwell
Lake Lenwood
Lake Lenhaven
Lake Lenwell



Map of the James Creek Watershed
Huntingdon County, Pa.

METHOD

Sampling units were made by cutting 12 ounce beverage cans in half forming a trough rounded on the bottom. Each measured 3" X 5" thus having a total exposed surface area of 15 square inches. Three sizes of limestone gravel were selected as experimental substrate types from a local gravel company. Stones up to ½ inch in diameter were used in the pea gravel class. Medium gravel consisted of stones of up to 1½ inches in diameter while large gravel samples held stones in excess of 2½ inches diameter.

Stations were selected in the stream that had a naturally occurring gravel bottom kept fairly free of sediments by moderate currents. Each station had a water depth of 8 inches and a current velocity of 2-3 feet per second. On September 11, 1973 eighteen sampling units (six of each of the three gravel sizes) were placed at each of the three stations selected. Samples were positioned so each gravel type would have equal exposure to the current and, likewise, to invertebrate drift.

Each week beginning on September 18 for six weeks, three samples (one of each gravel type) were removed from each station. Samples were preserved in 10% formalin upon collection in the field.

In the lab, samples were washed through a set of screens to remove mud and silt. Mesh sizes of 10, 18 and 60 per inch were used. Loss of organisms from this procedure was determined to be insignificant. Inspection of the screens and material passing through them revealed no loss of invertebrates in the process whatsoever. The gravel was scrubbed with a soft toothbrush to remove all organisms. The washed samples were then preserved in 70% ethyl alcohol and sorted under a dissecting microscope at 10X

magnification. Numbers of aquatic invertebrates were recorded for each sampling unit and calculated or converted adjusted to number per square foot of substrate. The total number of organisms for each sample was reported. The mean number for each week was calculated from combined data from each station for the three gravel types. Growth of the community in total numbers was then graphed for the six week period.

Prior to the beginning of the experiment, qualitative sampling of benthic organisms on gravel substrate revealed a homogenity of invertebrate types throughout the study area. To determine the standing crop of the gravel community organisms, three Surber samples were taken from areas similar to and those selected as station sites. The samples were preserved in 10% formalin and transferred to 70% ETOH. Average numbers and wet weights of invertebrates are reported in Table 5. Relative importance of each invertebrate type was reported as both percent of total numbers and percent total weight. A further attempt was made to determine importance based on volumes of the organisms observed in the stomach contents of 40 fish collected in the study area. Wet weights were obtained after drying the invertebrates for 20 seconds on absorbent paper.

What f.s.h? obtained by standard methods tests were

Physical and chemical data recorded during the study period are reported in Table 1. No significant difference was noted in the water chemistry between sampling stations and consequently only results obtained at Station 1 are reported. ~~A Hach water test kit was used.~~

? Variance was calculated for each week's mean standing crop and an attempt was made to apply the students t-test to show that

te		9/11	9/18	9/22	10/2	10/9	10/23
r Temp. (°C)		23	16.7		16.1	17.8	7.5
ter Temp. (°C)		14.5	15		13.9	14.4	7.5
lume (m³/min.)		3.18	17.76		309.18	4.308	3.228
infall (cm.)			9.2		5.9	0	0
kalinity ($\frac{ppm}{CaCO_2}$)				40	25	55	50
2 (ppm)				12	14	4	4
rdness ($\frac{ppm}{CaCO_2}$)	Ca			120	105	140	125
	Mg			255	35	65	55
	Total			375	140	205	180
				8.60	8.10	8.38	8.29
ssolved O_2 (ppm)				10	8	10	9
rbidity (JTU)				16	92	0	9

Table 1. Water chemistry and data from Station 1 on James Creek.

each week's mean standing crop was significantly different from the mean standing crops of the other five weeks. Forbe's and Cole's coexistence formulas were applied to determine if any interspecific association existed among the colonizing invertebrates.

RESULTS

The colonizing invertebrate communities on all three types of gravel appeared to fit a sigmoid growth curve over the six week period. Growth of the community peaked on the fifth week then decreased significantly on the sixth (see Table 6). Some types of invertebrates found in Surber samples of the natural community never appeared in the sampling units. These include Planaria, Hemiptera, Sialis, Leucotrichia, Helicopsychidae, Curculionidae, Silphidae, Tabanidae and adult Acroneuria. All Plecoptera appearing in the sampling units were immature instar stages and difficult to identify. Adult Acroneuria were the only species ever observed in James Creek so the instars were assumed to be of the same type.

Pea Gravel: Chironomids appeared very early very quickly with 52% of the total number in the first week. The family maintained an average of 55% of the total number (21% total weight) throughout the period with little variation. Pseudocloeon and the Oligochaetes also colonized rapidly. The Hydropsychidae and Tipulidae did not appear in any great numbers until after the third week. Copepods colonized rapidly but almost disappeared from samples during the last three weeks of the study (see Table 2).

Medium gravel: Colonization followed a similar pattern although the medium gravel substrate supported a larger number of organisms than the other types; an average of 422 individuals per square foot, more than either pea or large gravel over the study period.

Large gravel: Colonization followed a similar pattern to that of pea gravel. Mayfly larva of the genus Heptagenia appeared to

"prefer" the large substrate over the other two.

Diversity indices were calculated from data reported in Tables 5 and 7.

1) Species richness or variety index (Margalef)*

$$d = \frac{S - 1}{\log N} = \frac{36 - 1}{\log 1584} = 10.93$$

where S = total number of taxa; and N = total number of individuals.

2) Shannon-Weaver** function for mean diversity

$$\bar{d} = \frac{C}{N}(N \log_{10} N - \sum n_i \log_{10} n_i)$$

where C = 3.321928; (converts base 10 log to base 2) N = total number of individuals; and n_i = total number in the i^{th} species.

$$N \log_{10} N = 5068.8$$
$$\sum n_i \log_{10} n_i = 3357.905$$

$$\bar{d} = \frac{3.321928}{1584}(5068.8 - 3357.905)$$

$$\bar{d} = 3.583$$

3) Shannon index of general diversity*

$$\bar{H} = -\sum (\frac{ni}{N}) \log (\frac{ni}{N}) = -\sum Pi \log Pi = 1.037$$

where ni = importance value for each species(% total no.); N = total of importance values; and Pi = importance probability for each species = ni/N.

4) Evenness index*

$$e = \frac{\bar{H}}{\log S} = 0.666$$

(See Table 7 for values used in calculations)

* from Odum page 144.

** from Weber page 17 Macroinvertebrates section.

	No./ft²	% Tot. No.	Wet Weight (mg.)	% Tot. Weight	Importance*
elenterata					
Hydra	2		+		
rbellaria					
Planaria	8	0.5	91.2	0.3	
igochaeta					
Naididae	172	10.9	246.0	0.8	
llusca					
Ancylus	46	2.9	1877.0	5.7	
Gastropoda	3	0.2	1353.3	4.1	
epoda					
Cyclopidae	76	4.8	+		
phipoda					
Gammarus minus	71	4.5	2780.0	8.5	
dracarina	1		+		
ecoptera					
Perlidae					
Acroneuria	11	0.7	1518.1	4.6	
hemeroptera					12.0
Heptagenidae					
Heptagenia	34	2.2	709.9	2.1	
Baetidae					
Baetis	9	0.6	19.4		
Leptophlebidae					
Choroterpes	14	0.9	37.8	0.1	
phemeridae	3	0.2	8.1		
onata					
Aeshnidae	2		1785.6	5.5	
goptera					
Coenagrionidae	1		892.8	2.7	
ptera	1		+		1.6
galoptera					
Sialidae	3	0.2	164.4	0.5	3.0
Sialis					
richoptera					
Hydroptilidae					
Leucotrichia	22	1.4	35.2	0.1	
Hydropsychidae	74	4.6	9075.0	27.8	15.6
Philopotamidae	39	2.4	117.8	0.3	
Helicopsychidae	2		+		
pidoptera	1		54.3	0.2	
leoptera					
Elmidae	317	20	3238.0	9.9	
Psephenidae					
Psephenus	59	3.7	3872.5	11.8	
Curculionidae	1		+		
Silphidae	1		+		
Adult	5	0.3	96.1	0.3	5.0
ptera					
Tipulidae					
Antocha	86	5.4	542.2	1.7	

(continued)

	No./ft.^{2}	% Tot. No.	Wet Weight (mg.)	% Tot. Weight	Importance*
ironomidae					17.0
Phaenopsectra	31	1.9	132.6	0.4	
Polypedilum	417	27.0	1381.0	4.2	
Conchapelopia	20	1.3	66.3	0.2	
Microtendipes	33	2.1	109.2	0.3	
Pupae	18	1.1	59.7	0.2	
banidae	1		2598.2	7.9	
ults					13.8
TAL	1584		32861.7		

* Based on 40 fish stomach content analysis

Metric Conversion: No./m^2 = No./ft^2 x 10.76

Table 5. Average numbers and wet weights of aquatic invertebrates collected from three Surber samplings of medium gravel substrates occurring naturally in James Creek. Current velocity was 2ft./sec in the areas where samples were collected.

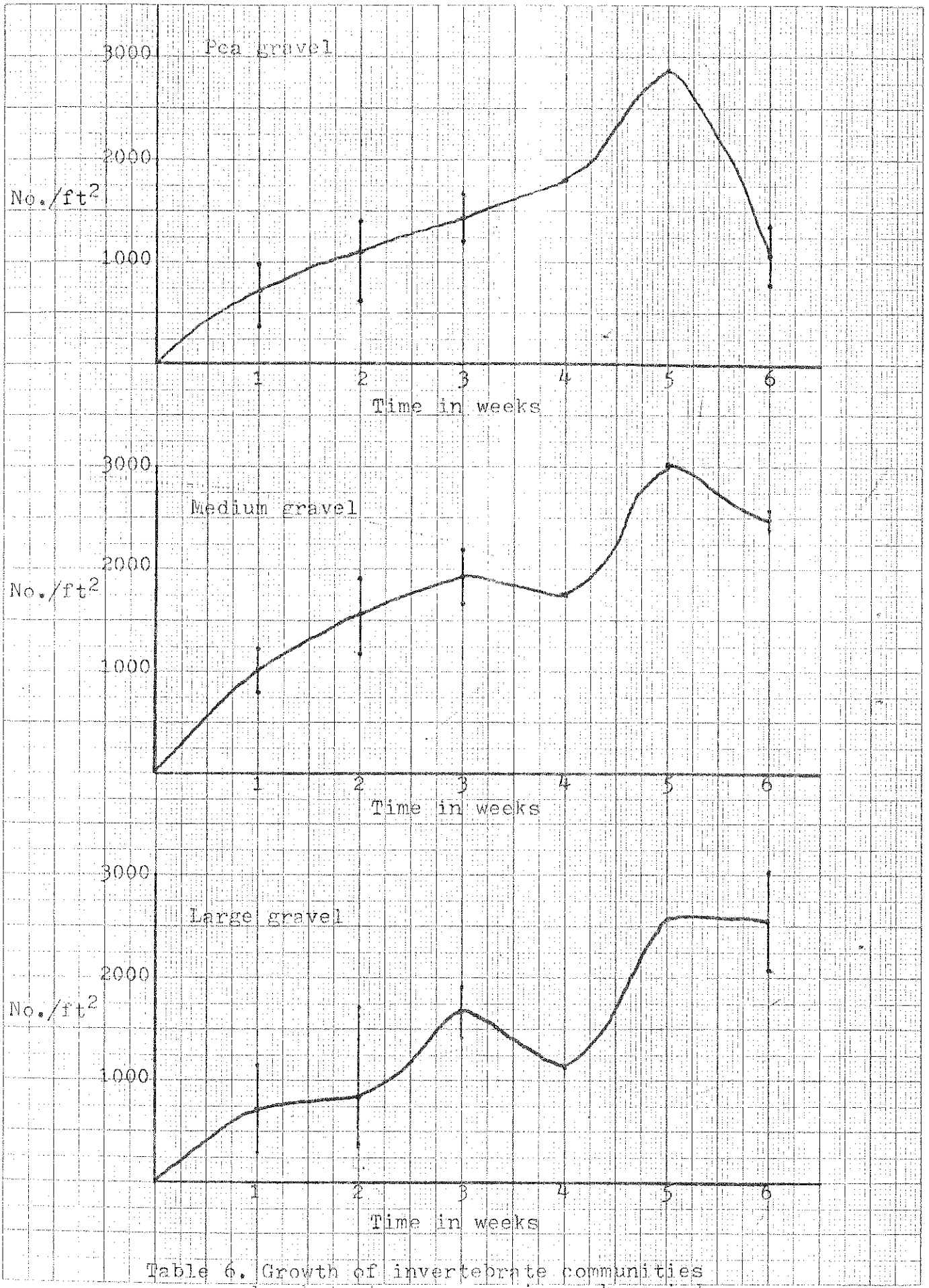


Table 6. Growth of invertebrate communities on gravel substrates over a six week period.

TAXA	$n_i \log_{10} n_i$	Pi	logPi	PilogPi
Coelenterata				
Hydra	0.6021			
Turbellaria				
Planaria	7.2247	.005	-2.301	-.0115
Oligochaeta				
Naididae	384.5109	.109	-0.962	-.1049
Mollusca				
Ancylus	26.4869	.029	-1.538	-.0446
Gastropoda	1.4314	.002	-2.698	-.0054
Copepoda				
Cyclopidae	142.9418	.048	-1.318	-.0633
Amphipoda				
Gammarus minus	131.4393	.045	-1.346	-.0606
Plecoptera				
Perlidae				
Acroneuria	11.4553	.007	-2.155	-.0151
Ephemeroptera				
Heptagenidae				
Heptagenia	38.4702	.022	-1.658	-.0365
Baetidae				
Baetis	8.5882	.006	-2.222	-.0133
Leptophlebidae				
Choroterpes	16.0458	.009	-2.041	-.0184
Ephemeridae	1.4314	.002	-2.698	-.0054
Odonata				
Aeshnidae	0.6021			
Megaloptera				
Sialidae				
Sialis	1. 4314	.002	-2.698	-.0054
Trichoptera				
Hydroptilidae				
Leucotrichia	29.5333	.014	-1.854	-.0259
Hydropsychidae	138.3231	.046	-1.337	-.0615
Philopotamidae	62.0515	.024	-1.620	-.0289
Helicopsychidae	0.6021			
Coleoptera				
Elmidae	792.8358	.200	-0.698	-.1396
Psephenidae				
Psephenus	104.4803	.037	-1.432	-.0530
Adult	3.4949	.003	-2.523	-.0076
Diptera				
Tipulidae				
Antocha	166.3669	.034	-1.267	-.0684
Chironomidae				
Phaenopsectra	46.2322	.019	-1.721	-.0327
Polypedilum	1092.5967	.270	-0.568	-.1534
Conchapelopia	26.0206	.013	-1.886	-.0245
Microtendipes	50.1110	.021	-1.678	-.0352
Larvae	22.5949	.011	-1.958	-.0215
SUM Σ	3357.9048	.998		-1.0366

Table 7. Figures used for calculating indices from Surber sampling data (Table 5).

Explain?

DISCUSSION

Statistical Analysis

The James Creek study was originally set up to investigate the establishment of aquatic invertebrate communities on gravel substrates. Statistical analysis of data was patterned after the method employed by Nilsen and Larimore (1973), applying the student's t- test to show that each week's mean standing crop (numbers) was significantly different from the mean standing crops of the other five weeks. However, the large variance due to few samples prohibited the use of the t- test, for accurate results. Sudden, heavy periods of rainfall during the course of the experiment caused the loss of sampling units from washout at two stations. Of the original 54 samples placed in the stream on September 11, only 36 were used throughout the study.

Forbes' and Cole's coefficient formulas, applied to the weekly data, failed to establish any positive interspecific associations. Data?

Three Surber samples, taken in gravel substrate areas with current velocities of 2-3 ft./sec., were used to determine the standing crop. It was found to be 1584 total organisms per square foot or 32.862 grams, wet weight. Criteria for grading streams on the basis of productivity (Surber (1937)) indicate that James Creek is a Grade I or very "rich" stream.

Some indices of diversity were applied to the 36 species of invertebrates identified in the Surber samples by methods described in Odum (71) and Weber (75). Species diversity has a number of components dependent upon physical factors of the community, two of which are 1) the richness of species and 2) the distribution of individuals among the species. Margalef's species

richness or variety index can be used to compare communities provided the number of species, S, is a linear function of the log of N, the number of individuals per species (Odum (1971)). This index is merely a means of summarizing data on total numbers and total taxa and is concerned with only the richness of species in a community. The evenness component and the Shannon-Weaver function for mean diversity both reflect the second component of diversity; the distribution of individuals among the species.

The evenness index, e, was found to be 0.666. This is a reflection of the apportionment of the 1584 individuals among the 36 species. This value usually ranges from 0 to 1 (Weber (1973)). Mean diversity, $\bar{d}$, was found to be 3.583 and, in general, can be expected to be between 3 and 4 in unpolluted water and less than 1 in polluted waters.

The Shannon index of general diversity, $\bar{H}$, combines the variety and evenness indices in one general index of diversity. It is best for making comparisons where one is not interested in separating out diversity components because it is reasonably independent of sample size. Thus, fewer samples are required to obtain a reliable index for comparisons (Odum (1971)).

A shortcoming of the Shannon-Weaver function should be noted, based on the definition of the importance value, P_i, in the equation $\bar{H} = -P_i \log P_i$. Dickman (1968) feels that $\bar{H}$ fails to reflect significant changes in a community's structure because it is only sensitive to changes in relative abundance of a few of the trophic levels of a community. The index is swamped by the large numbers of individuals of the lower trophic levels such as bacteria, rotifers, or chironomids. Dickman redefined P_i in terms of relative productivity, as $\frac{pr}{PR}$ where pr = the

productivity of a particular species and PR = the total sample productivity. Productivity is the species mean sample density and biomass times the annual turnover rate (number of times a species reproduces in one year). This new index would then be sensitive to all trophic levels of a community. Information of turnover rates was not available to calculate this revised index for the James Creek study.

Clime and Clemons (1972) study of diversity includes the use of Sorensen's K community coefficient which measures the degree of similarity between two communities. This function could not be applied to the data collected in this study. (Then why mention it?)

Community Characteristics

In general, James Creek is a very productive stream characterized by high diversity of species. High diversity implies longer food chains which tends to increase the stability of a community. Stability seems to be more directly correlated with diversity than with productivity (Odum (1971)). Percival and Whitehead (1929) provide an excellent list of food types and preferences of a large number of aquatic insects for setting up trophic relationships and found that only about 10% of the individuals in a given stream community are carnivorous species.

Anderson and Lehmkuhl (1968) report a tenfold increase in density of benthic samples during the month of October. This increase is evidently due to the hatching of eggs of many species which in turn is probably related to decreasing autumn temperatures. In accordance, many immature forms of aquatic insect larva were observed in the James Creek samples. Reduced temperatures

also tend to reduce the growth rates of aquatic larval forms (Nilsen (1973)). Evidence exists (MacKay (1969), Frison (1935)) that the number of different species is lowest in spring and fall. It appears then that James Creek is very productive and has many species present even during the fall "slow" season.

Heavy autumn rainfalls could have affected this study in two ways. First, a one inch rainfall would result in approximately a fourfold increase in numbers of invertebrates in the drift (Anderson). Thus the samples would be exposed to this increased drift and one could conceivably experience close to "climax" conditions, in terms of numbers, prematurely in the period of exposure time. Also, some species, such as the Ephemeroptera and Plecoptera, retain characteristic periodicity in high water periods while the chironomids in the drift increase or decrease according to the amount of rainfall. Other aspects of stream drift have been investigated by Dimond (1967), Lehmkuhl (1972), Reisen (1972), and Waters (1961). Date Ref? ( )

Secondly, increased flow in James Creek from the rains resulted in the deposition of much silt and sediment in the sampling units, often completely covering the gravel. Chironomid numbers increase with the presence of a fine silt substrate (Percival (1928), Thorup (1966)). Thus the numbers of chironomids observed may have resulted from a change in the sampling substrate type (from gravel to silt). Buscemi (1961) and others have worked in the area of sedimentation. ref?

Turbidity of the water increased with the autumn rains and temporarily affects the light penetration in the stream (Nilsen (1973)). Pearson has shown that illumination directly affects the drift

rate in streams and this could be another factor influencing colonization of the sample units.

Detailed fauna lists of a particular community have little practical use for other scientists because communities differ vastly from place to place. In well defined communities, it is possible to separate the fauna into:

1) characteristic fauna
2) species occurring in large numbers throughout the entire year
3) species not so numerous as (2) but occurring throughout the entire year
4) species occurring only accidentally.

Another group of investigators (Thorup (1966), Coker (1968)), to promote community analysis on a more universal scale, have begun classifying fauna into morphological life-forms with little emphasis on species. Thus the stone fly larva Aeroneuria becomes a "clinger", the oligochaete, Naididae, a "burrower", ect.

The composition and growth rate of invertebrate communities on gravel substrates are undoubtedly influenced by a number of factors such as have been discussed. [Efforts were made to keep current velocity, chemical parameters, light, temperature, position of the sample units and presence of colonizing organisms constant between stations during the investigation.] Of all other factors, the composition of the bottom appears to be the most important in determining the quanitity of aquatic invertebrates. Although the substrate is often modified by the current velocity, in the microhabitats around and beneath stones velocity appears less important. Species will select a preferred type of substrate

over a wide range of current velocities (Linduska [1942]). Substrate type seems most useful as a basis for determining the quantity of invertebrates produced; it is a manifestation of a certain combination of ecological factors because the existence of the substrate itself depends on stream velocity, surrounding vegetation, local light conditions, chemical composition of the water, geographical history of the locality, ect. The substrate itself influences the chemical composition of the water and food conditions at the locality and thus the type of aquatic invertebrate community.

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PEA GRAVEL

TAXON	1st week			2nd week			3rd week		4th week	5th week	6th week	
Station	1	2	3	1	2	3	1	2	2	1	1	2
Annelidae												
Naididae	86	10	134	202	67	29	115	77		295	106	96
Pollusca												
Ancylus				355		29	67	10	134	230	29	
Copepoda												
Cyclopidae	58	67		58	106	48	134		86			19
Amphipoda												
Gammarus minus	67			10			29		10		77	19
Hydracarina				10				10	10			
Plecoptera												
Perlidae												
Acroneuria		10			29			38		19	29	29
Ephemeroptera												
Heptagenidae												
Heptagenia	10	38	38	19	19	19	38	19	106	67	173	
Baetidae												
Baetis	48	19	10	67	67	38	58		38			29
Leptophlebidae												
Choroterpes	19	86	29		173	58	29	48	58	10	19	19
Ephemeridae								19				
Trichoptera												
Hydropsychidae				19					10	29	67	
Philopotamidae	10	38	19	29	67	48	67	29	29	163	125	38
Coleoptera												
Elmidae	38	86	29	67	67	10	115	154	211	134	29	86
Psephenidae												
Psephenus	58	10				10	19		77	67	29	10
Adult	10	10					10				10	
Diptera												
Tipulidae												
Antocha							19	19	10		10	10
Chironomidae												
Phaenopsectra	10	19	19		29		29	29	38	77	38	29
Polypedilum	336	394	77	364	518	154	595	702	739	1574	566	403
Conchapelopia	38	48	29	10	77	67	77	58	77	38	10	10
Microtendipes	10	106		10	154	38	221		134	106	29	
Pupae	19	38		48	29	96	48	10	38	67	10	
TOTAL	817	999	394	1268	1402	644	1670	1222	1805	2876	1356	797
MEAN		737			1105			1446	1805	2876	1077	

Table 2. Numbers per square foot of invertebrates collected from sample units containing pea gravel and located at three stations in James Creek.

Metric Conversion: No./m^2 = No./ft^2 x 10.76

MEDIUM GRAVEL

Station	1st week			2nd week			3rd week		4th week	5th week	6th week	
	1	2	3	1	2	3	1	2	2	1	1	2
AXON												
nelidae												
Naididae	19	19	19	221	86	86		173	125	586	202	288
ollusca												
Ancylus				384	10	58				173	221	29
opepoda												
Cyclopidae	67	134	10	58	106	67		221			19	
mphipoda												
Gammarus minus	38		10	48	38		86	86	19	38	38	19
ydracarina									10			
lecoptera												
Perlidae												
Acroneuria	10	48	10				29	67			19	48
phemeroptera												
Heptagenidae												
Heptagenia	19	29	125	38	67		29	58	29	67	134	106
Baetidae												
Baetis	86		29	29	38	10	10	154	10	48	48	
Leptophlebidae												
Choroterpes	10	86	58	10	154	10	38	29		29	29	38
ygoptera												
Coenagrionidae						10						
richoptera												
Hydropsychidae				106				19	29	106	96	19
Philopotamidae	29	29	144	77	67	106	96	134	86	154	125	173
oleoptera												
Elmidae		48		77	67	67	67	269	192	115	125	134
Psephenidae												
Psephenus	192	10	10				67		10		125	10
Adult	10									10	10	
iptera												
Tipulidae												
Antocha	10	10		19						296	19	29
Chironomidae												
Phaenopsectra		38			19		19	58	134	10	48	221
Polypedilum	307	489	221	797	692	614	826	896	981	1258	826	1219
Conchapelopia	96	96	48		86	58	96		58	38	154	58
Microtendipes	67	134	96	10	134	58	230	67	29	58	125	154
Pupae	19	58	10	38	67	48	96	38	58	58	38	38
Adults			10		19							
TAL	979	1228	800	1912	1650	1192	1689	2209	1770	3017	2401	2583
EAN		1002			1585			1949	1770	3017		2492

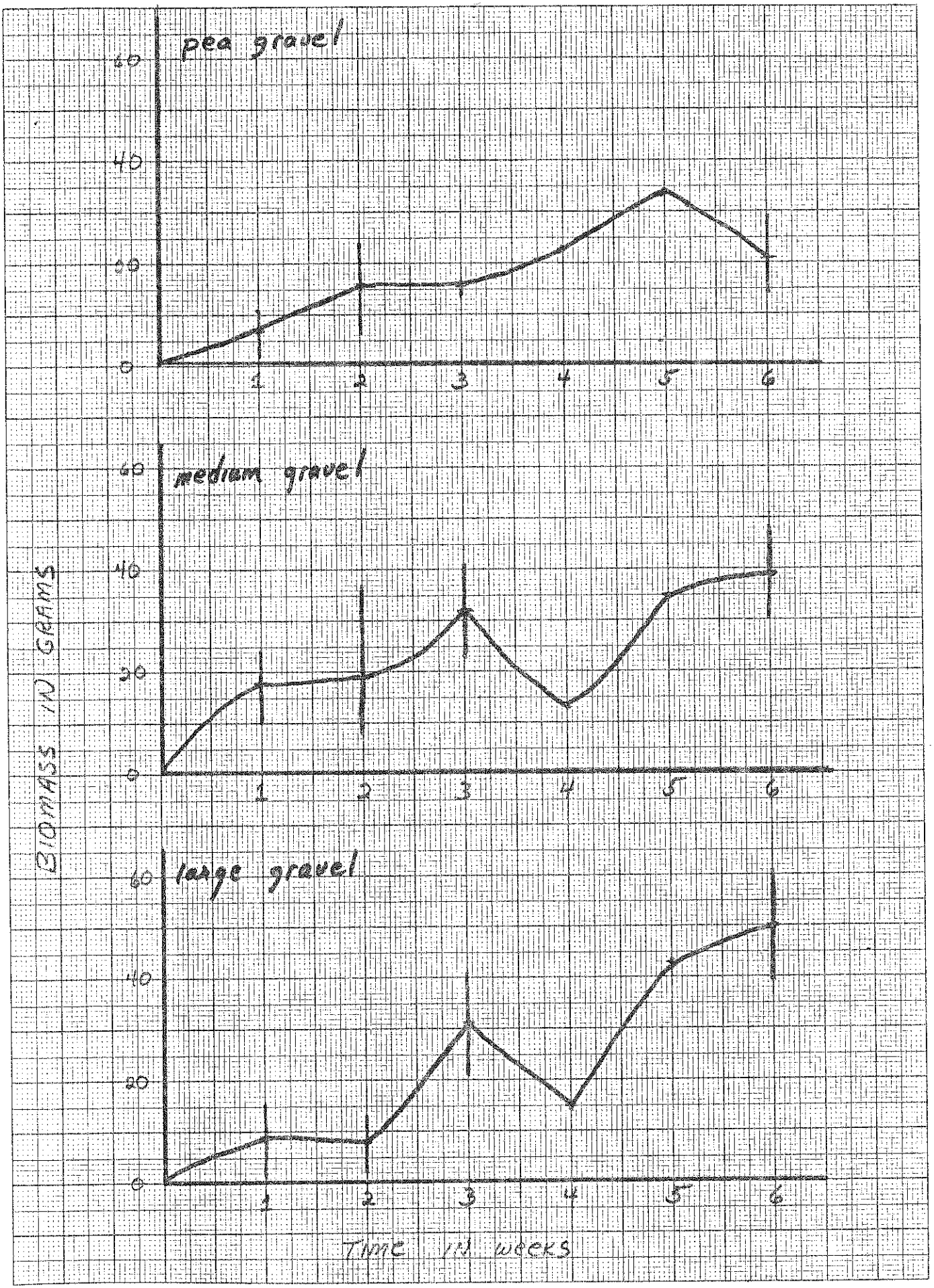
Table 3. Numbers per square foot of invertebrates collected from sample units containing medium gravel and located at three stations in James Creek.

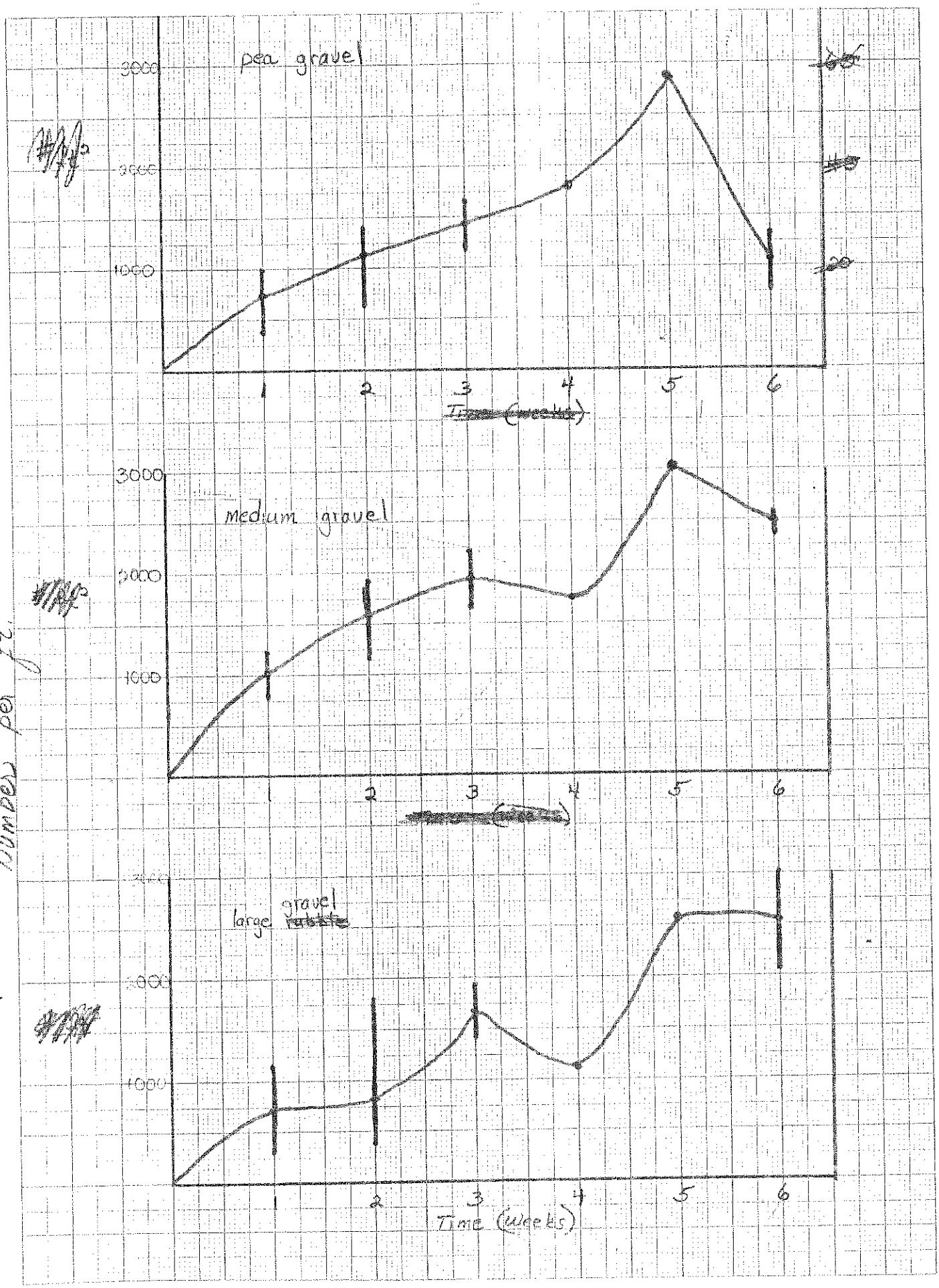
Metric Conversion: No./m^2 = No./ft^2 x 10.76

LARGE GRAVEL	1st week			2nd week			3rd week		4th week	5th week	6th week	
Station	1	2	3	1	2	3	1	2	2	1	1	2
TAXON												
Annelida												
Naididae	19	38	10	48	96	10	77	96	29	384	77	298
Mollusca												
Ancylus				144	19		221	67	19		211	29
Copepoda												
Cyclopidae	77	125		10	173		154	19				
Amphipoda												
Gammarus minus					10		29	10	10	10	29	19
Hydracarina		10	10									
Plecoptera												
Perlidae												
Acroneuria	19	10			19			48	10	29	29	106
Ephemeroptera												
Heptagenidae												
Heptagenia	10	58	38	29	58	29	77	144	10	48	58	221
Baetidae												
Baetis	77	10		10			19	58	10	86	10	77
Leptophlebidae												
Choroterpes	38	29	29	10	19	10	29	29	19	10		
Odonata												
Aeshnidae						10						
Trichoptera												
Hydropsychidae	19							77	29	154	77	86
Philopotamidae	19	19	29	19	154	29	19	67	125	125	67	173
Coleoptera												
Elmidae	19	48	10		115		77	77	115	182	154	38
Psephenidae												
Psephenus	19	19		10			77	38	29		38	10
Adult							10	19		19		10
Diptera												
Tipulidae												
Antocha	10				10			19			10	
Chironomidae												
Phaenopsectra		29			77		86	106	38	29	19	134
Polypedilum	259	452	115	106	623	278	461	864	596	1228	1258	1718
Conchapelopia	67	144	19		86	38	29	29	29	77	19	48
Microtendipes	67	154	38		182		48	144	19	182	29	19
Pupae		10	10	10	67		10	19	38	29	10	19
TOTAL	719	1155	308	396	1708	404	1423	1930	1125	2592	2095	3005
MEAN		727			836			1677	1125	2592	2550	

Table 4. Numbers per square foot of invertebrates collected from sample units containing large gravel and located at three stations in James Creek.

Metric Conversion: No./m^2 = No./ft^2 x 10.76


pea gravel
medium gravel
large gravel
BIOMASS IN GRAMS
TIME IN WEEKS
0
20
40
60
1
2
3
4
5
6


pea gravel
3000
1000
1
2
3
4
5
6
Medium gravel
3000
1000
1
2
3
4
5
6
large gravel
1000
1
2
3
4
5
6
Time (weeks)
Numbers per ft²

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and
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1974

THE EFFECTS OF UNDERWATER EXPLOSIONS ON FISHES

Raystown Reservoir at Trexler Bridge

Huntingdon County, Pennsylvania

February 20 and 21, 1974

Robert L. Fisher
Todd Beck

INTRODUCTION

Several bridges were to be removed from the Raystown Resevoir area by the U.S. Army Corps of Engineers prior to innundation by water. This was done by the use of high explosives placed both in the water (plume shots) and by charges on the super-structure. Since it is well known that underwater explosions are detrimental to aquatic life, tests were designed with the cooperation of the Corps of Engineers in an attempt to determine the effects of various charges on fishes in screened enclosures placed at various distances and depths from the charge. Tests were conducted only with the "plume" charges.

The study followed an ineffective attempt to survey fish mortality resulting from "plume" charges set off earlier under the Entriken Bridge.

The Trexler Bridge had 15 feet of water under it at the time of the blasts, February 20 and 21, 1974. On the first day a 25 pound charge was set off while a lighter charge of 15 pounds was used on the following day.

MATERIALS AND METHODS

Each cage was 24" x 24" x 12", built of 1 inch^2 clear white pine and covered with aluminum screen wire. One side was left open and later covered with cheesecloth after 6 to 10 fish were placed inside. Cages were numbered from 1 to 35 equipped with an eyebolt for easy attachment to the nylon line.

Cages were set out with fishes at varied depths and at different distances from the charges. For the 25 pound charge, one cage was placed on the surface at 5 m. from the blast; 3 cages at 10 and 15 m., and 2 cages at 20, 30, 40 and 50 m. For the 15 pound charge, 2 cages were placed at 40, 50, 60, 70 m. and only one cage on the bottom at 80 m. Cages were clipped to a knotted nylon rope and weighted with concerete blocks or stones.

After each explosion, native fish killed or injured were collected for later autopsy. Cages were unfastened and transported 500 yeards downstream to observe mortality. Dead fish were numbered and preserved as they died for one week after the explosions. About 24 fish of various species served as a control. They were kept in a live box at our docking area about 500 yds. downstream from the bridge.

Fish used in the cages were obtained locally with a 230 V shocker from James Creek on February 18 and 19. Control fishes showed some indication of slight damage due to shocking, transport, and handling resulting in approximately 1% of the mortality.

Fish used in the study included 10-14 in. Common White Sucker (Catostomus commersoni), 6-8 in. Norther Hog Sucker (Hypentelium nigricans), 2-4 in. Margined Madtom (Noturus insignis), 3-5 in. Carp (Cyprinus carpio), 1-3 in. various types of Sunfish (Lepomis sp.), 5-7 in. Rockbass (Ambloplites rupestris), 5-7 in. Smallmouth Bass (Micropterus dolomieui), 5-7 in. Largemouth Bass (Micropterus salmoides), 3-5 in. Golden Shiner (Notemigonus crysoleucas), 2-4 in. Rosy-faced Shiner (Notropis rubellus), 2-4 in. Spot-finned Shiner (Notropis spilopterus), 2-4 in. Blunt-nosed Minnow (Pimephales notatus), 2-4 in. Spot-tailed Shiner (Notropis hudsonius), 5-6 in. Common Shiner (Notropis cornutus), 2-4 in. Johnny Darter (Etheostoma nigrum), and 5-7 in. River Chub (Hybopsis micropogon).

RESULTS

A. Trexler Bridge, February 20, 1974, East Span, 25 pound charge
Water Temperature 38.5° F Air Temperature 43.0° F

Surface Cages

Distance	Taxa	Results
10 m	Noturus insignis	died immediately
	Cyprinus carpio	survived after 8 days
	two Lepomis sp.	survived after 8 days
	Micropterus dolomieui	died immediately
	Notropis rubellus	died immediately
	Notropis cornutus	died immediately
15 m	two Noturus insignis	died within 24 hrs.
	two Cyprinus carpio	died immediately
	two Lepomis sp.	died immediately
	Micropterus dolomieui	died within 24 hrs.
	Notropis spilopterus	died immediately
	Pimephales notatus	died immediately
20 m	Hypentelium nigricans	died within 24 hrs.
	two Cyprinus carpio	died immediately
	two Lepomis sp.	died immediately
	two Notemigonus crysoleucas	died immediately
	Notropis spilopterus	died immediately
40 m	Cyprinus carpio	survived after 8 days
	five Lepomis sp.	survived after 8 days
	Micropterus salmoides	survived after 8 days
	two Notropis spilopterus	survived after 8 days
50 m	Hypentelium nigricans	survived after 8 days
	Noturus insignis	survived after 8 days
	Cyprinus carpio	survived after 8 days
	five Lepomis sp.	survived after 8 days
	Ambloplites rupestris	survived after 8 days
	Micropterus dolomieui	survived after 8 days
	two Notropis spilopterus	survived after 8 days
	Pimephales notatus	survived after 8 days

Bottom Cages (for 25 pound charge)

Distance	Taxa	Results
10 m	Catastomus commersoni	died within 24 hrs.
	three Noturus insignis	died within 24 hrs.
	two Cyprinus carpio	died within 24 hrs.
	Ambloplites rupestris	died within 24 hrs.
	three Micropterus salmoides	died within 24 hrs.
	two Notropis spilopterus	died within 24 hrs.
15 m	Catastomus commersoni	died within 24 hrs.
	two Noturus insignis	died within 24 hrs.
	two Cyprinus carpio	died within 24 hrs.
	three Lepomis sp.	died within 24 hrs.
	two Ambloplites rupestris	died within 24 hrs.
	Micropterus dolomieui	died within 24 hrs.
	Micropterus salmoides	died within 24 hrs.
	two Notropis spilopterus	died within 24 hrs.
20 m	Catastomus commersoni	died within 24 hrs.
	Noturus insignis	died after 72 hrs.
	two Cyprinus carpio	died immediately
	three Lepomis sp.	died immediately
	Notemigonus crysoleucas	died immediately
	Notropis spilopterus	died immediately
30 m	Catastomus commersoni	died immediately
	two Noturus insignis	died immediately
	two Cyprinus carpio	died immediately
	four Lepomis sp.	died immediately
	Pimephales notatus	died immediately
40 m	Catastomus commersoni	died immediately
	two Noturus insignis	died immediately
	Cyprinus carpio	died immediately
	four Lepomis sp.	died immediately
	Ambloplites rupestris	died immediately
	Micropterus dolomieui	died immediately
	two Notropis spilopterus	died immediately
	two Pimephales notatus	died immediately
50 m	Noturus insignis	died within 24 hrs.
	two Cyprinus carpio	died within 24 hrs.
	two Lepomis sp.	died within 24 hrs.
	Notropis rubellus	died within 24 hrs.
	Notropis rubellus	survived after 8 days
	two Micropterus salmoides	survived after 8 days
	Notropis spilopterus	survived after 8 days

B. Trexler Bridge, February 21, 1974, West Span, 15 pound charge
Water Temperature 39.5° F Air Temperature 51.0° F

Surface Cages

Distance	Taxa	Results
40 m	two Lepomis sp.	died within 24 hrs.
	Micropterus dolomieui	survived after 7 days
	Notemigonus crysoleucas	survived after 7 days
	two Notropis spilopterus	survived after 7 days
50 m	Lepomis sp.	survived after 7 days
	Micropterus dolomieui	survived after 7 days
	Notropis spilopterus	survived after 7 days
60 m	Catastomus commersoni	survived after 7 days
	Hypentelium nigricans	survived after 7 days
	Noturus insignis	survived after 7 days
	two Lepomis sp.	survived after 7 days
	Lepomis sp.	died within 24 hrs.
	Micropterus salmoides	survived after 7 days
	Notemigonus crysoleucas	survived after 7 days
	Notropis rubellus	survived after 7 days
	three Notropis spilopterus	survived after 7 days
	Pimephales notatus	survived after 7 days
70 m	four Lepomis sp.	survived after 7 days
	Micropterus salmoides	survived after 7 days
	two Notropis rubellus	survived after 7 days
	two Notropis spilopterus	survived after 7 days
	Notropis hudsonius	survived after 7 days
	Hybopsis micropogon	survived after 7 days

Bottom Cages (for 15 pound charge)

Distance	Taxa	Results
50 m	Hypentelium nigricans	survived after 7 days
	two Noturus insignis	died after 48 hrs.
	Noturus insignis	died immediately
	four Lepomis sp.	died immediately
	two Notropis spilopterus	died immediately
60 m	Noturus insignis	survived after 7 days
	Cyprinus carpio	died after 48 hrs.
	Cyprinus carpio	died after 5 days
	two Lepomis sp.	died immediately
	Ambloplites rupestris	survived after 7 days
	Notemigonus crysoleucas	survived after 7 days
	two Notropis spilopterus	died after 48 hrs.
70 m	Noturus insignis	survived after 7 days
	two Lepomis sp.	survived after 7 days
	two Notemigonus crysoleuca	survived after 7 days
	Notropis rubellus	survived after 7 days
	two Notropis spilopterus	survived after 7 days
	Micropterus dolomieui	died immediately
	Lepomis sp.	died after 72 hrs.
80 m	Noturus insignis	died after 48 hrs.
	Lepomis sp.	died after 48 hrs.
	two Micropterus salmoides	died after 48 hrs.
	Lepomis sp.	survived after 7 days
	two Notropis spilopterus	survived after 7 days

After the 25 pound explosion, 78 white crappie (Pomoxis annularis) and a few Spotfin shiners (Notropis spilopterus) were collected on the surface close to the blast. They were all about 2.5 inches in length. After the smaller blast, about 12 Pomoxis were observed on the bottom and several larger fish were collected and autopsied (see appendix). On February 22, only eight additional Pomoxis and Notropis (length 2-4") were found dead in the entire downstream area.

CONCLUSIONS

For the 25 pound explosion:

1) only 17% of all the fish survived the blast up to 50 m. away. Of these survivors, 77% were in surface cages and only 23% were closer than 30 m. to the blast.

2) No fishes survived in bottom cages closer than 40 m. to the blast.

3) Three fish survived in a surface cage at 10 m. while fish of the same type were killed as far away as 40 m. This probably was due to the cage and fish being blown out of the water thus escaping the harmful effects of the shock wave.

4) Lepomis, Cyprinus, Micropterus and Notropis spilopterus showed lowest mortality of all types. However, results were not conclusive as to the species effects of the explosions.

For the 15 pound explosion:

1) 64% survived from 40 to 80 m. from the blast.

2) Of these survivors, 67% were in surface cages.

Detrimental effects were observed as far away as 150 m., while several fish survived as close as 10 m.

Autopsies revealed:

1) bruised or ruptured liver

2) ruptured air bladder

3) dorsal peritoneum covering kidney ruptured

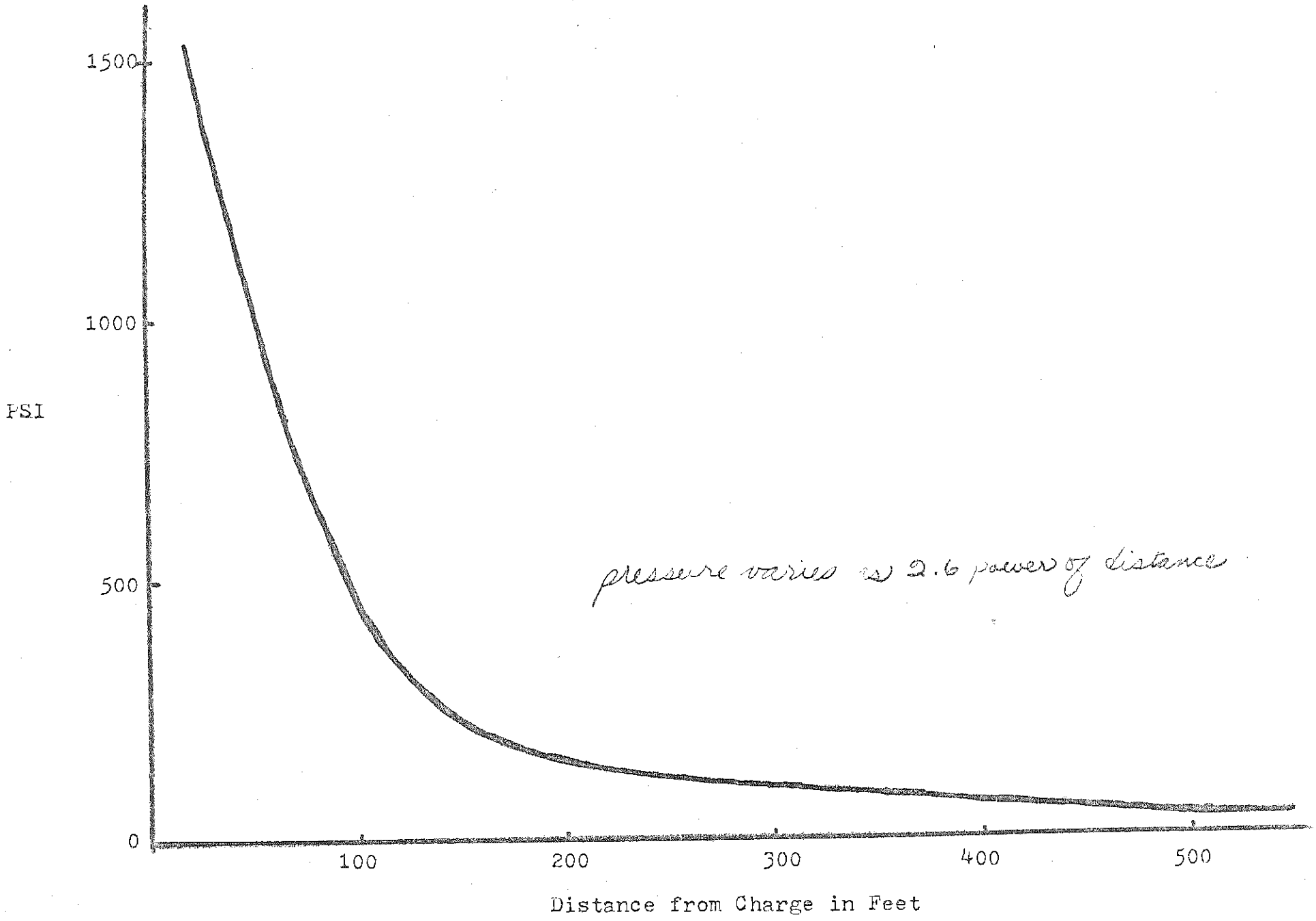
4) blood clotting in body cavity

5) walls of body cavity badly bruised

6) tissue and bone dorsal and posterior to swim bladder badly ruptured

APPENDIX - Autopsies

Name	Length	Sex	Location
Pomoxis annularis	12.5	Female	within 20 m. of blast
Pomoxis annularis	12.5	Female	within 20 m. of blast
Micropterus dolomieui	13.25	Male	150 m. + from blast
Ambloplites rupestris	8.5	Female	within 30 m. of blast
Salmo trutta	14.25	Female	within 30 m. of blast


1500
1000
500
0
PSI
100
200
300
400
500
Distance from Charge in Feet
pressure varies as 2.6 power of distance

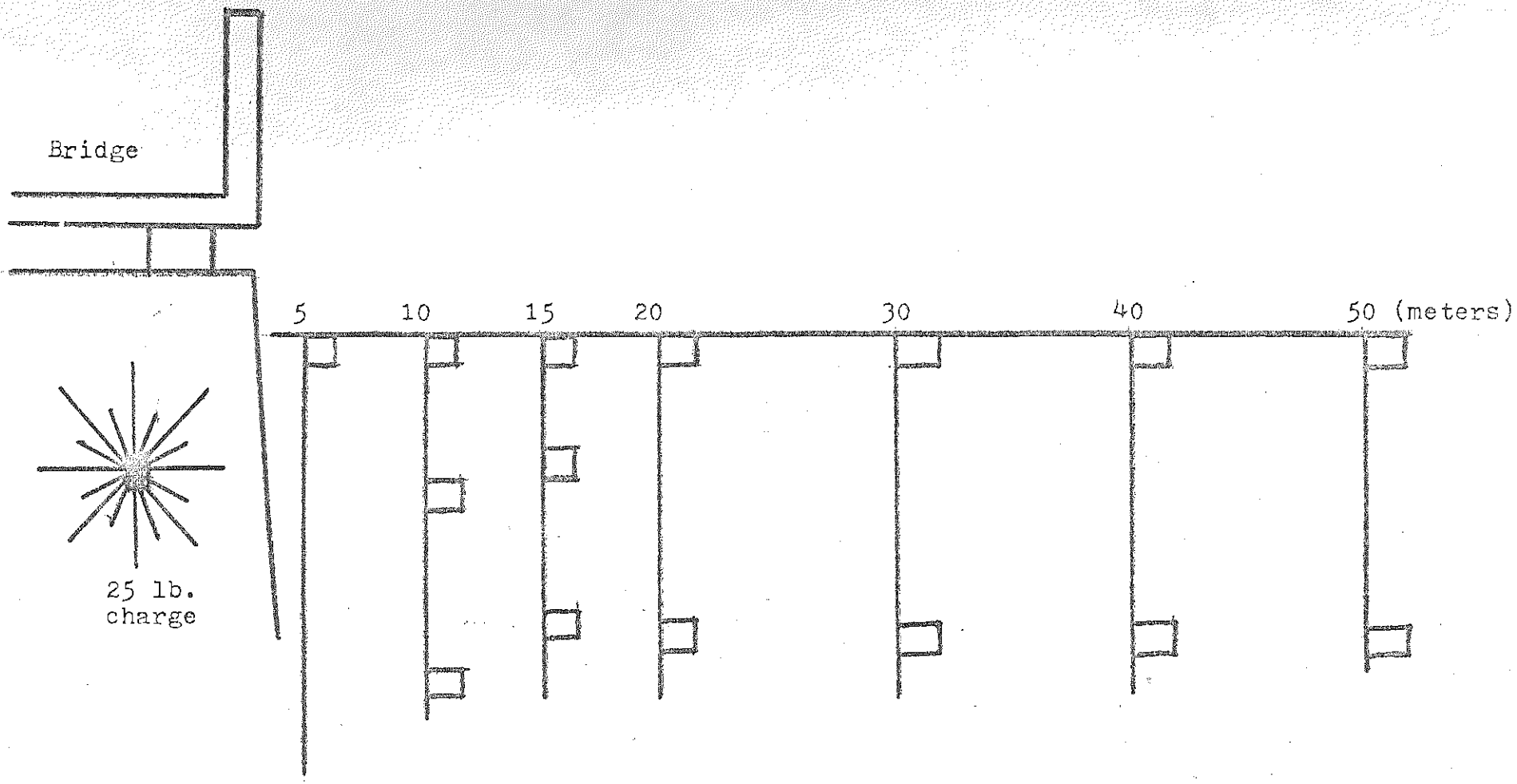
Trexler Bridge February 20, 1974 25 lb. charge

	Surface						Bottom					
	10 m.	15 m.	20 m.	30 m.	40 m.	50 m.	10 m.	15 m.	20 m.	30 m.	40 m.	50 m.
Catastomus commersoni							X	X	X	X	X	
Hypentelium nigricans			X			0						
Noturus insignis	X	X					X	X	X	X	X	X
Cyprinus carpio	0	X	X		0		X	X	X	X	X	X
Lepomis sp.	0	X	X	0	0			X	X	X	X	X
Ambloplites rupestris							X	X			X	
Micropterus dolomieui	X	X						X			X	
M. salmoides					0		X	X				0
Notropis rubellus	X											X
N. spilopterus		X	X	X	0		X	X	X		X	
Notemigonus crysoleucas			X						X			
Pimephales notatus		X								X	X	

Trexler Bridge February 21, 1974 15 lb. charge

	Surface				Bottom					
	40 m.	50 m.	60 m.	70 m.	40 m.	50 m.	60 m.	70 m.	80 m.	Control
Catastomus commersoni			0							0
Hypentelium nigricans			0			0				0
Noturus insignis			0			X	0	0	X	0
Cyprinus carpio							X			0
Lepomis sp.	X	0	0	0		X	X	0	0	0
Ambloplites rupestris							0			0
Micropterus dolomieui	0	0		0				X		0
M. salmoides			0	0					X	0
Notropis rubellus			0	0				0		X
N. spilopterus	0	0	0	0		X	X	0	0	0
Notemigonus crysoleucas	0		0				0	0		0
Pimephales notatus			0	0						X


Top View
50
15
40
13
30
11
20
9
5
7
10
4
5
1
Current
Top View
Current
80
70
60
50
40
BRIDGE
50m
40m
30m
20m
15m
10m
5m
80m
70m
60m
50m
40m
SIDE VIEWS
distances in meters from blast


Bridge
5
10
15
20
30
40
50 (meters)
25 lb.
charge

1975

The Establishment of Benthic Macroinvertebrates on Artificial Substrates in Lake Raystown, Pa.

Al Crane
Spring Term 1975
Independent Study

Abstract

A survey of the benthic macroinvertebrate community and the distribution of its members over the different depths and bottom types was undertaken in the Juniata College field station harbor during March, April, and May 1975.

A series of five (partial) dredge samples were gathered using a Ponar dredge to compile a reference collection and gain experience in identifying the resident macroinvertebrates of the field station harbor. The results obtained from the five dredge samples showed that the Oligochaetes (Lumbricidae), the Chironomids (Tendipedidae), the Plecoptera, and the Pea Clams (Pisidium) were most abundant.

A set of sixteen multiplate, hardboard samplers, set out along two transect lines in the harbor and exposed for a period of six weeks, of which fifteen were recovered was used to calculate the average population and the diversity indices. The results obtained showed the Oligochaetes (Enchytraeidae, Lumbricidae), the Cladocera (Eurycercus), the Copepods (Limnocalanus, Diaptomus), the Chironomids (Tendipedidae), and the Ephemeroptera were most abundant.

Calculated from the sampler data gathered, the number of invertebrates per square meter was equal to 93.75. The diversity indices calculated from the sampler data were: the species richness or variety index, $d=9.7552$; the Shannon - Weaver function for mean diversity, $\bar{d}=13.5471$; the Shannon index of general diversity, $\bar{H}=1.1319$; and the eveness index, $e=.8312$.

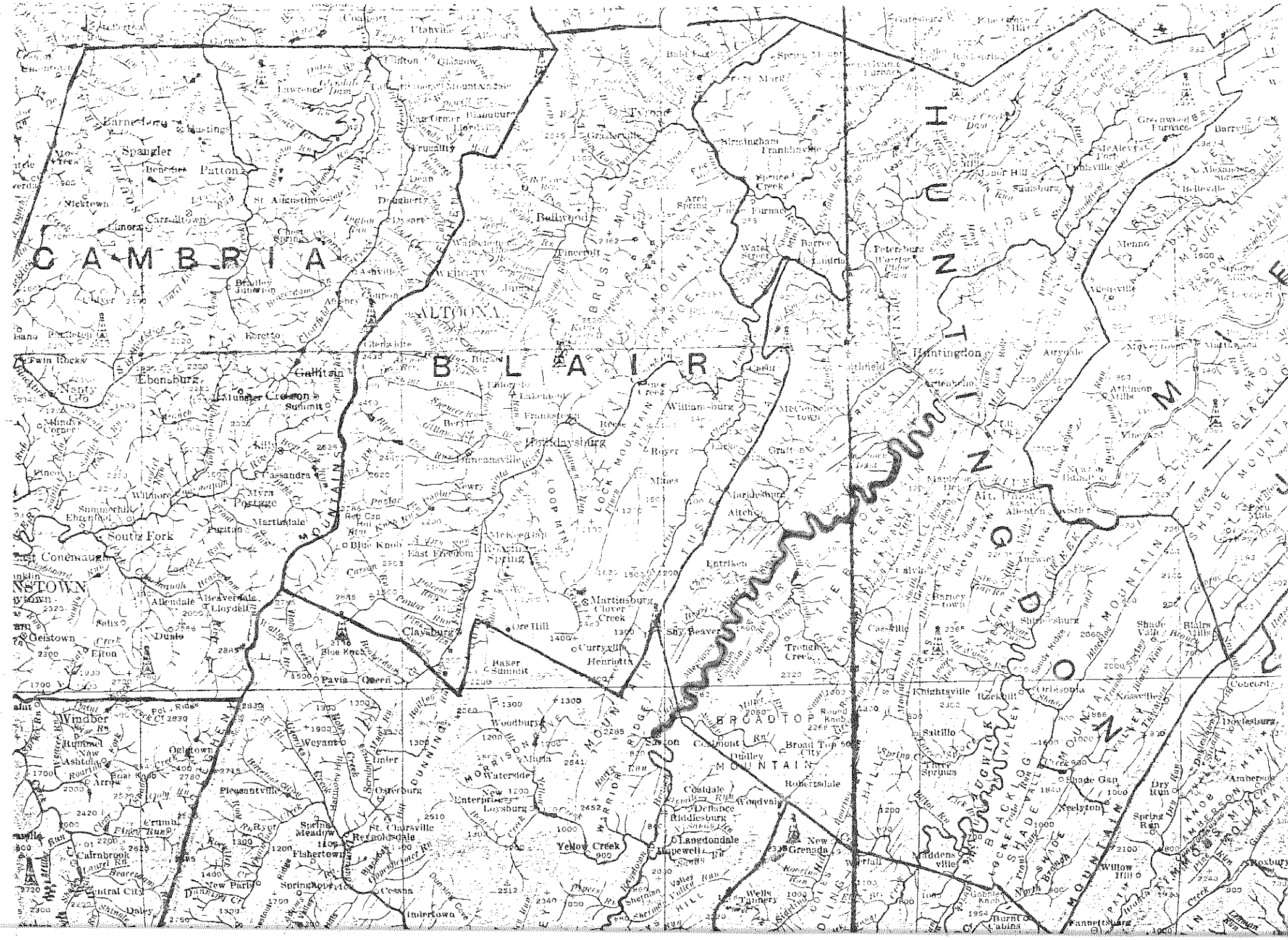
The Study Area

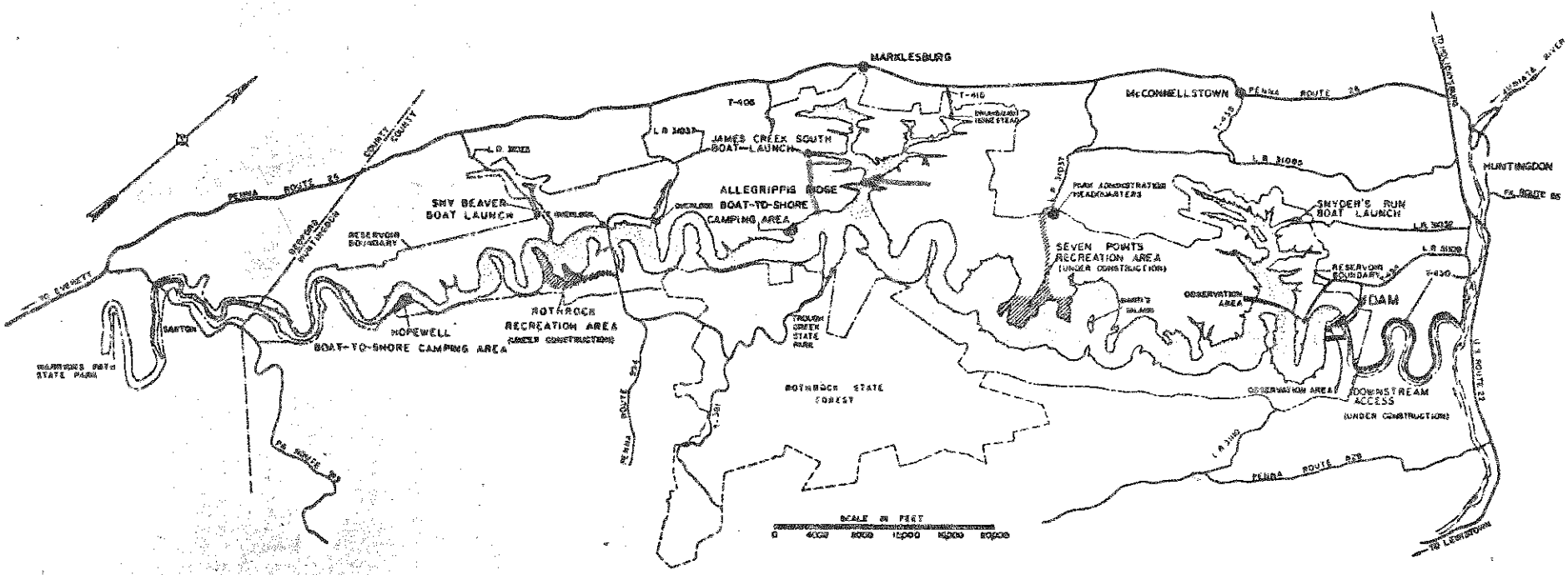
The Raystown Lake Project

The 8,300 acre, 30 mile long Raystown Lake follows the river bed of the old Raystown Branch of the Juniata River in Huntingdon County, Pennsylvania. Authorized in 1962 by the Flood Control Act, the dam site built by the Army Corps of Engineers, was completed in 1974. The dam site is located approximately 5.5 miles upstream from the junction of the Raystown Branch with the Juniata River and approximately 92 miles upstream from the junction of the Juniata River with the Susquehanna River.[1] The present water level of 786 feet above sea level was first attained in early March of 1975. This was preceeded by a partial filling of the lake and then a large draining of the lake in the fall of 1974 to allow clearing operations to be completed.

The Field Station Harbor

The Juniata College Field Station harbor lies on the eastern margin of the field station property which lies approximately 3.5 miles east north east of the village of Entriken. The field station harbor lies approximately 9 miles south west of the Raystown Dam breast. The .25 mile long harbor is bordered on the north by an unnamed ridge and to the south by Allegrippis Ridge. It is fed from the west by a small shale bottomed stream. The harbor covers an old road, the old stream bed, a clear cut forest area, and an old field. The deepest part of the harbor which lies at the mouth of the harbor is approximately 55 feet, located over the old stream bed.


CAMBRIA
BLAIR
HUNTINGDON
ALTOONA
Ebensburg
Hollidaysburg
Huntingdon
Windber
Johnstown
Spangler
Patton
Carrolltown
Nicktown
Twin Rocks
Nanty Glo
Gallitzin
Munster
Cresson
Summit
Williamsburg
Martinsburg
Clover Creek
Claysburg
Blue Knob
Pavia
Queen
Baker Summit
Curryville
Henrietta
Ore Hill
Sly Beaver
Troutg Creek
Entriken
Alexandria
Mill Creek
Shade Gap
Orbisonia
Three Springs
Robertsdale
Coalsdale
Riddlesburg
Defiance
Langdondale
Yellow Creek
Saltillo
Knightsville
Dudleyville
Broad Top City
Broad Top
Woodbury
Weyant
Osterburg
Pleasantville
Fishertown
Reynoldsdale
St. Clairsville
Cairnbrook
Central City
New Paris
Springhope
Ceasna
Waterside
Loysburg
Enterprise
Coaldale
Defiance
Riddlesburg
Langdondale
Yellow Creek
Tatesville
Maddensville
Fannettsburg
Burnt Cabins
Willow Hill
Neelyton
Dry Run
Spring Run
Roxbury
Mercersburg
Shippensburg
Blairs Mills
Shade Valley
Concord
Doylestown
Amberson
Mount Union
Petersburg
Warriors Mark
Birmingham
Frankstown
Tyrone
Bellwood
Tipton
Altoona
Hollidaysburg
Huntingdon
Mount Union
Shade Gap
Broad Top
Broad Top City
Robertsdale
Saltillo
Knightsville
Shippensburg
Mercersburg
Fannettsburg
Burnt Cabins
Willow Hill
Neelyton
Dry Run
Spring Run
Roxbury


HARRISBURG
McCONNELLSTOWN
PENNA ROUTE 26
PENNA ROUTE 994
PENNA ROUTE 829
T-406
T-416
T-410
T-430
L.R. 31085
L.R. 31086
L.R. 31087
L.R. 31088
L.R. 31089
L.R. 31090
L.R. 31091
L.R. 31092
L.R. 31093
L.R. 31094
L.R. 31095
L.R. 31096
L.R. 31097
L.R. 31098
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L.R. 31101
L.R. 31102
L.R. 31103
L.R. 31104
L.R.

United States

Department of the Interior

Geological Survey

Commonwealth of Pennsylvania

Department of Environmental Resources

Toppgraphic and Geologic Survey

Entriken, Pa.

1963 Photorevised 1972

Map Key



Study Area



Lake Area

——— Access Roads

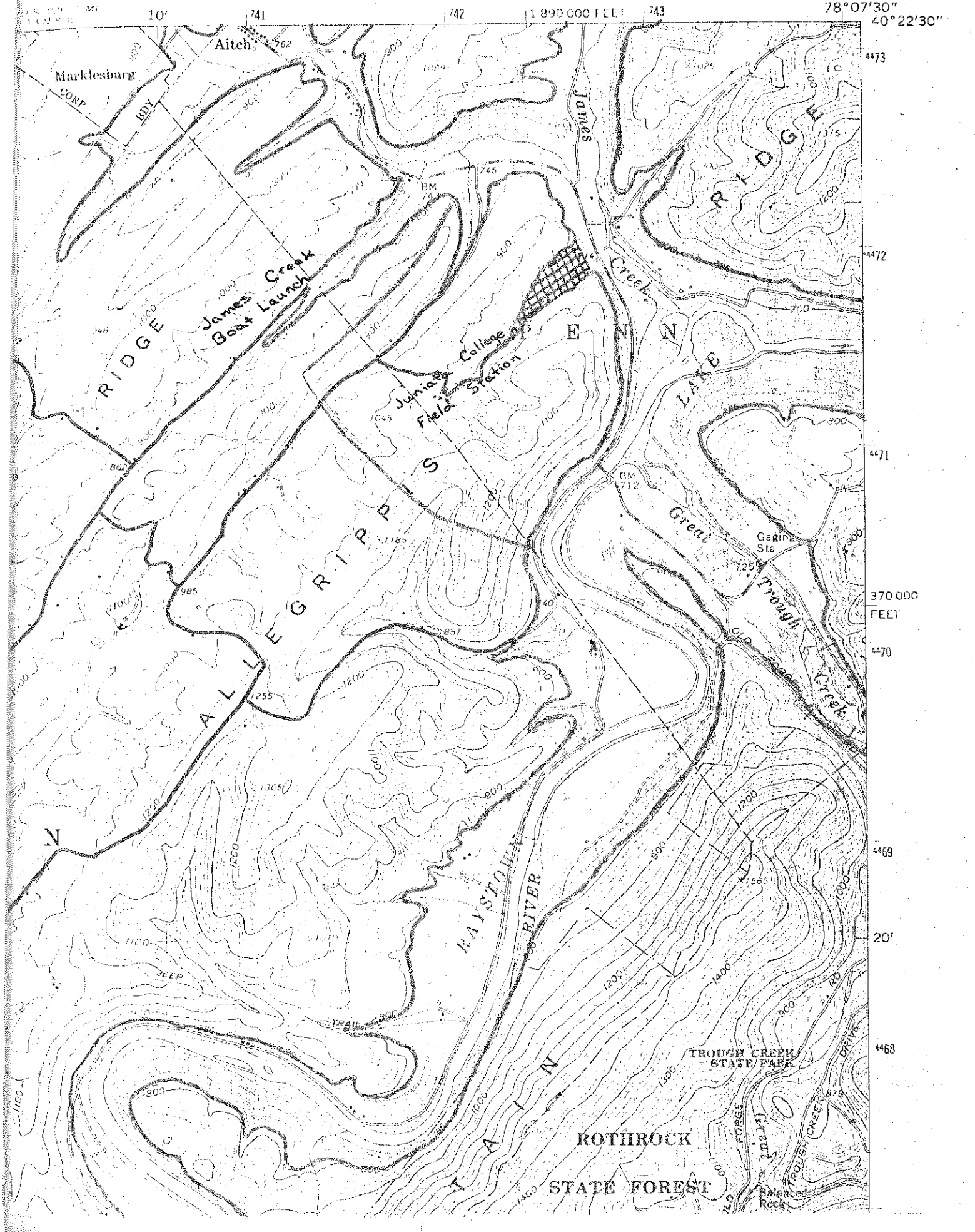


1 Mile

Contour Interval 20 feet

Photocopied and Modified in Part May 1975

ENTRIKEN QUADRANGLE
PENNSYLVANIA
7.5 MINUTE SERIES (TOPOGRAPHIC)



Key to Harbor Map



Submerged Area

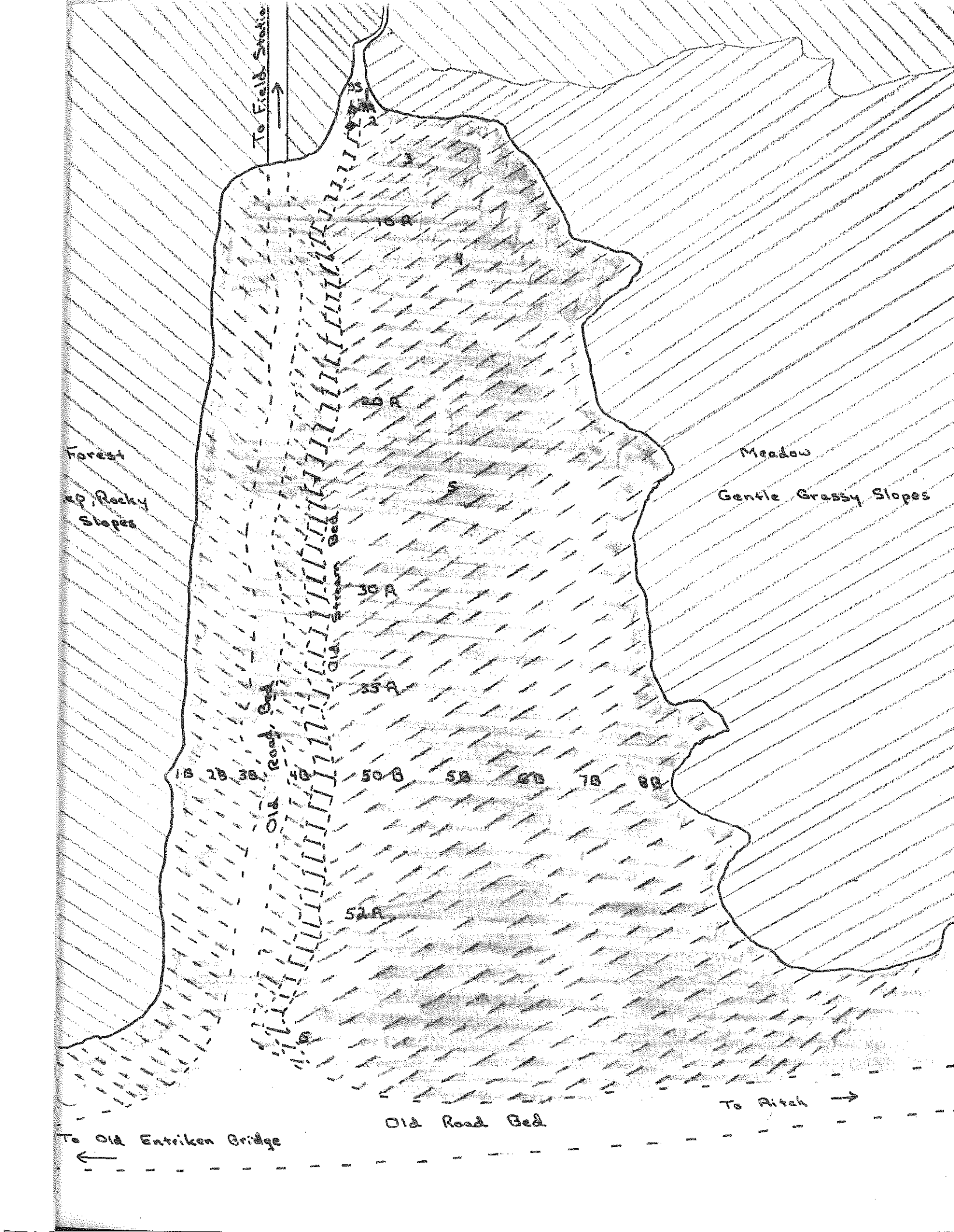


Forest Area



Meadow Area

#	Dredged Sample Site
#A.B	Sampler Site
SS	Stream Sampler Site


To Field Station
Forest
Meadow
Gentle Grassy Slopes
Old Road Bed
Old Road Bed
To Aitah
To Old Entriken Bridge
1B
2B
3B
4B
5B
6B
7B
8B
10A
20A
30A
33A
52A

Depth of Sampling Stations

1 = 6 inches

2 = 3 feet

3 = 5 feet

4 = 10 feet

5 = 15 feet

6 = 55 feet

SS = 2 feet

1A = 3 feet

10A = 10 feet

20A = 20 feet

30A = 30 feet

35A = 35 feet

52A = 50 feet

1B = 1 foot

2B = 10 feet

3B = 20 feet

4B = 30 feet

50B = 40 feet

5B = 30 feet

6B = 20 feet

7B = 10 feet

8B = 1 foot

Introduction

The study was undertaken to extablish base line data for future surveys of the same type, as the benthic community will undoubtably undergo a large successional change as the lake community matures. Other objectives fo the study were to learn something about limnological methods in the lentic environment and to explore the composition of the benthic macroinvertebrate community.

Lake Raystown is presently an oligotrophic lake (poor in nutritive values) and has characteristics of most oligotrophic lakes as described by Alsterberg (1927) namely relatively great depth and steep sides. In such basins not only can very little sediment deposit remain on the sides but also the contact area of a water stratum of given depth with the basin is much smaller on the steep bottom slope than on the more gentle slopes of many eutrophic (rich in nutritive values) lakes.[2] Many physical factors affect the productivity, among them; length of shoreline, the slope of the bottom, and the presence of protected shoal areas proposed by Welch (1935); and the rate of water renewal, temperature, and dissolved oxygen content as proposed by McNaughton and Wolf (1973). The age of the lake must also be considered when evaluating the productivity as each successive year after the birth of the lake more nutrients will accumulate from runoffs and present populations, allowing a larger carrying capacity than the previous year up to a certain level.

The multiplate, hardboard samplers were selected for the study due to the ease of handling, the standardization of the sampling unit, the negligible amounts of extraneous material

contained, permitting faster more efficient processing, and the fact that the bottom substrate was not constant and the samplers offered a partial solution to the problem of specific substrate type organism sampling.

Methods

Artificial substrate samplers were made of fourteen 7.5 centimeter diameter discs, and twenty four 2.5 centimeter diameter spacers of .3 centimeter thick tempered hardboard. The samplers were arranged on a six inch .625 centimeter diameter eyebolt so that there were eight single spaces, one double space, two triple spaces, and two quadruple spaces. The samplers, having an effective surface area of .13 square meters, were then positioned on two transect lines at different depths and anchored on the bottom with a red milk bottle float to mark each sampling station (refer to map for positions in harbor). A total of sixteen sampling stations were established, of which fifteen were recovered after a recommended exposure period of six weeks.[3] The fifteen samplers were recovered through use of scuba gear and one gallon plastic salad dressing jars which were opened upon reaching the bottom and closed after inserting the sampler, then brought to the surface and labeled.

During the six week exposure period the benthic organisms were sampled from different depths using a Ponar dredge. The dredge was lowered over the side of the johnboat until the bottom was reached and the dredge triggered. Samples were brought to the surface, emptied into plastic dish pans, and packed into holding jars for the trip to the lab. A total of five dredge samples were analyzed from different depths along with one specimen picked by hand from the shoreline at the mouth of the stream.

The dredged samples were preserved in 70% denatured

ethanol prior to sorting and the sampler specimens preserved in 70% ethanol after sorting.

Sorting was accomplished in the lab by sieving using a U.S. Standard No. 30 sieve to wash excess silt and dirt away, then examining the processed sample in first a white enamel then a black dissection pan filled with .75 inches of water as recommended by Solem (1973). Specimens were removed from sampling discs and rocks using a soft toothbrush after the samplers were disassembled for processing. Numbers and types of organisms present at each sampling station were recorded and specimens stored in small vials prior to identification.

Identification of the specimens was accomplished using numerous taxonomic keys and a dissection microscope set at 30x magnification. Specimens were then labeled and stored in vials according to species and location.

A set of tables was then drawn up for the dredged specimens and numbers recorded along with the % of total numbers. A set of tables was also drawn up for the sampler specimens recording numbers present, % of total numbers, number per square meter, $n_i \log n_i$, P_i, $\log P_i$, and $P_i \log P_i$. These figures were later used for calculating the diversity indices for the sampler specimens.

A second set of tables was drawn up for both the dredged specimens and the sampler specimens to determine if there were any relationships between the species found and the depth and bottom type where the sampling station was located.

Physical measurements were taken on five different dates

to determine temperature and dissolved oxygen levels. Graphs were compiled to determine if there was any general trend occurring over the measurement period.

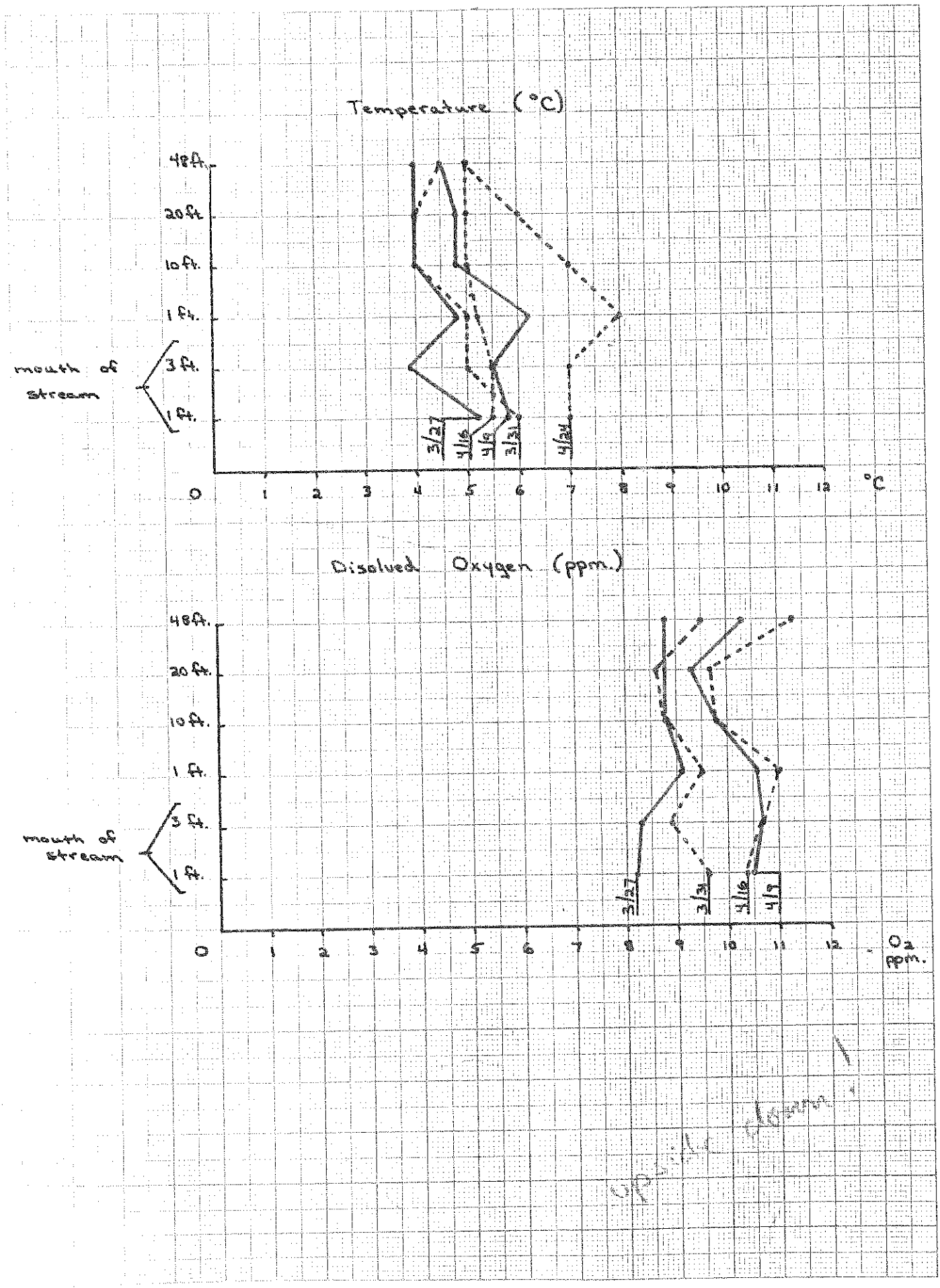
It was noticed when retrieving the samplers that a heavy algal growth was located on the upper five feet of the milk bottle float lines. A sample was obtained, preserved in 70% denatured ethanol, and brought back to the lab for qualitative analysis.

Dissolved Oxygen and Temperature Measurements

°C

ppm.

			3/27	3/31	4/9	4/16	4/24
Mouth of Stream	edge	1ft.	5.2°	6.0°	5.8°	5.5°	7.0°
			8.2	9.6	10.5	10.4	---
	center	3ft.	3.9°	5.0°	5.5°	5.5°	7.0°
			8.3	8.9	10.7	10.7	---
Meadow Side of Harbor	edge	1ft.	4.8°	5.0°	6.2°	5.2°	8.0°
			9.1	9.5	10.6	11.0	---
		10ft.	4.0°	4.0°	4.8°	5.0°	7.0°
			8.8	8.8	9.8	9.8	---
		20ft.	4.0°	4.0°	4.8°	5.0°	6.0°
			8.8	8.6	9.3	9.7	---
		48ft.	4.0°	4.5°	4.5°	5.0°	5.0°
			8.8	9.5	10.3	11.3	---


Temperature (°C)
48ft.
20ft.
10ft.
1 ft.
3 ft.
1 ft.
mouth of stream
3/27
4/16
4/9
3/31
4/24
0
1
2
3
4
5
6
7
8
9
10
11
12
°C
Dissolved Oxygen (ppm.)
48ft.
20 ft.
10 ft.
1 ft.
3 ft.
1 ft.
mouth of stream
3/27
3/31
4/16
4/9
0
1
2
3
4
5
6
7
8
9
10
11
12
O2 ppm.

Dredged Specimens Data

Total # of Individuals = 170
Total # of Species = 22

	#	% Total #
Annelida		
Oligochaeta		
Enchytraeidae	2	1.18
Lumbricidae	50	29.41
Insecta		
Coleoptera		
Dryopidae	1	.59
Collembola		
Hypogastruridae	2	1.18
Diptera		
Simuliidae		
Prosimulium	1	.59
Stratiomyiidae		
Eulalia	1	.59
Tabanidae		
Chrysops	3	1.76
Tendipedidae	32	18.82
Diamesinae	2	
Tanypodinae	3	
Tipulidae		
Limnophila	1	.59
Ormosia	2	1.18
Polymeda	1	.59
Pseudolimnophila	2	1.18
Tipula	5	2.94

Dredged Specimens Data (con't.)

	#	% Total #
Ephemeroptera		
Baetidae		
Ameletus	1	.59
Heptageniidae		
Heptagenia	2	1.18
Neuroptera		
Sialidae		
Sialis	1	.59
Plecoptera		
Chloroperlidae		
Alloperla	1	.59
Chloroperla	14	8.24
Nemouridae		
Brachyptera	2	1.18
Perlodidae		
Isoperla	15	8.82
Molusca		
Pelecypoda		
Sphaeriidae		
Pisidium	26	15.29

Sampler Specimens Data

Total # of Individuals = 180
Total # of Samplers = 15
Surface Area/Sampler = .13m^2
Total Surface Area = 1.92m^2

	#	% Total #	#/m^2	$n_i \log n_i$	P_i	$\log P_i$	$P_i \log P_i$
Annelida							
Oligochaeta							
Enchytraeidae	11	6.11	5.641	11.4553	.0612	-1.2132	-.0743
Lumbricidae	10	5.55	5.128	10.0000	.0556	-1.2549	-.0647
Arthropoda							
Cladocera							
Chydoridae							
Eurycercus	12	6.66	6.154	12.9501	.0667	-1.1758	-.0784
Copepoda							
Centropagidae							
Limnocalanus	14	7.77	7.180	16.0457	.0778	-1.1090	-.0862
Diaptomidae							
Diaptomus	10	5.55	5.128	10.0000	.0556	-1.2549	-.0697
Coelenterata							
Hydridae	8	4.44	4.103	7.2247	.0445	-1.3516	-.0601
Insecta							
Coleoptera							
Hydraenidae	1	.55	.513	0.0000	.0055	-2.2596	-.0124
Collembola							
Hypogastruridae							
Anurida	1	.55	.513	0.0000	.0055	-2.2596	-.0124
Diptera							
Tendipedidae							
Chironominae	42	23.33	21.539	68.1764	.2336	-0.6315	-.1475

Sampler Specimens Data (con't.)

	#	% Total #	#/m^2	$n_i \log n_i$	P_i	$\log P_i$	$P_i \log P_i$
Diptera							
Tendipedidae							
Diamesinae	8	4.44	4.103	7.2247	.0445	-1.3516	-.0601
Podonominae	7	3.88	3.590	5.9156	.0388	-1.4111	-.0547
Tanypodinae	24	13.33	12.308	33.1250	.1335	-0.8745	-.1167
Ephemeroptera							
Baetidae							
Caenis	9	5.00	4.615	8.5881	.0501	-1.3001	-.0651
Paraleptophlebia	1	.55	.513	0.0000	.0055	-2.2596	-.0124
Heptageniidae							
Heptagenia	1	.55	.513	0.0000	.0055	-2.2596	-.0124
Stenonema	2	1.11	1.026	.6020	.0111	-1.9546	-.0216
Leptophlebiidae							
Thraulodes	1	.55	.513	0.0000	.0055	-2.2596	-.0124
Traverella	2	1.11	1.026	.6020	.0111	-1.9546	-.0216
Plecoptera							
Perlidae							
Neoperla	2	1.11	1.026	.6020	.0111	-1.9546	-.0216
Perlodidae							
Isoperla	5	2.77	2.564	3.4948	.0277	-1.5575	-.0431
Odonata							
Lestidae							
Archilestes	1	.55	.513	0.0000	.0055	-2.2596	-.0124

Sampler Specimens Data (con't.)

	#	% Total #	#/m^2	$n_i \log n_i$	P_i	$\log P_i$	$P_i \log P_i$
Molusca							
Gastropoda							
Physidae							
<u>Physa</u>	1	.55	.513	0.0000	.0055	-2.2596	-.0124
Planorbidae							
<u>Gyraulus</u>	7	3.88	3.590	5.9156	.0388	-1.4111	-.0547

Dredged Specimens Location List

	1	2	3	4	5	6
Annelida						
Oligochaeta						
Enchytraeidae		2				
Lumbricidae			43		3	
Insecta						
Coleoptera						
Dryopidae		1				
Collembola						
Hypogastruridae						
Anurida		1	1			
Diptera						
Simuliidae						
Prosimulium		1				
Stratiomyiidae						
Eulalia			1			
Tabanidae						
Chrysops			3			
Tendipedidae		20	4	5		3
Diamesinae		2				
Tanypodinae		3				
Tipulidae						
Limnophila		1				
Ormosia		2				
Polymeda		1				
Pseudolimnophila		2				
Tipula		4	1			

Dredged Specimens Location List

	1	2	3	4	5	6
Insecta						
Ephemeroptera						
Baetidae						
Ameletus	1					
Heptageniidae						
Heptagenia			2			
Neuroptera						
Sialidae						
Sialis		1				
Plecoptera						
Chloroperlidae						
Alloperla		1				
Chloroperla		14				
Nemouridae						
Brachyptera		1	1			
Perlodidae						
Isoperla			15			
Molusca						
Pelecypoda						
Sphaeriidae						
Pisidium		2	24			

Sampler Specimens Location List

	SS	1A	10A	20A	30A	35A	52A	1B	2B	3B	4B	50B	5B	6B	7B	8B
Annelida																
Oligochaeta																
Enchytraeidae							1			1	2		7			
Lumbricidae	2		1		1	1	1	1					1			2
Arthropoda																
Cladocera																
Chydoridae																
Eurycercus			1	1				5						4	1	
Copepoda																
Centropagidae																
Limnocalanus	2	1	2					3		1			2	1		2
Diaptomidae																
Diaptomus	4					1				3			1		1	
Coelenterata																
Hydridae					1							5	2			
Insecta																
Coleoptera																
Hydraenidae			1													
Collembola																
Hypogastruridae																
Anurida									1							
Diptera																
Tendipedidae																
Chironominae	1	1		5		8		12		2	2	1	2		1	7
Diamesinae					2			3					1			2

Sampler Specimens Location List

	SS	1A	10A	20A	30A	35A	52A	1B	2B	3B	4B	50B	5B	6B	7B	8B
Insecta																
Diptera																
Tendipedidae																
Podonominae			1	2	2								1		1	
Tanypodinae	2	1	4		4			3		1		1	3			5
Ephemeroptera																
Baetidae																
Caenis					1	2					1	1	3	1		
Paraleptophlebia	1															
Heptageniidae																
Heptagenia								1								
Stenonema										1	1					
Leptophlebiidae																
Thraulodes	1															
Traverella										2						
Plecoptera																
Perlidae																
Neoperla	1	1														
Perlodidae																
Isoperla	5															
Odonata																
Lestidae																
Archilestes						1										

Sampler Specimens Location List

	SS	1A	10A	20A	30A	35A	52A	1B	2B	3B	4B	50B	5B	6B	7B	8B
Molusca																
Gastropoda																
Physidae																
Physa				1												
Planorbidae																
Gyraulus						1					2		4			

Results

Diversity indices calculated from data gathered from sampler specimens.

1) Species richness or variety index (Margalef)[4]

$$d = \frac{S - 1}{\log N} = \frac{23 - 1}{\log 180} = 9.7552$$

where S = the total number of taxa; and N = the total number of individuals.

2) Shannon - Weaver function for mean diversity[5]

$$\bar{d} = \frac{C}{N} (N \log N - n_i \log n_i)$$

where C = 3.321928 (converts $\log_{10}$ to $\log_2$); N = total number of individuals; n_i = total number of individuals in the $i^{\underline{th}}$ species.

$$N \log N = 405.9490$$

$$n_i \log n_i = 201.922$$

$$\bar{d} = \frac{3.321928}{180} (405.9490 - 204.0270)$$

$$\bar{d} = 3.7745$$

3) Shannon index of general diversity[4]

$$\bar{H} = - \left(\frac{n_i}{N}\right) \log \left(\frac{n_i}{N}\right) = - P_i \log P_i = 1.1319$$

where n_i = importance value for each species (% of total number); N = total of importance values; and P_i = importance probability for each species = $\frac{n_i}{N}$.

4) Evenness index[4]

$$e = \frac{\bar{H}}{\log S} = .8312$$

Algal Sample Findings

The results of the qualitative examination of the algal sample revealed that the majority of the algal organisms present were the Chrysophyta (Golden Algae). The majority of the Chrysophyta found were the unicellular forms but some filamentous diatoms were found. The species *Tabellaria* and *Fragilaria* were most common with some *Tribonema* composing the group of filamentous diatoms.

Very few Chlorophyta (Green Algae) were found and those found were mainly of the species *Ulothrix*.

Discussion

Statistical Analysis

Four indices of diversity described in Odum (1971) and Weber (1973) were applied to the data from the 23 species of benthic invertebrates obtained with the multiplate hardboard samplers. Controled by environmental conditions, species diversity is dependent upon the number of species and the distribution of individuals among species. Species diversity indices provide measurement of diversity through ratios between the number of species and importance values (numbers, biomass, productivity, etc.).[6]

Margalef's species richness or variety index can be used to compare one community with another, provided that it is first determined that S, the total number of species, is a linear function of the log or square root of N, the total number of individuals. The species richness index is a means of sumarizing the data on total numbers of species and individuals, and says nothing about the distribution of individuals among species. The value of species richness for the study was found to be 9.7552.

The evenness index is ameasure of the distribution of individuals between species and usually ranges in value from 0 to 1 (Weber 1973). The evenness index, e, was equal to .8312 in this study. The evenness index of .8312 is also an indicator that there is no pollution degradation at the field station harbor. Slight levels of degradation by oxygen demanding waste have been found to reduce evenness values to below .50. Waters known to be unaffected by oxygen demanding

wastes have been found to have evenness indices values generally ranging from .60 to .80 (Weber 1973).

The Shannon Weaver index of mean diversity, $\bar{d}$, presented by Lloyd, Zar, Kar (1968) in the machine formula form, can be expected to be between 3 and 4 in unpolluted waters and in polluted waters generally less than 1 as found by Wilhm (1959) (Weber 1973). Mean diversity is affected by both numbers of species and the distribution of individuals among species. The value for mean diversity in this study was .3775 which is characteristic of relatively unpolluted waters. The problem with using $\bar{d}$ as a pollution indicator is that where pollution is at slight to moderate levels, $\bar{d}$ lacks the sensitivity to demonstrate differences (Weber 1973).

The Shannon index of general diversity, $\bar{H}$, combines the variety and evenness components as one overall index of diversity. This index is best used in making comparisons between communities where it is not necessary to separate diversity components and is reasonably independent of sample size thus fewer samples are necessary to obtain a reliable index for comparison purposes (Odum 1971). The Shannon index value for this study was 1.1319.

Project Discussion

The field station harbor benthic community exhibits a high degree of diversity of species, however undoubtably the full carrying capacity in numbers of organisms has not been reached as is evidenced by the low numbers of organisms recovered.

The only trends which can be determined from the study is the areas where most organisms were found. For the dredged specimens, 88.02% of the organisms recovered were found in three to five feet of water near the mouth of the stream in two dredge samples. With the sampler specimens, 61.11% of the organisms were found at or above twenty feet of water. No trends could be determined as to the main locality of species pertaining to depth or substrate due to the lack of a larger number of organisms being recovered.

Problems were encountered during dredging due to the fact that the jaws of the Ponar dredge would not close completely due to the wedging of small stones, sticks, or bunches of leaves between them and the fact that at times the trigger mechanism would fail to operate. The problem with trigger mechanism operation can be resolved by the use of a short length of medium to heavy chain to attach the dredge to the recovery line. The problem of incomplete closure of the jaws is unresolved at this time.

Problems encountered with the multiplate hardboard samplers were movement and loss of sampling stations due to high winds, heavy rains causing the lake level to rise approximately three feet, and heavy wave action. The solution to these two problems

is to use an anchor weighing approximately ten pounds and allowing at least six feet of slack in the float line.

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Footnotes

1) Army Corps of Engineers Raystown Project Office Reprint - General Information, Raystown Lake Project, 6 pages, 1975

2) Welch, Paul S., Limnology, McGraw Hill Book Co., Inc., New York, 1935, pp. 133

3) Weber, C.I., Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents, U.S. Environmental Protection Agency, Cincinnati, July 1973, pp. 10, Macroinvertebrate Section

4) Odum, E.P., Fundamentals of Ecology, W.B. Saunders Co., Philadelphia, 1971, pp. 144

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6) Odum, E.P., Fundamentals of Ecology, W.B. Saunders Co., Philadelphia, 1971, pp. 149

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1976

A SURVEY OF THE DISTRIBUTION OF THE NATIVE FISHES OF THE RAYSTOWN DRAINAGE 1976

Terrance N. Glunt
&
Richard O. Hall
Senior Research
Dr. Fisher
May 26, 1976

I. Abstract

A survey of the distribution of the native fishes of the Raystown Drainage, in Bedford, Blair, Fulton, Huntingdon, and Somerset Counties, Pennsylvania was made. Shawnee Lake and its drainage, and Raystown Lake were omitted from this survey. This information was used to prepare distribution maps for each species collected in the drainage as a result of this study.

II. Introduction

Several studies have been done on fish of the Susquehanna River Drainage, however, no recent studies, since the compleation of the U.S. Army Corps of Engineers Dam on the river in 1972 have dealt solely with the Raystown Drainage. In light of the dam and the predictions of greatly increased influxes of people to the Raystown Drainage area (because of Raystown Lake) and greatly increased recreational uses of the streams of the Raystown Drainage, a study of this type seems appropriate.

The purpose of this paper is to give an idea of species location and relative abundance within the Raystown Drainage with additional insight into reasons for this.

III. Procedures

In collecting the fish for this survey, several different methods were used. First, in deciding on streams to sample, a copy of "The Stream Map of Pennsylvania" was used. It showed the Raystown Drainage in its entirety including secondary and most of the tertiary feeder streams (in respect to the Raystown, as it is actually a tertiary stream itself in relation to the Susquehanna River). From here we went to the U.S.G.S. Topographic 15' quadrangles to select exact sample sites and access points paying special attention to stream topography. This was done so as to give the best representation of stream locales. When looking at the distribution of the sampling sites it may appear, at first, that some sections were missed. This is not the case. In selecting sites for this survey, because of the large size of the area to be studied and limited amount of time, it was necessary to choose those that were most varied in any particular areas, so that any "gaps" were actually areas deemed redundant in stream features by us(it should be pointed out that all streams on the Stream Map of Pennsylvania were at least observed and that many more not listed on this map but on the U.S.G.S. topos were also sampled or at least observed).

When collecting specimems two primary methods were used, both with varying amounts of success. The first of these entailed the use of a 110 volt A.C. "Tiny Tiger"

shocking rig placed on a backpack frame and connected to two hand held electrodes. This method was successful in most all conditions except very shallow rocky bottom streams (less than two inches), and in extremely fast water where fish came up and were carried away faster than was always possible to trap them. Its greatest asset was in shocking deep holes for larger fish that would have been difficult to seine.

The second method used was that of hand seining. Three different size nets were used of varying dimensions(4ft., 8ft., & 12ft.). The largest of these was best in medium to large streams with moderate to slow currents and depths not in excess of two and a half feet. Above these limits one could not move fast enough to hold fish in the nets. The smaller seines were particularly good in the shallow fast moving waters.

In using these nets we developed several different approaches. One of the best, in smaller streams, was to have one of us place the four foot seine at a narrow section of the stream and the other come down in front of the net turning over stones and rocks(the larger of which were replaced as they had been). This brought out various sculpins, darters, and often daces, the first two of which were frequently missed by the shocking method, being semi-protected under rocks. The seins also proved their worth as the shocking system was often prone to mechanical difficulties or failure.

After collecting the fish, all necessary data concerning the stream and fish was recorded and the specimens were then placed in one gallon plastic containers(one per sample site), labled, and immersed in a ten percent formalin solution. They were later keyed out, measured, bottled, and labled back at the lab(resources and references used for keying are cited in the bibliography).

IV. Discussion

Ambloplites rupestris - rockbass

This species was found to inhabit slow moving, clear to mildly turbid streams. With the Raystown Branch being classified as a type 1 stream for convenience of classification, the rockbass was seen to remain in the type 1 and type 2 waters especially living in the deeper pools and under embankments and overgrown bushes and trees.

Campostoma anomalum - stoneroller minnow

The stoneroller minnow was found to inhabit type 2 streams most often and occasionally small specimens were found in type 3 waters. They live in the riffles or current areas of pools that have sandy and rocky bottoms and have sufficient current to keep the bottom free from siltation, since they need the rocks and pebbles to make nests for their eggs.

Catostomus commersoni -- common white sucker

This species generally inhabits the type 2 streams, but the young were found up in the type 3 streams and some of the larger ones were found in the transaction zone between type 1 and type 2 areas such as Shy Beaver Run and Coffee Run. They were found to live in the slower moving pools of these streams usually along the bottom in areas where there is some sand or mud along with the rocks.

Cottus bairdi - mottled sculpin

The mottled sculpin was found almost exclusively in the type 3 streams and only once in a while was located in the slower type 2 waters. They inhabited the riffles of swift creeks and stay near the bottom under or near rocks. When they were found in the type 2 streams they still inhabited the riffles where the current was considerably faster.

Cottus cognatus - slimy sculpin

The slimy sculpin was found less abundant than the mottled sculpin and was located only in type 3 streams in the riffles of clear water and no sand or silt on the bottom. They also stayed close to the bottom and near or under rocks.

Ericymba buccata - silver jawed minnow

This species was only found in streams which had a moderate to swift current but also a great amount of sand and turbidity. The streams were both transitions between type 2 and type 3 near the junction of two type 3 areas. There was a large sediment load in suspension in both so that there was a sand bottom but the silt stayed suspended.

Erimyzon oblongus - creek chubsucker

The creek chubsucker was found in Little Trough Creek in a section that was mildly turbid and had a sand, mud

bottom. The current was slow to moderate with no riffles and only a wide deep section of stream. This area was a type 2 stream and had some overhanging trees and bushes but no large rocks in the water.

Esox americanus - grass pickerel

This species was found in slow moving water of the type 2 variety, and was caught in pools with muddy or sandy bottoms. There was a lot of vegetation in the water where this species was found and the water was turbid. The mud from the bottom seemed stagnant after kicking it up during capture, thus the water in the bottom of the pool was not moving much at all and it is in these areas that this species is found.

Etheostoma blennioides - greenside darter

These darters were found in the riffles of Type 2 streams near their junction to a type 1 water area. They live among the grasses and algaes of the riffles and stay near the bottom of the streambed near the rocks. None were found in the riffles of type 3 streams and only in the type 2 areas described above were they located, especially when there is vegetation in the riffles of the stream.

Etheostoma nigrum - Central Johnny darter

The Johnny darter was found to be more abundant in the drainage than the greenside darter. It was found, not

only in the riffles of streams, but in other areas of the streams where the water was generally swift. The bottoms of these areas were sandy and rocky and there was much less vegetation than that found where the greenside darter was captured. It is widespread in the drainage, but remains in the type 2 streams.

Exoglossum maxillingua - Cutlips minnow

The cutlips minnow was located in streams of the type 2 variety and only in places where the bottom was sandy and somewhat rocky and free from silt. The current was always moderate to swift, and they were caught always near rocks on the bottom, and swam from one rock to another when endangered (by the seine or shocker).

Hybopsis micropogon - river chub

This species inhabits slow moving waters of the type 2 sort and lives in streams where there is a rocky bottom and moderate to swift current. There was algae on the rocks quite extensively, but there was no grass type of vegetation in the water, and the water remained quite clear.

Hypentelium nigricans - northern hogsucker

The distribution of this species centers around streams of moderate gradient and therefore around those with a slow to moderate current, specifically in the pools of these waters. The streams are of a type 2 variety and always had a rocky bottom with pockets of sand forming the pools in between. There was also quite a bit of plant matter in the

water, both algae and detritus from overhanging trees. The northern hogsucker inhabits these sandy bottomed pools in those streams and tend to lie near the bottom of the stream-bed.

Ictalurus nebulosus - brown bullhead

The brown bullhead is located in slow to moderately moving water of the type found in type1, type 2, and the transition area between them. It lives on the bottom of the stream bed in sandy and slightly rocky areas, where there is a pool or a deep wide section of the stream. There was also a high amount of plant matter in the water, both in the form of algae and detritus from bushes and trees.

Lepomis gibbosus - pumpkinseed

This species of sunfish is found in slow to moderately moving water in type 1 or type 2 streams where there is a pool or a backwater. They were found in both areas of high vegetation and also over areas where there were just rocky bottoms and sand. They did not tend to stay near the bottom, but instead swam through all the stratifications of the stream area. The only part of the stream that they did not inhabit was the riffle area and any other swiftly moving water.

Lepomis macrochirus - bluegill

The bluegill inhabits the same areas as the pumpkinseed mentioned before and was captured at the same locations.

Micropterus dolomieui - smallmouth bass

This species inhabits type 1 and type 2 streams where the current is not swift and there is sufficient cover, such as rocks or logs in the water. The streams were clear to slightly turbid and generally there were overhanging banks with pools under them. It is in these pools that the bass were caught. The bottom of the streams were rocky with sand accumulating in the pool bottoms.

Notropis cornutus - common shiner

This species is an extremely abundant and widespread fish which occupies all type streams, but only to a small extent in the type 3 waters. They live in moderate to swift water and only in areas where there is a rocky or a sand bottom. The turbity of the streams also varied so that the fish were caught in both clear and turbid streams, and only in those waters where the silt and mud accumulated on the bottom or the stream was too shallow or fast, were they absent.

Notropis hudsonius - spottail shiner

This shiner is also distributed widely, but it has remained in the type 2 streams, especially those which are clear, fast, and have rocky bottoms. It is not as abundant as the common shiner, and was not found in some of the more turbid or sandy streams that the common shiner was found in.

Notropis rubellus - rosyface shiner

The rosyface shiner was found in type 2 streams where the water is clear and moderate to swift in current. The species is widely dispersed geographically but its relative abundance compared to the rest of the shiners is small. They lived in areas with little vegetation and almost always had just a flat rocky bottom with a little sand, and very little turbidity if any.

Notropis spilopterus - spotfin shiner

This shiner differs from the rest in that it was only found in streams with high turbidity, and sandy bottoms. The current in these streams was moderate to fast and the fish were captured on the sandy bottoms. This species of shiner is also widely dispersed geographically, but it has a low relative abundance compared to other shiners. The streams were of type 2 were more or less level without any pools..

Noturus insignis - margined madtom

This species of 'catfish' inhabits the bottoms of pools or slow moving waters of type 1 or type 2 streams. It essentially occupies the same area as the brown bullhead, living in a stream where there is a lot of plant matter both in the water and as detritus. The streams where these madtoms were caught were also the same streams where the brown bullheads were caught.

Pimephales notatus - bluntnose minnow

This species inhabits streams which are clear, swift (usually), and have rocky bottoms with sand in between the rocks. It is extremely widespread and lives mainly in type 2 streams with a high relative abundance. It was found in waters with both a high amount of vegetation and also in some that had no vegetation visible at all, but not in any where the vegetation made the water turbid. It lives along the bottom among the rocks on the sandy bottom but does not lie on it like suckers and "catfish'.

Rhinichthys atratulus - blacknose dace

This could be the most widespread and abundant fish in the drainage. It was found in all three types of streams and also in waters that were slow to fast. But they inhabit the moderate to swift streams the most and were more abundant in streams with no turbidity. Most of them were caught in the riffles of streams where there was nothing but rocky bottom, but some were even found in pools which lie between sets of riffles along the streambed.

Rhinichthys cataractae - longnose dace

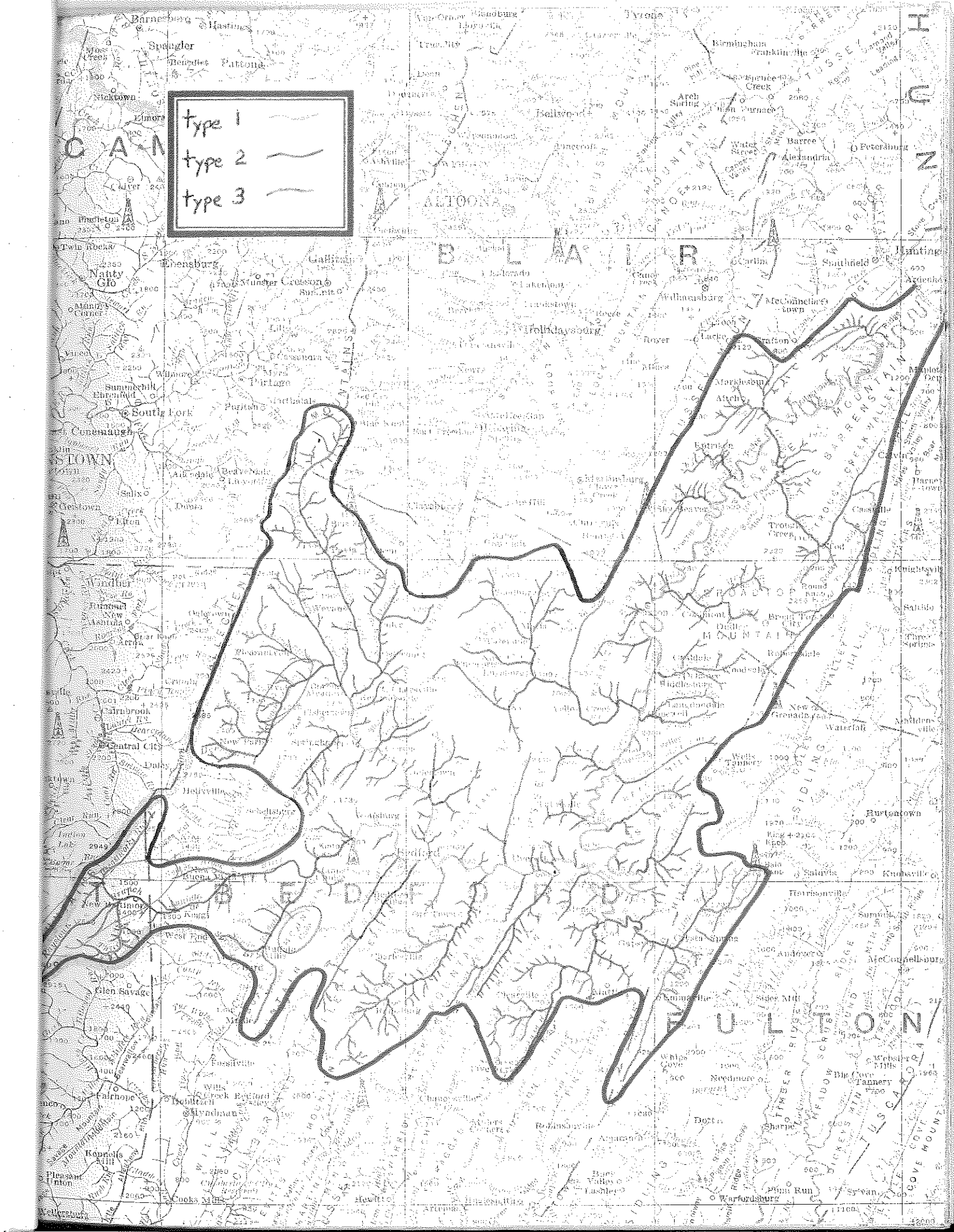
This dace is just as widespread as the blacknose dace, but it does not seem to be as abundant. It occupies the same areas of the stream as the other and is usually found in the riffles of clear, swift streams.

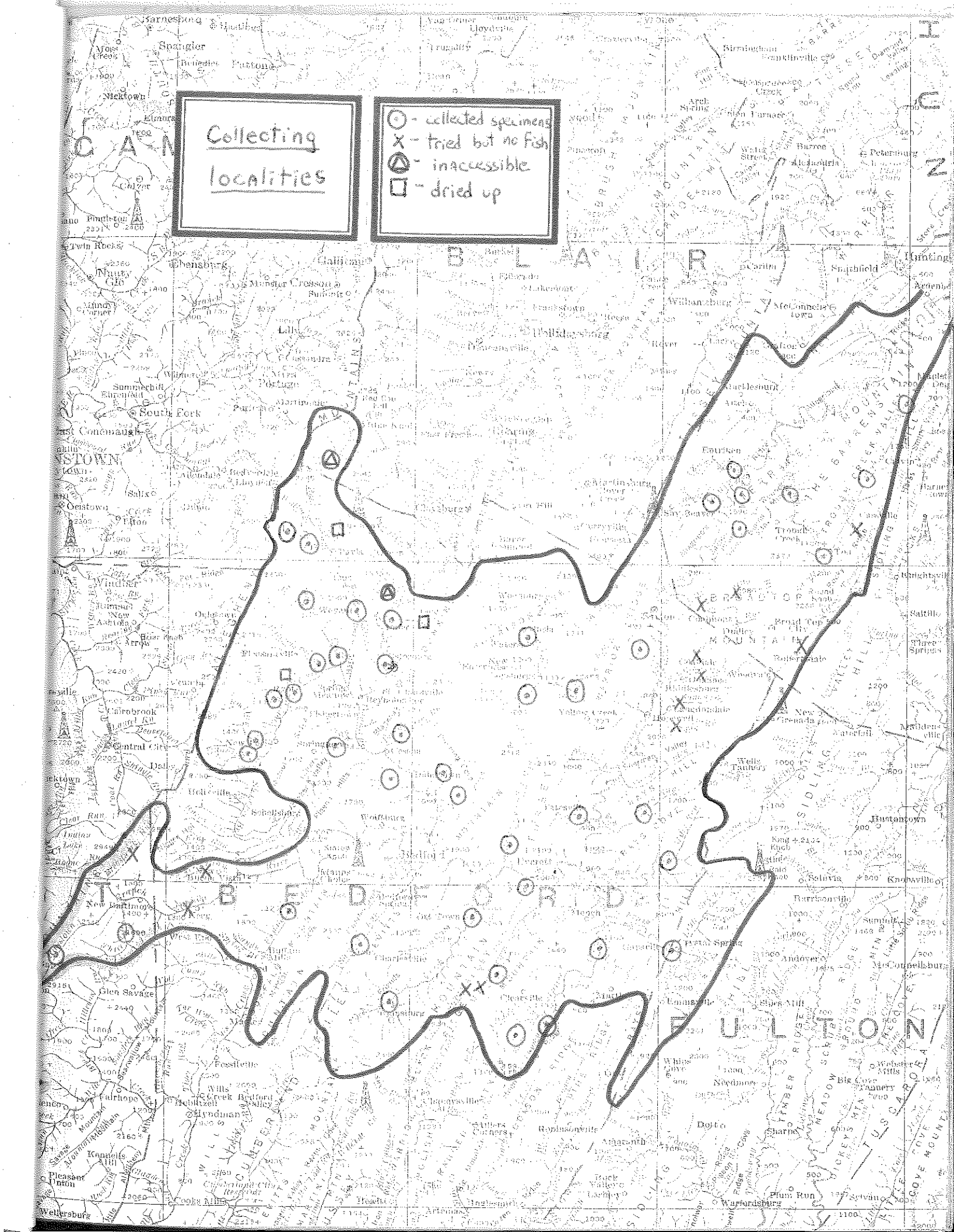
Semotilus atromaculatus atromaculatus - Northern creek chub

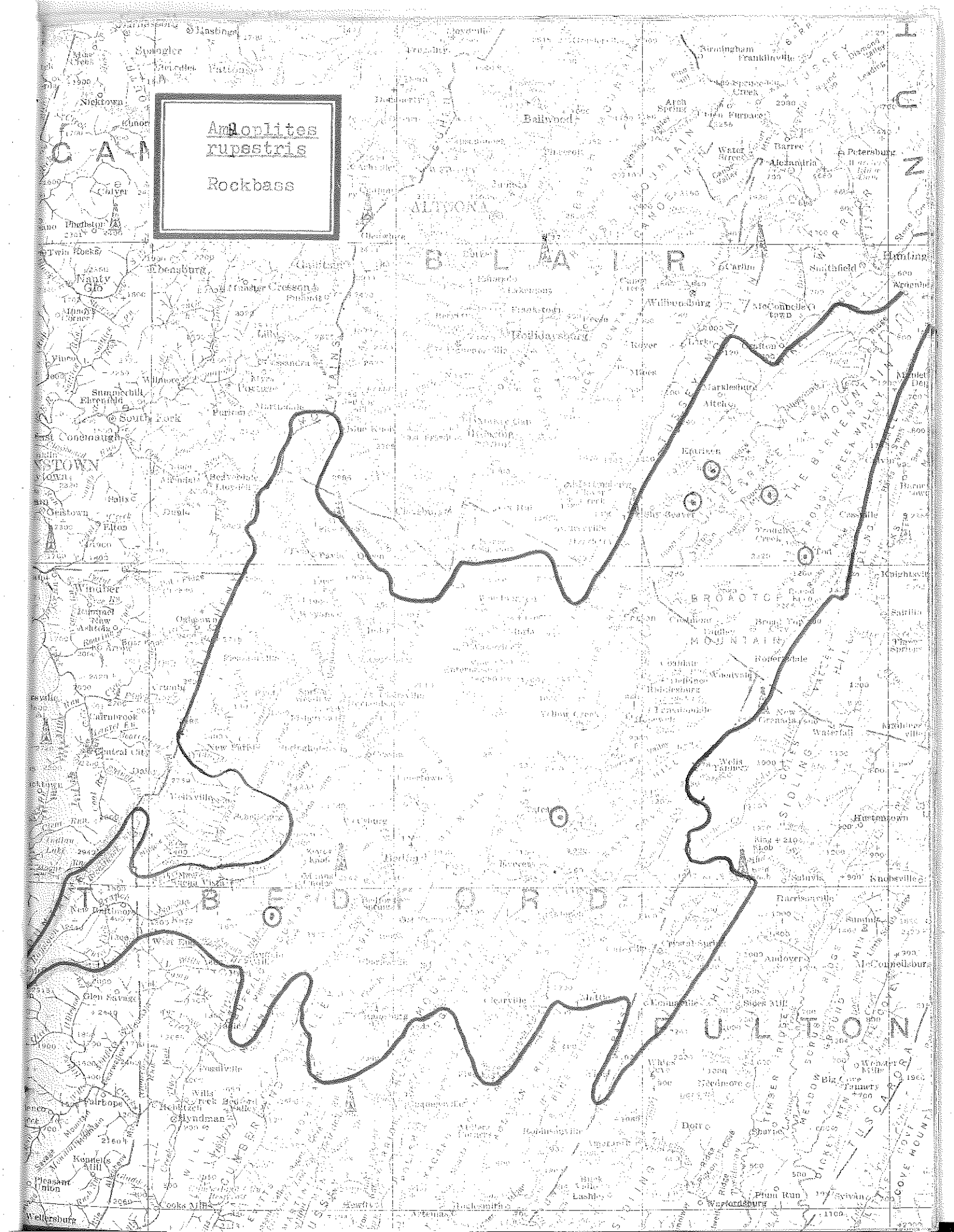
The creek chub is very dispersed geographically, but not relatively abundant in any one area as compared to another. It lives in Type 2 streams and was found in clear, fast running water with little vegetation in the water and a rocky bottom with sand. None were found in any water that was turbid to any degree and even though it lives mainly in the faster parts of streams, it can be found in pools that have a steady current going through them.

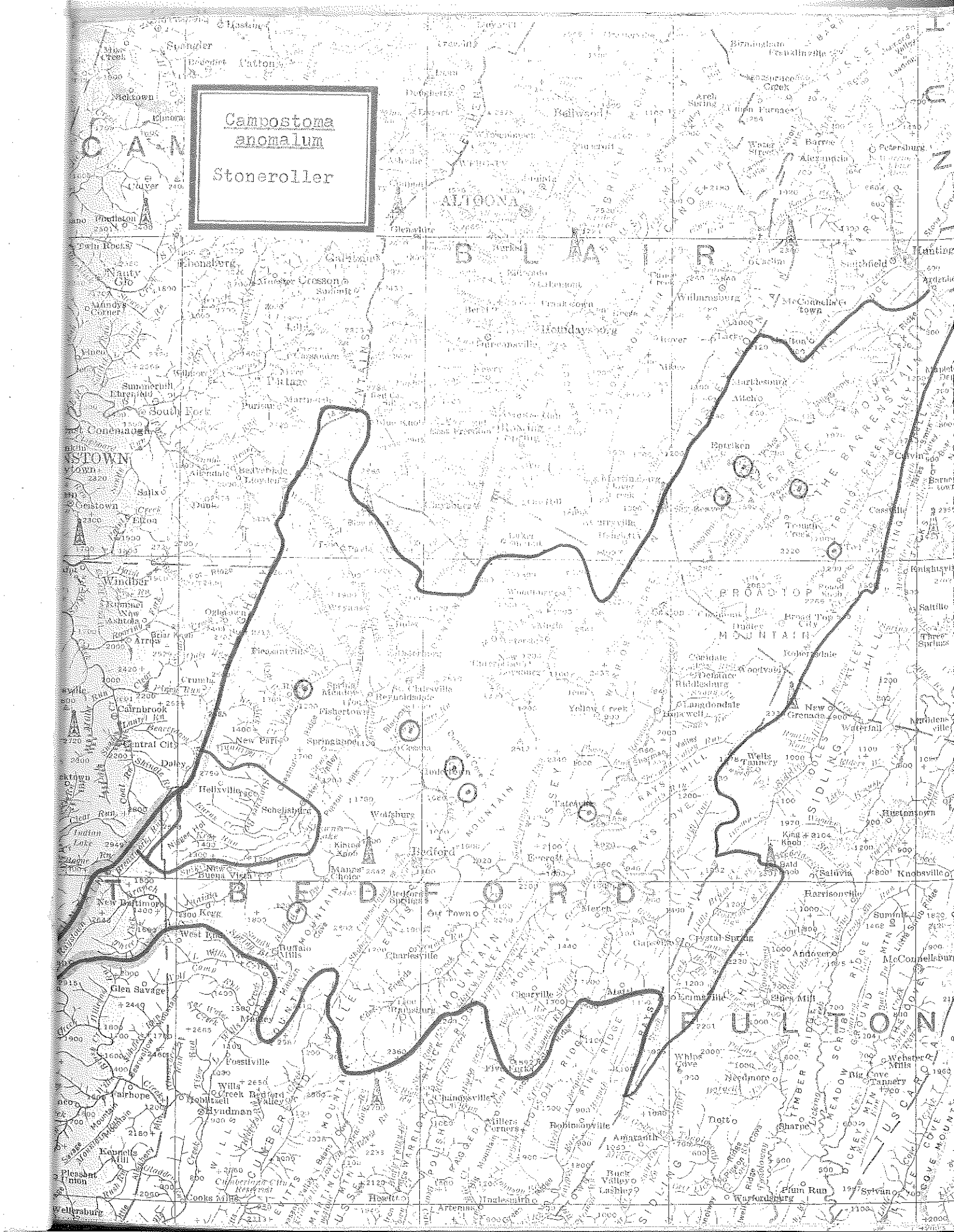
Semotilus corporalis - fallfish

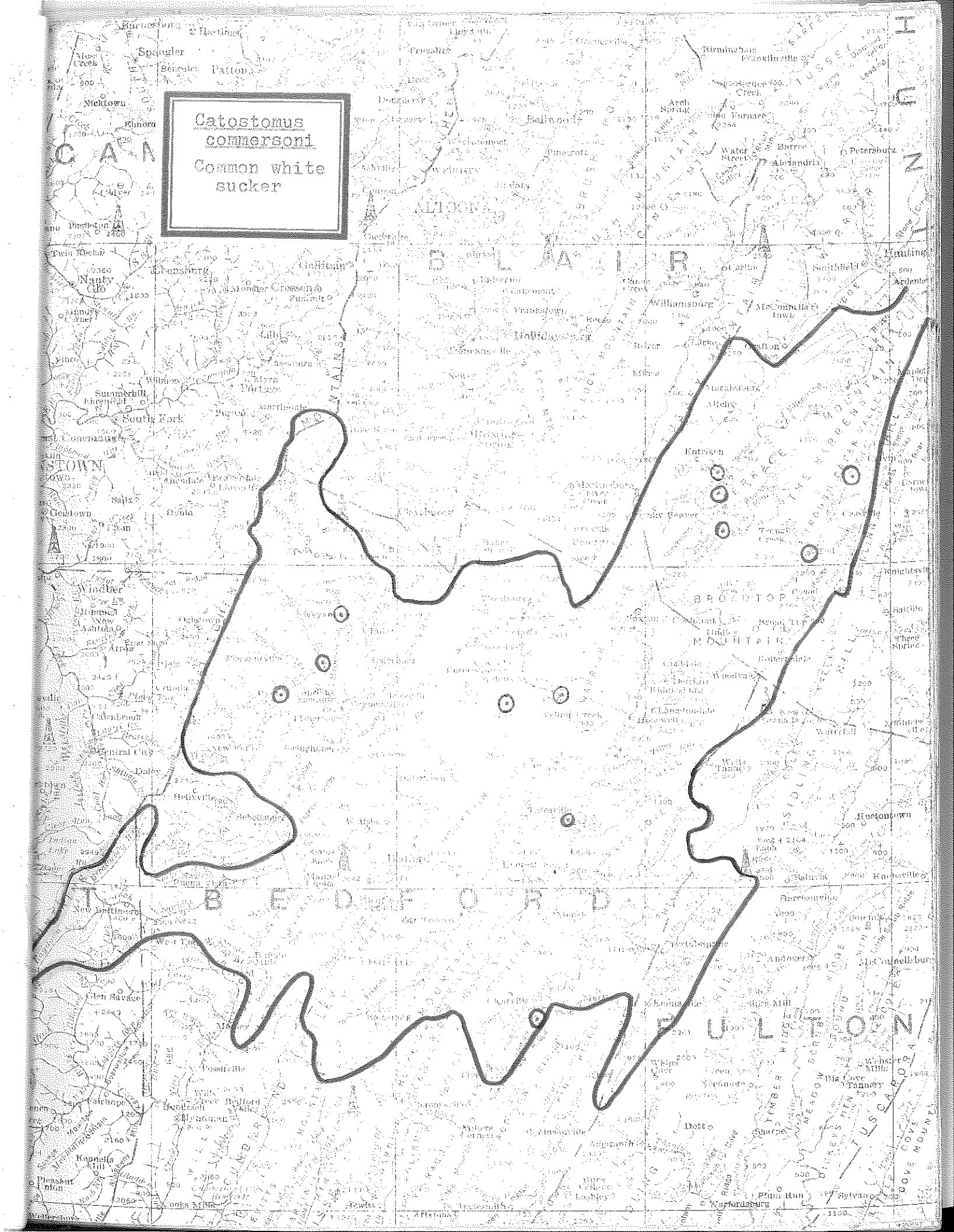
This species is also widespread, but is found in the faster, clear streams of the drainage that are type 2 variety. It is not as abundant as the creek chub, and is found in the faster parts of the stream compared to the creek chub. There also was very little vegetation in any of the streams that fallfish were found in, with very little detritus, too.

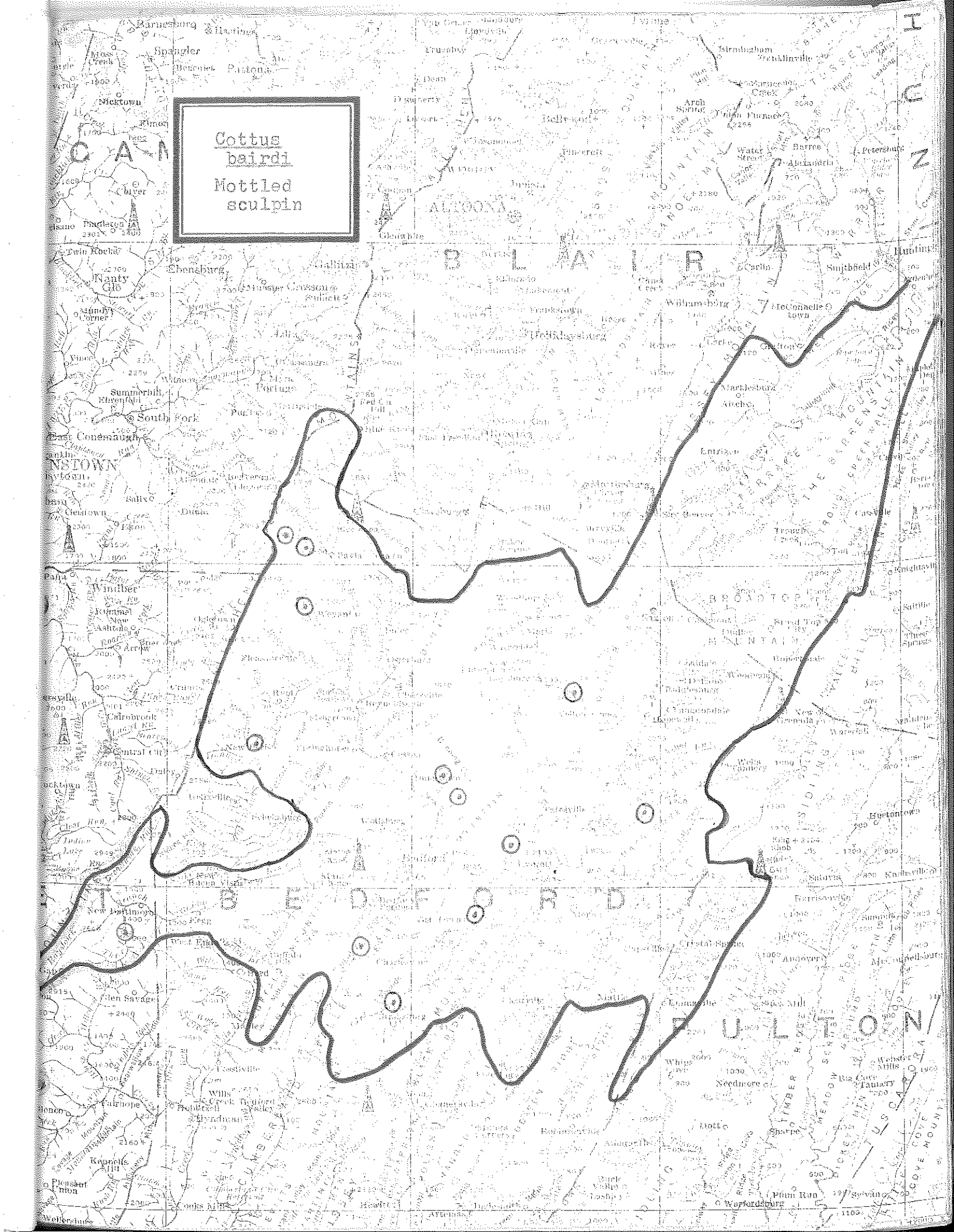

type 1
type 2
type 3
BEDFORD
FULTON
BLAIR
CAMBRIA
SOMERSET
HUNTINGDON
Barnesboro
Hastings
Spangler
Patton
Nicktown
Elmora
Twin Rocks
Ebensburg
Nanty Glo
Munster
Cresson
Gallitzin
Altoona
Tyrone
Birmingham
Bellwood
Arch Spring
Barree
Alexandria
Petersburg
Hollidaysburg
Williamsburg
Martinsburg
Roaring Spring
Saxton
Riddlesburg
Hopewell
Everett
Bedford
Schellsburg
New Paris
Fishertown
Buena Vista
Imler
Osterburg
Woodbury
Central City
Windber
Jerome
New Ashland
Berlin
Salisbury
Meyersdale
Elton
Conemaugh
South Fork
Summerhill
Ehrenfeld
Portage
Wilmore
Cassandra
Carrolltown
Glen Savage
Fairhope
Boswell
Kennels Mill
Pleasant Union
Cooks Mills
Fossilville
Rockhill Furnace
Shade Gap
Three Springs
Knobsville
Harrisonville
McConnellsburg
Big Cove Tannery
Webster Mills
Needmore
Dublin
Warfordsburg
Plum Run
Sweet Root Mountain
Tussey Mountain
Allegheny Mountain
Dunning Mountain
Wills Mountain
Evitts Mountain
Sideling Hill
Tuscarora Mountain
Big Cove Mountain
Timber Ridge
Scrub Ridge
Dickeys Mountain
Broad Top Mountain
Warrior Ridge
Jacks Mountain
Shade Mountain
Blue Knob
Allegheny Front
Brush Mountain
Canoe Creek
Frankstown Branch
Juniata River
Raystown Branch
Little Juniata River
Aughwick Creek
Sherman Creek
Licking Creek
Tonoloway Creek
Big Wills Creek
Little Wills Creek
Sideling Hill Creek
Town Hill Creek
Dunning Creek
Shobers Run
Yellow Creek
Clear Shade Creek
Piney Creek
Stonycreek
Conemaugh River
Blacklick Creek
Little Conemaugh River
Laurel Hill Creek
Quemahoning Creek
Stony Creek
Shade Creek
Paint Creek
Indian Creek
Dunlap Creek
Redstone Creek
Cove Creek
Wills Creek
Potomac River
Maryland
Pennsylvania

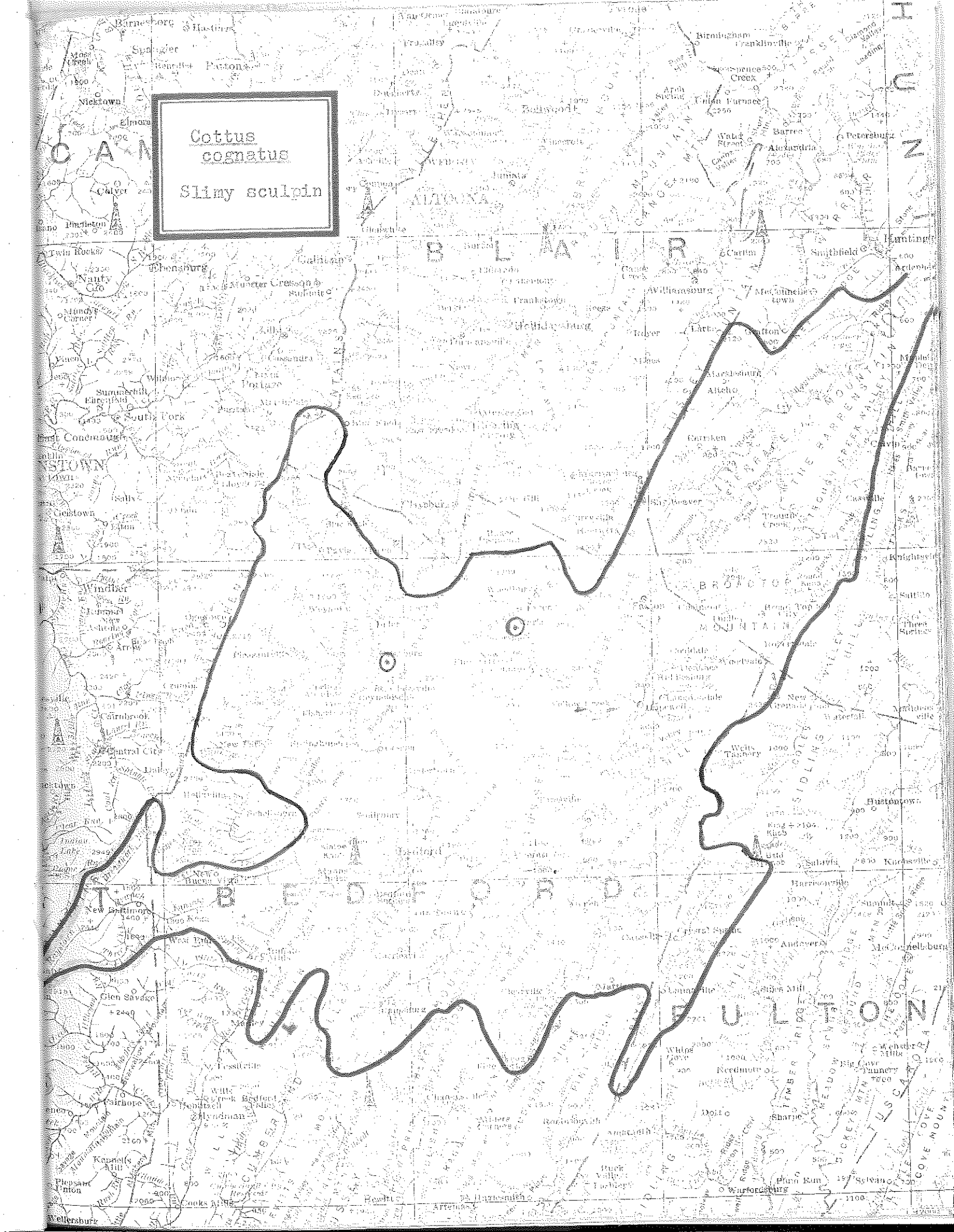

Collecting localities
○ - collected specimens
X - tried but no fish
△ - inaccessible
□ - dried up
BEDFORD
FULTON
BLAIR
CAMBRIA
Barnesboro
Spangler
Patton
Nicktown
Carrolltown
Twin Rocks
Ebensburg
Gallitzin
Hollidaysburg
Altoona
Huntingdon
Saltillo
Three Springs
Broad Top Mountain
Bedford
Everett
Schellsburg
Wolfsburg
Glen Savage
Fossilville
Wills Creek
Bedford Valley
Myerstown
Pleasant Union
Cooks Mills
Wellersburg
Warfordsburg
Plum Run
Needmore
Big Cove
Tannery
McConnellsburg
Knobville
Huntstown
Meadow Ridge
Sideling Hill
Tuscarora
Allegheny Mountains
Chestnut Ridge
Dunning Creek
Raystown Branch
Juniata River

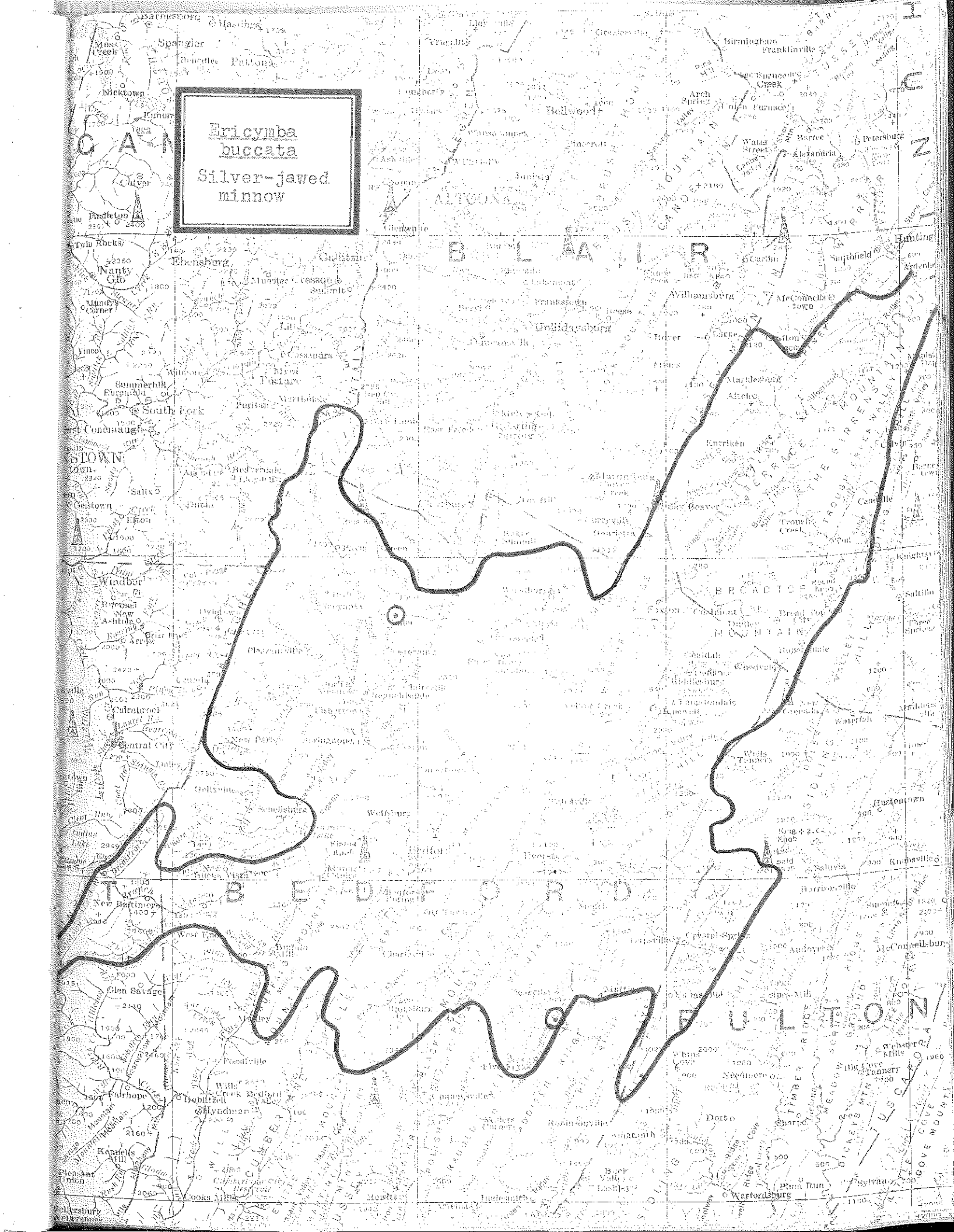

Ambloplites
rupestris
Rockbass

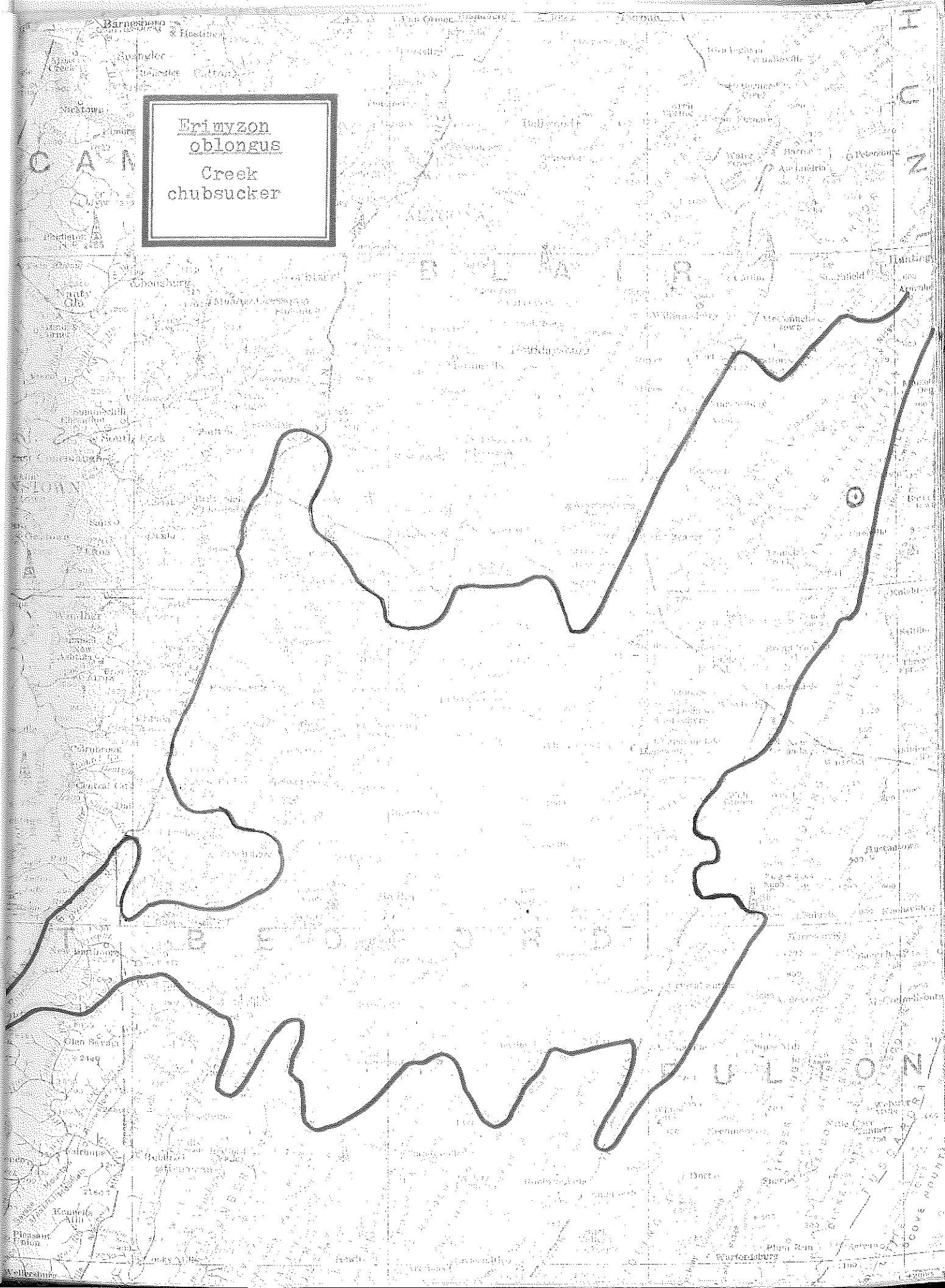

Campostoma anomalum
Stoneroller

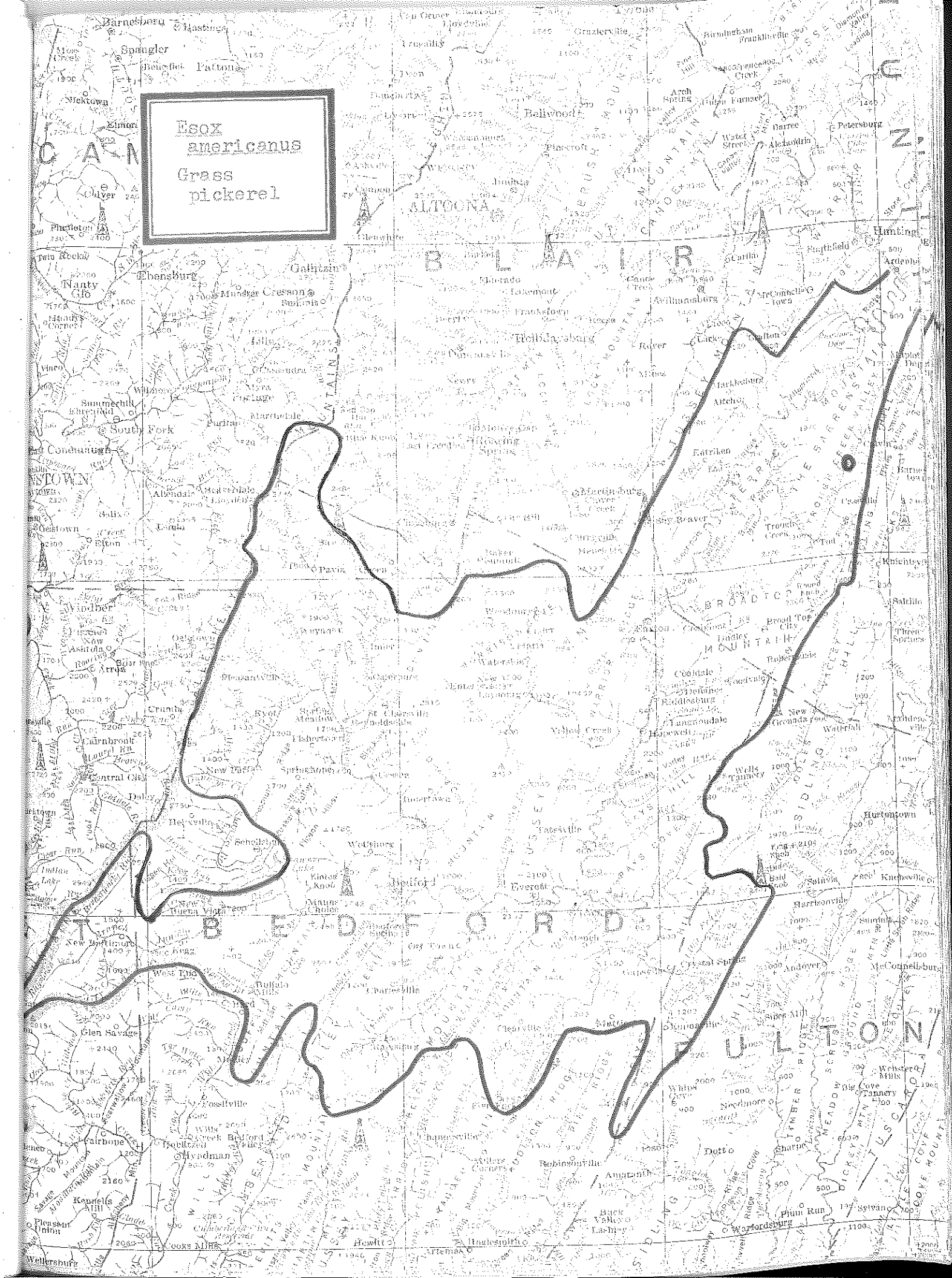

Catostomus commersoni
Common white sucker

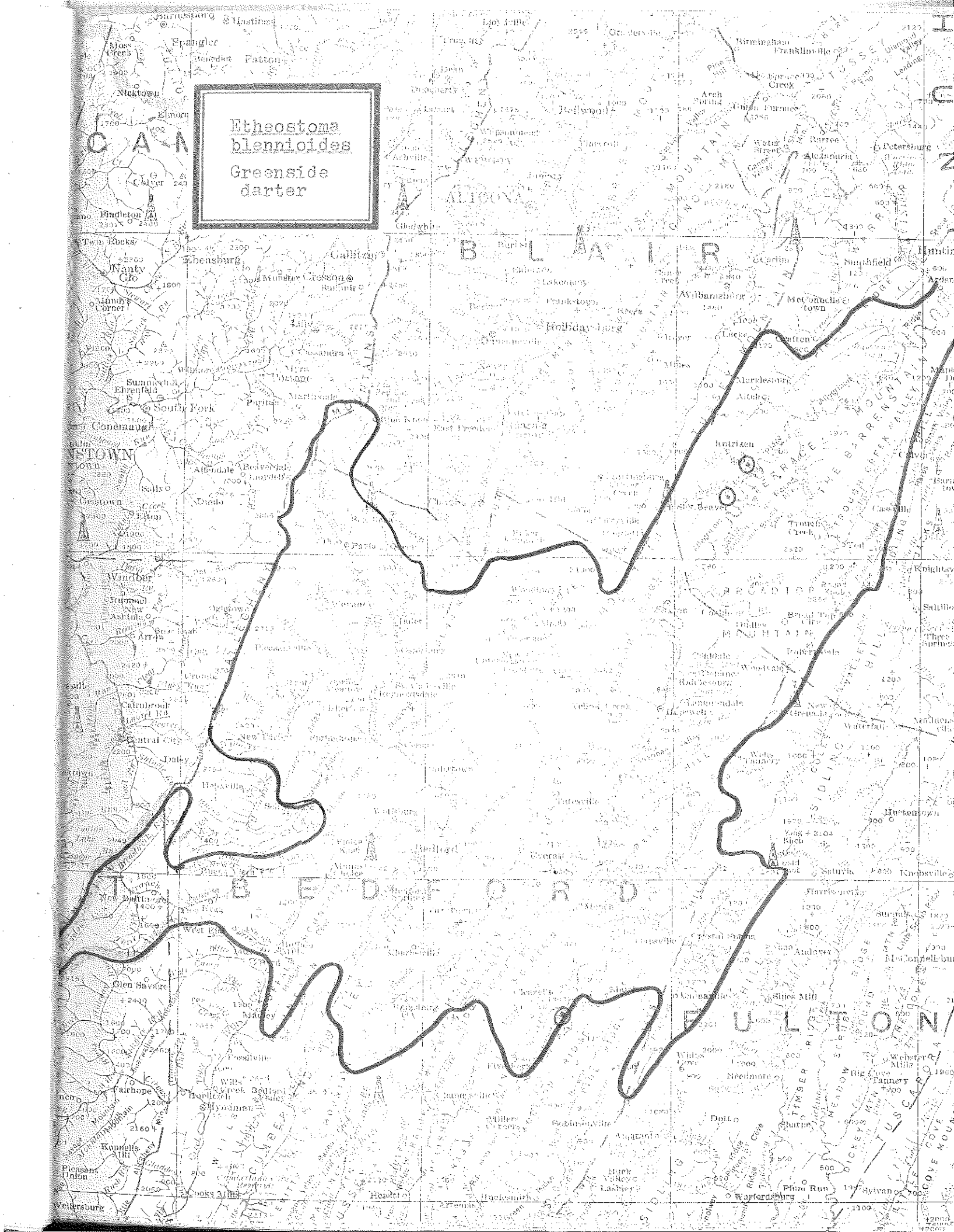

Cottus bairdi
Mottled sculpin

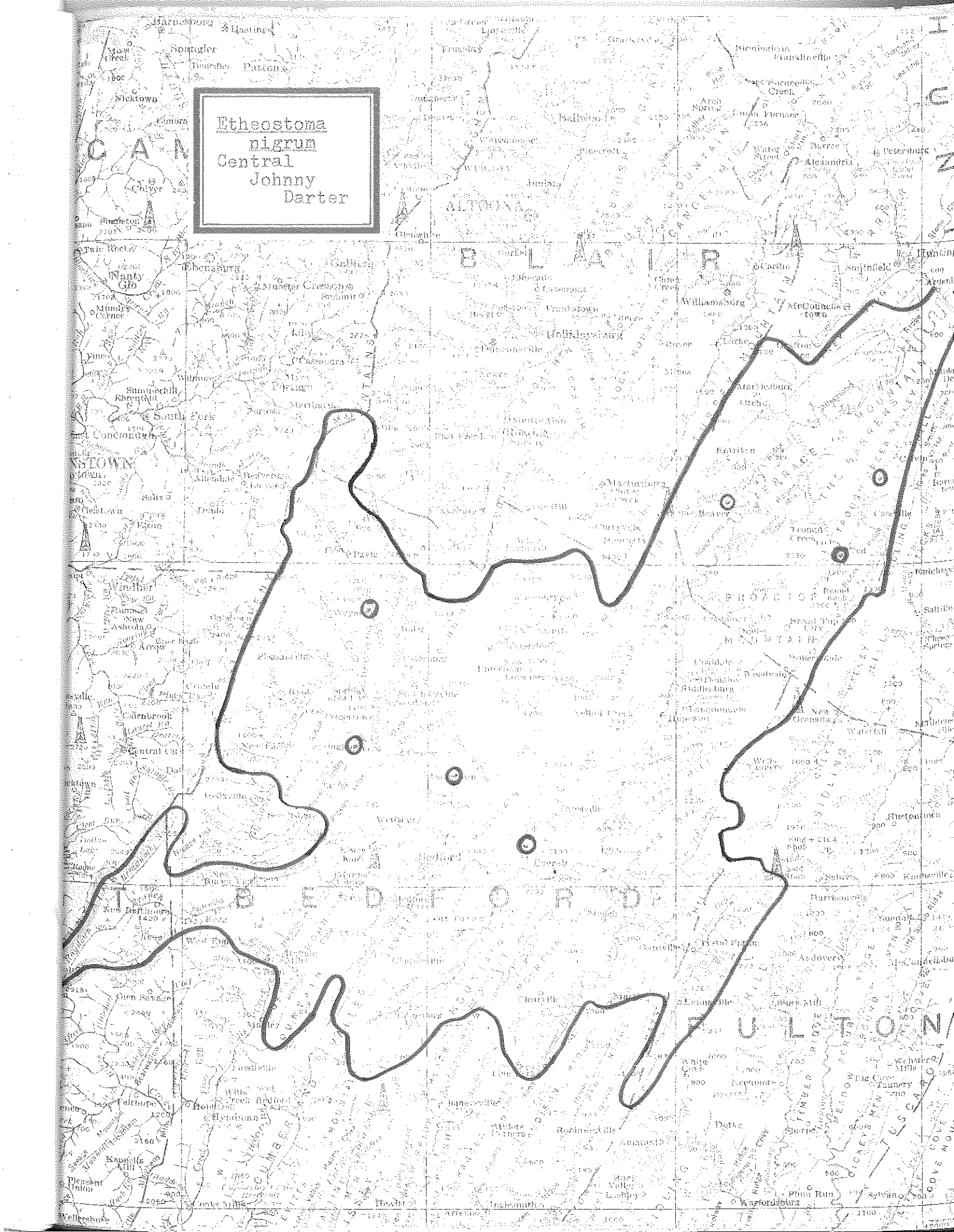

Cottus
cognatus
Slimy sculpin

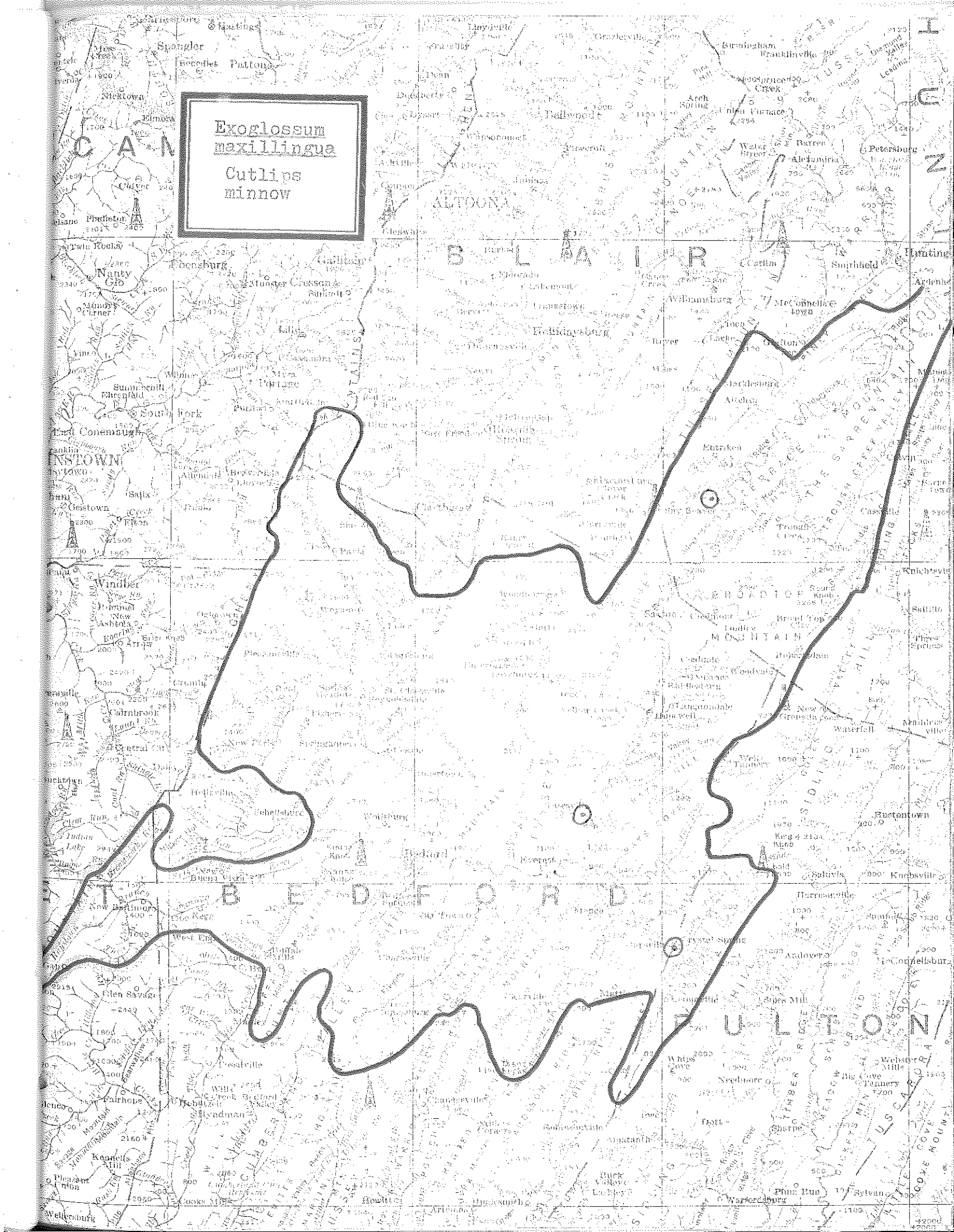

Ericymba
buccata
Silver-jawed
minnow

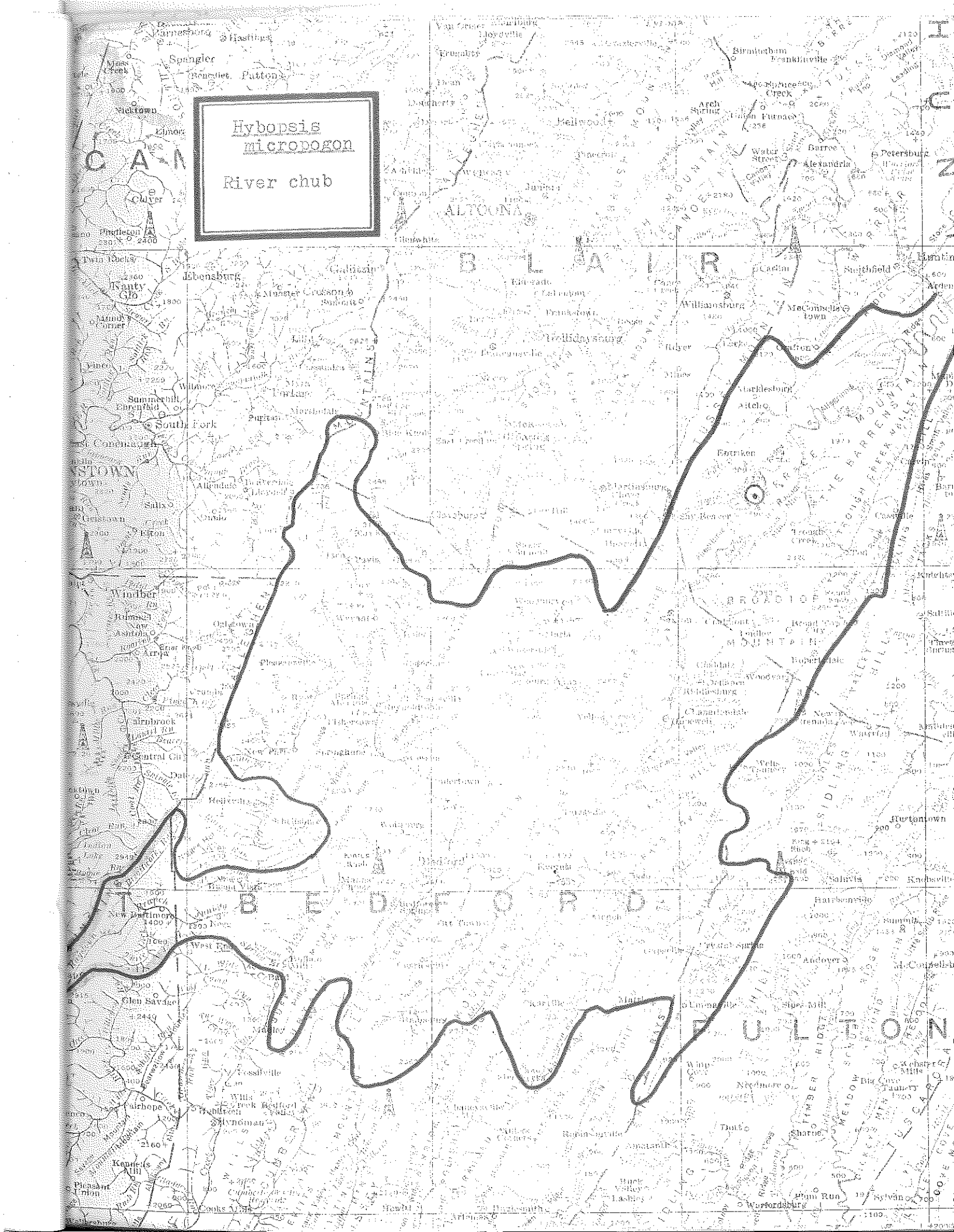

Erimyzon oblongus
Creek chubsucker

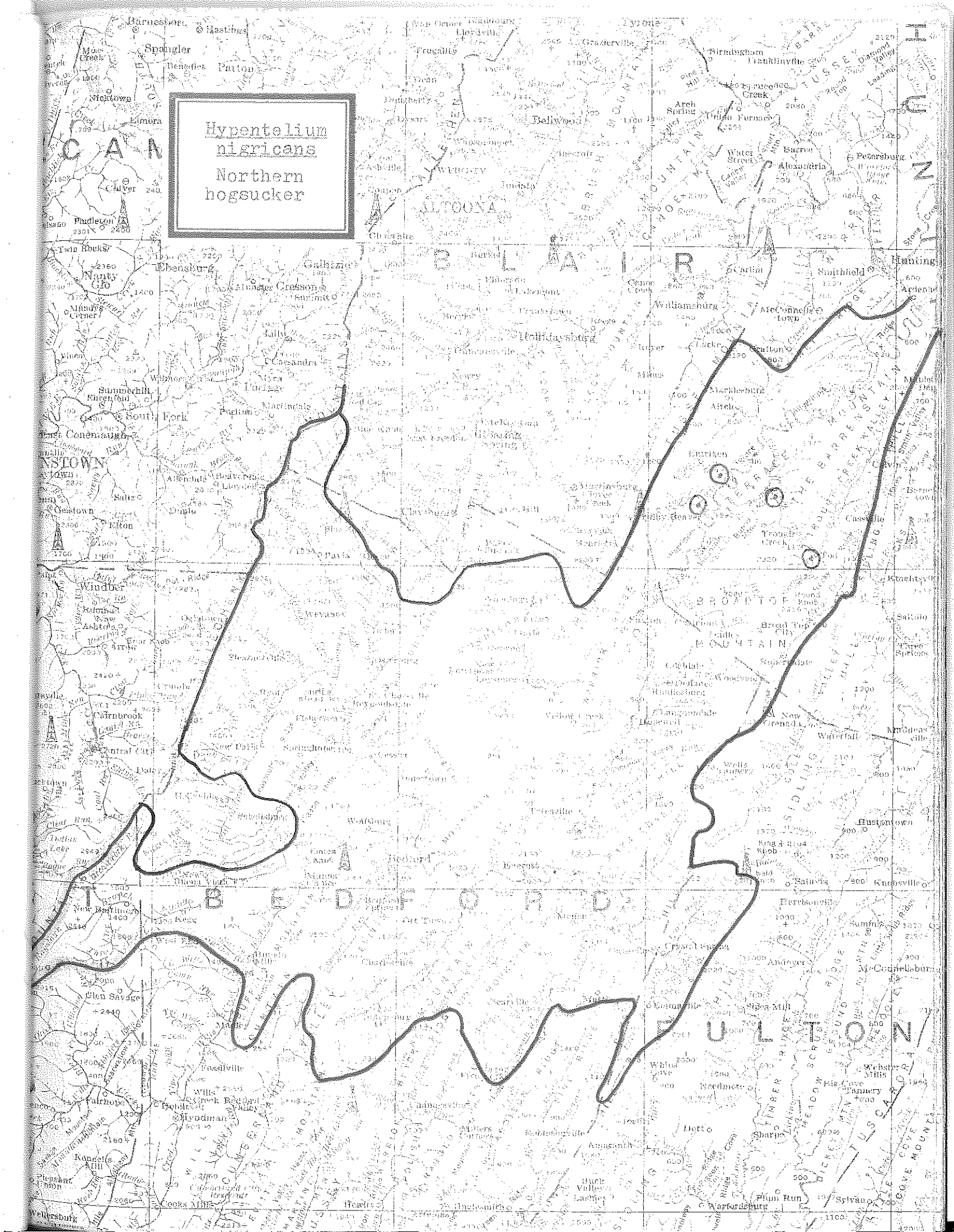

Esox
americanus
Grass
pickerel

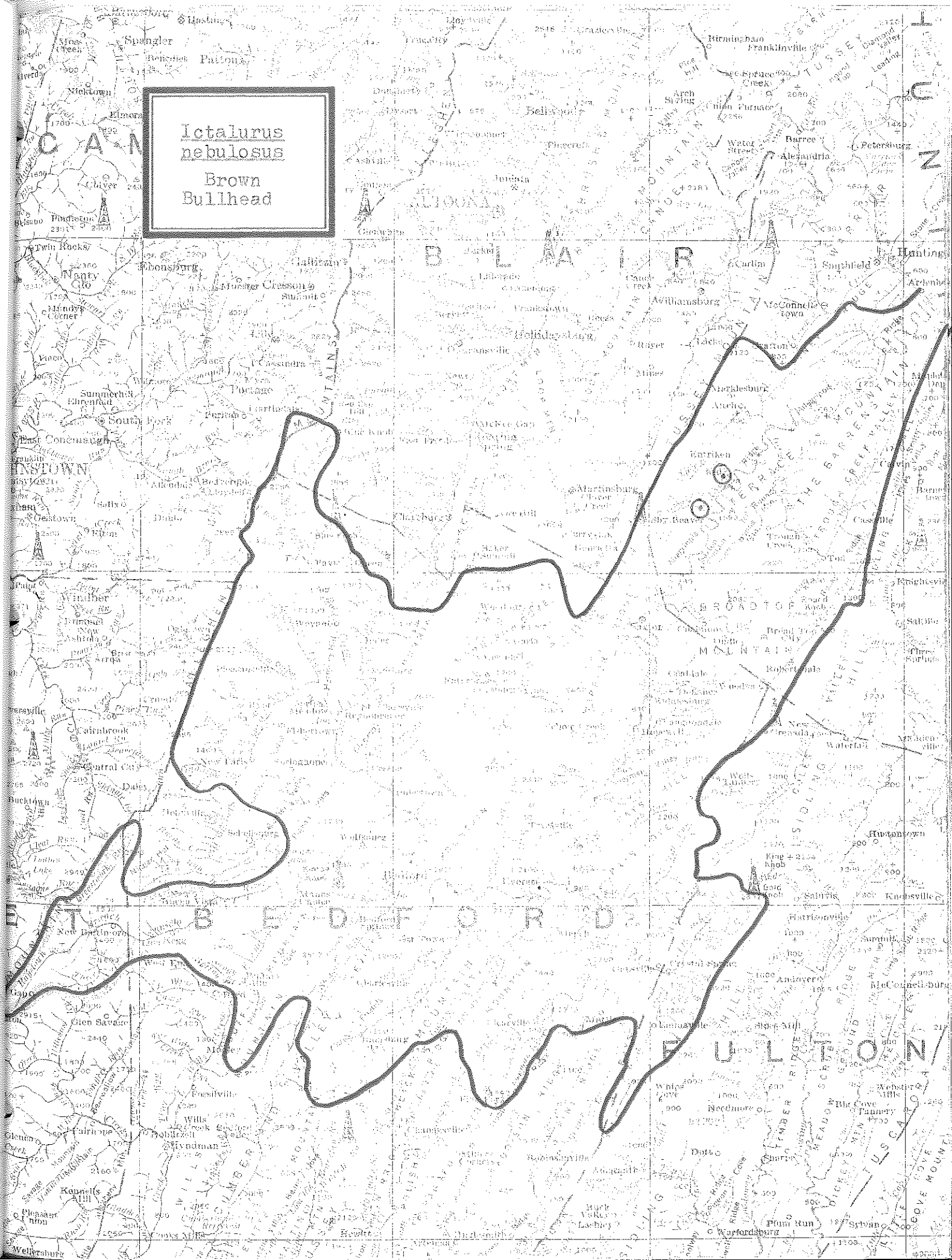

Etheostoma
blennioides
Greenside
darter

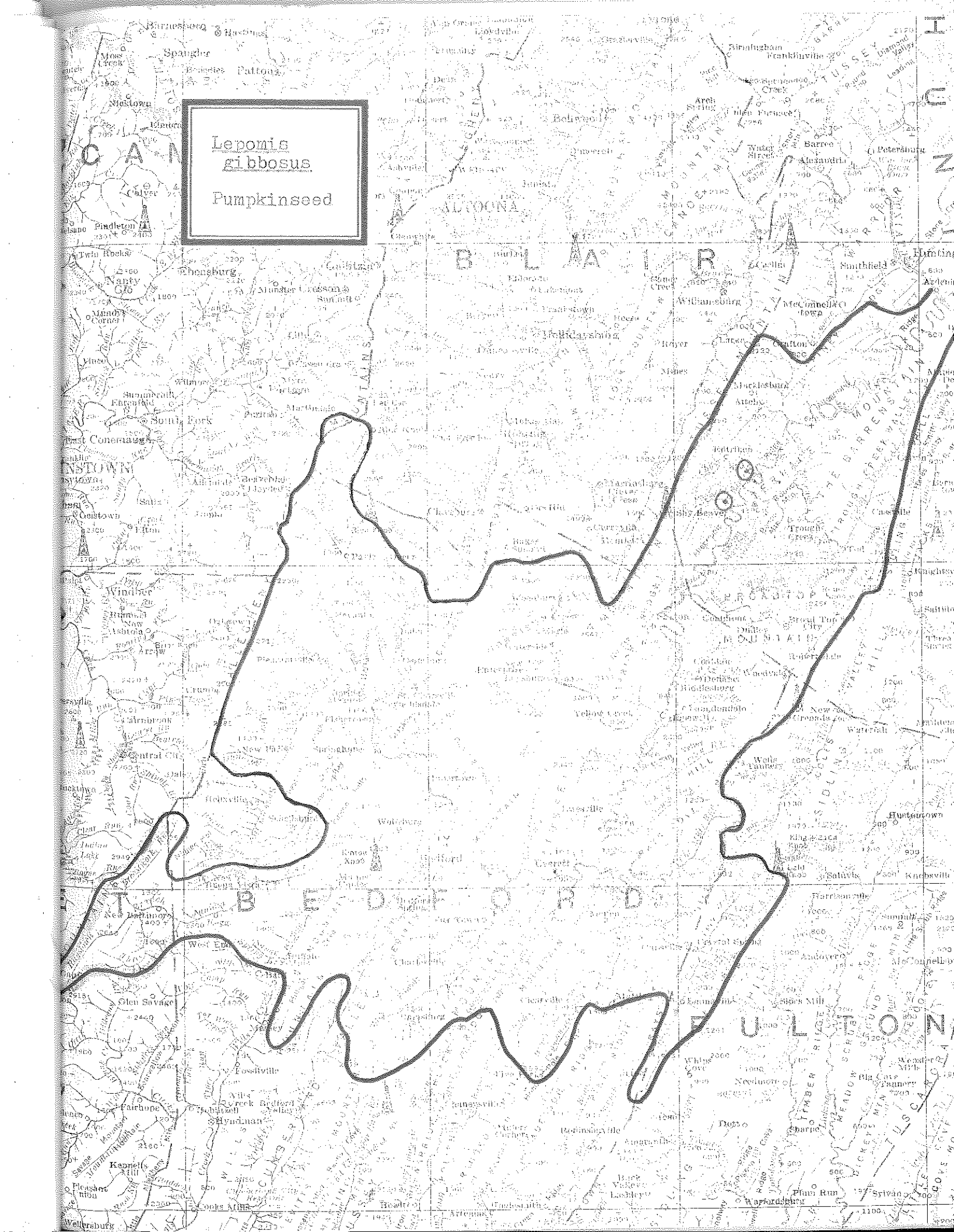

Etheostoma
nigrum
Central
Johnny
Darter

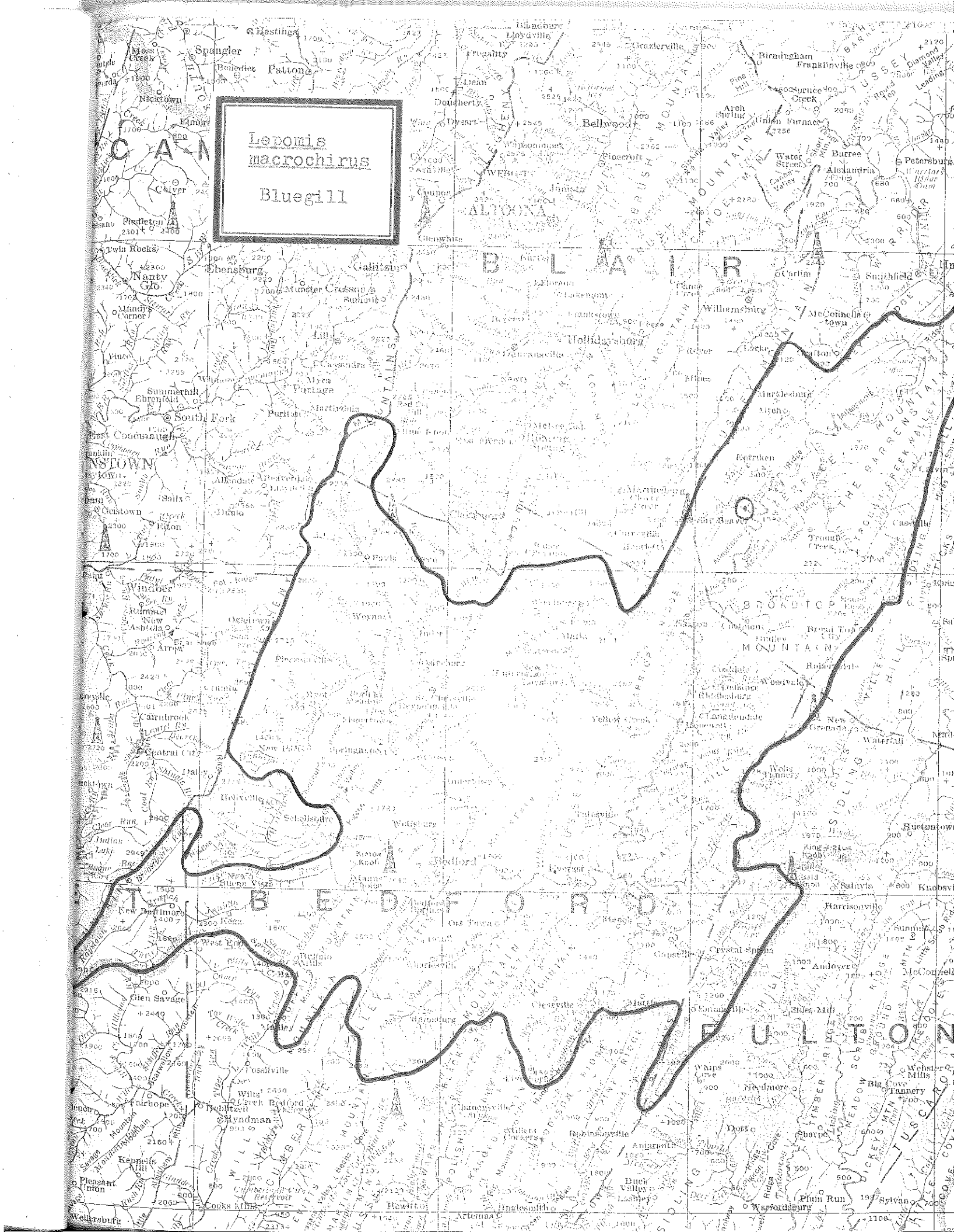

Exoglossum maxillingua
Cutlips minnow
BLAIR
BEDFORD
FULTON
ALTOONA
HOLLIDAYSBURG
HUNTINGDON
BROAD TOP MOUNTAIN
TUSCARORA MOUNTAIN
JACKS MOUNTAIN
SIDLING HILL MOUNTAIN
EVITTS MOUNTAIN
WILLS MOUNTAIN
TUSCARORA VALLEY
JUNIATA RIVER
FROG RUN
SPRUCE CREEK
Spangler
Hastings
Patton
Nicktown
Elmora
Cresson
Gallitzin
Tunnelton
Portage
Summerhill
Ehrenfeld
South Fork
East Conemaugh
Johnstown
Geistown
Windber
Central City
Cairnbrook
New Baltimore
Ellen Savage
Fairhope
Keagys Mill
Pleasant Union
Wellersburg
Cooks Mills
Hewitt
Dunnstown
Burk Cullers
Plum Run
Warfordsburg
Sylvan
Needmore
Whips Cove
Webster Mills
Big Cove Tannery
Sharpe
Dott
Andover
McConnellsburg
Harrisonville
Knobsville
Saluvia
Bustontown
Waterfall
Knightsville
Saltillo
Three Springs
Orbisonia
Mapleton
Mount Union
Petersburg
Alexandria
Barree
Water Street
Union Furnace
Arch Spring
Birmingham
Franklinville
Spruce Creek
Tyrone
Tipton
Duncansville
Bellwood
Greenwood Furnace
Roaring Spring
Martinsburg
Williamsburg
Frankstown
Hollidaysburg
Lakemont
Gaysport
Blandburg
Carlim
Smithfield
Huntingdon
Ardenia
Alexandria
Mapleton
Jacksonville
Alfarata
Entriken
Cassville
Trough Creek
Saxton
Coalmont
Robinsdale
Broad Top
Ludlow
Todd
Dudley
Rainsburg
Langdondale
New Grenada
Manns Choice
Schellsburg
Buena Vista
Bedford
Clearville
Hyndman
Osterburg
Fishertown
Woodbury
Loysburg
Claysville
Grazierville
Hopewell
Piney Knob
Sugar Knob
Cove Mountain
Sideling Hill Creek
Raystown Branch Juniata River
Little Juniata River
Shobers Run
Dunning Creek
Yellow Creek
Brush Creek
Wills Creek
Evitts Creek
Licking Creek
Dunnings Creek
Clear Run
Indian Lake
Shawnee
Twin Rocks
Nanty Glo
Mundys Corner
Vinco
Lilly
Munster
Ebensburg
Sidman
Beaverdale
Carrolltown
Chest Springs
Patton
Clearfield
Curwensville
Irvona
Coalport
Glen Hope
Westover
Penfield
Karthaus
Ramey
Grampian
Luthersburg
Reynoldsville
Brockway
Punxsutawney
Big Run
Falls Creek
Sykesville
Corsica
Brookville
Sligo
Shippenville
Clarion
Strattanville
Curllsville
Knox
Parker
Foxburg
Kittanning
Ford City
Templeton
Mahoning
Rural Valley
Leechburg
Apollo
Vandergrift
Saltsburg
Blairsville
Indiana
Homer City
Coral
Josephine
Armagh
Derry
New Florence
Seward
Bolivar
Torrance
Stahlstown
Donegal
Mount Pleasant
Scottdale
Connellsville
Uniontown
Smithfield
Brownsville
Belle Vernon
Monessen
Charleroi
Donora
Monongahela
Elizabeth
McKeesport
Irwin
North Huntingdon
Greensburg
Latrobe
Derry
Ligonier
Jeannette
Murrysville
Export
Delmont
New Kensington
Arnold
Tarentum
Natrona
Oakmont
Verona
Aspinwall
Sharpsburg
Etna
Millvale
Pittsburgh
Bellevue
Avalon
Ben Avon
Emsworth
Sewickley
Edgeworth
Leetsdale
Coraopolis
Moon
Crafton
Ingram
Carnegie
Bridgeville
Canonsburg
Washington
Burgettstown
Hickory
Oakdale
Imperial
Robinson
Cecil
Midway
Finleyville
Bentleyville
Monongahela
Fredericktown
Rices Landing
Waynesburg
Carmichaels
Clarksville
Jefferson
Mount Morris
Greene
Dunkard
Fairchance
Smithfield
Uniontown
Hopwood
Perryopolis
Belle Vernon
Fayette City
Newell
Dawson
Connellsville
Normalville
Mount Pleasant
Scottdale
Jones Mill
Ligonier
Latrobe
Youngwood
Greensburg
Irwin
North Huntingdon
Jeannette
Murrysville
Export
Delmont
New Kensington
Arnold
Tarentum
Natrona
Oakmont
Verona
Aspinwall
Sharpsburg
Etna
Millvale
Pittsburgh
Bellevue
Avalon
Ben Avon
Emsworth
Sewickley
Edgeworth
Leetsdale
Coraopolis
Moon
Crafton
Ingram
Carnegie
Bridgeville
Canonsburg
Washington
Burgettstown
Hickory
Oakdale
Imperial
Robinson
Cecil
Midway
Finleyville
Bentleyville
Monongahela
Fredericktown
Rices Landing
Waynesburg
Carmichaels
Clarksville
Jefferson
Mount Morris
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Fayette City
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Ligonier
Latrobe
Youngwood
Greensburg
Irwin
North Huntingdon
Jeannette

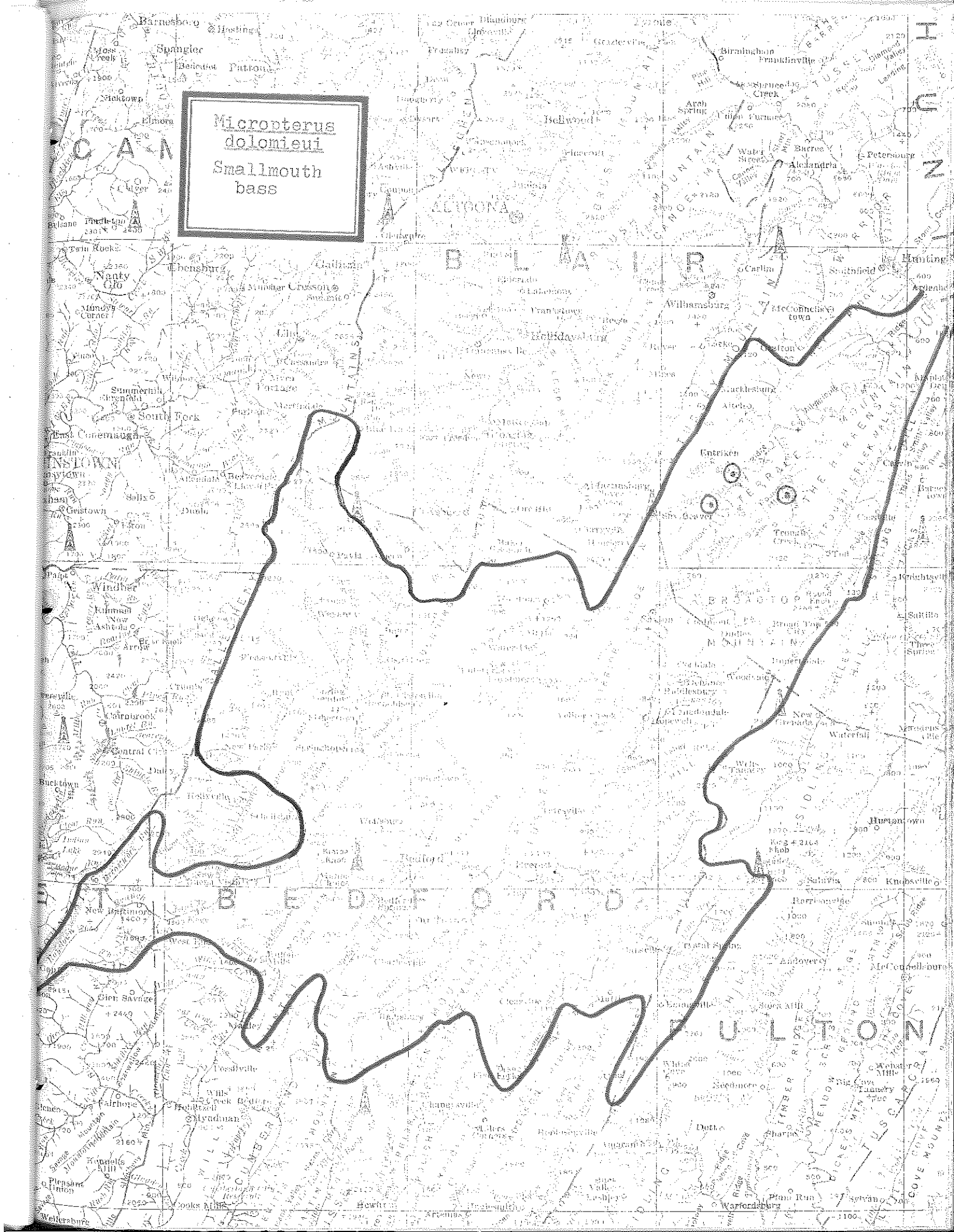

Hybopsis micropogon
River chub

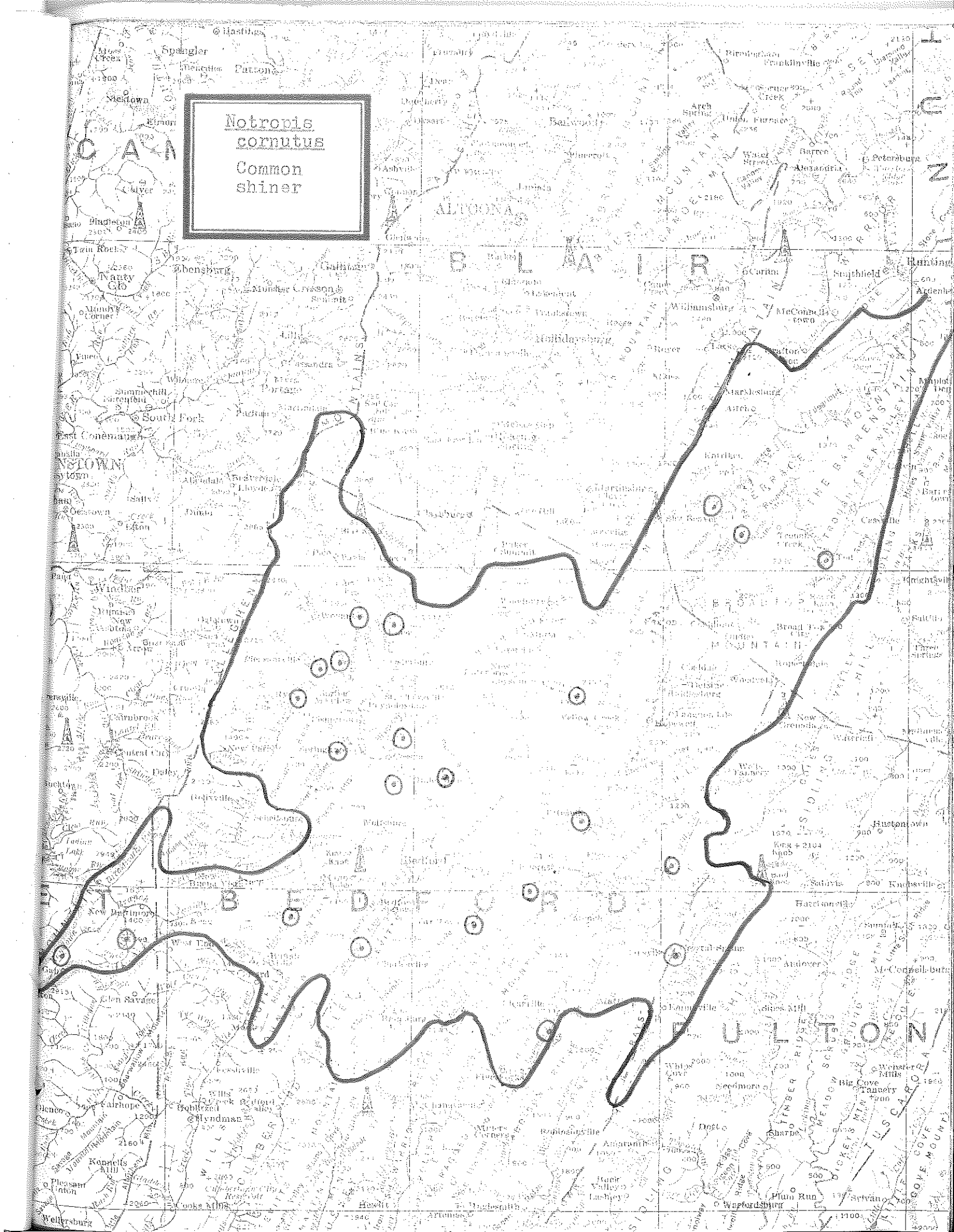

Hypentelium nigricans
Northern hogsucker

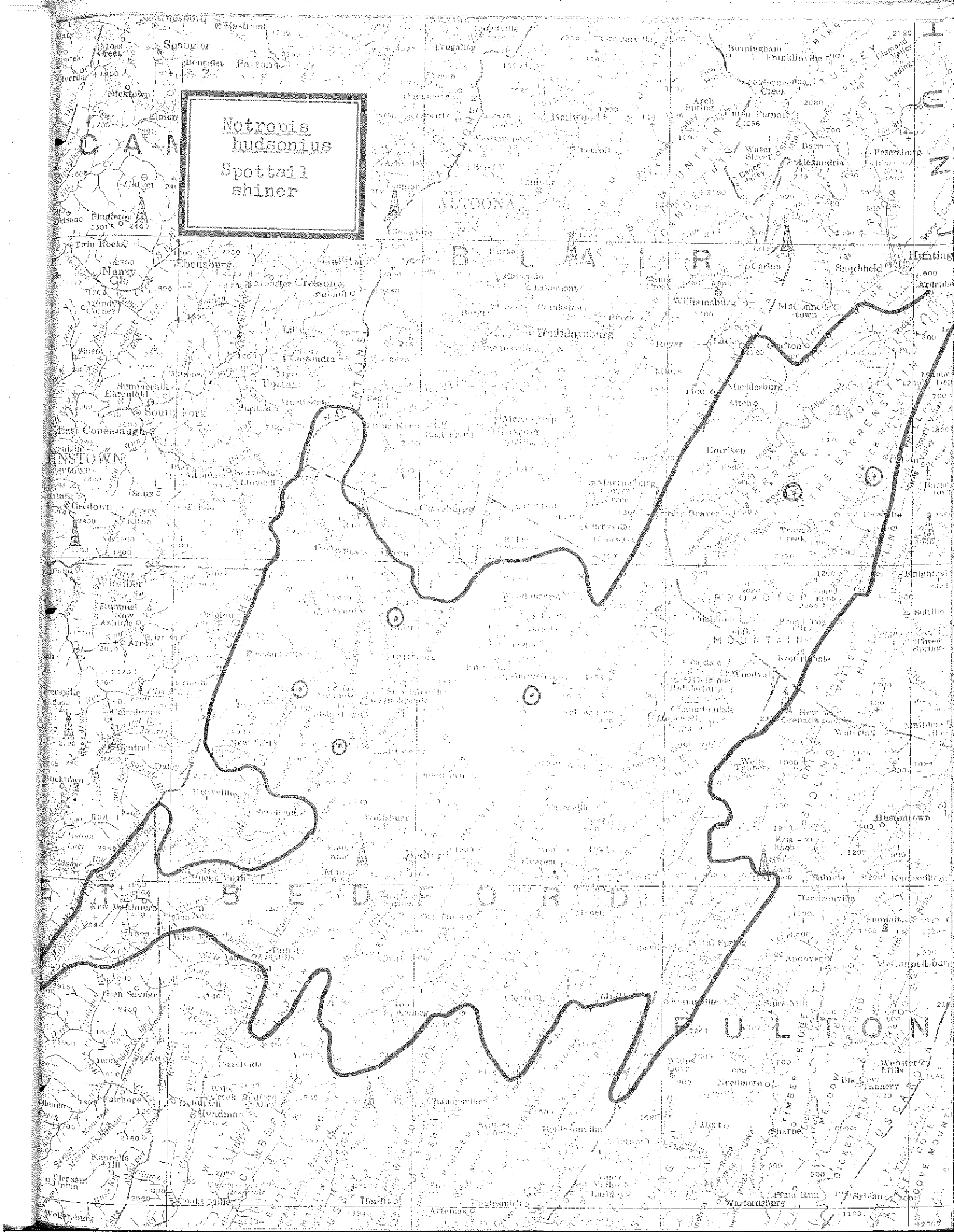

Ictalurus
nebulosus
Brown
Bullhead

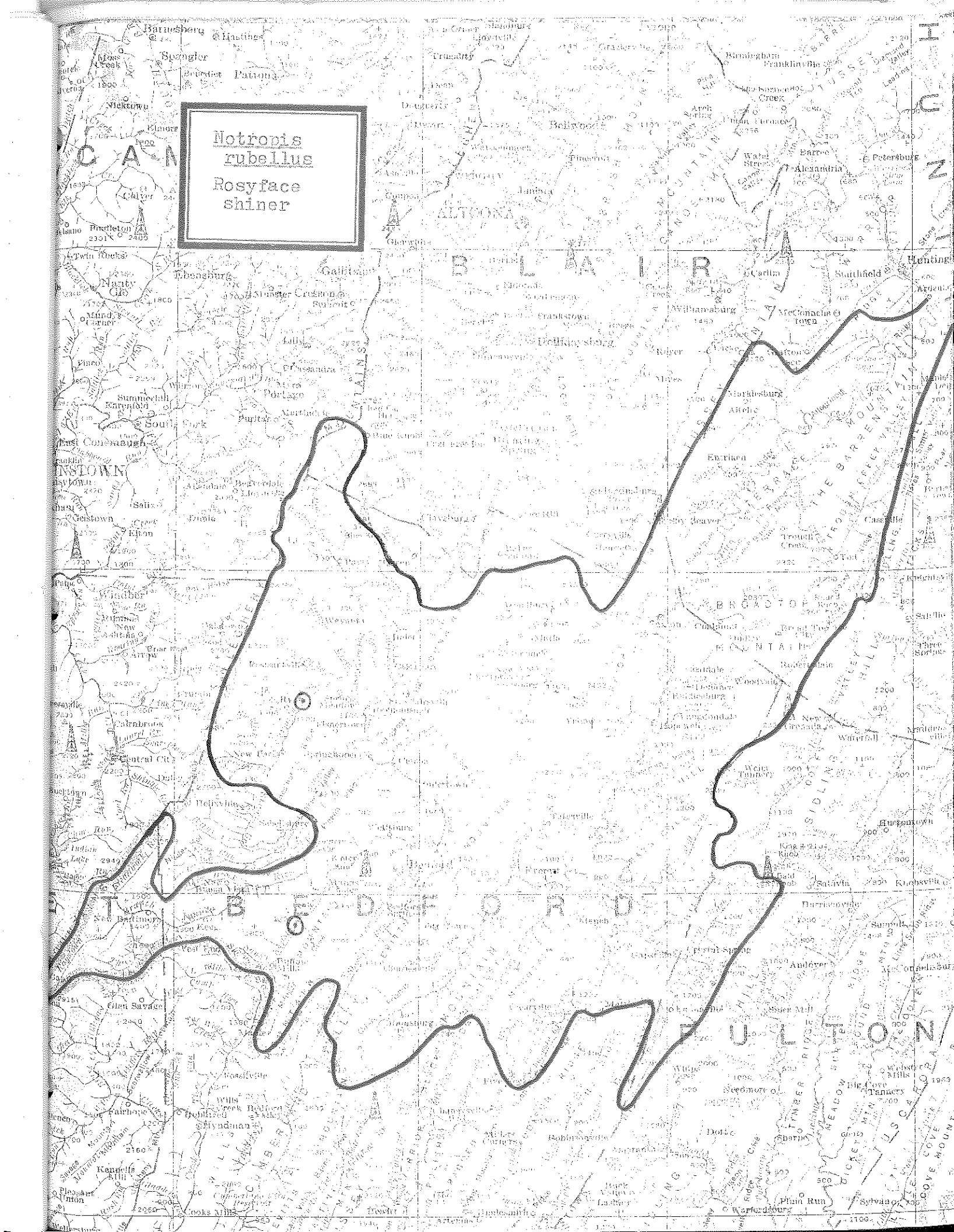

Lepomis
gibbosus
Pumpkinseed

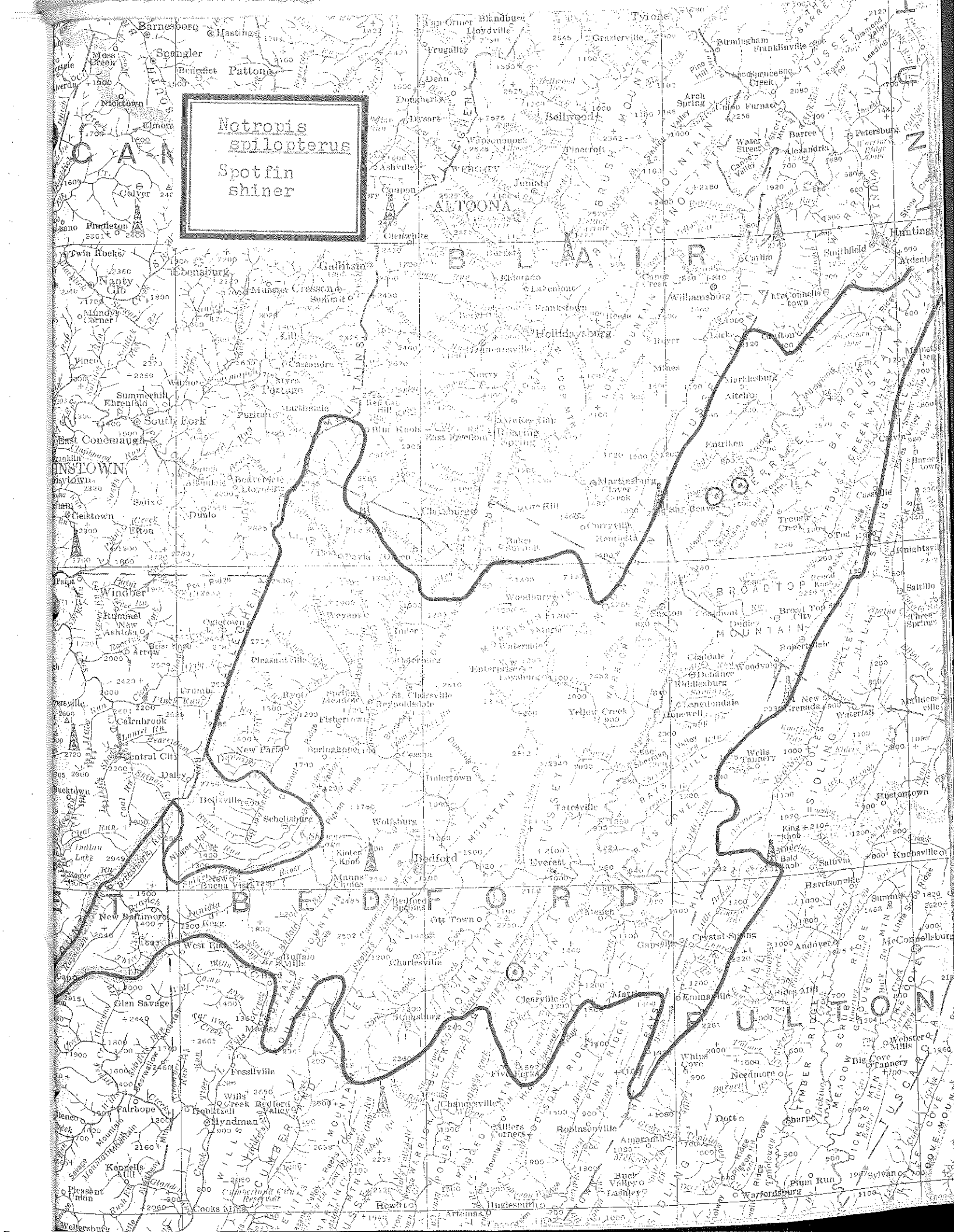

Lepomis
macrochirus
Bluegill

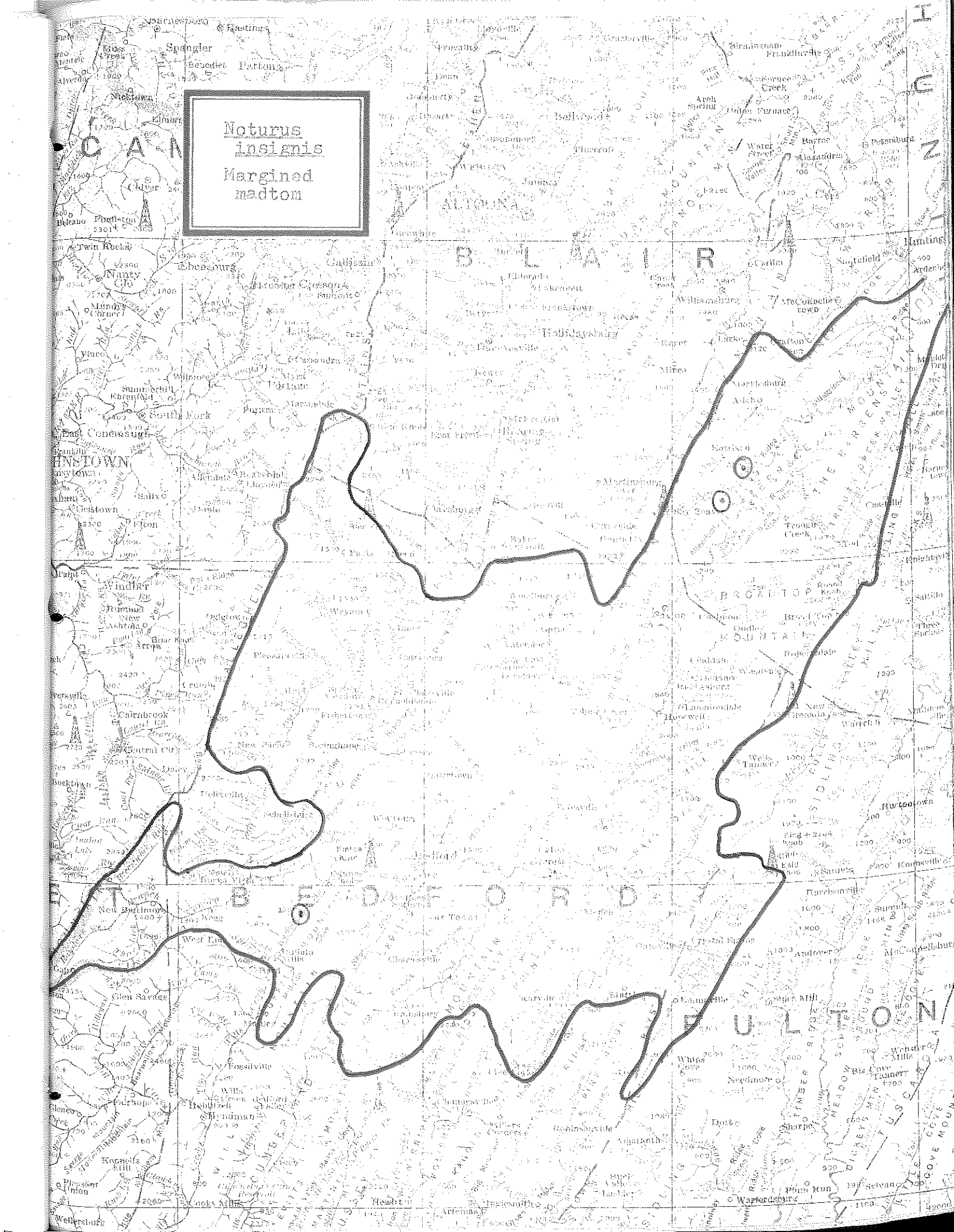

Micropterus
dolomieui
Smallmouth
bass

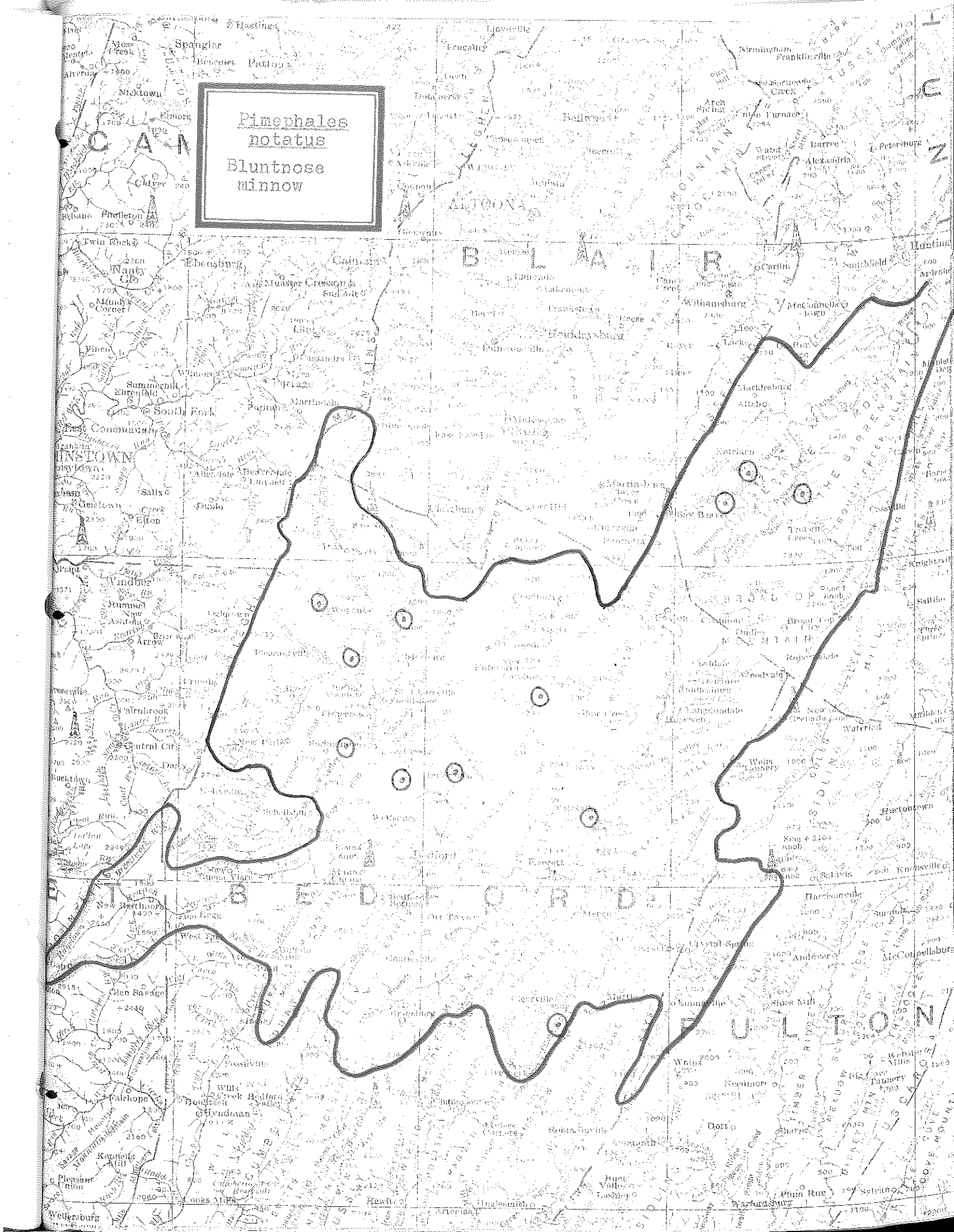

Notropis
cornutus
Common
shiner

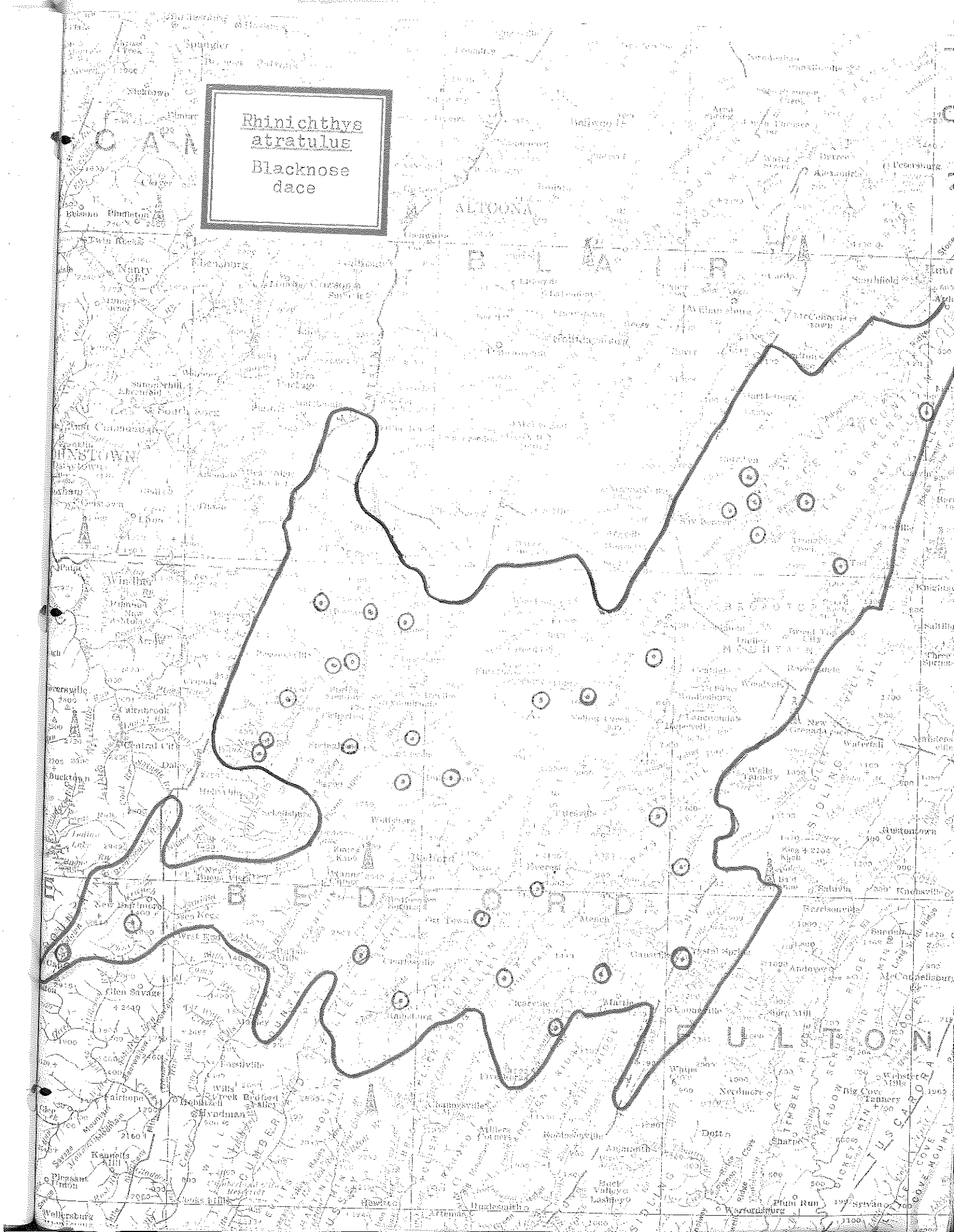

Notropis
hudsonius
Spottail
shiner

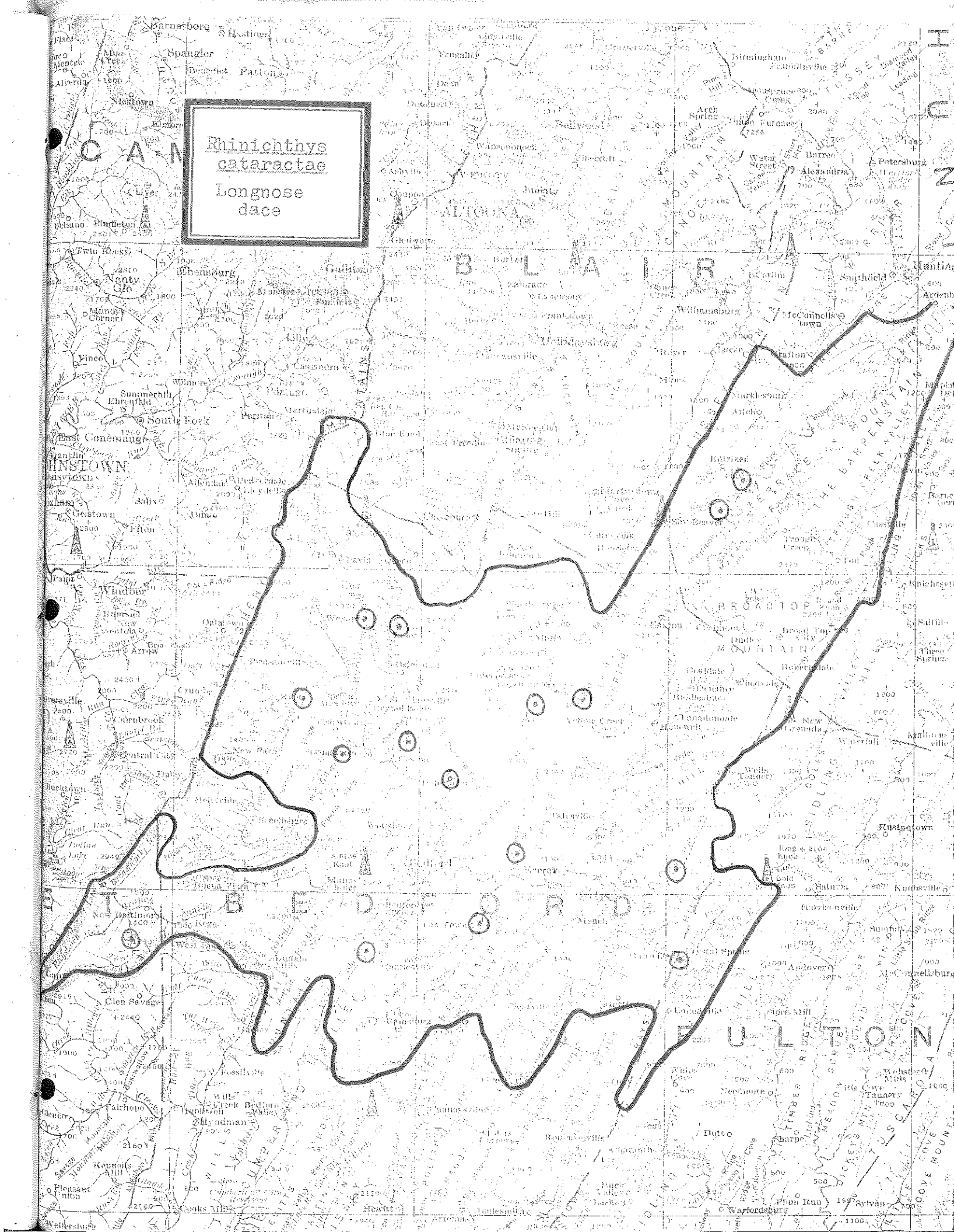

Notropis
rubellus
Rosyface
shiner

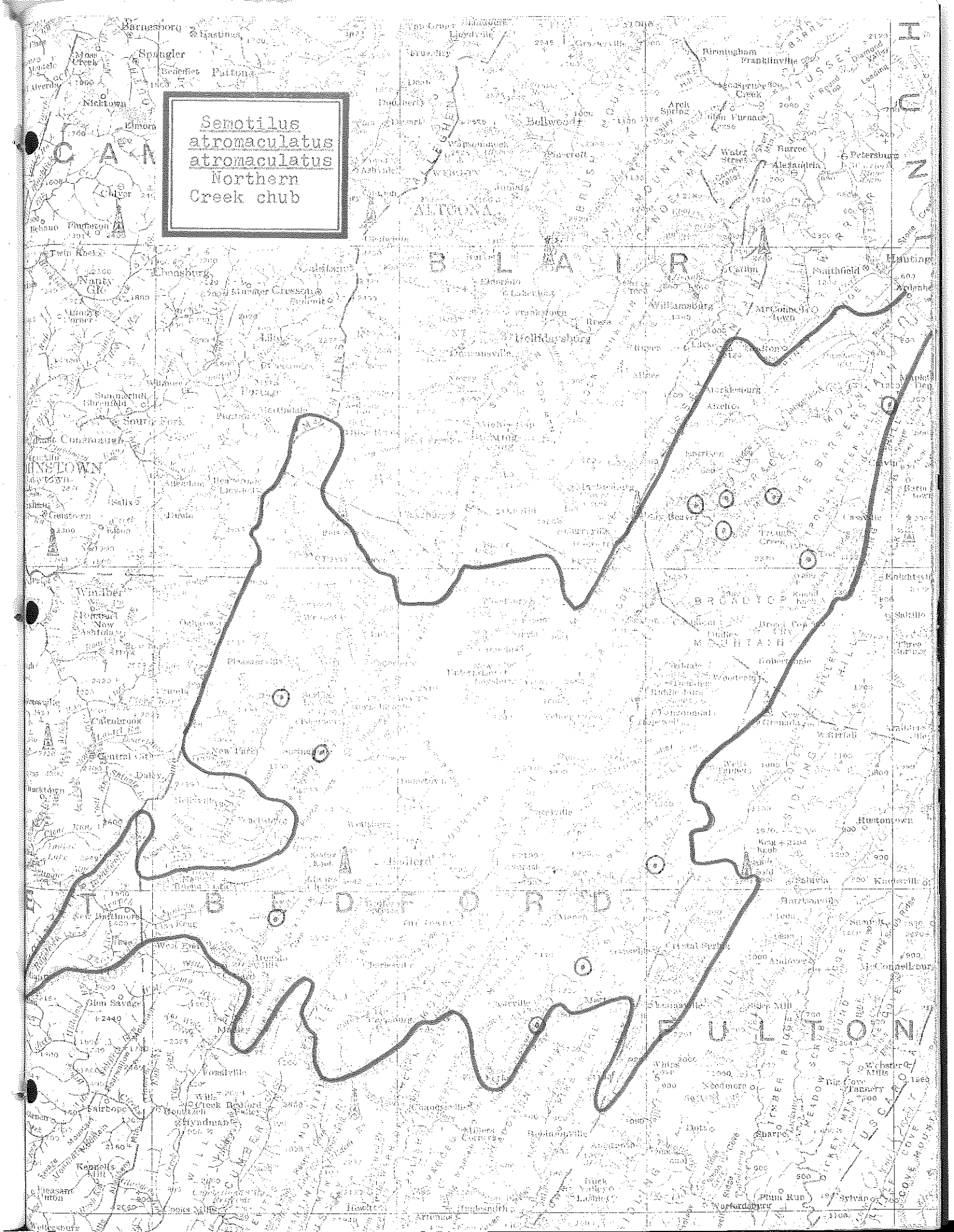

Notropis
spilopterus
Spotfin
shiner

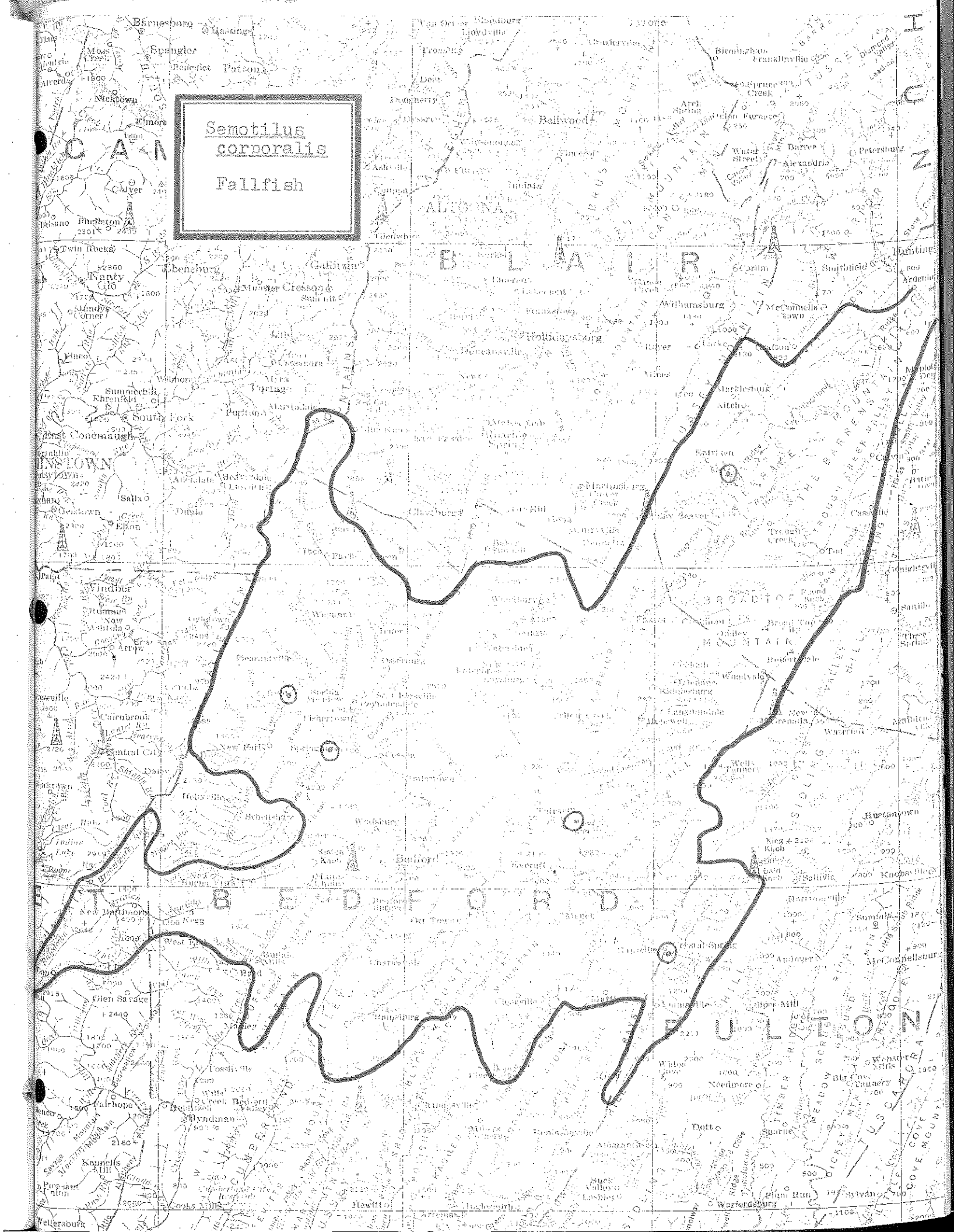

Noturus
insignis
Margined
madtom


Pimephales
notatus
Bluntnose
minnow


Rhinichthys atratulus
Blacknose dace


Rhinichthys cataractae
Longnose dace


Semotilus
atromaculatus
atromaculatus
Northern
Creek chub
CAMBRIA
BLAIR
HUNTINGDON
FULTON
ALTOONA
HOLLIDAYSBURG
HUNTINGDON
Barnesboro
Spangler
Patton
Nicktown
Elmora
Twin Rocks
Cresson
Summerhill
Gallitzin
Ebensburg
Hastings
Lloydville
Birmingham
Franklinville
Bellwood
Water Street
Barree
Petersburg
Alexandria
Williamsburg
McConnellstown
Smithfield
Hesting
Ardenhe
Martinsburg
Roaring Spring
Saxton
Riddlesburg
Broad Top City
Coalmont
Huntingdon
Mapleton Depot
Barton
Winslow
Calvinbrook
Central City
Dudley
New Paris
Bedford
Fishertown
Glen Savage
Fossilville
Fairhope
Kerrells
Pleasant Union
Cooks Mills
Hyndman
Bedford Springs
Schellsburg
Bloody Run
Everett
Breezewood
Fort Littleton
Needmore
Webster Mills
Big Cove Tannery
Sharpsburg
Plum Run
Mercersburg
Orbisonia
Three Springs
Shade Gap
Dublin
Mount Union
Shirleysburg
Petersburg
Knobsville
Saltillo
Huntingdon
Warriorsmark
Spruce Creek
Pennsylvania Furnace
Arch Spring
Water Street
Canoe Valley
Leading Ridge
Diamond Valley
Round Top
Sinking Valley
Tussey Mountain
Bald Eagle Mountain
Allegheny Mountain
Dunning Mountain
Wills Mountain
Sideling Hill
Tuscarora Mountain
Jacks Mountain
Terrace Mountain
Broad Top Mountain
Warrior Ridge
Shade Mountain
Rays Hill
Timber Ridge
Meadow Ridge
Scrub Ridge
Dickey Mountain
Cove Mountain
Tuscarora Creek
Juniata River
Raystown Branch
Frankstown Branch
Little Juniata River
Aughwick Creek
Licking Creek
Sideling Hill Creek
Wills Creek
Dunning Creek
Yellow Creek
Shobers Run
Buck Run
Brush Creek
Great Trough Creek
Little Trough Creek
Shade Creek
Stone Creek
Standing Stone Creek
Frankstown
Williamsburg
Hollidaysburg
Martinsburg
Roaring Spring
Saxton
Riddlesburg
Broad Top City
Coalmont
Huntingdon
Mapleton Depot
Barton
Winslow
Calvinbrook
Central City
Dudley
New Paris
Bedford
Fishertown
Glen Savage
Fossilville
Fairhope
Kerrells
Pleasant Union
Cooks Mills
Hyndman
Bedford Springs
Schellsburg
Bloody Run
Everett
Breezewood
Fort Littleton
Needmore
Webster Mills
Big Cove Tannery
Sharpsburg
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Orbisonia
Three Springs
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Broad Top Mountain
Warrior Ridge
Shade Mountain
Rays Hill
Timber Ridge
Meadow Ridge
Scrub Ridge
Dickey Mountain
Cove Mountain
Tuscarora Creek
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Aughwick Creek
Licking Creek
Sideling Hill Creek
Wills Creek
Dunning Creek
Yellow Creek
Shobers Run
Buck Run
Brush Creek
Great Trough Creek
Little Trough Creek
Shade Creek
Stone Creek
Standing Stone Creek


Semotilus
corporalis
Fallfish

VI. Discussion of Methods and Procedures

There are several areas where error could have taken or did take place. These can be put into three catagories: mechanical, natural, and human. In the first category, mechanical, one problem was holes in the seines from rocks (which were constantly repaired—but the problem kept occuring) and small fish slipping through the netting itself before reaching the bucket. Additionally, there were several times, such as Coffee Run and John's Branch, that the shocker was not putting out enough of a charge and several fish escaped.

In the second catagory, natural, rain was often a problem, causing high water and turbidity. Also stream topography and river flows made effecient handling of the seines or collecting nets (with the shocker) impossible at times.

Finally, human error was a factor. This manefested itself in many ways. Effecient seining and shocking methods came about only through practice. There were certainly streams that were surveyed better than others due to various human errors (none of which have been perceived as major). Also stream site location (sampling site) is a matter of judgement and, hence, an area with room for error. All in all though, factors worked in our favor (except weather) and we feel we achieved our objectives.

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1977

RAYSTOWN FIELD STATION
JUNIATA COLLEGE

FISH SPECIES COMPOSITION AND DISTRIBUTION STUDY OF LAKE RAYSTOWN (MARKLESBURG AREA), HUNTINGDON COUNTY, PENNSYLVANIA

Submitted to:

Dr. Robert L. Fisher

Submitted by:

William L. Good
David R. Bowman

5/18/77

Abstract

Lake Raystown in Huntingdon and Bedford Counties, Pennsylvania, is a relatively new lake. Very little is known about its fish species composition and distribution. The Marklesburg Area of the lake was investigated using trap netting and electrofishing. The results of the study are listed and discussed.

Introduction

Lake Raystown located mainly in Huntingdon County, Pennsylvania, as it exists today, is a relatively new lake. It is formed by the Raystown Dam on the Raystown Branch, 5.5 miles upstream of the Juniata River. The Dam was constructed between 1968 and 1973 and extended the dimensions of the old lake from a length of 9-10 miles, covering 575 acres to a length of 27 miles and covering 8,300 acres.

Since 1973, the Pennsylvania Fish Commission has been undertaking an extensive stocking program in the lake. (see Table 1) There is relatively no data available on what fish species are present and what their distribution is in the new lake. (Preliminary Fishery Survey of Raystown Dam, Huntingdon County, Pennsylvania by James A. Filson) For this reason it was decided that a study of an area of the lake could provided needed information. The Marklesburg area (see map) was choosen because it is one of two major

backwater areas of the lake. It consists of many embayments often shallow in depth, which could provide suitable spawning and feeding areas for a variety of fish.

Methods and Materials

Two methods of fish capture were employed for this study. Three trap nets and a boat mounted electrofisher were supplied by the Pennsylvania Commission.

Sites for the trap nets were chosen by consulting a contour map showing approximate depths of the area. One trap net was set in area #6 and two in area #4 (consult map). The trap net were processed daily for a period of three days.

Electrofishing was carried out using a 16 foot fiberglass boat equipped with a direct current, 23o volt electrofishing unit. The unit was operated effectively running between 150-200 volts with an amperage of 4, in an area no deeper than 1 meter. The electrofishing unit was used extensively To sample the shoreline and backwater areas of the Marklesburg Area.

A largemouth bass population estimate of a backwater area (#10 on map) was attempted. The area was shocked a series of nights, involving marking fish by fin clipping (left pelvic fin) and noting the number recaptured each night. The Peterson ratio for population estimation was applied to this data (William E. Ricker, "Method of Assessment of Fish Production").

The majority of the fish collected during the entire

study were processed by taking length-weight measurements. All fish caught were released into the area of capture.

Results

(See Tables 1-8 and Graphs 1-2)

Table 1

PENNSYLVANIA FISH COMMISSION STOCKING PROGRAM

LAKE RAYSTOWN, HUNTINGDON COUNTY - 8,300 ACRES

Year	Species	Size	Number
1973	Largemouth Bass	fry	516,400
	Largemouth Bass	1-2"	157,195
	Muskellunge	fry	302,000
	Northern Pike	fry	500,000
	Striped Bass	1-6"	20,875
	Walleye	fry	10,000,000
1974	Tiger Muskellunge	5-7"	16,600
	Northern Pike	fry	500,000
	Striped Bass	1-4"	29,120
	Walleye	fry	10,000,000
1975	Brown Trout	6-9"	14,000
	Tiger Muskellunge	5-6"	16,600
	Striped Bass	1-2"	42,000
1976	Brown Trout	6-8"	16,500
	Rainbow Trout	3-5"	28,900
	Muskellunge	9-12"	6,411
	Smelt	5-6"	400
	Smelt	fry	1,000,000
	Striped Bass	1-6"	33,010
	Lake Trout	4-6"	10,000

Table 2

TOTAL CATCH-ELECTROFISHING

(4/20/77, [illegible], 4/22, 4/26, 4/27, 4/29, 4/30, 5/1, 5/4, 5/5)

Largemouth Bass (Micropterus salmoides)	- 169
Smallmouth Bass (Micropterus dolomieui)	- 1
Rock Bass (Ambloplities rupestris)	- 1
Blue Gill (Lepomis macrochirus)	- 103
Pumpkinseed (Lepomis gibbosus)	- 9
Striped Bass (Roccus saxatilis)	- 1
White Crappie (Pomoxis annularis)	- 29
Black Crappie (Pomoxis nigromaculatus)	- 33
Yellow Perch (Perca flavescens)	- 8
Carp (Cyprinus carpio)	- many
Goldfish [illegible]	- 4
White Sucker (Catostomus commersoni)	- many
Hog Sucker (Hypentelium nigricans)	- 2
Brown Bullhead (Ictalurus nebulosus)	- 8
Muskellunge (Esox masquinongy)	- 7
Fall Fish (Semotilus corporalis)	- 1
Blunt-nose Minnow (Pimephales notatus)	- many
Golden Shiner (Notemigonus crysoleucas)	- many
Spotfin Shiner (Notropis spilopterus)	- many
Spot tailed Shiner (Notropis hudsonicus)	- 5
Gizzard Shad (Dorosoma cepedianum)	- 1

Table 3

TOTAL CATCH-TRAP NETTING
(4/20/77, 4/21, 4/22)

Largemouth Bass (Micropterus salmoides)	- 1
Rock Bass (Ambloplities rupestris)	- 2
Blue Gill (Lepomis macrochirus)	- 388
Pumpkinseed (Lepomis gibbosus)	- 19
White Crappie (Pomoxis annularis)	- 520
Black Crappie (Pomoxis nigromaculatus)	- 202
Yellow Perch (Perca flavescens)	- 28
Carp (Cyprinus carpio)	- many
Quillback (Carpoides cyprinus)	- 6
Goldfish	- 1
White Sucker (Catostomus commersoni)	- 12
Hog Sucker (Hypentelium nigricans)	- 2
Redhorse Sucker (Moxostoma macrolepidotum)	- 1
Brown Bullhead (Ictalurus nebulosus)	- 40
Muskellunge (Esox masquinongy)	- 1
Blunt-nose Minnow (Pimephales notatus)	- 10
Golden Shiner (Notemigonus crysoleucas)	- many
Spot tailed Shiner (Notropis hudsonicus)	- 1
American Eel (Anguilla bostoniensis)	- 1

Table 4

LENGTH DISTRIBUTION and AVERAGE WEIGHTS - ELECTROFISHING
(4/20/77, 4/21, 4/22, 4/26, 4/27, 4/29, 4/30, 5/1, 5/4, 5/5)

	Largemouth Bass		White Crappie		Blue Gill		Brown Bullhead	
Length (mm)	Avg. wt.(g)	#	Avg. wt.	#	Avg. wt.	#	Avg. wt.	#
50-74	--	--	--	--	--	2	--	--
75-99	--	2	--	17	--	33	--	--
100-124	15	15	13	1	34	13	--	--
125-149	32	15	30	1	50	16	--	--
150-174	--	1	48	5	70	21	--	--
175-199	--	1	77	4	114	18	--	--
200-224	118	9	--	--	--	1	--	--
225-249	163	24	--	--	--	--	200	1
250-274	225	31	--	1	--	--	224	5
275-299	303	22	--	--	--	--	295	2
300-324	360	45	--	--	--	--	--	--
325-349	550	5	--	--	--	--	--	--
350-374	700	1	--	--	--	--	--	--
* * *								
450-474	--	1	--	--	--	--	--	--

Table 5

LENGTH DISTRIBUTION and AVERAGE WEIGHTS - TRAP NETTING
(4/20/77, 4/21, 4/22)

	White Crappie		Black Crappie		Blue Gill		Brown Bullhead	
Length (mm)	Avg. wt. (g)	#	Avg. wt.	#	Avg. wt.	#	Avg. wt.	#
50-74	--	3	--	4	--	9	--	--
75-99	--	226	--	13	--	32	--	--
100-124	--	4	--	1	22	18	--	--
125-149	33	12	27	5	44	53	--	--
150-174	47	57	54	27	79	203	215	1
175-199	74	72	86	34	117	66	270	1
200-224	112	110	137	33	158	6	--	--
225-249	192	19	232	16	--	1	175	5
250-274	280	48	262	45	--	--	273	24
275-299	351	30	390	19	--	--	275	7
300-324	440	9	492	5	--	--	450	2

Table 6

AITCH AREA LARGEMOUTH BASS POPULATION STUDY
(5/5/77, 5/6, 5/9, 5/12, 5/13, 5/14)

Total Number of Bass Caught-- 108

Length (mm)	Avg. wt. (g)	#(number)
225-249	190	23
250-274	214	37
275-299	352	15
300-324	422	29
325-349	476	3
500-524	--	1

Date	# Caught/Night	Progressive Total	# Marked Recaptured/Night
5/5	9	9	--
5/6	7	16	0
5/9	22	38	0
5/12	35	73	2
5/13	11	84	1
5/14	24	108	3

$N = \frac{MC}{R}$ (Peterson Ratio) ---- 1^{st} estimate (5/12); $N = \frac{(38)(35)}{2} = 665$

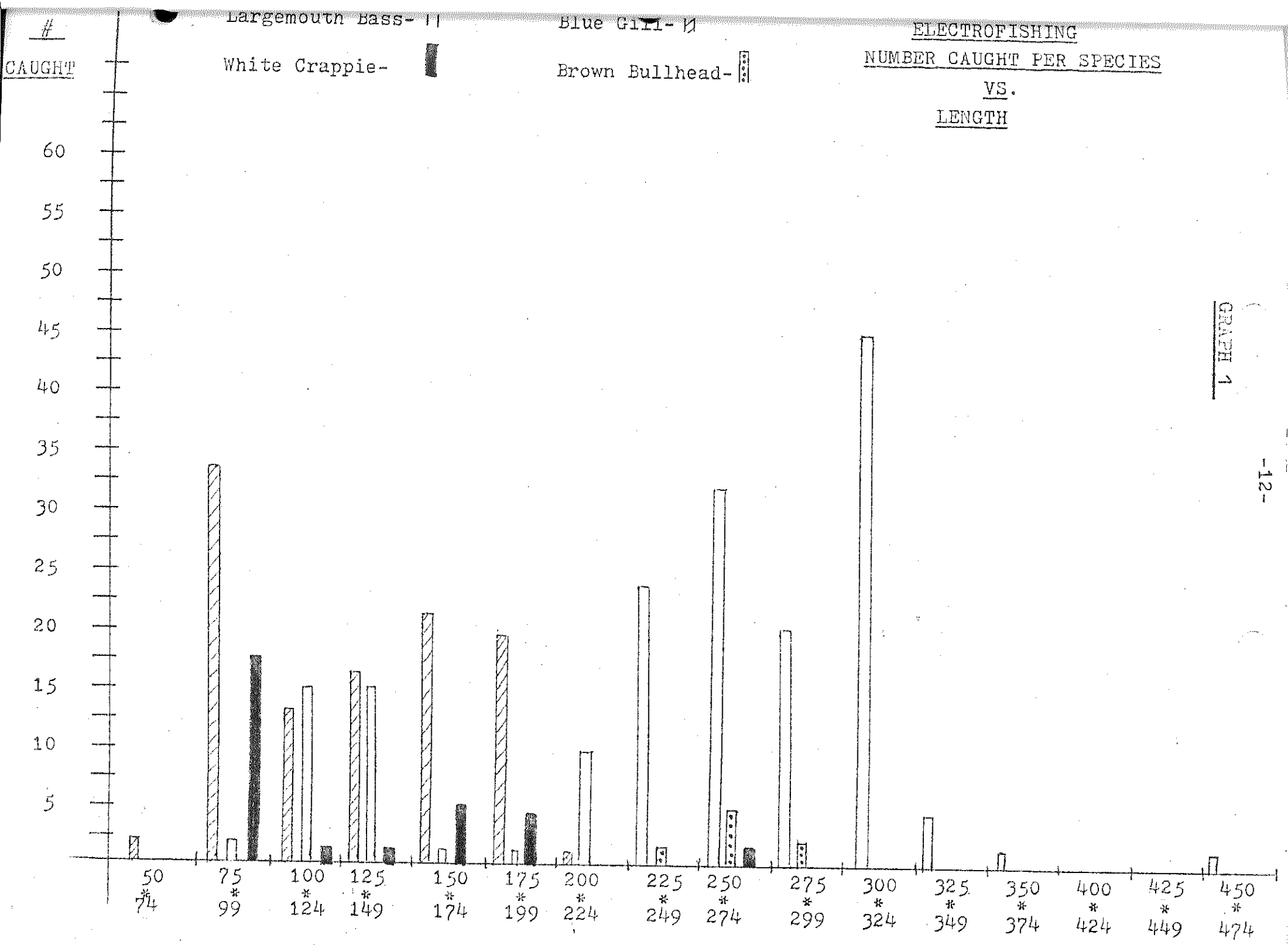
2^{nd} estimate (5/13); $N = \frac{(73)(11)}{1} = 803$ 3^{rd} estimate; $N = \frac{(84)(24)}{3} = 672$

ELECTROFISHING-- NIGHTLY CATCHES Table 7	4/20/77 Area:11 Area:10	4/22/77 Area:7	4/26 Area: 13-14-15	4/27 Area: 11-10	4/29 Area: 3-4	4/30 Area: 15, 1	5/1 Area: 6	5/4 Area: 1-2	5/5 Area: 12		
Largemouth Bass	50	24	2	13	24	19	14	9	2		
Smallmouth Bass						1					
Rock Bass			1								
Blue Gill	20	23	5	10	10	14	4	2			
Pumpkinseed		2			3	3		1			
Striped Bass	1										
White Crappie	7	7		4	5		4				
Black Crappie	1			2	2		2				
Yellow Perch	2	1			3	2	1				
Carp	2	many	1	1		1					
Goldfish	1			2							
White Sucker	7	1		3	1	2	2		many		
Hog Sucker					1						
Brown Bullhead	18			1			5		2		
Muskellunge	2	1							1		
Fall Fish						1					
Blunt-nose minnow	1			1	2	3	many	many	many		
Golden Shiner	many			many	11		many	many	many		
Spotfin Shiner	1	6	many	4	8	3	many	many	many		
Spot tailed Shiner	1			4							
Gizzard Shad	1										

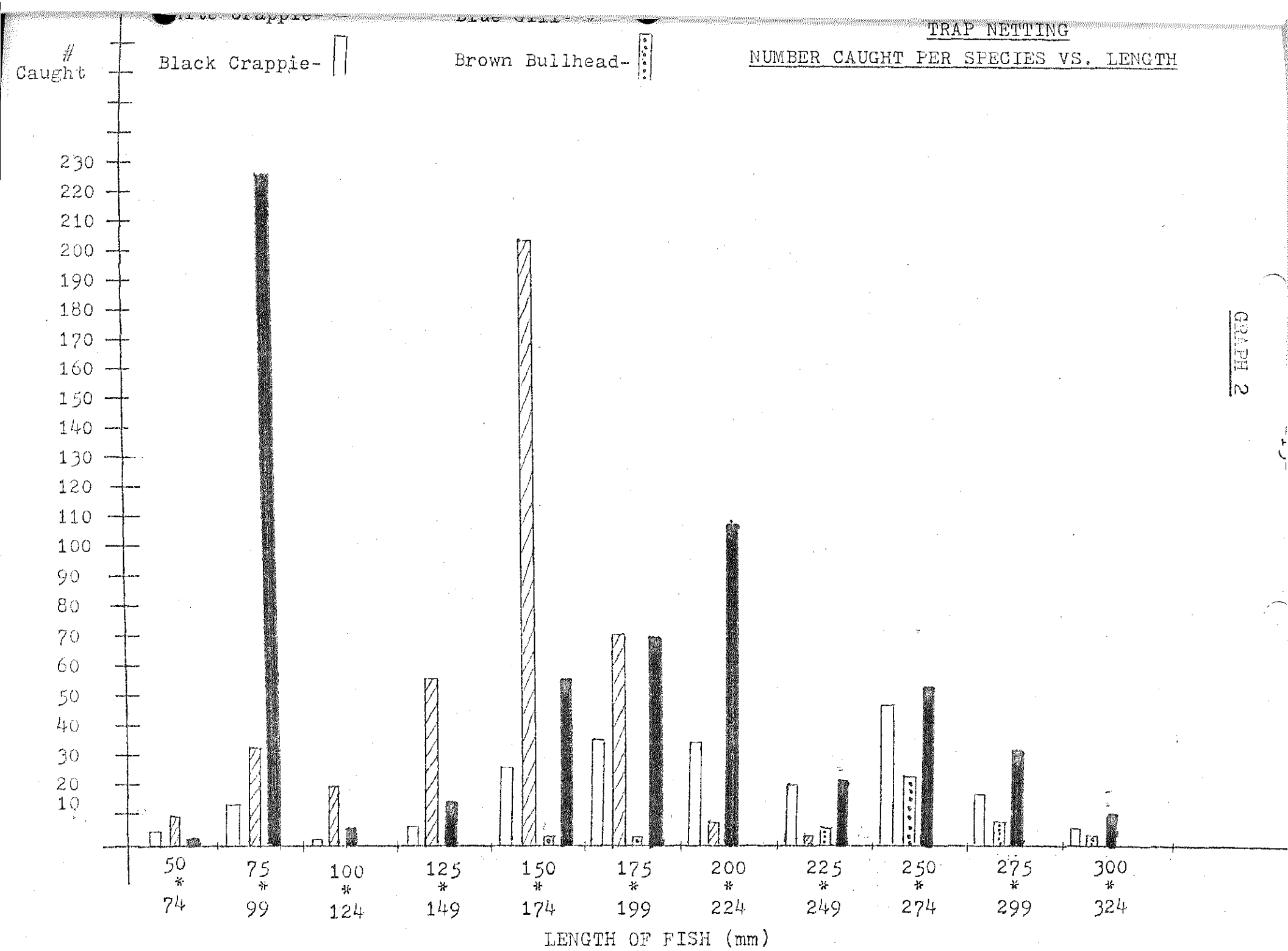
DAILY CATCHES

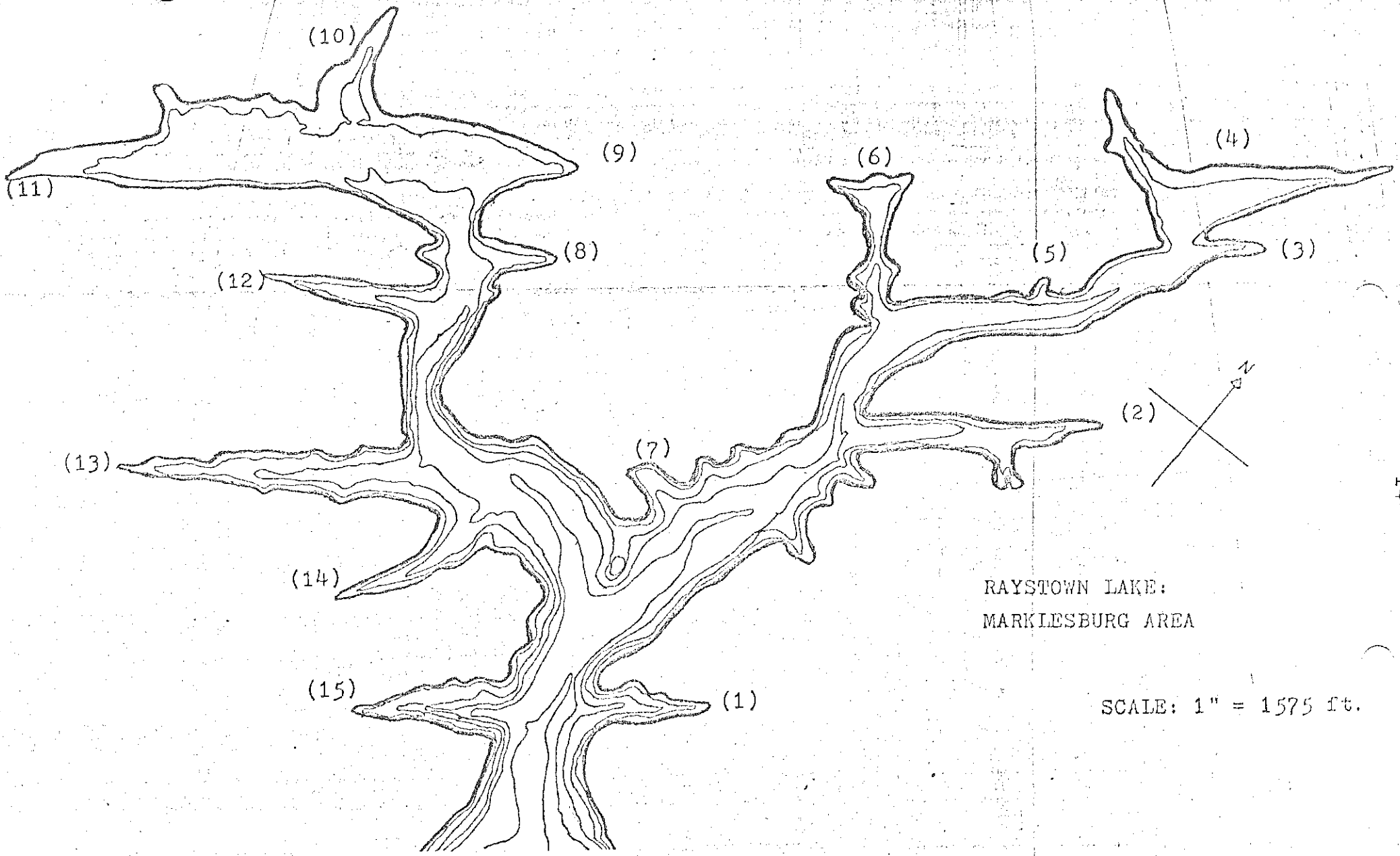
Table 8

	Area:6	Area:4 N.W.shore	Area:4 S.shore	Area;6	Area:4 N.W.shore	Area:4 S.Shor	Area:6	Area:4 N.W.	Area:4 S. Shore
Largemouth Bass			1						
Rock Bass				1	1				
Blue Gill	15	70	36	12	25	29	4	90	12
Pumpkinseed		8	4		7	1		5	2
White Crappie	33	11	30	23	38	56	10	95	60
Black Crappie	12	23	19	11	32	22	5	61	16
Yellow Perch		3	1	1	12	1		5	1
Carp	1	1			12				
Quillback	1	4					1		
Goldfish	1								
White Sucker		3			5	3		1	1
Hog Sucker		1			1				
Redhorse Sucker								1	
Brown Bullhead	2	5	1	6	5	2	3	17	5
Muskellunge		1							
Blunt-nose Minnow	2	6			2				
Spot tailed Shiner			1						
American Eel		1							
Golden Shiner		5		1		1		3	


CAUGHT
Largemouth Bass- ||
White Crappie-
Blue Gill- ||
Brown Bullhead-
ELECTROFISHING
NUMBER CAUGHT PER SPECIES
VS.
LENGTH
60
55
50
45
40
35
30
25
20
15
10
5
50 * 74
75 * 99
100 * 124
125 * 149
150 * 174
175 * 199
200 * 224
225 * 249
250 * 274
275 * 299
300 * 324
325 * 349
350 * 374
400 * 424
425 * 449
450 * 474

GRAPH 1


TRAP NETTING
NUMBER CAUGHT PER SPECIES VS. LENGTH
Black Crappie-
Brown Bullhead-
Caught
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
50 * 74
75 * 99
100 * 124
125 * 149
150 * 174
175 * 199
200 * 224
225 * 249
250 * 274
275 * 299
300 * 324
LENGTH OF FISH (mm)
GRAPH 2



RAYSTOWN LAKE:
MARKLESBURG AREA

SCALE: 1" = 1575 ft.

Discussion

As indicated by the results, the trap netting yielded high numbers of black and white crappies while the electrofishing produced high numbers of largemouth bass. Both methods also yielded a great diversity of other species in smaller numbers.

Since both methods yielded a similar capture(in both diversityand number) of fish species other than largemouth bass and crappies, it was assumed that an accurate approximation of the fish species composition and distribution in the Marklesburg Area was obtained.

Complete data was not taken on carp, golden shiners, spotfin shiners and white suckers because of the limited time factor, but it was acknowledged that they were present in large numbers and widely distributed. As indicated, we also ran into many other species, but these appeared to be relatively uncommon at least by our methods of capture. The most complete data was taken on Game fish.

As expected, the areas that yielded high numbers of fish were shallow, backwater areas that contained submerged debris. Thisis probably due to two factors: the capture methods used are most effective in shallow water and the submerged debris acts as cover for the fish(there is very little aquatic vegetation present).

We observed many young bluegill, laregmouth bass and crappie, indicating that there is active reproduction of these species occuring in the area of study. This fact, in addition to the presense of large numbers of shiners and minnows(bluntnose) indicates

that there is ample food source for the larger fish inhabiting the area.

From the bar graphs of number caught per species vs the length several observations can be made. The data for black and white crappie indicates that the white crappie is the more successful species of the two. The total number of white crappie in most size categories is greater. Also, the number of young white crappie is dramatically higher than the number of black which might indicate that white crappie are breeding more successfully than the black. These generalizations refer mainly to the trap netting results (area no. 4 & 6).

The largemouth bass population appears to be widely distributed throughout most of the area studied. The bass that were captured were of a variety of sizes; however, the majority were adults ranging from 225 to 325 mm.

The population estimate of largemouth bass in area no. 10 did not produce any dramatic results, but did allow us to make some some interesting observations. According to our estimate there are between 600 and 800 largemouth bass in this area. The validity of the figure is questionable due to the low number of recaptures. It is interesting to note that the bass in the size range 275mm -- 324mm were significantly heavier(approximately 40 grams) than those caught elsewhere. This correlates with the field observation that the majority of the largemouth bass caught in this area were gravid females. It is possible that this area due to physical features is a suitable site for breeding.

An interesting hypothesis explaining the low recapture

number of largemouth bass in the population study area could be due to the fact that after being shocked a few times, the bass might tend to avoid any further contact with the electrofisher.

In summary, it would seem that due to to the large amount of cover present, apparent reproduction, adequate food supply and the capture of large numbers of fish, the Marklesburg Area is an excellant fish habitat.

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THE FOLLOWING ARE COPIES OF THE

ORIGONAL DATA SHEETS

Trolishing

a - (11)

4/20/77

start → 9:15 PM

stop → 10:30 PM

AREA: Raystown Lake

IES	LMB		WC		BG		Brown Bullhead		Musky		Striped Bass			
< 24														
→ 49														
→ 74														
→ 99			3											
→ 124					1									
→ 149					4									
→ 174					3									
→ 199					5						1			
→ 224	1													
→ 249	2		1				2							
→ 274	6						10		1					
→ 299	5		1				3							
→ 324	11													
→ 349	4													
→ 374	700g													
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+														
Σ	Gizzard Shad		White Sucker		Goldfish		Golden Shiner							
	1		3		1		Many							

sctrotishing

rea – (10)

R AREA: Raystown Lake

4/20/77

start → 8:00 PM

stop → 8:30 PM

IES	LMB		WC		BC		BG		YP		Brown Bullhead		Musky	
≤ 24														
→ 49														
→ 74														
→ 99					1		3		2					
→ 124	1													
→ 149							1							
→ 174			1				2							
→ 199							1							
→ 224														
→ 249	4													
→ 274	5		1								3		1	
→ 299	3													
→ 324	7													
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+	white sucker		Golden Shiner		Carp		Spot-tail Shiner		Spot-tail Shiner		Island mask.			
Σ	4		10		2		1		1		1			

ctvo Fishing

4/22/77

a: (7)

Start - 8:00 PM

stop - 9:00 PM

ER AREA: Raystown Lake

IES	LMB	LMB		WC		BG		PS		Musky		YP		
≤ 24														
→ 49														
→ 74														
→ 99				7		6						1		
→ 124	15g 29g					6								
→ 149	25g 35g 25g 30g 25g					4		1						
→ 174						4		1						
→ 199	120g					2								
→ 224		2				1								
→ 249	190g													
→ 274	230g 245g													
→ 299	270g 245g 290g	1								110g				
→ 324	315, 355 350, 405 340g	1												
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474	1													
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+	Carp		white Sucker		spot-fin shiner									
Σ	Many		1		6									

Electrofishing

Area: (15)-(14)-(13)

AREA: Raystown Lake

4/26/17

start - 8:40

stop - 10:15

IES	LMB		Rock Bass		B.G.										
< 24															
→ 49															
→ 74															
→ 99					4										
→ 124					1										
→ 149															
→ 174															
→ 199															
→ 224	115g		165g												
→ 249	180g														
→ 274															
→ 299															
→ 324															
→ 349															
→ 374															
→ 399															
→ 424															
→ 449															
→ 474															
→ 499															
→ 524															
→ 549															
→ 574															
→ 599															
→ 624															
+															
Σ	Carp		Spot-fin Shiner												
	1		many												

...tro fishing

...a - (11)

R AREA: Raystown Lake

4/27/77
Start: 10:00 PM
Stop: 10:30 PM

IES	LMB		BG		WC		BC							
≤ 24														
→ 49														
→ 74							1							
→ 99			5		1		4							
→ 124			34g		13g									
→ 149														
→ 174			65g 55g											
→ 199														
→ 224	120g													
→ 249	155g 175, 185													
→ 274	225g 200, 210 215													
→ 299														
→ 324														
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+														
Σ	carp		White Sucker		Golden shiner		Spot tailed shiner		Ethmi nose Minnow					
	1		1		6		1		1					

Trolling

(10)

4/21/77

Start: 830 AM

Stop: 9:30 PM

AREA: Raystown Lake

IES	LMB		WC		BG		Brown Bullhead							
< 24														
→ 49														
→ 74					2									
→ 99														
→ 124														
→ 149					55g 45									
→ 174			55g		90g 85									
→ 199			65g											
→ 224														
→ 249														
→ 274	220g						210g							
→ 299	350g 310													
→ 324	440g													
→ 349	500g													
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
624														
+														
Σ	Golden Shiner		Gold fish		spotfin shiner		Spotted Shiner		White Sucker					
	Many		2		2		4		2					

etrol fishing

rea (3) - (4)

ER AREA: Raystown Lake

4/29/77
start 9:30
stop 11:00

CIES	LMB	LMB		BG		WC		BC		PS		YP		
≤ 24														
→ 49														
→ 74								1				2		
→ 99				8		4		7		1		2		
→ 124	10g 15			1										
→ 149	20g 35			35g 45		30g								
→ 174	40g			80g, 70 50, 60, 80		50g				60g 60				
→ 199				6		100g 75g								
→ 224	110g 130g													
→ 249	150g, 150 140, 145													
→ 274	220, 280 150, 210 235	1												
→ 299	250g													
→ 324	450g 410 340, 320 430	1												
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624	Hog Sucker		White Sucker		Golden shiner		Blunt nose		Spot-fin Shiner					
+	1		1		11		2		8					
Σ														

ectro Fishing

ea - (15), (1), J-2 Island

ER AREA: Lake Raystown

4/30/77

Start - 9:30 AM

Stop - 11:20 PM

CIES	LMB	LMB	BG	BG	PS	PS		SMB		YP				
≤ 24														
→ 49														
→ 74														
→ 99	2		4							2				
→ 124	15g 15, 15	4	3											
→ 149	35g 32 37 35 36	7	55g	2	1									
→ 174			85g		100g	2								
→ 199			125g 110, 110											
→ 224		1						110g						
→ 249	150g 166													
→ 274	255g 215, 210 250													
→ 299	315g 340													
→ 324	435g 360													
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+														
Σ	White Sucker		Carp		Spot-fin Shiner		Black Nose Minnow			Redfish				
	2		1		3		3			1				

ctrofishing

ea; (6)

AREA: Lake Raystown

5/11/77

start - 10:45

stop - 11:00 84

ES	LMB	LMB		BG		WC	Brown Bullhead		BC		Yellow Perch			
< 24														
→ 49														
→ 74														
→ 99				3		2			2		1			
→ 124	25g 15													
→ 149														
→ 174				85g 75		40g								
→ 199						70g								
→ 224														
→ 249	175g						200g							
→ 274	240g 270, 230						225g 200 210							
→ 299	400g, 320 345						320g							
→ 324	460g, 340 385, 450 450	6												
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
< 624														
+														
Σ	White Sucker		Golden Shiner		Spottail Shiner		Bluntnose							
	2		Many		Many		Many							

Electrofishing

Data: ① - ②

Start - 8:30 PM

Stop - 9:45 PM

AREA: Raystown Lake

IES	LMB		BG		PS									
< 24														
→ 49														
→ 74														
→ 99														
→ 124	1													
→ 149	30g		45g											
→ 174					80g									
→ 199			110g											
→ 224	140g 135													
→ 249	174, 170 165, 150 160													
→ 274														
→ 299														
→ 324														
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+														
Σ	Golden Shiner		Bluntnose		spot-tin Shiner									
	many		many		many									

ectrofishing

5/5/77

Area (12)

Start: 9:30

ER AREA: Raystown Lake

Stop: 10:30

CIES	LMB		Brown Bullhead		Musky										
≤ 24															
5 → 49															
0 → 74															
5 → 99															
0 → 124															
5 → 149															
0 → 174															
5 → 199															
0 → 224															
5 → 249	260g														
0 → 274			275g												
5 → 299			290g												
→ 324	400g														
5 → 349															
0 → 374															
5 → 399															
0 → 424															
5 → 449															
0 → 474															
5 → 499															
0 → 524															
5 → 549															
0 → 574															
5 → 599															
→ 624															
5 +					6 to 2 mm										
Σ	White Sucker		Golden Shiner		Spot fin Shiner		Blunt nose								
	many		many		many		many								

Trap Netting

Area : (6)

WER AREA: Raystown Lake

Set time: 5:00 PM (4/19/77)

Pull time - 2:00

Re-set - 2:15

4/20/77

CIES	WC	WC		BC	BC		BG	BG		Brown Bullhead					
≤ 24															
5 → 49															
0 → 74	2														
5 → 99	17			1											
0 → 124							10g 26								
5 → 149	26g						50g								
0 → 174	48g 42g			58g			90g 82 96 64 90	12							
5 → 199	66g, 92 82	2		84g 100			115g, 150 110, 132, 116	7							
0 → 224	92g	1		160g											
5 → 249	160g 182			204g 212											
0 → 274	296g, 210 286, 250 282	7		260g 245 175	1					230g 200					
5 → 299	305g, 370 312, 375 306	2		395g											
0 → 324															
5 → 349															
0 → 374															
5 → 399															
0 → 424															
5 → 449															
0 → 474															
5 → 499															
0 → 524															
5 → 549															
0 → 574															
5 → 599															
0 → 624															
5 +	Quill back		Carp		Blunt nose		Goldfish								
Σ	1		1		2		1								

Trap Net. 4/20/77

Area (4) N.W. Shore set 1/2 5:30 Pull time, 3:45 P.
(4/19/77) Reset - 3:55 P.

WATER AREA: Raystown Lake

SPECIES	WC	WC		BC	BC		BG	BG		YP		PS		Brn Bull
≤ 24														
25 → 49														
50 → 74				1			2							
75 → 99	130			(4)			9			2				
100 → 124							2					20g 20 20		
125 → 149							30g, 40 30, 35, 40	3				25g 30		
150 → 174	40g, 35						60g 65 70, 75 60	39				60g, 60 55		215
175 → 199				90g 100			100g 110 120, 50, 80	10						175
200 → 224	135g			180g, 120 110, 95						95g				
225 → 249	160g 210			240g 220										175
250 → 274				320g, 250 265, 230 290										170g
275 → 299	340g, 380 370, 340 320			330g 350 315, 290 400	1									
300 → 324				475, 500										450
325 → 349														
350 → 374														
375 → 399														
400 → 424														
425 → 449														
450 → 474														
475 → 499														
500 → 524														
525 → 549														
550 → 574														
575 → 599														
600 → 624														
625 +														
Σ	Quillback	Hog Sucker	White Sucker	Golden Shiner	Blue Nose	Carp	American Eel	Musky						
	4	1	3	5	6	1	1	30.0 inches						

Trap Net

4/20/77

Area: (4) south shore

Set time - 5:15 PM (4/19/77)

Pull time: 2:50 P

ER AREA: Raystown Lake

Reset: 3:00 P

CIES	WC	WC		BC	BC		BG	BG		BS	BS		YP	Brown Bull
≤ 24														
5 → 49														
0 → 74							1							
5 → 99	13			1			2							
0 → 124							20g	1						
5 → 149	30g						40g, 50 50, 50, 50			45g 45	1			
0 → 174	46g, 50 42			60g 45	1		100g, 95 60, 70 95	15		90g				
5 → 199	65g, 55 50, 90, 70	5		85g, 75 35, 105			115, 105 125, 140 130	6					80g	
0 → 224	100g, 115 95, 125g 138	2		135g, 120 170, 160										
5 → 249	220g, 222 212, 190			245g 250										
0 → 274	260g, 315 315, 310 300	7		312g, 300 240										230g
5 → 299	325g, 410			450g										
→ 324														
5 → 349														
0 → 374														
5 → 399														
0 → 424														
5 → 449														
0 → 474														
5 → 499														
0 → 524														
5 → 549														
0 → 574														
5 → 599														
→ 624														
5 +														
Σ	spot tail		Largemouth Bass											
	1		1 (320-324mm)											

Trap net

Area (2)

4/20/77 set time 2:40 PM

4/21/77 pull time 1:40 PM reset " 1:50 PM

WATER AREA: Raystown Lake

SPECIES	WC	WC		BC	BC		BG	BG		BBH				
≤ 24														
25 → 49														
50 → 74														
75 → 99								1						
00 → 124														
25 → 149							45g 40							
50 → 174	40g 55 50			40g			110g 70 70 60 50	4						
75 → 199	70g 40 75 105 95	5		65g			90g 110							
00 → 224	110g 110 40			160g 190 150 150 150			190g							
25 → 249				250g										
50 → 274	250g 270 210 230 26	1		310g 280						310g 280 230 290				
75 → 299	310g 330 360			350g						250g 250				
0 → 324	450 450													
25 → 349														
50 → 374														
75 → 399														
00 → 424														
25 → 449														
50 → 474														
75 → 499														
00 → 524														
25 → 549														
50 → 574														
75 → 599														
→ 624														
25 +	Yellow perch	Golden shiner	Rock bass											
Σ	1	1	1											

Trapper

area ④ northwest shore

set time 3:55 PM

pull time

reset " 3:40 PM

ER AREA: Raystown Lake

CIES	WC	WC		BC	BC		BG	BG		BBH		YP	PS
< 24													
5 → 49												1	
0 → 74												2	3
5 → 99		7			2			2				6	40g
0 → 124							20g						50g 50 60 60 20 50
5 → 149	50g 00			20g 30 30			40g 70 50 60 40	19					
0 → 174	50g 50 50 50	3		50g 40 40 60 70			45g 90 100 40 55	2				80g	
5 → 199	70g 80 60 50			90g 90 90 70 40			140g 120 130 130 120	2				130g	
00 → 224	100g 150 100 120 40	4		200g 150 100 90 100	2		170g 160 140			260g			
25 → 249	235g			240g									
50 → 274	370g 280 300 240			260g 360 350 240						350g 300		240g	
75 → 299	350g 300			460g 500 350						270g			
00 → 324	350g			500						450g			
25 → 349													
50 → 374													
75 → 399													
400 → 424													
425 → 449													
450 → 474													
475 → 499													
500 → 524													
525 → 549													
550 → 574													
575 → 599													
00 → 624													
625 +	carp	rock bass		Blunt nose minnow	white sucker	Hog sucker							
Σ	12	1		2	5	1							

Trap net

Area ④ south shore

4/20/11
3:00 PM

4/21/11
Pull time 2:40 PM
Reset " 2:45 PM

WATER AREA: Raystown Lake

SPECIES	WC	WC		BC	BC		BG	BG		BBH				
≤ 24														
25 → 49														
50 → 74														
75 → 99	13							5						
100 → 124							20g 25 30							
125 → 149	30g						45g 35 40							
150 → 174	60g 50 40 40 50	1		60g 55 55			70g 75 55	9						
175 → 199	70g 70 55g 70 80	2		60 60 75			150 90 100 90	1						
200 → 224	130g 100 100 110 110	7		150g			130							
225 → 249	170g 210 150 130 190			195g						350				
250 → 274	310 350 300 240 250			240g 330 370 330 400	8					240				
275 → 299	450 315 400 430			450 ↑										
300 → 324	450 450													
325 → 349														
350 → 374														
375 → 399														
400 → 424														
425 → 449														
450 → 474														
475 → 499														
500 → 524														
525 → 549														
550 → 574														
575 → 599														
600 → 624														
625 +	Yellow perch	white sucker	Pumpkin seed	Golden shiner										
Σ	1	3	1	1										

Trap net
rea (6)

4/21/(
1:50 PM

4/22/77
pull time 9:20 AM

AREA: Raystown Lake

ES	WC	BC	[illegible]	BG	[illegible]		BDH							
24														
49														
74														
99														
124														
149														
174	1	1		4										
199	4													
224														
249		2												
274	2	2		[illegible]			1							
299	3			[illegible]			2							
324														
349														
374														
399														
424														
449														
474														
499														
524														
549														
574														
599														
624														
+	Quill back													
Σ	(1)													

vap Net.

ea: 4 - N.W. Shore

ER AREA: Raystown Lake

4/22/77

Bell Time: 10:45

CIES	WC		BC		DG		PS		BGH		YP			
≤ 24														
5 → 49														
0 → 74	1		2		4									
5 → 99	36		4		13						2			
0 → 124	4		1		8		1				1			
5 → 149	4		2		13		3							
0 → 174	12		8		42		1							
5 → 199	18		15		9									
0 → 224	10		9								1			
5 → 249	2		3		1				4		1			
0 → 274	2		10						11					
5 → 299	3		6						2					
0 → 324	3		1											
5 → 349														
0 → 374														
5 → 399														
0 → 424														
5 → 449														
0 → 474														
5 → 499														
0 → 524														
5 → 549														
0 → 574														
5 → 599														
0 → 624														
5 +														
Σ	Northern Sucker		Lunate Sucker		Golden Shiner									
	1		1		3									

pp Net

ea: 4 - South Shore

ER AREA: Raystown Lake

4/22/22

Pull time - 10:00 AM

CIES	WC		BC		BG		PS		YP		BBH			
≤ 24														
→ 49														
→ 74			1											
→ 99	10		1											
→ 124							1							
→ 149	4				3				1					
→ 174	20		5		3		1							
→ 199	14		4		5									
→ 224	4		2		1									
→ 249	3		1											
→ 274	4		2								1			
→ 299														
→ 324	1										2			
→ 349											1			
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+														
Σ	White Sucker													

Electrofishing

a - 10 Bass Study

ER AREA: Raystown Lake

5/5/77

Start : 11:00 PM

Stop : 12:00 PM

CIES	LMB	LMB												
≤ 24														
→ 49														
→ 74														
→ 99														
→ 124														
→ 149														
→ 174														
→ 199														
→ 224														
→ 249	229, 150 200													
→ 274	239, 260 240													
→ 299														
→ 324	480, 440 460													
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+														
Σ														

electrofishing

Already Marked = (WH)

5/6/77

a: 10 Bass Study

Start: 10:30 PM

Stop: 12:30 PM.

ER AREA: Raystown Lake

CIES	LMB	LMB												
≤ 24														
→ 49														
→ 74														
→ 99														
→ 124														
→ 149														
→ 174														
→ 199														
→ 224														
→ 249	145g/150													
→ 274	225g													
→ 299	310g													
→ 324	340g, 410 420													
→ 349														
→ 374														
→ 399														
→ 424														
→ 449														
→ 474														
→ 499														
→ 524														
→ 549														
→ 574														
→ 599														
→ 624														
+														
Σ														

Electrofishing

Area: 10, Bass Study

WATER AREA: Raystown Lake

Already Marked = (4")

5/9/77
Start: 9:30 PM
Stop 11:00 PM

SPECIES	LMB	LMB													
≤ 24															
→ 49															
→ 74															
→ 99															
→ 124															
→ 149															
→ 174															
→ 199															
→ 224															
→ 249	160g, 180, 180, 160	180													
→ 274	250g, 220, 220, 270, 230, 270	240, 200, 210, 220, 200, 210													
→ 299	320g, 290														
→ 324	470, 400, 410														
→ 349															
→ 374															
→ 399															
→ 424															
→ 449															
→ 474															
→ 499															
→ 524															
→ 549															
→ 574															
→ 599															
→ 624															
+															
Σ															

trolfishing

: 10. Bass Study (

R AREA: Raystown Lake

Already Marked = (WT)

5/12/77

Start. 9:00 P

Stop 11:00 P

IES	LMB	LMB
≤ 24		
→ 49		
→ 74		
→ 99		
→ 124		
→ 149		
→ 174		
→ 199		
→ 224		
→ 249	209, 170 140, 150, 210	4
→ 274	209 (230) 210, 220, 190	6
→ 299	300, 310 450, 270 350	1
→ 324	450, 360 (410) 450 450	
→ 349	450, 510	
→ 374		
→ 399		
→ 424		
→ 449		
→ 474		
→ 499		
→ 524	1	
→ 549		
→ 574		
→ 599		
→ 624		
+		
Σ		

electrofishing

Already Marked = (wt.)

5/13/77

Area: 10, Bass Study.

Start: 9:30 PM

Stop 11:00 PM

WATER AREA: Lake Raystown

SPECIES	LMB	LMB												
≤ 24														
25 → 49														
50 → 74														
75 → 99														
100 → 124														
125 → 149														
150 → 174														
175 → 199														
200 → 224														
225 → 249	200g													
250 → 274	310g, 210 (240) 240													
275 → 299	280g, 415 420													
300 → 324	415g, 450, 435													
325 → 349														
350 → 374														
375 → 399														
400 → 424														
425 → 449														
450 → 474														
475 → 499														
500 → 524														
525 → 549														
550 → 574														
575 → 599														
600 → 624														
625 +														
Σ														

Electrofishing

Already Marked = (10+)

5/14/77

Start: 9:00 AM

Stop: 12:00 PM

10 - Bass study

AREA: Lake Raystown

SPECIES	LMB	LMB
< 24		
→ 49		
→ 74		
→ 99		
→ 124		
→ 149		
→ 174		
→ 199		
→ 224		
→ 249	(200) 190 220	
→ 274	250g, 260 265, 210	(240) (250)
→ 299	390g 310, 400	
→ 324	410g, 380 350 440, 370	6
→ 349	440	
→ 374		
→ 399		
→ 424		
→ 449		
→ 474		
→ 499		
→ 524		
→ 549		
→ 574		
→ 599		
→ 624		
+		
Σ		

ectro fishing

a: 10 - Bass study

R AREA: Lake Raystown

Already Marked = (LMB)

5/14/77

Start: 9:00 PM

Stop: 12:00 PM

IES	LMB	LMB													
≤ 24															
→ 49															
→ 74															
→ 99															
→ 124															
→ 149															
→ 174															
→ 199															
→ 224															
→ 249	(200) 190 220														
→ 274	250g, 220 265, 210	(240) (250)													
→ 299	390g 310, 400														
→ 324	410g, 380 380 440, 370	6													
→ 349	440														
→ 374															
→ 399															
→ 424															
→ 449															
→ 474															
→ 499															
→ 524															
→ 549															
→ 574															
→ 599															
→ 624															
+															
Σ															

SEASONAL VARIATION
of
OXYGEN AND PLANKTON DISTRIBUTION
in
Raystown Lake

Independent Study- 1976-1977
by
Elaine Keithan

INTRODUCTION

Many lakes show changes in the stratification of oxygen, temperature, pH and chlorophyll content in the water during the different seasons of fall, winter and spring. Physical chemical and biological conditions of the Raystown Lake were monitored to determine seasonal variations and variations with depth.

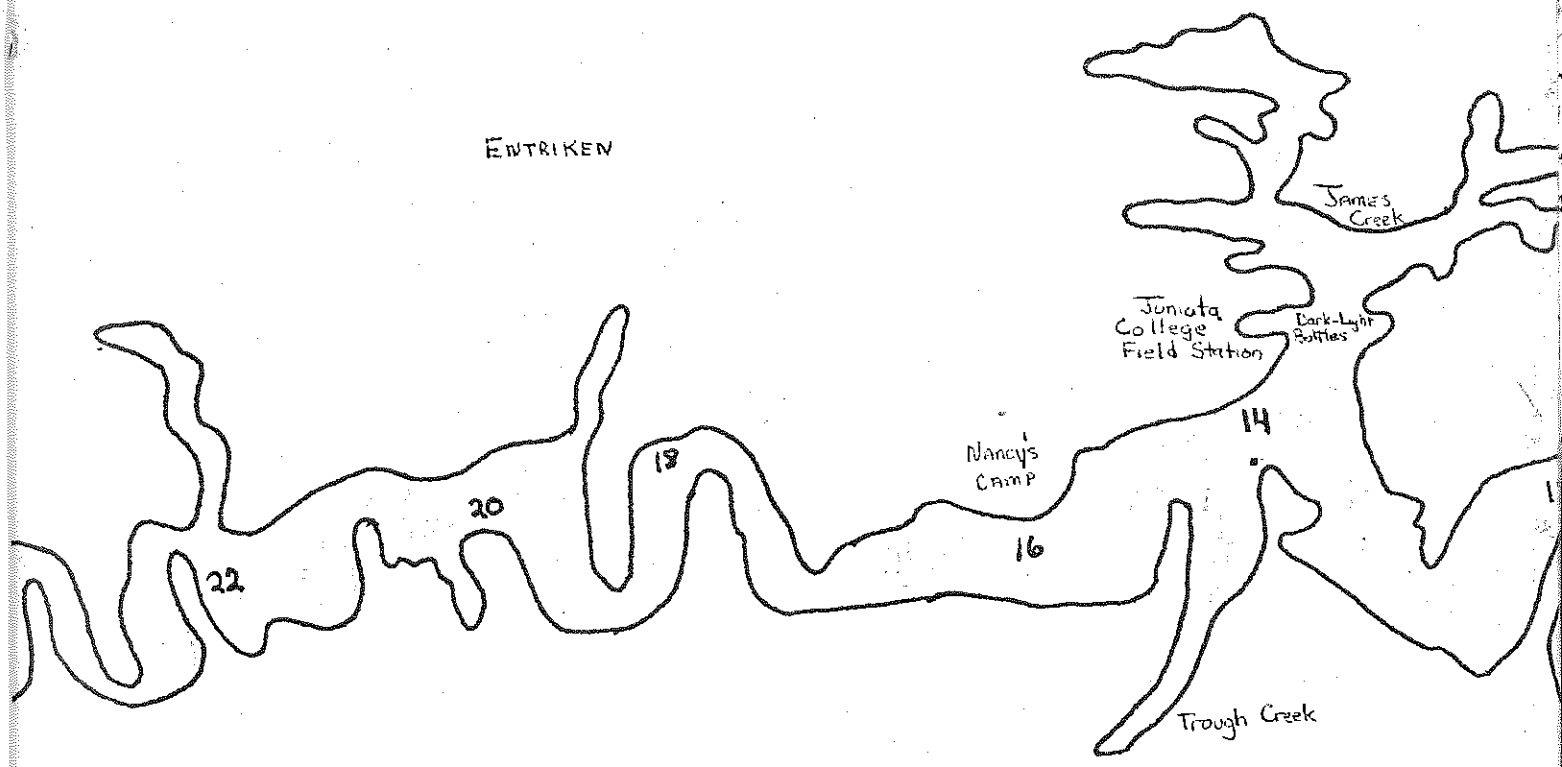
Stations were selected along the Raystown Lake at two mile intervals from the dam (station 1) through to the Shy Beaver area (station 22). Samples were taken at each of these stations every two weeks at varying depths (three meter intervals to the bottom), and were collected using the Kemmer bottle on board the Juniata College houseboat. The oxygen content was determined utilizing the Winkler method of oxygen determination. Water samples were also collected in 200 ml. polyethelene bottles which were used to measure temperature, pH and plankton chlorophyll a for analysis of the seasonal variations of phytoplankton communities. The technique used for chlorophyll a is that of Richards and Thompson, J. Mar. Res., 11: 156, 1952. After water samples were filtered, acetone was used to extract pigments from the cells, and the fluorescence, due to excitation of the chlorophyll, was measured with a fluorometer.

The secchi disk was used each day samples were taken for the measurement of the light penetration in the water. It is not actual measure of light penetration but served as a rough index to make comparisons of the water at the differing times of the seasons.

Photosynthesis was also measured every month by the "light and dark bottle" method. The increase of oxygen arising from photosynthesis is measured in a B.O.D. bottle containing a sample of water, and at the same time the decrease of oxygen in a darkened bottle is used to measure any

respiration occuring simultaneously with photosynthesis.

During the last two months of the study a conductivity meter (YSI Model 33) was used to measure ion concentrations as another means of observing the water chemistry. The following is a map of the stations along the lake.



2 0 2

Scale In Miles

DISSOLVED OXYGEN

The dissolved oxygen content of a lake is important to the organisms in having an adequate supply. In the dynamics of natural waters, oxygen supplying and oxygen consuming processes are in constant action. The minimal oxygen requirement of organisms may be conditional somewhat by other environmental conditions such as temperature, and perhaps certain conditions in the organism itself such as age or life-stage. In most aquatic organisms, respiration is independent of varying oxygen tensions and show no visible sign of a declining supply until very low levels have been reached. Certain fishes (trout and others) have a higher dissolved oxygen minimum under certain conditions (about 1 to 2.5 cc/liter) than have many other fishes. Many animals do not show evidence of response to declining oxygen until it has been reduced to 0.2 to 0.3 cc/liter.

The dissolved oxygen content of the water being tested can be expected to change with depth turbulence, temperature, sludge deposits, light, microbial action, mixing, travel time, and other factors. If the dissolved oxygen falls below the minimum for any organism, certain events may occur: attempts to migrate, onset of diseases, or suffocation beneath ice cover.

Solubility Of O_2 In Water:

Oxygen is moderately soluble in water; proportional to the partial pressure in the gas phase (Henry's Law) and decreasing in a nonlinear manner with increasing temperature. The solubility for oxygen decreases to about half as the temperature is raised from the freezing point to 30°C. The following table shows values for both fresh and salt water.

Amount of oxygen dissolved infresh water and in sea water in equilibrium with atmospheric air: Krogh, A. (1941).

Temperature	Fresh Water	Sea Water
0	10.29	7.97
10	8.02	6.35
15	7.22	5.79
20	6.57	5.31
30	5.57	4.46

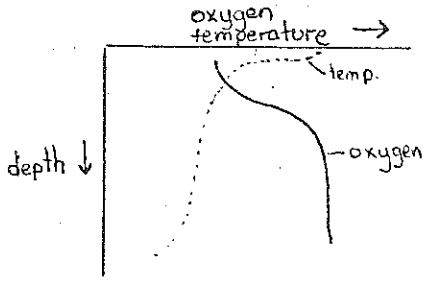
Catastrophic Oxygen Deficiency In Summer:

In some highly productive lakes low values of oxygen content may be found at the surface at the ends of periods of development of massive algal blooms. Nocturnal respiration of algae can produce a marked oxygen deficit at the surface. Intensity of algal and bacterial respiration is continually occuring and in quiet weather often produces slight but detectable variations in the oxygen content in the surface waters of productive lakes.

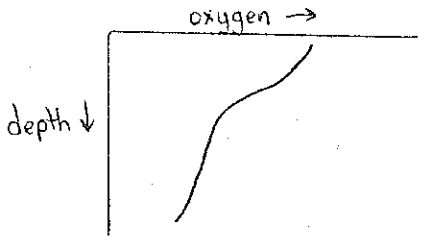
Distribution Of Oxygen In A Stratified Lake In Summer:

In a lake heating by wind-generated turbulence, the turbulent transport of heat into deeper water involves the exchange of warmer water containing less oxygen for colder water containing more oxygen per unit volume. The result is the production of a vertical distribution which has an inverse relationship to the temperature curve. A type of distribution termed orthograde is found in deep unproductive lakes and is characterized by a formation of an epilimnion which will cause some oxygen to leave the lake as temperature rises. Every level may be saturated with respect to its

Temperature and the pressure at the surface, but the absolute quantity of the gas per unit volume of water increases with depth. A typical orthograde graph is as follows:

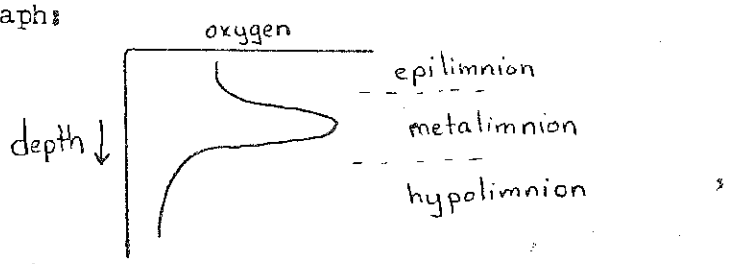


In the majority of small productive lakes a clinograde distrubution results. Lakes during summer stratification lose oxygen from the hypolimnion, the amount lost or oxygen deficit incressing in most cases with depth. A typical clinograde graph is as follows:



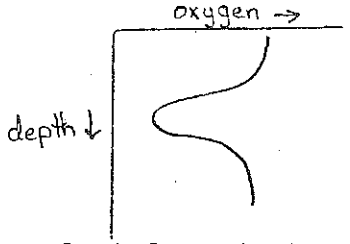
Agents of deoxygenation may be classified as: animal respiration; plant respiration at night or when the respiring organism has sedimented below the compensation point and is using reserves or is heterotrophic; bacterial respiration in the decomposition of sedimentary organic matter; chemical oxidation of organic matter in solution. In some lakes the metalimnion has the maximum oxygen concentration, termed positive heterograde. Usually in such cases, the lake is transparent enough to permit considerable photosynthesis and the oxygen is not lost by strong turbulent exchange.

A positive heterograde graph:



Negative heterograde distributions can occur in lakes also, meaning minimum

oxygen concentration in the metalimnion. This is possibly due to the decomposition of organic particles that fall from the epilimnion or that the minimum corresponds to a shelf in the bottom contour of the lake. At the depth of the shelf horizontal currents distrubute water that has lost oxygen to the sediments on the shelf. A negative heterograde graph:



The amount of oxygen lost from the hypolimnion during summer stratification increases with depth and becomes increasingly depleated as the stratification period progresses. The difference in the amount of oxygen present at the beginning and at the end of the stratification, below a given depth, is termed the oxygen deficit: the relationship of the metabolism in the stratum of the lake in which photosynthetic production occurs, and that in the stratum of heterotrophic decomposition of organic matter. The amount of oxygen consumption in the hypolimnion during stratification or oxygen deficit provides an indirect estimate of the productivity of the lake.

Vertical Distribution Of Oxygen During Winter Stagnation:

The persistent ice cover forming during the winter restricts the mixing of freshly oxygenated water from the surface of the lake into the depths. Often density currents occur in lakes when temperature is below four degrees centigrade. Heat being conveyed from the shallow to the deeper parts of the basin, is derived from solar radiation penetrating the ice and in some cases, heat is derived from the mud stored during the summer.

A significant reduction in the oxygen concentration with depth is most often observed. The synthesis of organic matter photosynthetically is reduced in the winter and the photic zone is confined to the upper layers. Respiratory utilizations and chemical oxidations increase with depth, although at a lower rate than in the summer, due to reduced temperatures.

Discussion Of Lake Raystown Data:

The results of the seasonal variation of temperature and oxygen stratification in the Raystown Lake can be correlated into a definite pattern over the months studied. The greatest degree of stratification is seen in September for both oxygen and temperature, with the typical graphs one would expect to observe during late summer months--an orthograde graph for oxygen and a clinograde graph for temperature. This holds true for all the sampled stations, each having an approximate temperature range difference of five degrees from the surface to the bottom waters. The over-all temperatures in October through November dropped several degrees as the weather became colder, however there is still a marked stratification noted with depth. The oxygen content of the waters during these months does not show a significant drop at any particular station, but shows the typical summer stratification, with the highest oxygen content at the surface, and the lowest oxygen content at the bottom. Homogeneous temperatures and oxygen contents with depth are not observed until December. At the deepest stations the temperatures were uniformly higher than those at the lower depth stations. For example, at Station 1 and 2 which are 24 meters or greater in depth, both had a uniform temperature of 6°C from surface to bottom in December; stations of lesser depths such as 16, 18, and 20 had uniform temperatures of 3.5, 3.0, and 3.0 respectively. At this time, station 22, with a depth of

12 to 15 meters, was frozen over.

The oxygen levels proved to have the opposite correlation with the various stations. There was a variation of 3 ppm. of oxygen content from station 1 through to station 20, with the lowest oxygen values at station 1 (where the highest temperatures were recorded) and the highest oxygen values at station 20 (where the lower temperatures were recorded). The variation of oxygen content with depth at each station was significantly uniform. During the months of January and February the lake was frozen and extreme cold temperatures made sampeling unfeasible.

In the early spring thermal stratification was again observed; March showing only a few degrees in variation with depth, and May showing a more distinct stratification, with temperature differences of up to 8 degrees from surface waters to bottom waters. The over-all temperature of the lake water increased as the air temperatures increased. Oxygen stratification was also evident once more during March and May; the greater degree of stratification being observed in May--the graphs depict this in showing an orthograde curve as compared to the more of less vertical curves in December. There is only a slight deviation in the comparison of the solubility values for oxygen in fresh water, as seen on the graph (in ml. O_2/liter) on page 5, with the values of oxygen content (in ppm.) measured at sample stations with corresponding temperatures.

Dissolved Oxygen
ppm.

		STATION												
		1	2	4	6	8	10	12	14	16	18	20	22	Trough Creek
Sept.	surface						8.33		10.61	13.06	8.98	8.98	8.16	10
	3						6.66		8.98	7.35	8.98	8.16	7.35	6.67
	6						5.83		8.57	6.53	7.35	7.35	7.35	6.67
	9						5.0		4.89	6.53	7.35	6.53	7.35	3.33
	12						5.0		4.08	6.53	7.35	6.53	6.53	1.67
	15						5.0		1.63	4.89	6.53	4.89		.83
	18	.					3.33		.82	.82	.41			
	21									.82	.33			
	24									.82	.25			
Oct.	surface	7.68	8.59	8.68	8.28	8.59				9.29	9.19	9.90	10.10	7.58
	3	7.27	8.28	8.38	8.28	8.59				9.24	9.29	10.0	10.20	9.29
	6	7.58	8.28	8.08	8.08	7.98				9.19	9.39	9.80	10.40	9.09
	9	6.87	6.87	7.88	7.58	7.78				9.09	9.19	9.29	10.10	8.99
	12	3.94	5.25	6.46	4.75	7.47				9.04	9.49	8.89	9.60	9.29
	15	6.97	5.65	3.03	5.45	3.54				9.29	9.70	9.90		9.90
	18	7.27	6.36	5.66		4.65				9.29				8.69
	21	8.18	7.27	6.26		4.65								
	24	8.48	7.58	6.46		4.65								
Nov.	surface				8.79	9.39	8.98	9.90	9.39	9.80	10.20	11.02	10.91	9.60
	3				8.79	9.29	8.89	9.49	9.90	9.80	9.70	10.30	10.91	9.90
	6				8.08	9.19	8.79	9.90	9.90	9.80	9.90	10.30	10.71	9.80
	9				8.79	9.19	9.09	9.49	9.90	9.80	10.10	10.30	10.71	9.29
	12				8.99	9.19	9.09	9.70	9.39	9.29	9.90	10.30		9.90
	15				8.69	9.19	7.78	9.60	9.09	9.39	10.10			
	18				4.94	7.37		9.39	9.09	8.32				
	21				4.44	3.74		7.78		8.38				
	24				7.37	4.14				7.07				

DEPTH - meters

Dissolved Oxygen

ppm.

		STATION												
		1	2	4	6	8	10	12	14	16	18	20	22	Trough Creek
DEC.	Surface	9.29	9.59	9.89	8.58	9.89	10.1	10.9	11.1	11.4	12.32	12.12	frozen	12.02
	3	9.29	9.59	10.30	8.28	10.9	10.1	10.9	10.5	11.6	12.42	13.32		12.5
	6	9.39	9.59	9.59	8.29	9.59	9.70	10.9	10.2	11.6	12.12	12.33		12.3
	9	9.39	9.39	9.79	9.09	10.1	8.69	10.7	10.7	11.6	12.12	12.32		12.2
	12	9.39	9.89	9.59	8.28	9.79	9.59	10.8	10.8	11.4	12.32	12.03		11.7
	15	9.49	9.59	9.69	8.38	9.79	9.79	10.5	10.8	11.4	12.32	12.52		11.7
	18	9.49	9.89	9.59		9.79	9.79	10.5	10.3	11.4	11.41			11.7
	21	9.29	9.39	9.49		9.79	9.79	10.7	10.9					
	24	9.39	9.39				9.79							
MAR.	Surface	12.22	11.51	11.51	11.31	11.41	10.8	10.8		11.0	11.0	10.8	11.5	
	3	12.22	11.91	11.11	10.90	11.41	11.1	11.0		10.7	11.0	11.2	11.5	
	6	11.62	11.91	11.51	10.30	10.90	10.9	10.9		10.8	10.3	11.2	11.8	
	9	10.2	11.61	11.31	9.69	11.41	11.2	10.7		10.8	10.9	11.2	11.7	
	12	9.89	10.10	11.31	11.01	11.31	11.0	10.5		10.8	11.0	11.3	11.1	
	15	9.79	11.91	11.11	11.51	11.31	11.0	10.9		10.8	10.8	8.9		
	18	9.89	11.11	10.6	10.0	11.21	10.9	10.9		10.6	10.8			
	21	8.78	10.61	10.81	10.40	11.31	10.3			10.4	9.3			
	24	8.98	10.61	11.41		11.21								
MAY	Surface	10.4	11.02	11.3	11.0	10.2	11.5	11.5		10.2	7.7	10.0	9.6	9.9
	3	11.9	12.3	11.1	11.9	11.7	11.8	11.5		10.6	10.2	10.0	9.6	10.6
	6	11.7	13.2	10.5	11.2	11.4	10.7	9.5		9.79	9.6	9.2	8.5	9.5
	9	10.5	11.8	10.2	11.2	11.2	11.0	10.6		9.6	9.5	9.0	7.3	9.7
	12	11.6	11.5	10.5	11.1	11.3	11.0	11.2		9.8	9.4	8.8	8.4	8.7
	15	11.8	11.4	10.6	11.1	11.3	11.3	11.2		9.7	9.6	8.5	7.7	9.0
	18	11.5	11.9	10.6	11.6	11.3	11.1	10.8		9.2	8.8	2.9		9.0
	21	11.9	11.7	10.6		11.4	11.1	10.5		8.9	8.5			8.5
	24			10.8		11.4	10.9	10.5		8.5	8.0			

DEPTH - meters

TEMPERATURE

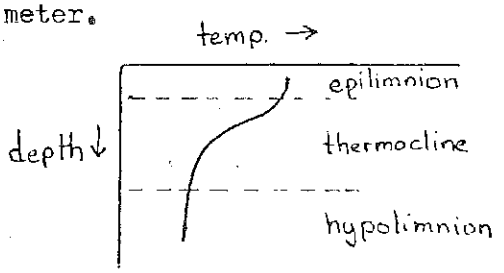
The temperature of lake waters is dependent on solar radiation which heats the water and the amount of evaporation which cools the water. The angle at which the solar radiation strikes the surface, evaporation from the surface, the amount of moisture in the air, and the speed of the wind, are all factors associated with the temperature of the water. The volume of water is also important in determining water temperature. The smaller the volume of water, the greater is its diurnal fluctuation.

Temperature can be used to determine the range of many plants and animals but it is not always correct to conclude that the range of a species is limited by temperature. Other effects that temperature has on certain species includes speed of development, activity or reproduction. For example the spawing of Micropterus dolomieu, the smallmouth bass, is stimulated by a fairly quick rise in temperature. The oxygen content of the water is also important to what kinds of organisms will be found in certain areas. The amount of oxygen that a given volume of water will hold in equilibrium decreases at temperature increases.

Stratification Of Water:

Water is a poor conductor of heat; the distribution of heat depends mainly on convection currents. Natural bodies of water are heated and cooled from the top, when they are in contact with the atmosphere and where the sun's rays strike. It is only those changes of temperature which increase the density of the surface waters that can produce convection currents, causing surface waters to decend and deeper waters to raise to the surface. The waters of a deep lake show great changes about

twice a year--usually in March after the ice has gone out, while the waters are being warmed to 0°C, and a longer period in autumn, while the waters are being cooled to 0° C. Between these time periods the deeper waters of a lake are usually regularly stratified according to their density. The different zones are explained as follows. The epilimnion is the zone of summer circulation; any significant changes in air temperatures are followed by the water due to movement of the water. The thermocline denotes a fall in temperature with increasing depth. The hypolimnion is a cold, relatively undisturbed region--defined by Birge (1897) as that layer in which the fall in temperature exceeds 1° C per meter.



Spring and Early Summer:

In the spring when the ice melts, the whole body of water is below 4° C; heating by incident radiation causes an increase in density at the surface and an unstable stratification. Any heating at the surface produces an expansion of the water, and the lake becomes stably stratified, with the least dense water at the surface. These newly warmed surface waters are mixed throughout the depth of the lake by horizontal movements facilitated by the presence of a density gradient. Wind generated currents are also a factor of mixing of waters and may put the entire body of the lake into circulation. This will continue until the waters are warm enough so that their thermal stratification and consequent resistance to moxture are high enough to overcome this disturbance of the wind. The surface may be stirred by storms but the deeper waters of the lake will have

passed into their summer rest.

Autumnal Cooling and Circulation:

During the autumn months there is initially little loss or gain of heat. After this period the lake begins to cool, with a characteristic steady increase in the thickness of the epilimnion as the temperature slowly falls due to a heat loss at the surface. As the cooling proceeds, the full autumnal circulation may not be achieved until mid winter in large deep lakes such as Raystown.

Winter Temperatures--Inverse Stratification and Winter Heating:

When a lake freezes there is a sudden loss of heat at the surface during a still night. In the few top meters a low stability stratification occurs and is preserved when the ice forms; the water in contact with the ice being at 0° C. while the water below a depth of 1 or 2 meters exhibits the temperature of free circulation just before freezing. When this takes place, depends on two main factors: the temperature of the circulating water--a deep lake takes longer to lose heat than a shallow one; the probability of the surface being undisturbed during a cold night--a small lake is less disturbed than a larger area.

After a lake is frozen it has been observed in a number of instances that there is ageneral increase in temperature throughout the main mass of water remote from the ice. The winter heating process occurs when solar radiation entering the ice heats the water, raising its density. A body of water slightly denser will flow down the slope of the basin toward the depths as a density current. This is termed inverse stratification. Heat also stored in the mud at the bottom will tend to be conducted into the

water, causing the density to fall and resulting in instability and convectional mixing. This may also cause duffusion of solutes out of the mud raising the density and resulting in a chemical density current which will displace water upward, warming the whole water mass and in some cases raising its concentration of solutes.

In 1895 Forel defined any lake that passed through the temperature of maximum density twice a year, as a temperate lake. This includes any lake in the temperate regions under continental climatic conditions, with a cold winter and a warm summer. Full circulation at or near the temperature of maximum density would occur twice a year; in the spring after the ice melts, and in the autumn or early winter before the lake freezes (note that maximum density of water varies with the pressure).

The most frequent divergence from the classical temperature curve is due to the formation of secondary thermoclines. Such a curve may occur due to heating by radiation during a warm day to produce a marked temperature gradient followed by a cold spell. This would produce a deep circulating eplimnion--the changes in weather leading to periods of cooling that reduce the temperature and increase the thickness of the epilomnion, alternating with warm periods that re-establish thermal stratification in the shallow layers. Another cause may be due to the fact that a lake is damed and water is intermittently drawn out from depths below the surface. An example of this is Lake Minnewanka, Bantf in which four thermoclines were recorded--the water is drawn out from a depth of about 10 meters.

TEMPERATURE

DEPTH (METERS)

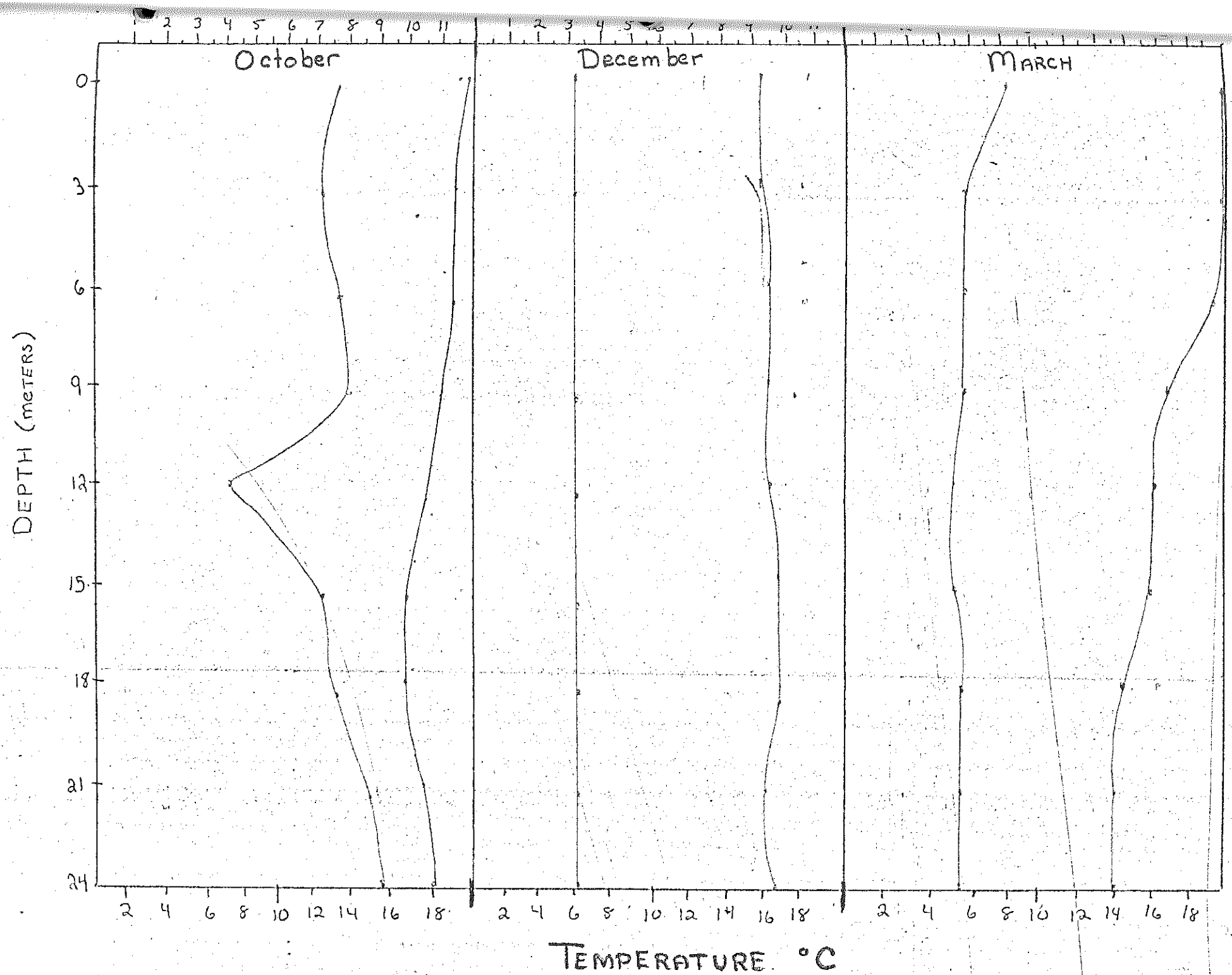
		STATION												
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DEC.	surface	6.0	6.0	5.5	5.5	6.3	5.5	4.0	4.0	3.5	3.0	3.0	frozen	3.5
	3	6.0	6.0	5.9	5.8	6.0	5.5	4.5	4.0	3.5	3.0	3.0		3.5
	6	6.0	6.0	5.7	5.8	5.7	5.2	4.0	4.0	3.5	3.0	3.0		3.5
	9	6.0	5.8	5.8	5.5	5.5	5.0	4.2	4.0	3.5	3.0	3.0		3.5
	12	6.0	5.9	5.9	5.5	5.7	5.5	4.0	4.0	3.5	3.0	3.0		3.5
	15	6.0	6.0	5.8	6.0	5.7	5.0	4.3	4.0	3.5	3.0	3.0		3.5
	18	6.0	6.0	5.5		5.8	5.0	4.5	4.0	3.5	3.0			3.5
	21	6.0	6.0	5.5		5.5	5.0	4.2	4.0					
	24	6.0	6.0				5.0							
MAR.	surface	7.1	8.4	8.0	9.2	7.0	8.0	5.9		11.3	10.8	13.5	13.0	
	3	5.0	5.8	5.2	5.3	5.2	6.9	5.8		8.8	8.7	13.0	13.0	
	6	5.0	9.0	5.1	5.3	5.0	6.3	6.2		7.9	10.0	8.7	6.5	
	9	5.0	5.0	5.1	5.0	4.5	5.3	6.0		7.5	7.4	8.4	10.0	
	12	4.9	5.0	5.0	5.0	5.2	5.8	6.2		7.5	6.9	9.5	10.2	
	15	4.9	5.0	5.0	5.6	4.8	5.8	6.1		7.1	6.9	9.6		
	18	5.0	5.0	5.0	5.0	5.0	5.8	6.1		7.5	7.4			
	21	5.0	5.0	5.1	5.0	4.3	5.9			7.0	6.9			
	24	5.0	5.0	5.1		5.0								
MAY	surface	16.0	15.9	15.6	15.0	16.0	14.8	15.2		12.9	18.2	17.0	17.5	17.5
	3	15.9	15.8	15.5	14.9	14.5	14.5	14.9		15.1	16.5	16.0	17.5	14.5
	6	15.0	14.5	14.2	13.0	14.1	11.0	11.4		12.8	13.2	14.0	14.8	13.1
	9	11.2	11.0	11.2	10.1	10.1	10.0	9.9		11.0	11.0	12.1	12.0	10.8
	12	10.0	10.0	10.0	9.8	9.0	8.9	9.2		9.9	10.3	9.5	10.8	9.8
	15	9.0	9.0	9.0	9.2	8.8	8.1	8.0		9.0	12.5	10.1	9.2	8.2
	18	9.0	8.5	9.0	9.1	8.8	8.0	7.8		8.8	9.0	8.8		7.8
	21	8.2	8.5	9.0		8.7	8.0	7.3		8.1	9.0			8.0
	24			8.4		8.7	7.5	7.2		9.5	8.8			

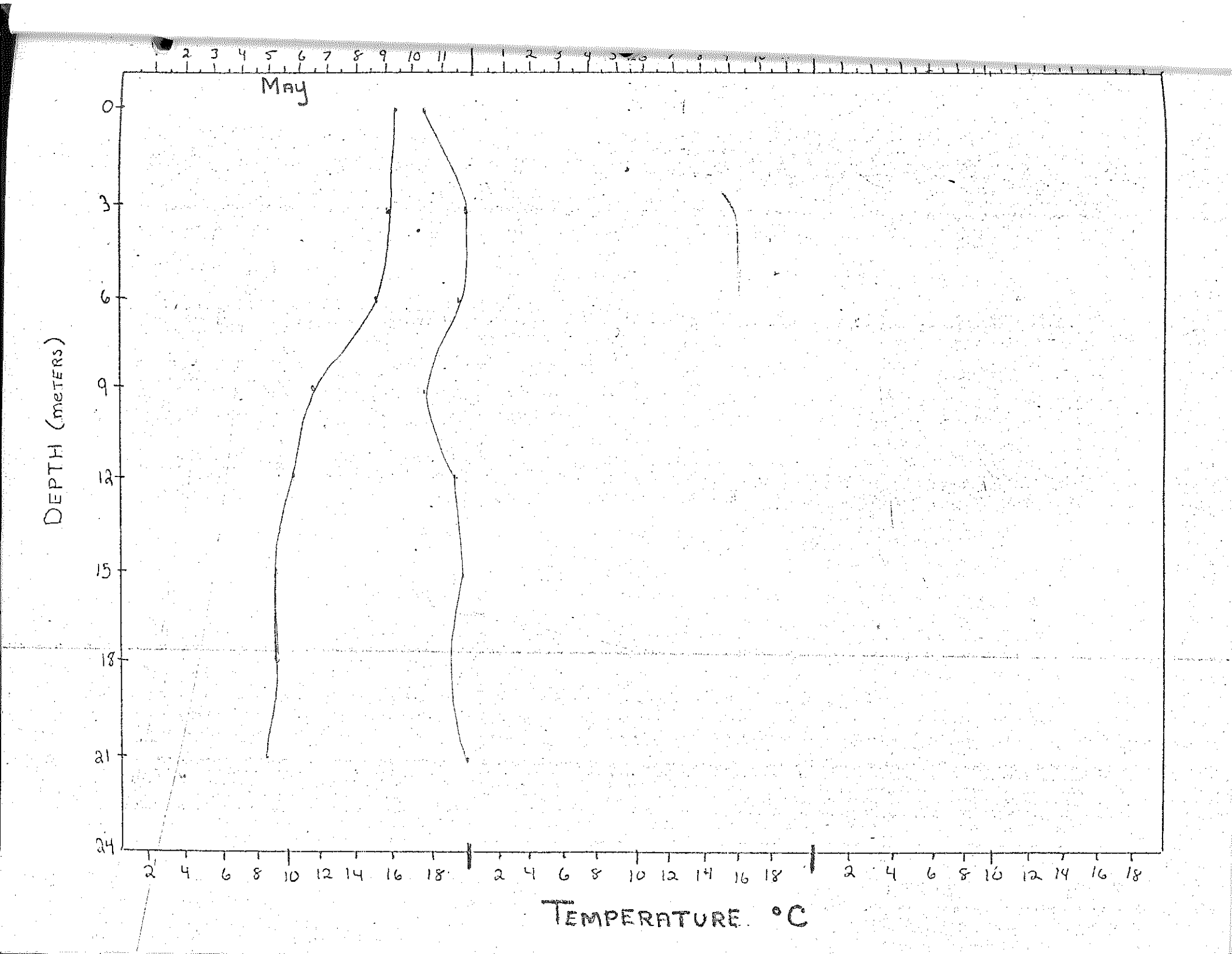
TEMPERATURE

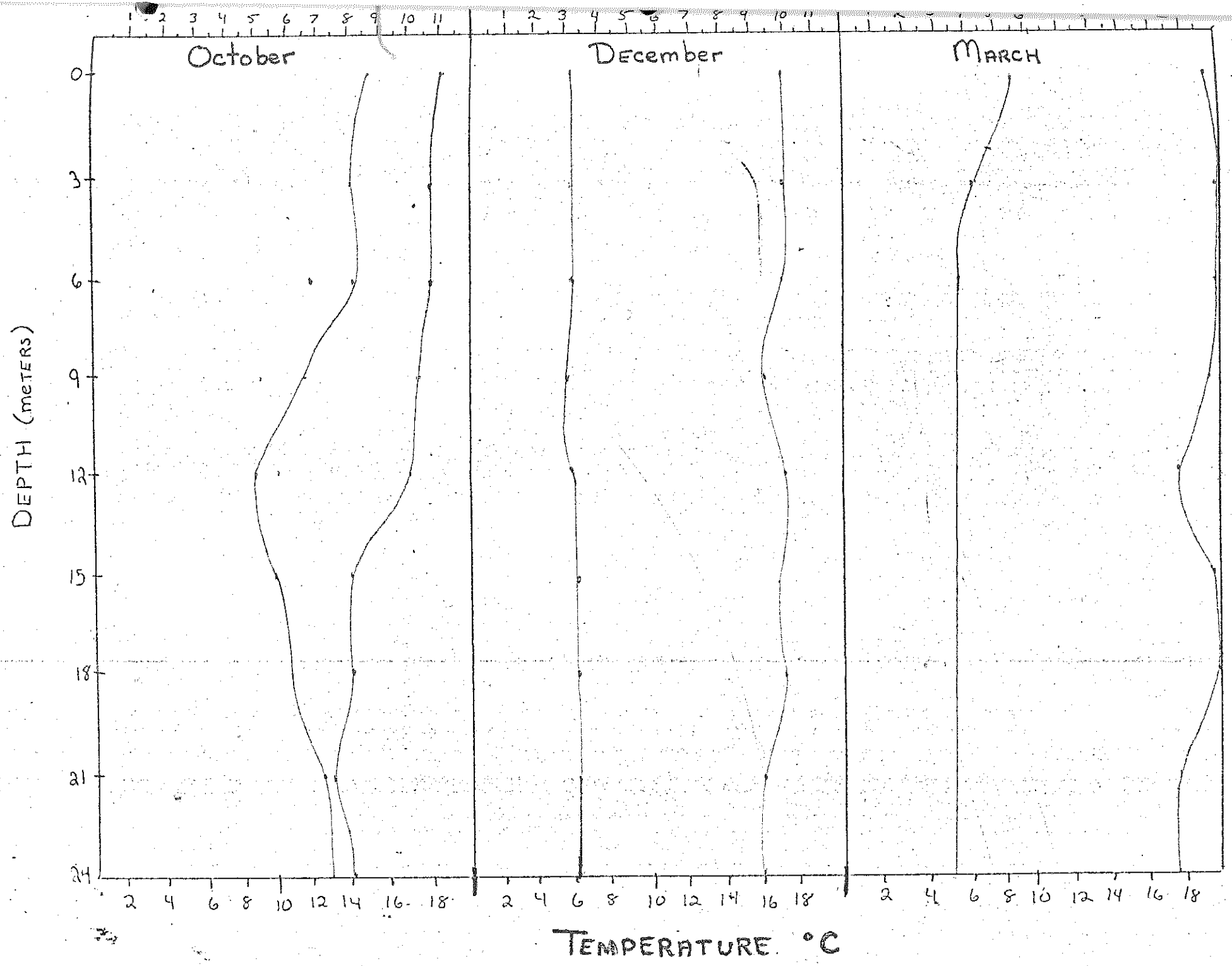
STATION

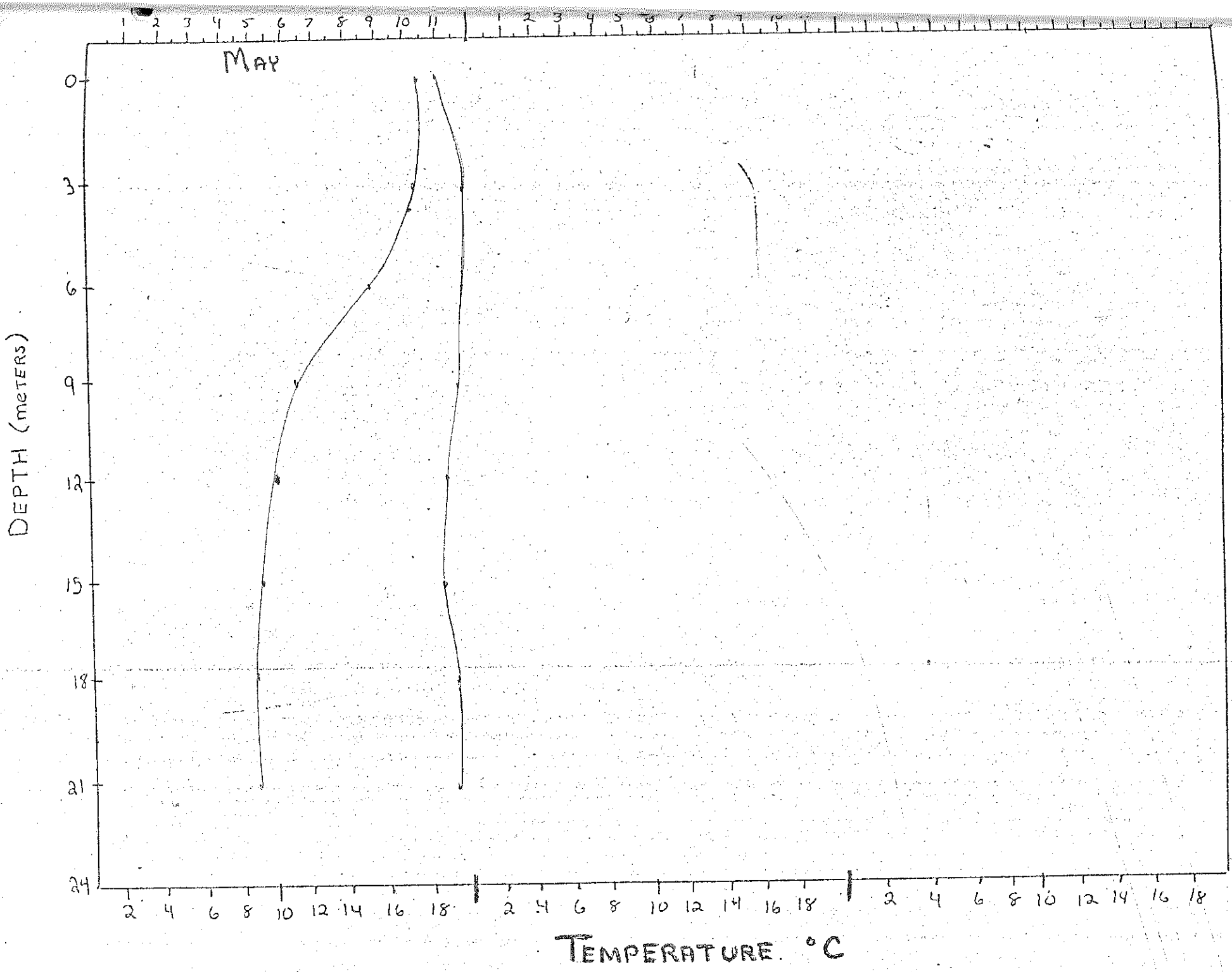
DEPTH (METERS)

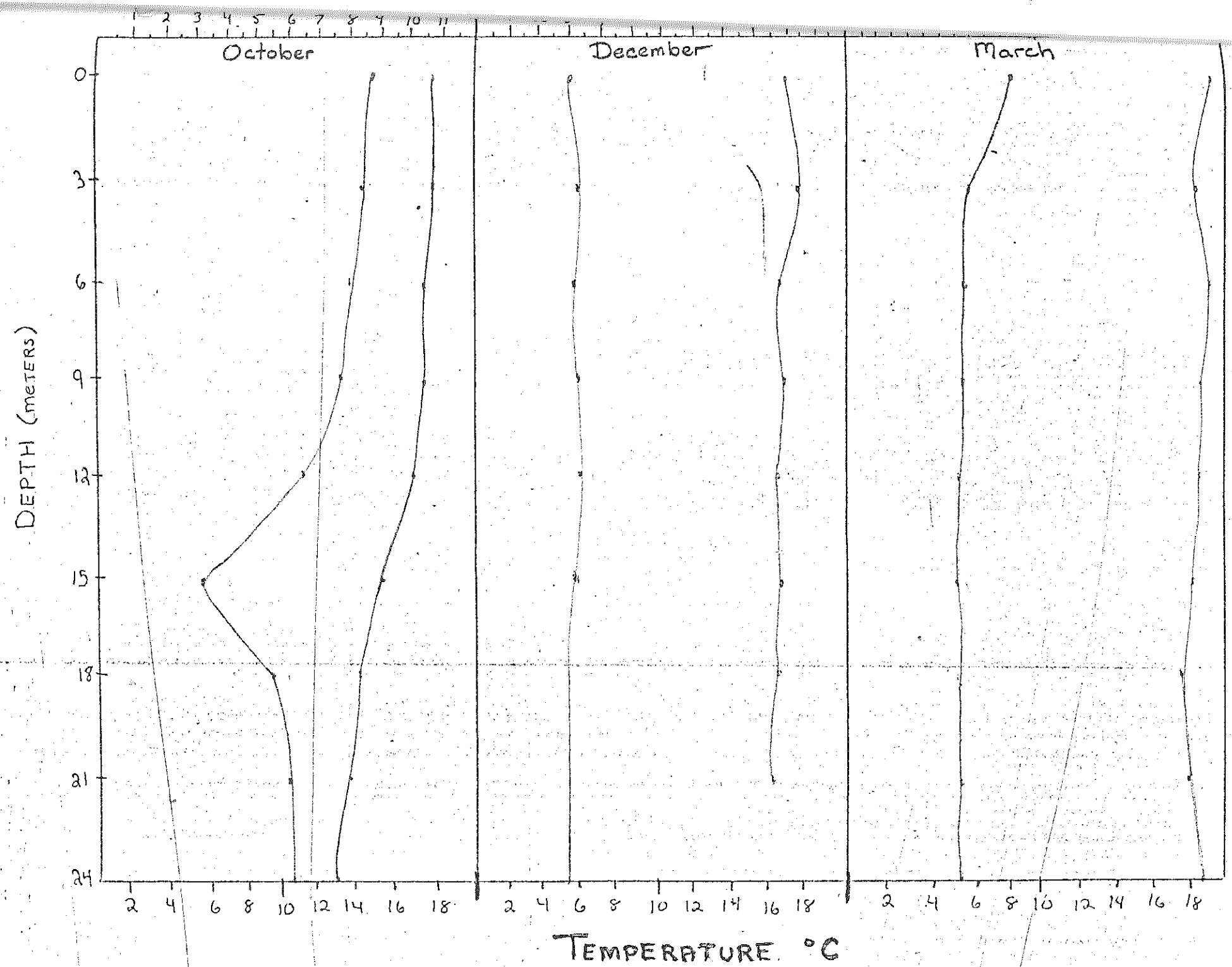
		1	2	4	6	8	10	12	14	16	18	20	22	Trough Creek
SEPT.	Surface						19.4		17.2	17.8	18.3	18.9	17.8	18.9
	3						18.8		16.7	17.2	17.8	18.3	16.7	18.9
	6						18.8		16.1	16.1	16.7	16.7	15.6	18.3
	9						16.7		15.8	15.6	16.1	16.1	16.1	17.2
	12						11.7		15.6	15.0	15.6	15.6	15.6	12.2
	15						10.6		15.0	14.4	15.0			11.7
	18						10		15.0	12.8	12.8			
	21									11.7	11.7			
	24									11.7	11.7			
OCT.	Surface	19.5	18.2	18.0	17.0	17.0				10.2	10.0	9.7	9.0	9.0
	3	19.0	18.0	18.0	17.0	17.0				10.0	10.0	9.8	9.0	10.0
	6	19.0	18.0	17.5	16.5	16.5				10.0	10.0	9.5	9.0	10.0
	9	18.5	17.5	17.5	16.0	16.5				10.0	9.5	9.2	9.0	9.5
	12	18.0	17.0	17.0	15.0	16.0				9.8	9.0	8.8	8.5	9.5
	15	17.0	14.0	15.5	16.0	14.5				9.5	9.0	8.0		8.5
	18	17.0	14.0	14.0		11.5				8.5				8.5
	21	17.5	13.0	13.5		10.5								
	24	18	14.0	13.0		10.0								
NOV.	Surface				11.0	10.2	10.2	9.8	9.5	8.0	7.0	6.8	7.5	8.0
	3				11.2	10.2	10.2	9.8	9.5	7.8	7.2	6.8	7.5	8.0
	6				10.8	10.2	10.2	9.2	9.5	7.8	7.0	6.8	6.8	7.8
	9				10.8	10.2	10.2	9.2	9.5	7.8	7.0	6.8	6.8	7.8
	12				10.8	10.2	10.2	9.2	9.2	7.8	7.0	6.8		7.2
	15				10.8	10.2	10.0	9.2	9.2	7.6	7.0			7.2
	18				9.2	10.0		9.2	9.0	7.6				
	21				9.2	9.8		9.2		7.6				
	24				9.2	9.8				7.6				

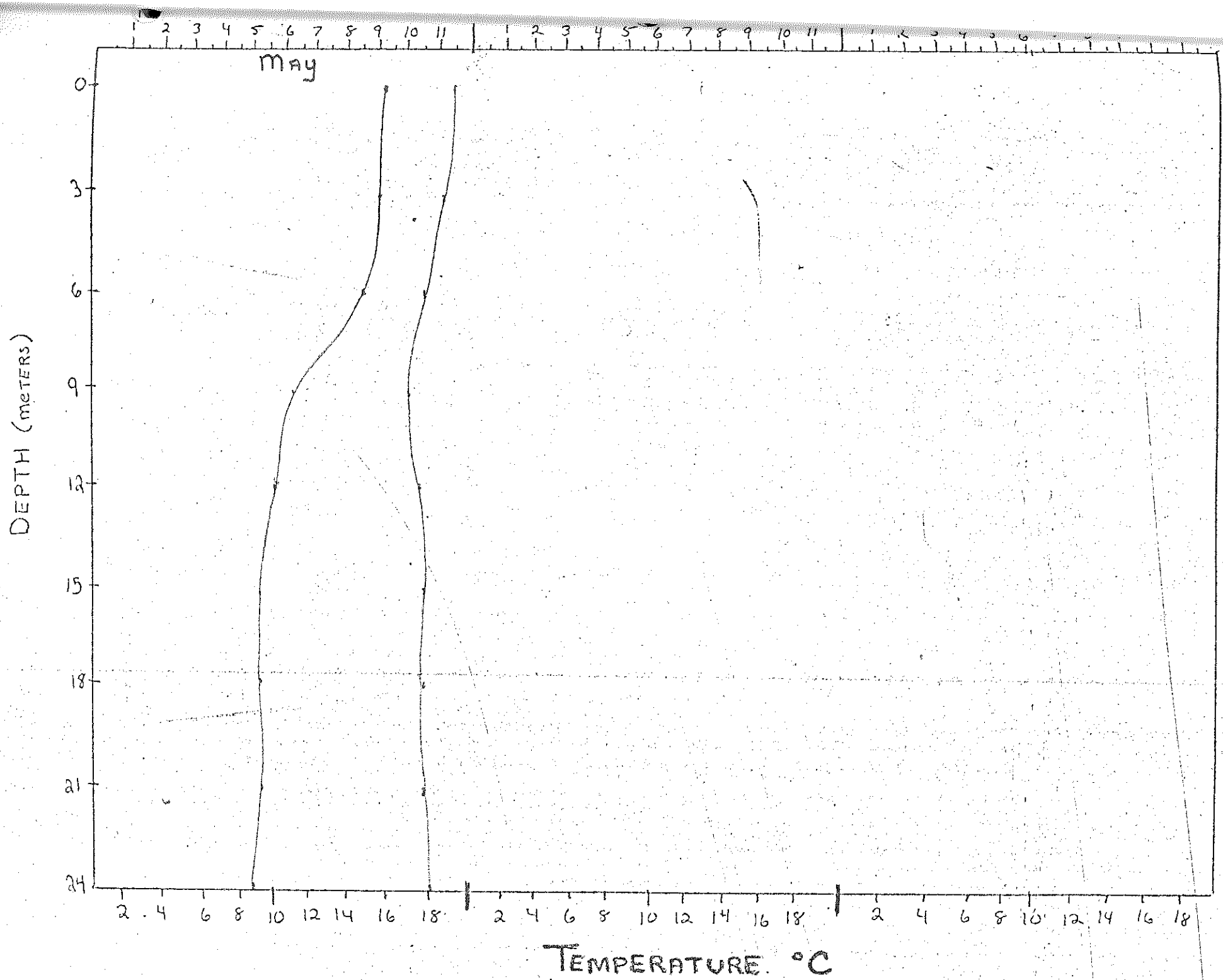

October
December
MARCH
DEPTH (METERS)
0
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2 4 6 8 10 12 14 16 18
TEMPERATURE °C

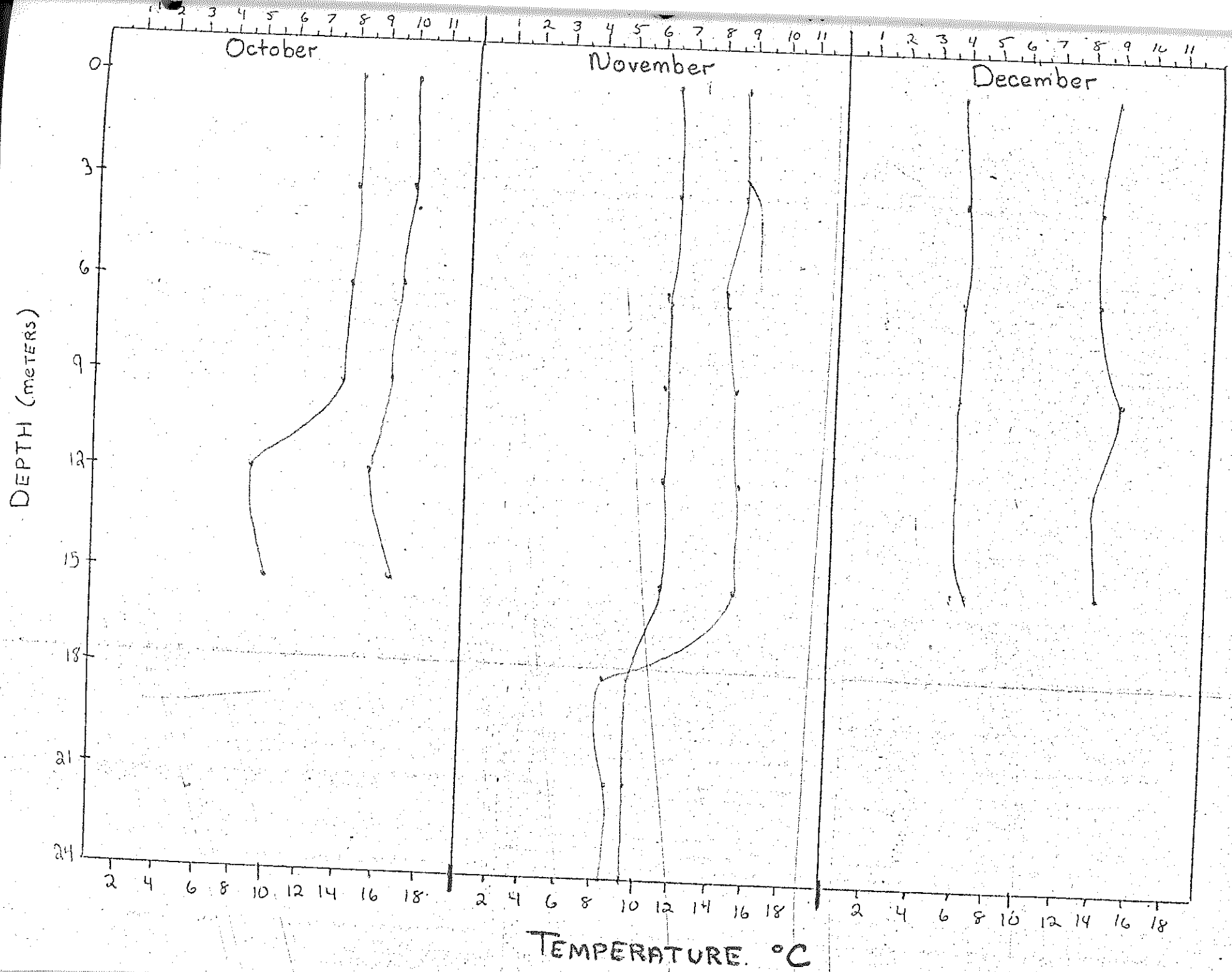

May
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DEPTH (meters)
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2 4 6 8 10 12 14 16 18
2 4 6 8 10 12 14 16 18
TEMPERATURE °C

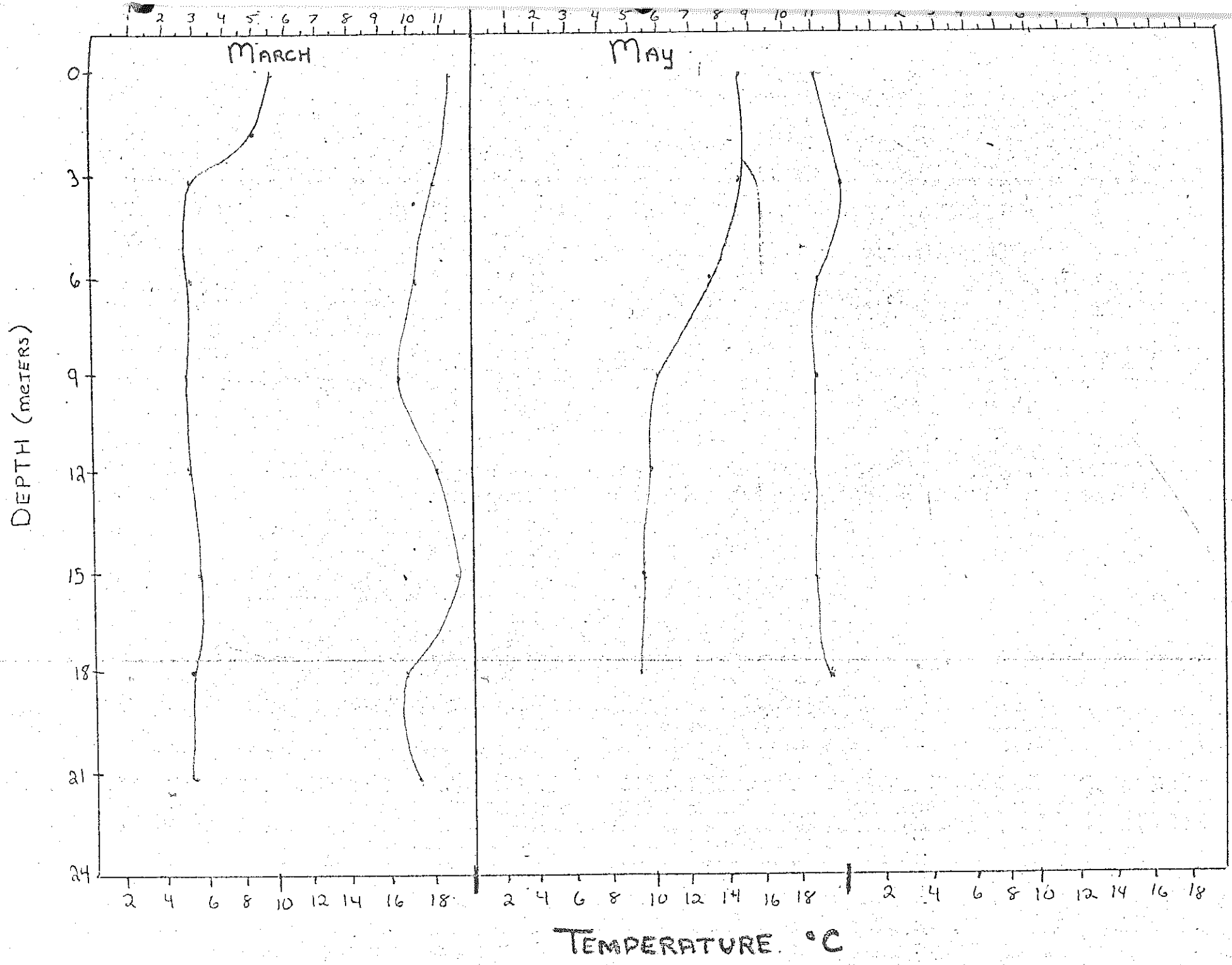

October
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March
DEPTH (meters)
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2 4 6 8 10 12 14 16 18
TEMPERATURE °C

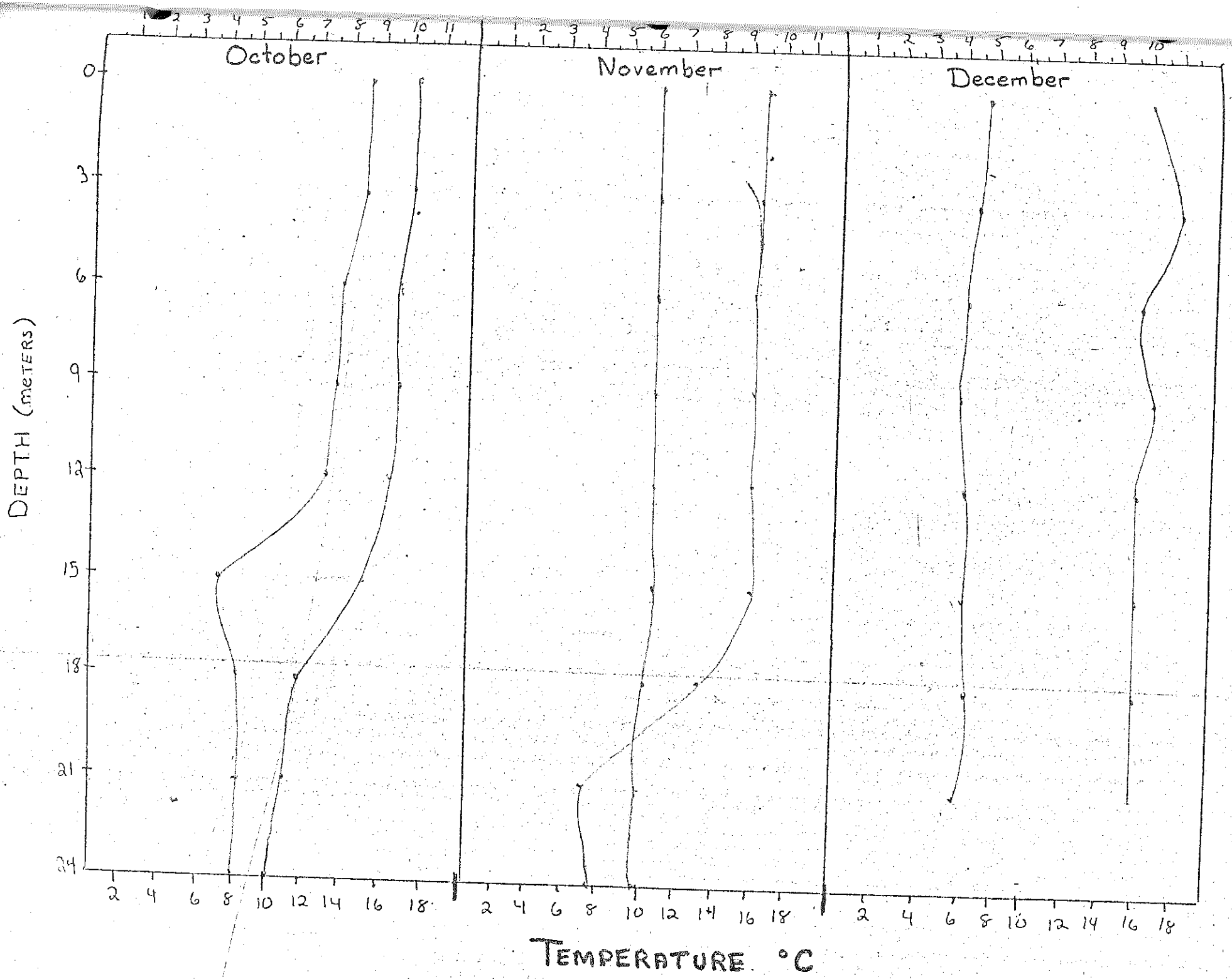

MAY
DEPTH (METERS)
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TEMPERATURE. °C

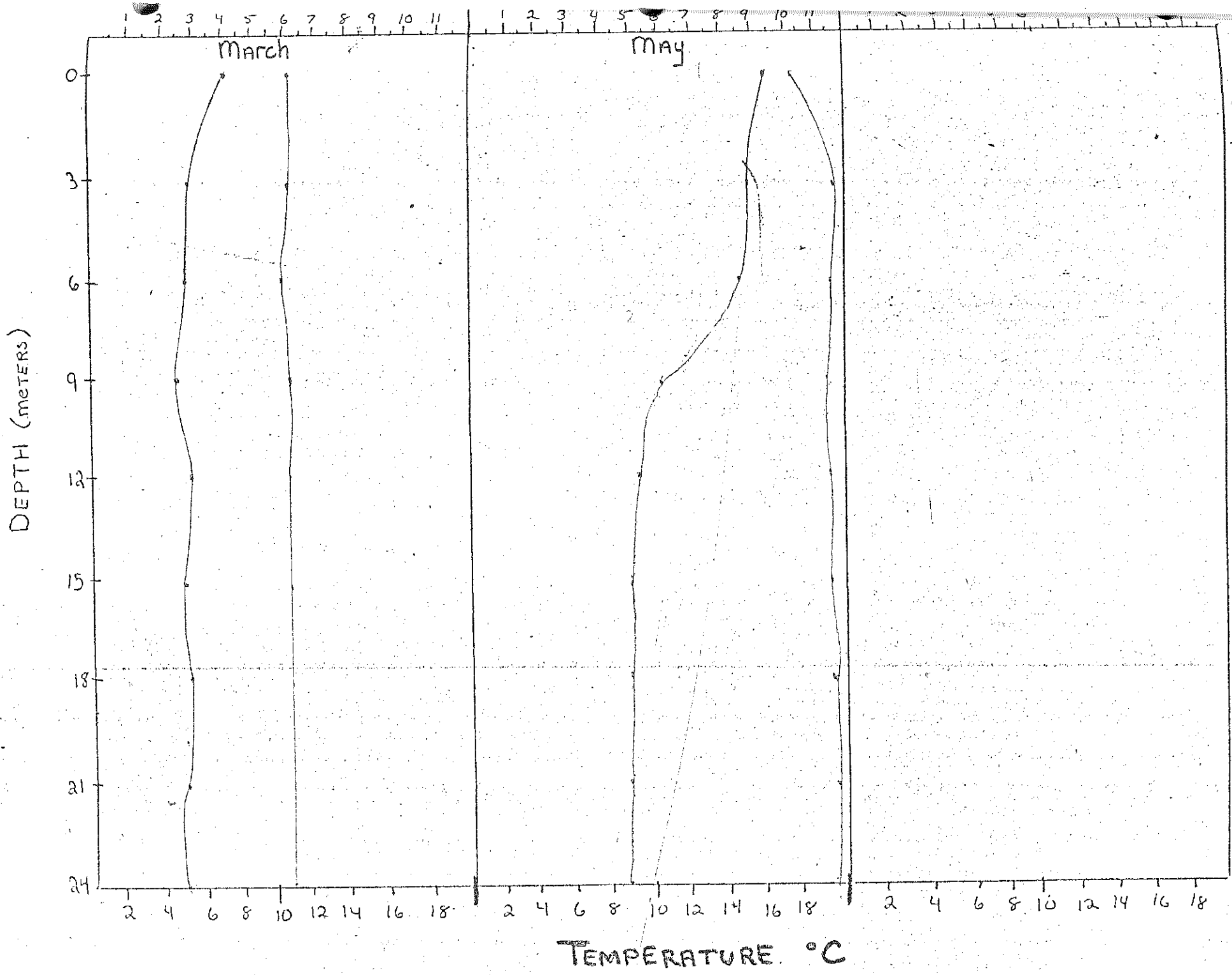

October
December
March
DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
TEMPERATURE °C

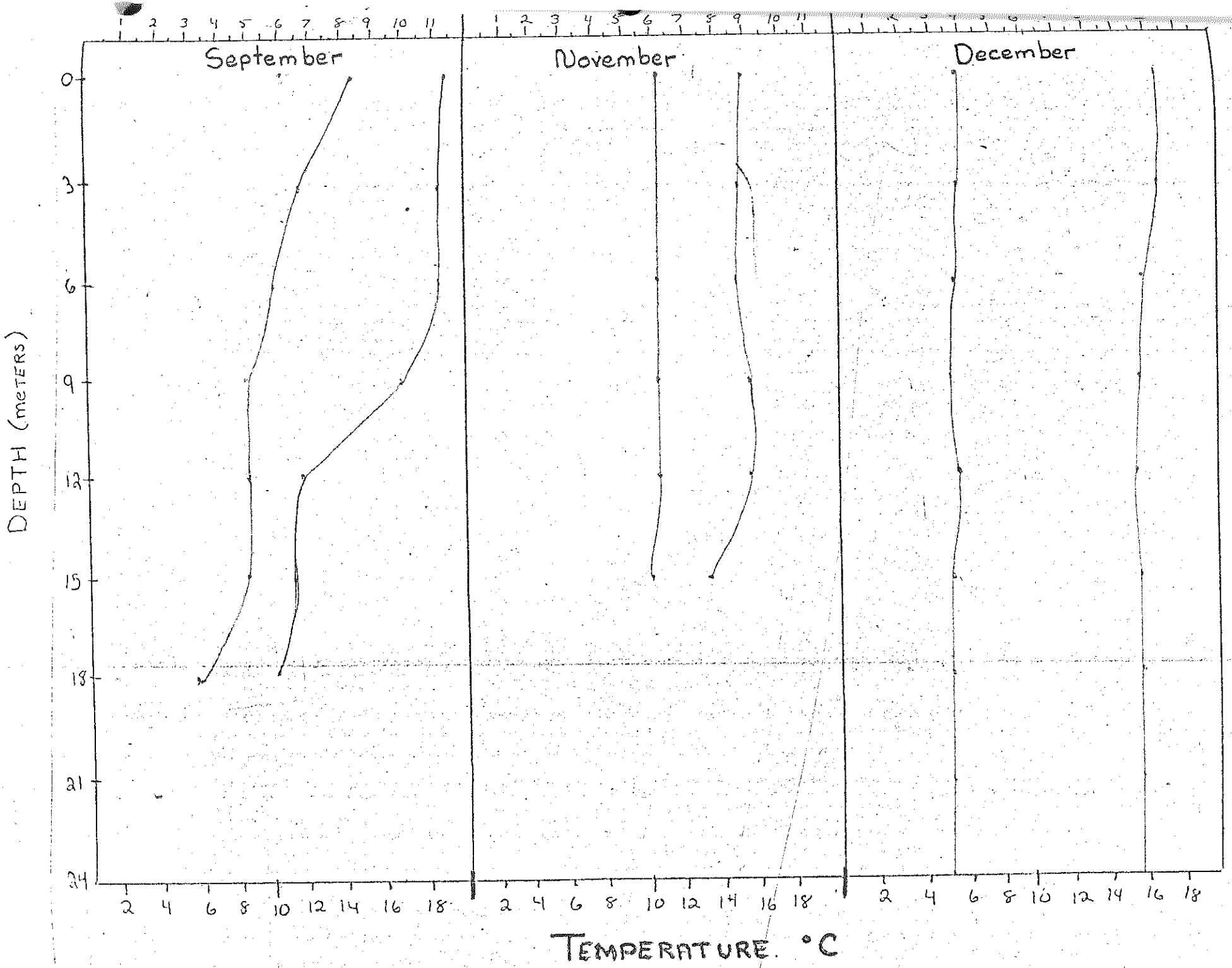

May
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1 2 3 4 5 6 7 8 9 10 11
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DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
2 4 6 8 10 12 14 16 18
TEMPERATURE °C

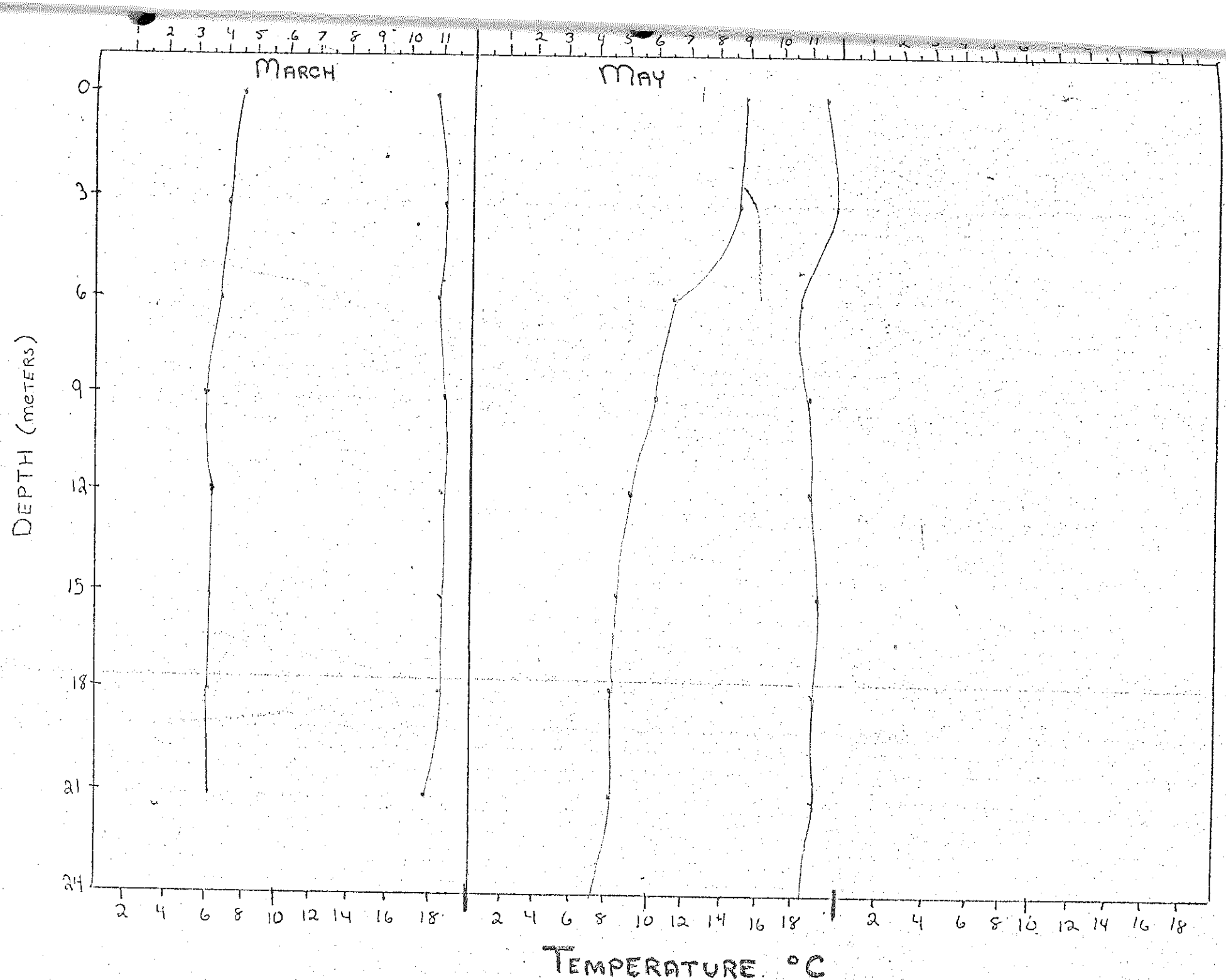

October
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December
DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
TEMPERATURE. °C

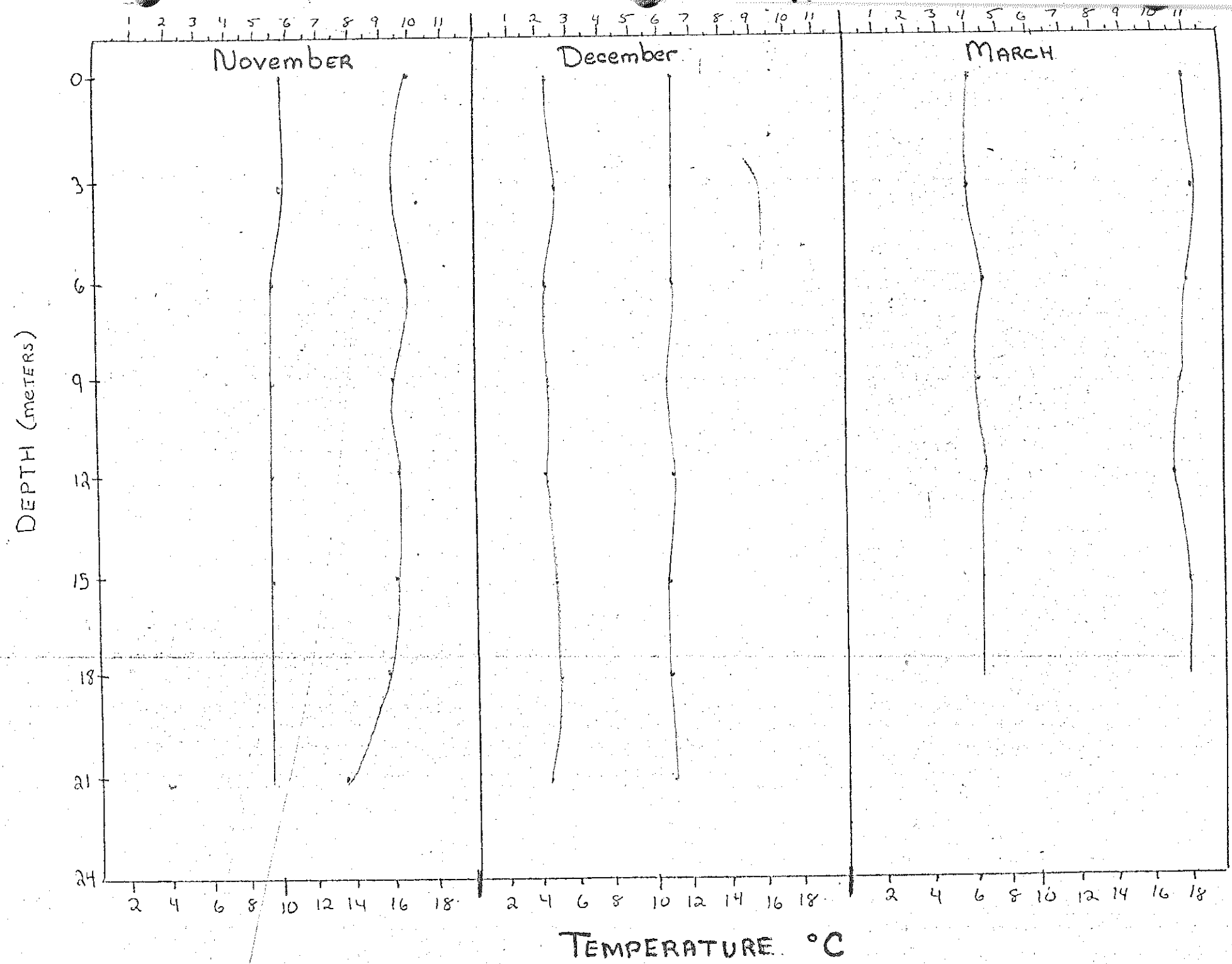

MARCH
MAY
DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
TEMPERATURE °C

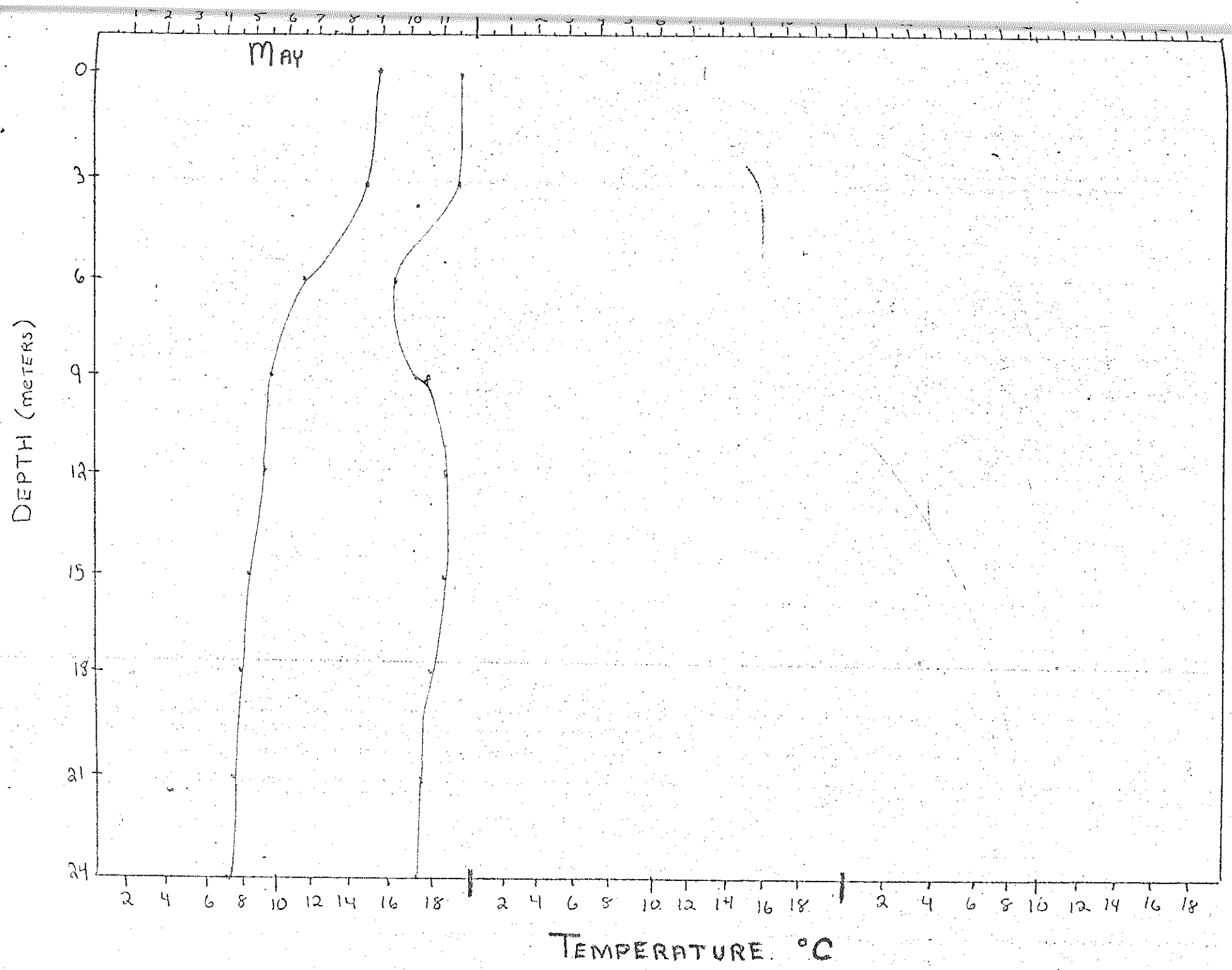

October
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2 4 6 8 10 12 14 16 18
TEMPERATURE. °C

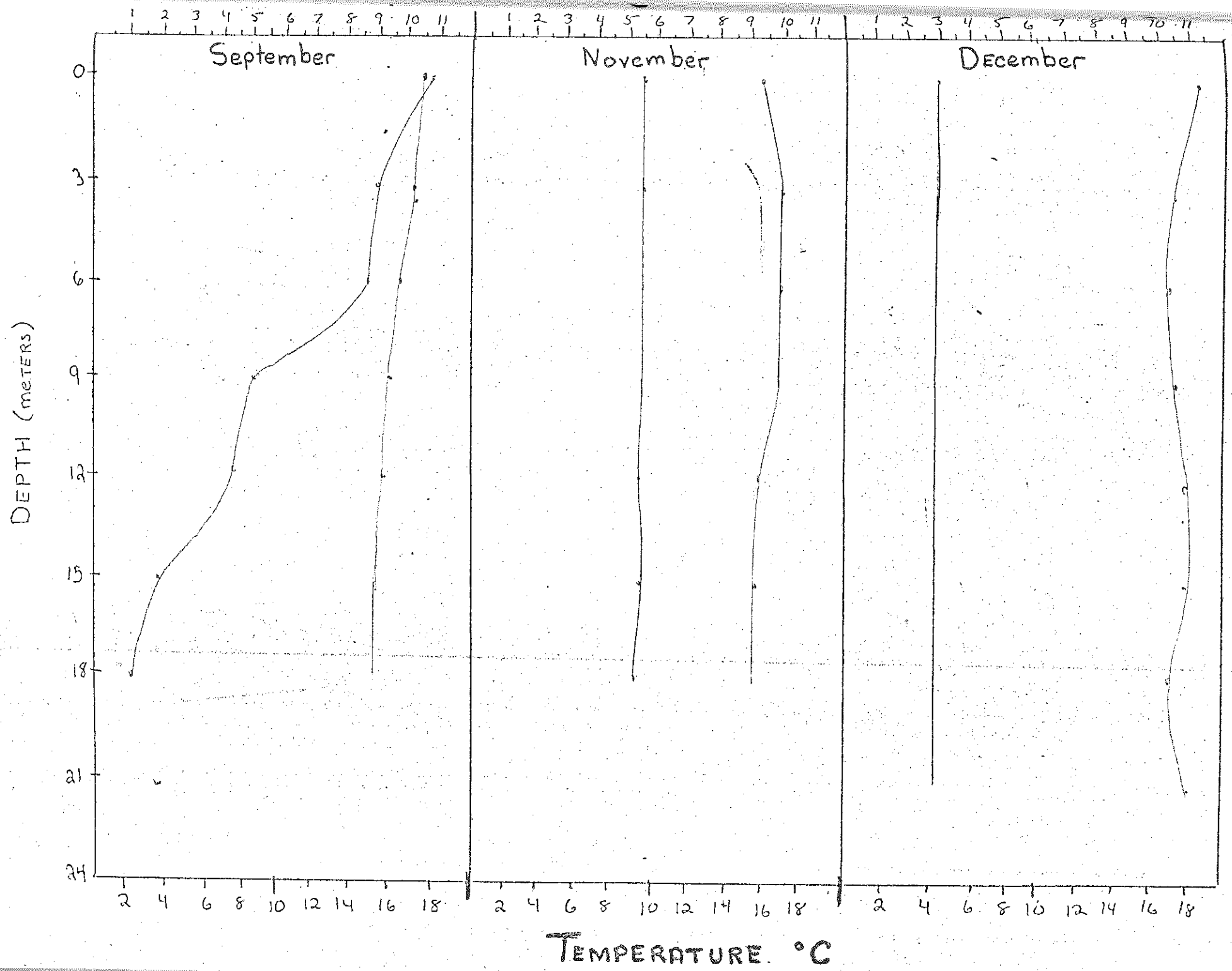

March
May
DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
TEMPERATURE °C

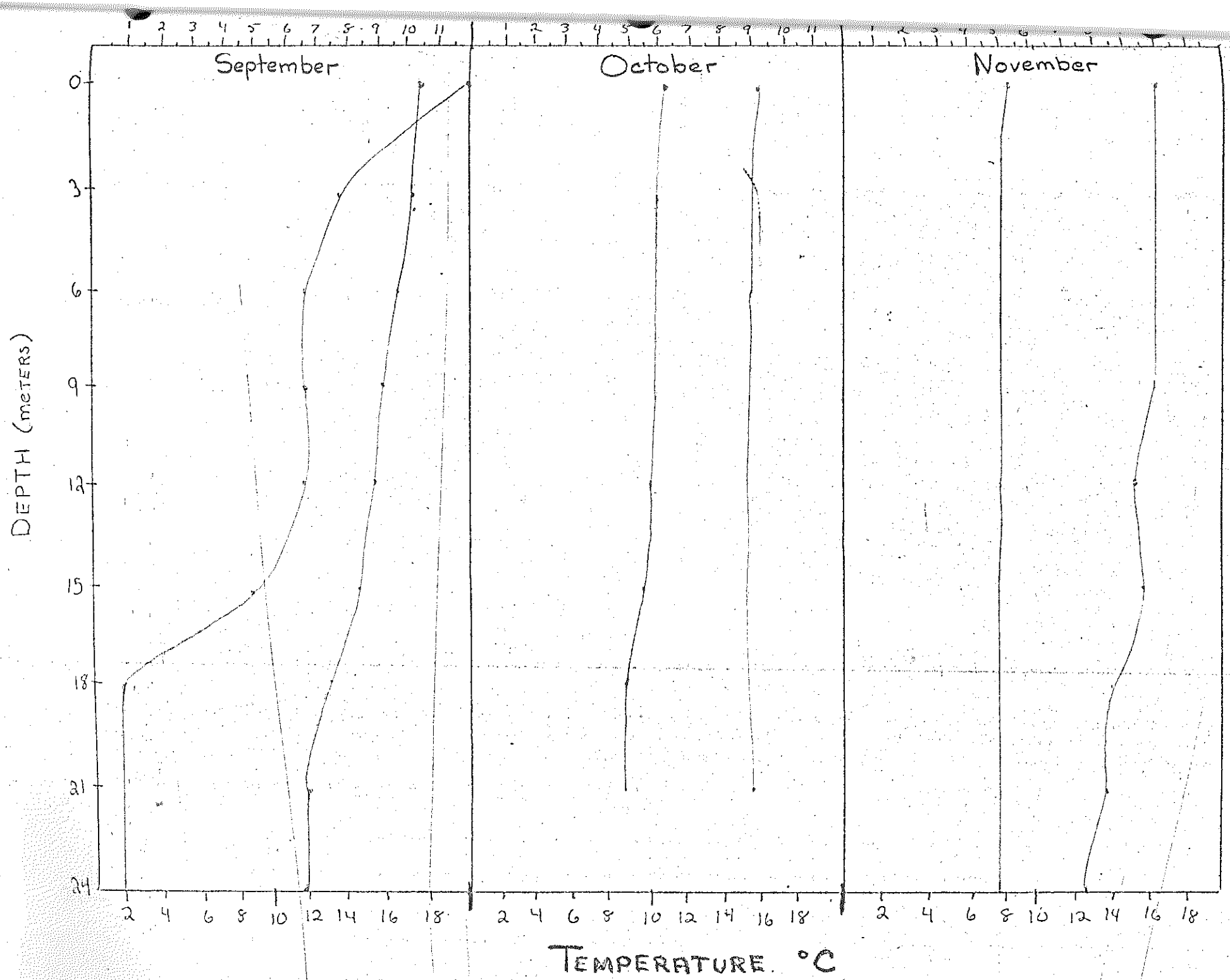

September
November
December
DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
TEMPERATURE. °C

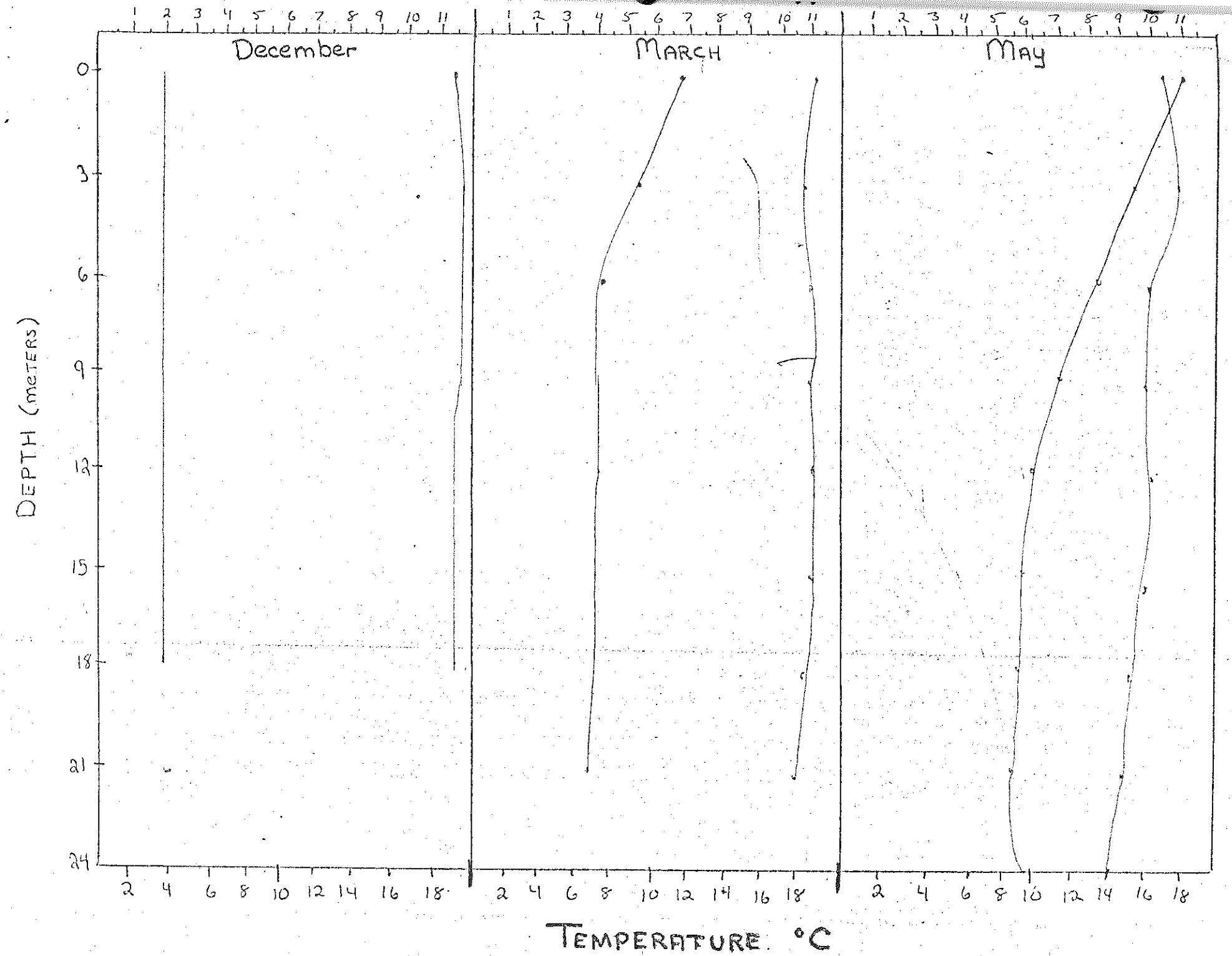

MARCH
MAY
DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
TEMPERATURE °C

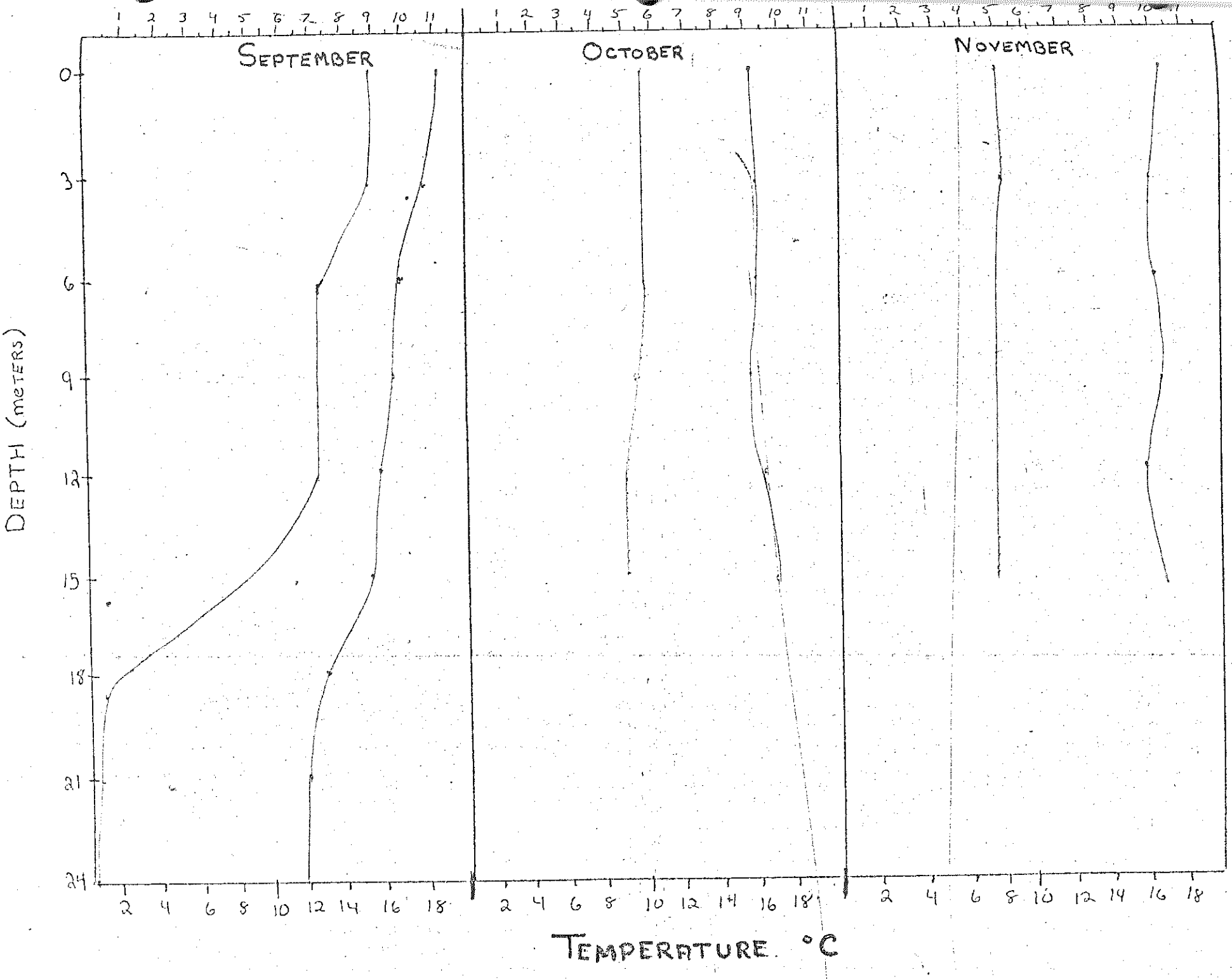

November
December
MARCH
DEPTH (METERS)
0
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1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C

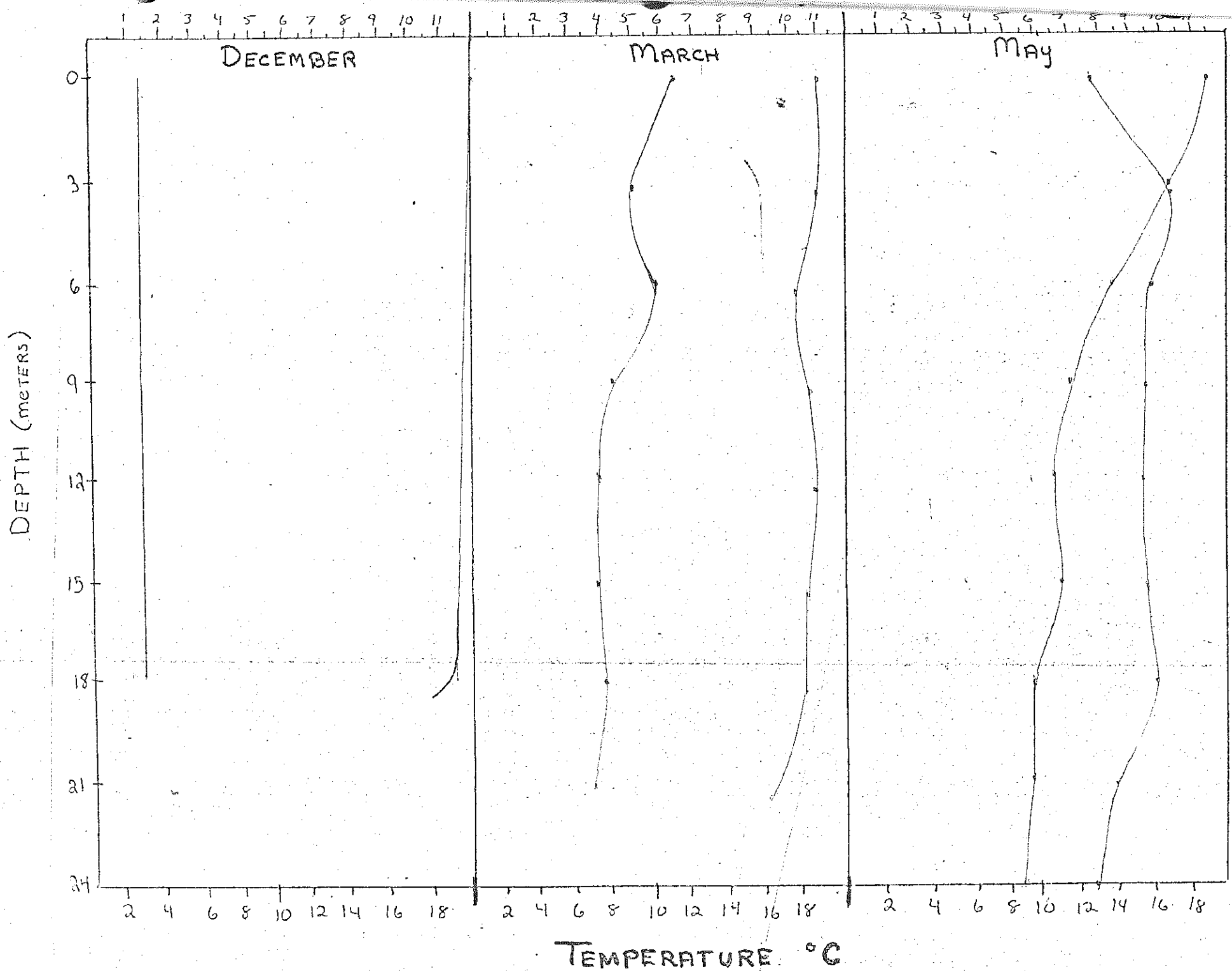

MAY
DEPTH (METERS)
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2 4 6 8 10 12 14 16 18
2 4 6 8 10 12 14 16 18
TEMPERATURE. °C

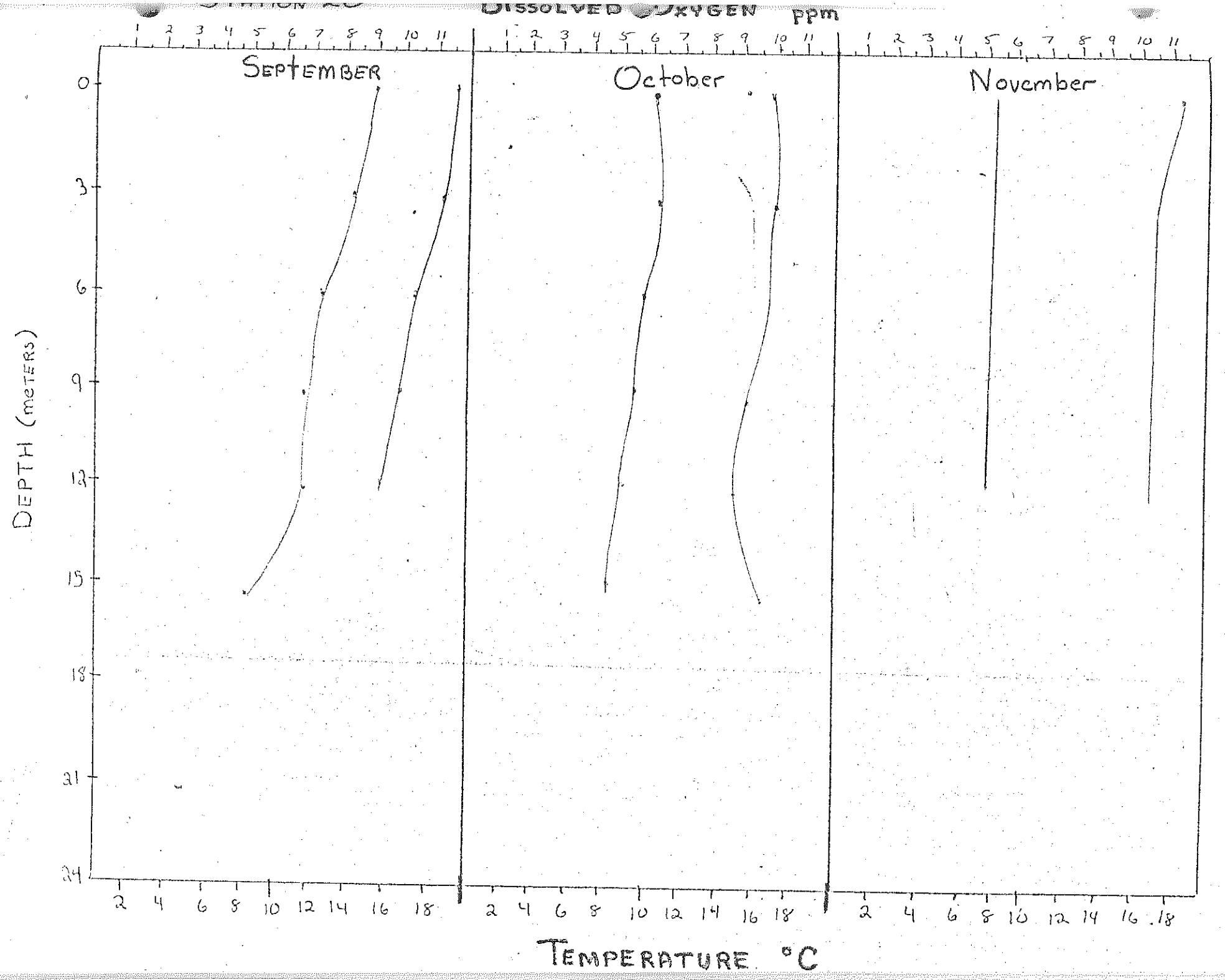

September
November
December
DEPTH (METERS)
0
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1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C

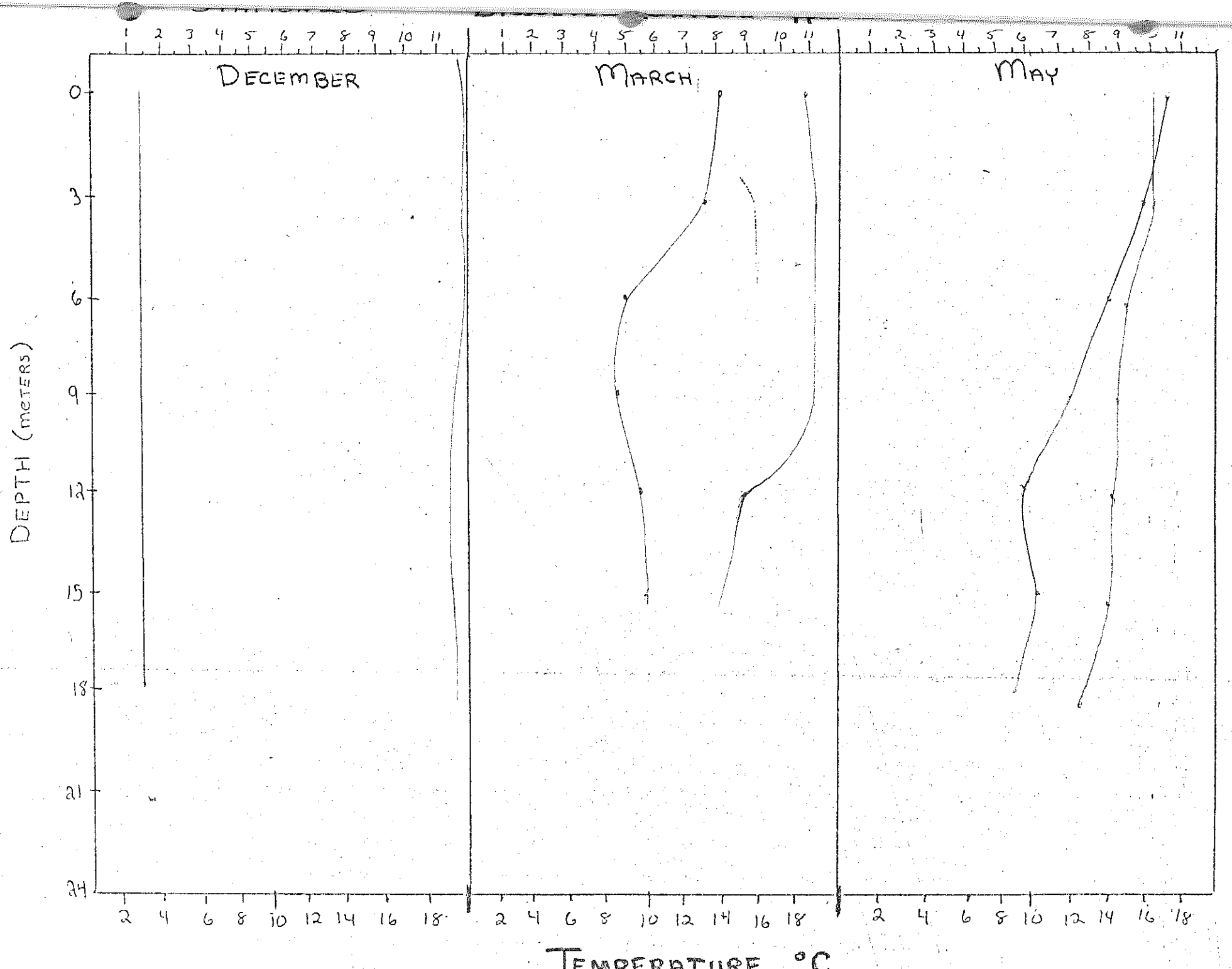

September
October
November
DEPTH (METERS)
0
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24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE. °C

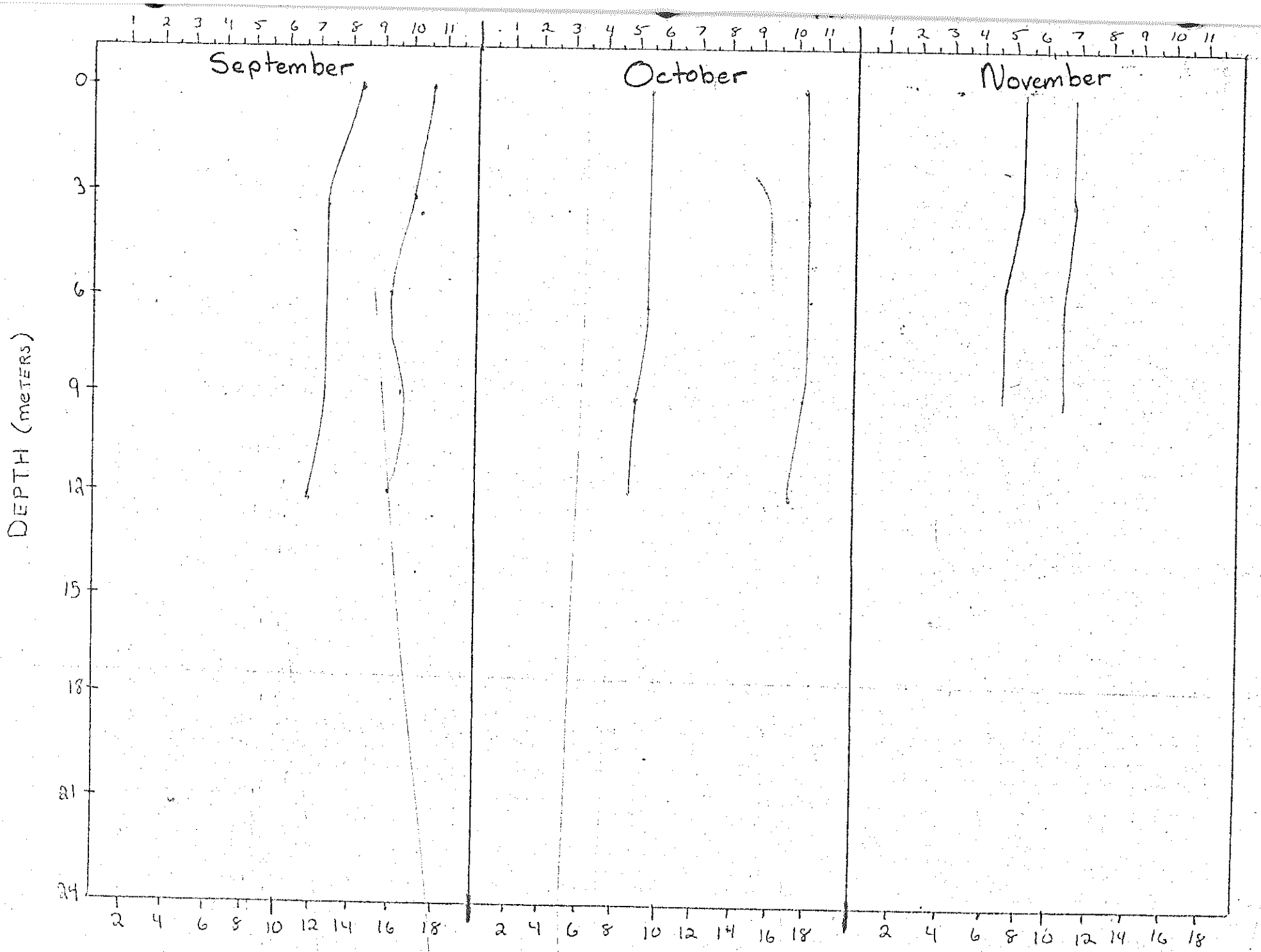

December
March
May
DEPTH (METERS)
0
3
6
9
12
15
18
21
24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C

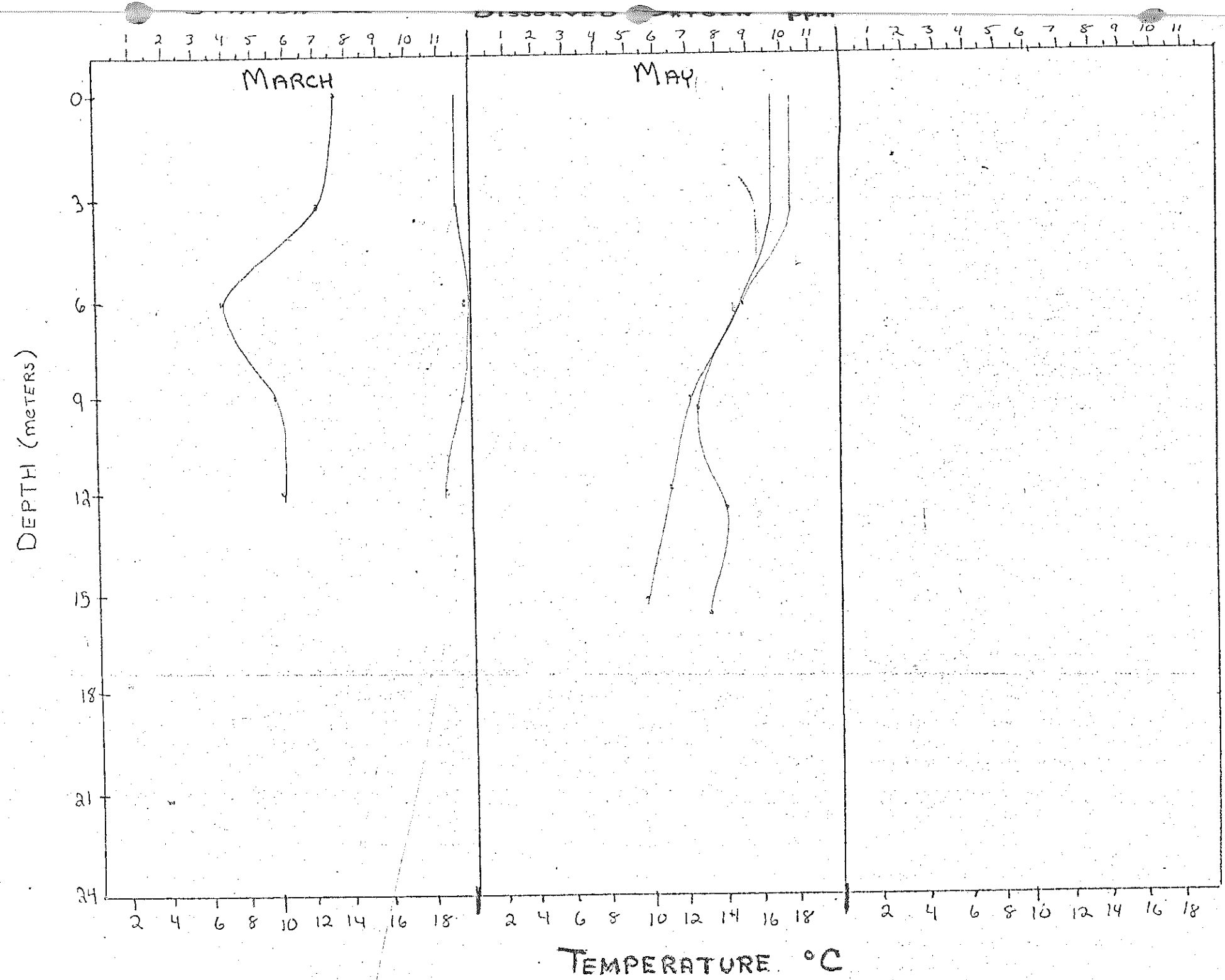

SEPTEMBER
OCTOBER
NOVEMBER
DEPTH (METERS)
0
3
6
9
12
15
18
21
24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C

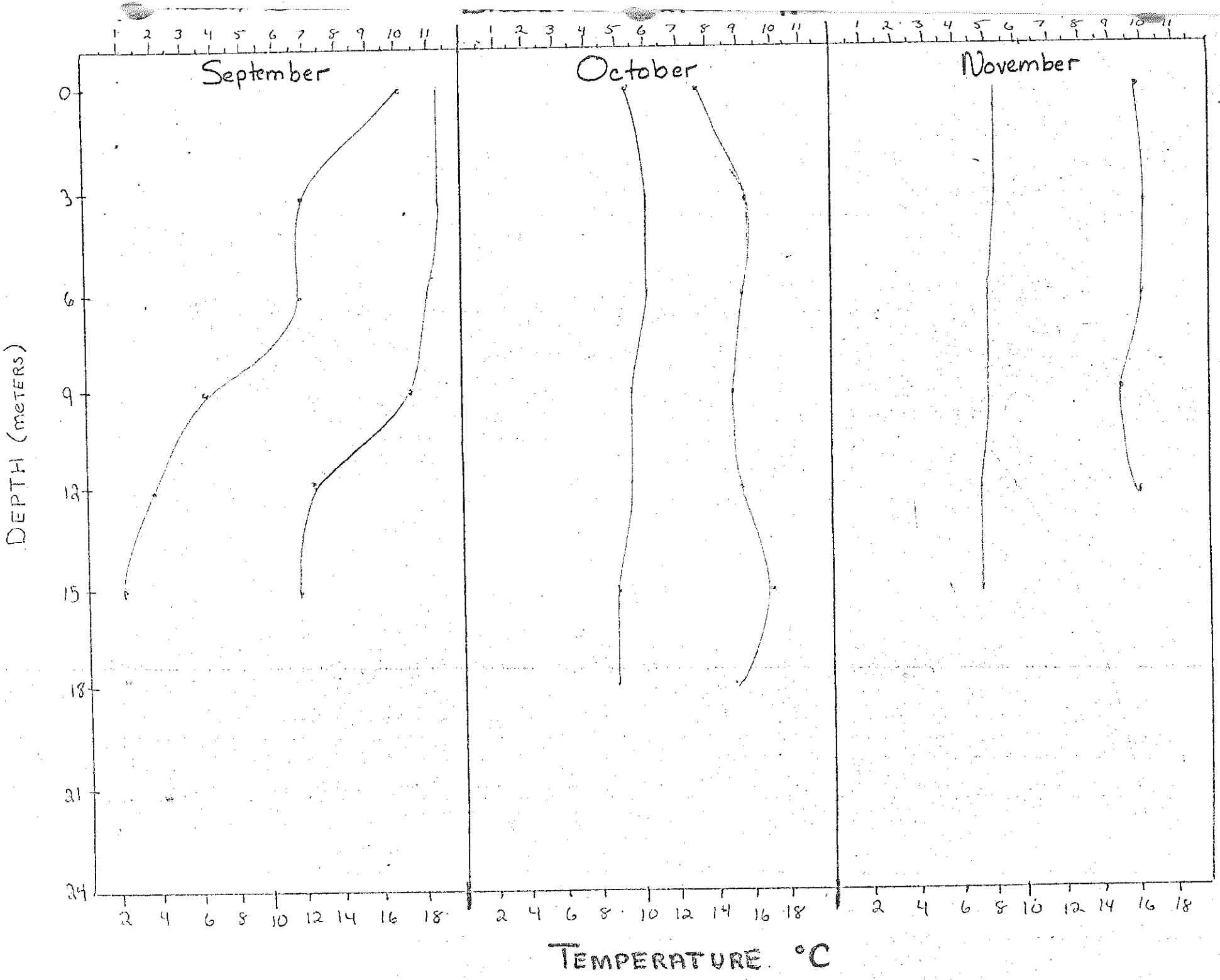

DECEMBER
MARCH
MAY
DEPTH (METERS)
0
3
6
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18
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24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C

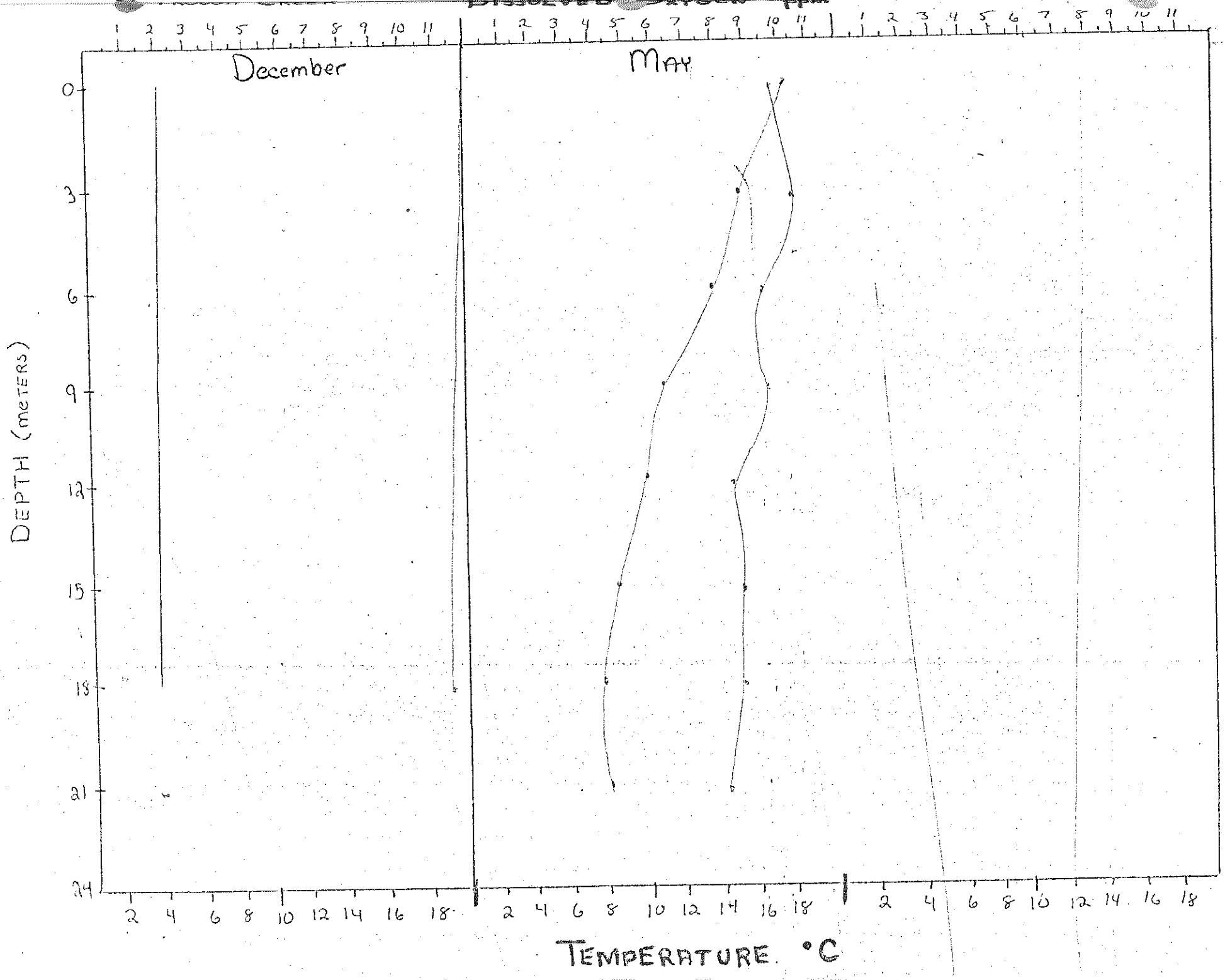

DISSOLVED OXYGEN ppm
1 2 3 4 5 6 7 8 9 10 11
SEPTEMBER
October
November
DEPTH (METERS)
0
3
6
9
12
15
18
21
24
2 4 6 8 10 12 14 16 18
TEMPERATURE °C


DECEMBER
MARCH
MAY
DEPTH (meters)
0
3
6
9
12
15
18
21
24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C


September
October
November
DEPTH (METERS)
0
3
6
9
12
15
18
21
24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C


MARCH
MAY
DEPTH (METERS)
0
3
6
9
12
15
18
21
24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C


September
October
November
DEPTH (METERS)
0
3
6
9
12
15
18
21
24
1 2 3 4 5 6 7 8 9 10 11
2 4 6 8 10 12 14 16 18
TEMPERATURE °C


December
May
DEPTH (METERS)
0
3
6
9
12
15
18
21
24
TEMPERATURE °C

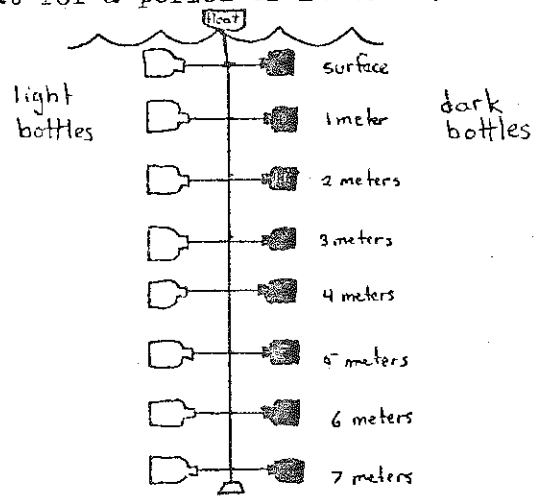
OXYGEN LIGHT AND DARK BOTTLE EXPERIMENT

Productivity on the primary level is the fixation of inorganic carbon into new organic material by means of solar energy. This material is then utilized as an energy source for physiological activities such as assimilation of food, respiration, movement, and reproduction. These activities are affected by environmental factors including the depth and stability of the photic zone; the concentration of limiting nutrients and rate of resupply; rate of grazing by herbivores and the presence of micronutrients. The light and dark bottle experiment is concerned mainly with the affect of light intensity and the amount of dissolved oxygen present in the water. These two factors can be used to determine net plant production by measuring the amount of oxygen produced by photosynthesis and subtracting the amount used by the plants themselves in respiration. Net production (amount of organic carbon produced) is related to oxygen produced by the plant, in that oxygen is given off by plants in direct proportion to the amount of organic carbon synthesized. The light intensity is known to decrease with depth of water and it is this factor that limits the habitat of plankton to an upper layer of water. The light falling on the surface water is continually changing in spectral composition throughout the day and with increasing depth. The extent of light penetration affects the compensation depth which is the point at which oxygen produced by photosynthesis is exactly equal to the amount utilized in respiration. Beyond this depth respiration exceeds photosynthesis, resulting in the eventual death of organisms due to lack of dissolved oxygen (assuming oxygen is not resupplied by circulating waters). The net evolution of oxygen arising from photosynthesis is calculated as follows: Light Bottle O_2 content - Dark Bottle O_2 content

Gross Photosynthesis = (Light Bottle - Initial Bottle) + (Initial Bottle - Dark).

Materials and Methods:

A series of 300 ml. BOD bottles were used, half wrapped with black tape (these are termed "dark bottles") so that no light can enter, thereby used to determine oxygen depletion due solely to respiration. The bottles were tied in pairs, one "light" bottle and one "dark" bottle, at distances of 1 meter apart for a total length of 7 meters. Each bottle was filled with a sample of water from the various depths and sealed taking care not to trap air bubbles. A separate sample of water was also taken so that initial dissolved oxygen could be determined. The set of bottles was then lowered into the water and tied to a float for a period of 24 hours.



Method Used to Determine Dissolved Oxygen:

1. Remove the stopper from the BOD bottle and add 1 ml. of manganous sulfate reagent, followed at once by 1 ml. of alkaline iodide solution. Restopper the bottle immediately and mix thoroughly by shaking until the manganous-manganic hydroxide is evenly dispersed.
2. Allow the floc to settle a few minutes, then shake again and let settle a second time until al least 1/3rd of the bottle is clear.
3. Remove stopper and add 1 ml. of concentrated sulfuric acid, restopper and mix so that the precipitate dissolves (the treated sample may be

held for up to 3 days under refrigeration before titration).

4. After an hour or so of acidification pour out 200 ml into a flask; add 1 ml. of starch indicator (solution turns dark blue).

5. Titrate with standard .025 N thiosulfate.

This method depends on the formation of a loose precipitate (floc) of manganous hydroxide which rapidly absorbes the oxygen dissolved in the water, thereby forming a higher oxide which may be in this form:

$$MnSO_4 + 2KOH \rightarrow Mn(OH)_2 + K_2SO_4$$

$$2Mn(OH)_2 + O_2 \rightarrow 2MnO(OH)_2$$

Upon acidification in the presence of iodide, iodine is released in a quantity equivalent to the dissolved oxygen present:

$$MnO(OH)_2 + 2KI + H_2O \rightarrow Mn(OH)_2 + I_2 + 2KOH$$

The liberated iodine is then titrated with a standard thiosulfate solution with a starch used as an indicator (Rainwater and Thatcher, 1960) :

$$I_2 + 2S_2O_3^{-2} \rightarrow S_4O_6^{-2} + 2I^{-1}$$

Experimental Results-- Juniata College Field Station Harbor:

The results of this experiment show that there was a loss of oxygen in the dark bottles due to respiration, however only three of the four sets put out to incubate conform with the theory of the experiment that the compensation depth should be able to be determined. Set 2 shows that in the surface to 3 meter "light" bottles there was a net increase in dissolved oxygen due to photosynthesis and that the surface was the compensation depth (the oxygen produced by photosynthesis is equal to the amount utilized in respiration). The compensation depth for set 3 is 6 meters and for set 4 it is between the surface and 1 meter depth.

As mentioned previously, sets 2,3 and 4 data shows that it is possible to calculate the compensation depth and net production at various depths using this "oxygen-bottle" experiment. The data from set 1 more or less indicates that respiration exceeded photosynthesis and that there was no effective plant production.

There are several possible reasons why the data collected would not show very significant changes which could result in a more precise interpretation of the dissolved oxygen that occurs in the experimental area: formation of bubbles in the bottles during incubation; waters contaminated by sewage or by decaying plant and animal material; temperature of dark and light bottles must be kept within a few degrees of each other, as respiration in the dark bottle will generally be a sensitive function of temperature; increased bacterial respiration resulting form increased bacterial growth on the glass surface of the bottles, however bacterial respiration is at a minimum in the 24 hour experimental time and need not be considered. There is also a factor of light intensity affecting photosynthetic production. During the period set 1 was out it rained--this being the probabal reason why respiration exceeded photosynthetic oxygen production. Another problem may be that the time period in which the bottles were immersed was not sufficient enough to get appreciable differences in dissolved oxygen content at the differing depths; a longer time period would probably show more significant results.

DARK - LIGHT BOTTLE DATA

station: Juniata College field station harbor

Oct. 30
7:00 pm → 7:00 AM
rain
Secchi Disk 4.5 ft.

DEPTH	TEMP °C	INITIAL ml. titrated	INITIAL ppm O_2	DARK ml. titrated	LIGHT ml. titrated	DARK ppm O_2	LIGHT ppm O_2
SURFACE	7	8.6	8.69	8.8	8.6	8.89	8.69
1 meter	9	8.7	8.84	9.0	8.8	9.09	8.89
2	8	8.4	8.48	9.0	8.6	9.09	8.69
3	9	8.7	8.79	9.0	8.7	9.09	8.79
4	9	8.8	8.89	9.1	8.7	9.19	8.79
5	9	8.6	8.78	9.1	8.8	9.19	8.89
6	8.5	8.6	8.78	8.9	8.8	8.99	8.89
7	8.5	8.8	8.89	8.9	89	8.99	8.99

Set 1

Nov. 7
2:00 pm
24 hr.
partly cloudy
Secchi Disk 4 ft.

SURFACE	9	8.8	8.9	8.5	9.2	8.59	9.29
1 meter	9	8.6	8.7	8.6	9.2	8.69	9.29
2	9	8.6	8.7	8.6	8.8	8.69	8.89
3	9	9.0	9.1	8.8	8.8	8.89	8.89
4	9	8.7	8.8	8.5	8.7	8.59	8.79
5	9	8.7	8.8	8.5	8.6	8.59	8.69
6	9	8.7	8.8	8.5	8.6	8.59	8.69
7	9	8.6	8.7	8.5	8.6	8.59	8.69

Set 2

Mar. 21
5:00 pm
24 hrs.
sunny → rain
Secchi Disk 3'
note: strong current - lost surf dk. bottle

SURFACE	7	10.6	10.7	9.6	10.7	9.7	10.8
1 meter	7	10.4	10.5	9.8	9.3	9.9	9.4
2	7	10.8	10.9	11.0	10.0	11.1	10.1
3	7	10.3	10.4	10.4	10.4	10.5	10.5
4	5	10.8	10.9	11.4	10.1	11.5	10.2
5	5	11.1	11.2	11.3	11.2	11.4	11.3
6	5	10.3	10.4	9.8	10.8	9.9	10.9
7	4	10.9	11.0	10.1	10.7	10.2	10.8

Set 3

May 5
2:30 pm
24 hrs.
overcast
Secchi Disk 7'

SURFACE	14	9.6	9.7	9.5	9.7	9.6	9.8
1 meter	14	9.7	9.8	9.6	9.8	9.7	9.9
2	14	9.7	9.8	9.7	9.7	9.8	9.8
3	14	10.0	10.1	9.7	9.9	9.8	10.0
4	14	9.8	9.9	9.7	8.6	9.8	8.7
5	14	9.8	9.9	9.7	9.8	9.8	9.9
6	12	9.8	9.9	9.2	9.5	9.3	9.6

Set 4

▭ indicates compensation depth

PHYTOPLANKTON

Many environmental factors have been considered as variables in the seasonal changes of phytoplankton observed. The effects of light and the temperature on the photosynthesis and growth of algae are inseparable because of the interrelationships in metabolism and light saturation. Experimental studies involving temperature can be discussed in at least four ways: populations found at abnormally ghgh temperatures may be due to the occurrence of transitory maxima above the limiting optimum temperature; variation in tolerance may be due to genetically determined ecotypes; the effects of temperature may be indirect, acting in different ways on different biological communities in regulating competition; temperature may be correlated with light or chemical parameters which may be the real independent variables.

Illumination is also a factor in seasonal succession. During the winter months when there is low illumination and low temperature, there is an accumulation of nutrients in the water. In the spring, with the increase in illumination and the support of the stored nutrients, there is a significant increase in the plankton population.

A pattern of seasonal succession can also be observed by the interaction of light and temperature. If, in the autecology of any group of planktonic organisms, the light and temperature requirements vary independently, it is possible to obtain four kinds of organisms, each characteristic of a season:

winter - late Jan. , early Feb.

low radiation, low temperature

spring - late April, early May

high radiation, low temperature

summer - late July, early Aug.

high radiation, high temperature

autumn - late Oct., early Nov.

low radiation, high temperature

	Low Light Species	High Light Species
Low temp. Species	Winter	Spring
High Temp. Species	Autumn	Summer

Findenegg (Carinthia II; 1943).

Chlorophyll levels can be used as a direct measure of algae populations and the algae serve as an indicator of the chemicals and nutrients available in their water supply. All algae contain chlorophyll a and a measuring of this pigment can yield some insight into the relative amount of algal standing crop. With fluorometry, chlorophyll measurements can be made directly on the sample without extraction or chemical treatment required. A fluorometer is an instrument for quantitative chemical analysis in which a sample is irradiated with ultraviolet light, and the same amount of a particular longer wavelength which is emitted, is measured. Optimum intensity is obtained at excitation and emission wavelengths of 430 and 663 nm., using an R-136 photomultiplier tube; excitation being regulated: 1x, 3x, 10x, 30x. Filters used were of CS-560 excitation and CS-2-64 emission.

The biomass of phytoplankton is observed to have a distinct periodicity

over the seasons. There is a great increase in phytoplankton numbers and biomass in the spring, usually beginning under the ice in late winter by diatoms adapted to low temperatures. This was observed in the Raystown Lake in the spring os 1977; the dominant diatom being Astronella. The spring mixiumum lasts approximately 3 months, followed by a low biomass in the summer until the second maximum in the autumn period. The winter season is characterized by low biomass and productivity of phytoplanktonic algae due to inadequate nutrients; growth limited to species that are adapted to low temperatures and low light irradiance.

The seasonal variation of phytopoankton in the Raystown Lake was observed to have slight variations. During the early spring (March, April), there was observed to be an increase in the chlorophyll a content of the waters sampled. This correlated with the spring algal bloom (Astronella was the most dominent organism). The vertical distribution of phytoplankton can also be determined from this data. The greatest levels of chlorophyll a in the water is found in the upper layers where phytoplankton utilize available light for photosynthesis.

CHLOROPHYLL a in mg/m^3

DEPTH (meters)

		1	2	4	6	8	10	12	14	16	18	20	22	Trough Creek
NOV.	surface				.004	.004	.003	.005	.003	.005	.001	.008	.004	.003
	3				.004	.003	.02	.005	.003	.005	.03	.004	.004	005
	6				.004	.004	.003	.005	.007	005	.006	.004	.005	.005
	9				.009	.004	.003	.006	.005	.005	.006	.005	.003	.004
	12				.004	.007	.004	.004	.004	.004	.004	.005		.007
	15				.002	.005	.004	.001	.007	.003	.007			.004
	18				.006	.001		.002	.006	.004				
	21				.002	.005		.001		.007				
	24				.002	006				.001				
DEC.	surface	.004	.004	.004	.003	.003	.003	.005	.007	.006	.007	.01		.01
	3	.006	.006	.005	.003	.007	.005	.006	.009	.007	.007	.007		.007
	6	.007	.004	.006	.004	.006	.006	.007	.006	.004	.004	.007		.01
	9	.006	.003	.007	.004	.006	.004	.006	.006	.005	.006	.01		.01
	12	.005	.007	.007	.004	.007	.005	.006	.007	.003	.006	.007		.008
	15	.007	.006	.007	.005	.007	.005	.006	.007	.007	.006	.007		.006
	18	.007	.004	.004		.006	.005	.006	.005	.005	.004			.007
	21	.007	.002	.006		.008	.005	.006	.005					
	24	.006	.006			.003	.005							
MAR.	surface	.05	.06	.08	.07	.01	.01	.05		.006	.008	.04	.06	
	3	.09	.09	.06	.09	.01	.004	.007		.01	.03	.04	.09	
	6	.09	.009	.07	.09	.006	.004	.007		.004	.007	.05	.006	
	9	.09	.009	.06	.01	.005	.007	.06		.01	.005	.004	.003	
	12	.06	.008	.04	.06	.007	.003	.002		.01	.006	.05	.009	
	15	.06	.006	.06	.05	.006	.004	.004		.005	.03	.008		
	18	.07	.05	.06	.07	.009	.005	.009		.005	.009			
	21	.07	.01	.08	.08	.005	.003			.006	.09			
	24	.08	.006	.08		.007								
MAY	surface	.06	.007	.005	.05	.01	.07	.007		.06	.009	.01	.05	.05
	3	.08	.007	.008	.06	.05	.05	.09		.08	.03	.07	.04	.01
	6	.05	.007	.004	.02	.04	.003	.003		.007	.009	.04	.009	.005
	9	.03	.01	.004	.002	.03	—	.004		.003	.002	.006	.005	.002
	12	.02	.005	.002	-	—	.004	.005		.003	.003	.003	.003	.001
	15	.007	.03	.002	-	—	.003	.004		.004	.004	.004		.001
	18	.001	.03	—	-	—	.002	—		.002	.002	.003		.002
	21	.003	.04	—		.0007	.002	-		.002	.006			.002
	24			.001		.003	.002	—		.002	.002			

LAKE WATER TRANSPARENCY - SECCHI DISK

The proceedure of the Secchi disk is simply to observe the depth at which a white and black disk, 20 cm. in diameter, let down from the surface just disappears from view; the observation being made from a shaded area of water surface. The actual Secchi disk transparency is taken by observing the point of disappearence, than lowering the disk a little farther and raising it to the point of reappearence and taking the mean of the two readings. This method of measuring the transmission of light is of value to limnological studies but is not free of subjective factors. Areas of consideration are the size of the disk used and disks painted with black and white quadrants. What the observer is actually doing is comparing the brightness of the water around it. The Secchi disk transparency is essentially a function of the reflection of light from its surface, and is therefore influenced by both the absorption characteristics of the water and of its dissolved and particulate matter. In this generalized way it has been used to estimate the approximate density of phytoplankton populations. In previous studies done, it has been shown that when a group of lakes were compared using the Secchi disk and a spectral sensitive photocell, there was a high correlation between the Secchi disk transparency and transmission. According to Yoshimura (1938) the Secchi disk disappears at a level of penetration of 5 per cent solar radiation (there are discrepancies with this value--others determined are 12 to 15 per cent). For example, the most transparent lakes are seepage lakes, such as Lake Tahoe which a value of 33 meters has been recorded; the transparency for most drainage lakes is correlated with the amount of suspended particles in the water which accounts for seasonal variation in Secchi disk transparency; most observers having

found transparency to be higher in winter than in summer.

In looking at the data on depths recorded for the Secchi disk during the various seasons and different stations, several characteristics can be noted. During overcast sky conditions the the transparency of the water was not as great as on sunny days. The shallower stations have comparatively lower transparency than stations of deeper waters, indicating a greater amount of suspended particulate matter due to mixing of shallow water and also runoff from the land and incoming water sources. In an overall view, the greatest transparency of the water was during the winter months when plankton levels were low and the ground frozen, preventing particulate matter entering the lake with ground runoff. The greatest depth for transparency was recorded as 20 feet on December 5, 1976 at station 1 (180 ft. depth) --at that time the ground was frozen and it was a bright sunny day.

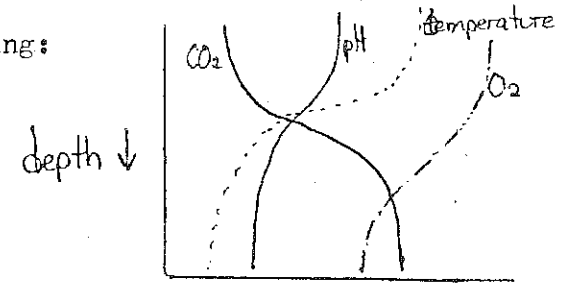
SECCHI DISK DATA

Date	Depth (feet)	Station	Sky Condition
October 6	7	20	sunny
	2	22	overcast
13	7.5	6	sunny
27	3	16	overcast
November 3	7	8	sunny
10	4.5	Trough Creek	scattered clouds
10	5.5	16	"
December 5	20	1	sunny
12	8.5	14	overcast
March 15	9.5	8	sunny
22	3	10	rain
27	2.5	16	overcast
27	2	20	"
April 27	6	8	sunny
26	6	10	overcast
May 3	7	16	sunny
8	5	20	sunny
8	4	22	sunny
10	7	14	overcast

pH

The vertical distribution of pH can be determined by the utilization of CO_2 in the trophogenic (zone of photosynthetic production) layers and its liberation in the tropholytic (aphotic, heterotrophic decomposition of organic matter) zone. Low pH values are found in waters rich in dissolved organic matter and high pH values are usually found where lake waters contain high concentrations of soda. Most lakes have a pH range between 6 and 9 and contain varing amounts of carbonate, regulated by the $CO_2 - HCO_3^- - CO_3^=$ system of buffering capacity (Wetzel, 1975).

The vertical distribution of pH is influenced by various biologically-mediated reactions and can be observed as an inverse to the amount of CO_2, in excess of respiration in the trophogenic zone, tends to reduce CO_2 content and to increase pH. The respiratory generation of CO_2 in the tropholytic zone and sediments decreases pH; this is augmented by microbial methane fermentation, nitrification of ammonia, and sulfide oxidation. A generalized graph looks like the following:



The distribution of CO_2 in lakes shifts seasonally due to photosynthetic utilization of CO_2 and induction of $CaCO_3$ precipitation--induced by many physical and biotic agents such as increasing temperature and bacterial metabolism. By the end of summer stratification there is a marked decrease in the CO_2 of the epilimnion and a slow progressive increase in the hypolimnion, meaning a progressive decrease in pH in the hypolimnion throughout the period

of stratification.

During the period this study took place, it is observed that there was not a significant variation in the pH at the particular stations over the seasonal changes. It is noted however, that there is a decrease in pH with depth at most of the stations and is most likely due to the increased CO_2 content of the water with depth (decreased O_2 with depth also), along with microbial methane production and decomposition of organic matter on the bottom.

pH

DEPTH (METERS)		STATION 1	2	4	6	8	10	12	14	16	18	20	22	Trough Creek
SEPT.	surface						7.05		7.13	7.42	6.80	7.38	7.56	7.42
	3						7.13		7.16	7.42	7.28	7.38	7.55	7.42
	6						7.16		7.18	7.35	6.92	7.31	7.48	7.48
	9						7.12		7.18	7.28	7.22	7.26	7.38	7.48
	12						6.98		7.14	7.38	7.16	7.18	7.32	6.58
	15						6.98		7.01	7.14	7.08	7.08		6.78
	18						6.91		6.94	7.01	6.94			
	21									6.92	6.88			
	24										6.78			
OCT.	surface	6.84	7.25	7.31	7.38	7.34				7.31	7.09	7.08	7.38	
	3	7.18	7.20	7.31	7.38	7.34				7.28	7.26	7.24	7.42	
	6	7.16	7.18	7.31	7.42	7.32				7.21	7.36	7.32	7.42	
	9	7.18	7.12	7.35	7.45	7.32				7.21	7.36	7.32	7.42	
	12	7.16	6.98	7.32	7.40	7.32				7.26	7.36	7.44	7.42	
	15	7.14	7.16	7.18	7.32	7.16				7.28	7.42	7.44		
	18	7.14	7.16	7.12		7.16				7.34				
	21	7.10	7.16	7.12		7.08								
	24	7.10	7.16	7.12		6.98								
NOV.	surface				7.29	7.38	7.44	7.48	7.48	7.15	7.2	6.96	7.1	7.30
	3				7.26	7.40	7.44	7.48		7.25	7.12	7.08	7.18	7.36
	6				7.26	7.40	7.46	7.53	7.48	7.32	7.18	7.15	7.18	7.32
	9				7.32	7.42	7.46	7.53	7.52	7.36	7.18	7.15	7.22	7.32
	12				7.32	7.45	7.43	7.53	7.54	7.38	7.18	7.15		7.32
	15				7.22	7.45	7.38	7.50	7.58	7.32	7.18			7.32
	18				7.16	7.36		7.52	7.64	7.32				
	21				6.98	7.30		7.46		3.65				
	24				7.05	7.30				7.20				

pH

STATION

DEPTH (METERS)	1	2	4	6	8	10	12	14	16	18	20	22	Trough Creek
DEC. Surface	7.20	7.22	7.20	7.12	7.20	7.26	7.33	7.25	7.45	7.62	7.66	frozen	7.36
3	7.22	7.22	7.20	7.12	7.16	7.26	7.33	7.25	7.50	7.62	7.66		7.36
6	7.22	7.22	7.23	7.16	7.20	7.26	7.42	7.30	7.52	7.68	7.62		7.38
9	7.28	7.22	7.22	7.16	7.20	7.28	7.42	7.30	7.55	7.62	7.68		7.42
12	7.30	7.24	7.26	7.16	7.20	7.30	7.42	7.20	7.55	7.68	7.66		7.42
15	7.30	7.24	7.26	7.16	7.20	7.30	7.42	7.25	7.55	7.68	7.62		7.42
18	7.32	7.26	7.26		7.22	7.30	7.45	7.25	7.55	7.74			7.36
21	7.32	7.26	7.26		7.22	7.32	7.45	7.25					
24	7.32	7.26				7.32							
MAR. Surface	7.68	7.6	7.5	7.64	7.45	7.2	7.5		7.4	7.4	7.45	7.45	
3	7.68	7.6	7.58	7.64	7.65	7.35	7.5		7.4	7.42	7.5	7.5	
6	7.65	7.6	7.58	7.48	7.68	7.5	7.45		7.4	7.45	7.5	7.5	
9	7.65	7.58	7.55	7.52	7.68	7.5	7.45		7.4	7.45	7.5	7.55	
12	7.62	7.58	7.60	7.58	7.68	7.5	7.45		7.4	7.45	7.5	7.5	
15	7.6	7.58	7.50	7.52	7.68	7.5	7.45		7.38	7.45	7.5		
18	7.6	7.52	7.50	7.58	7.67	7.5	7.40		7.30	7.45			
21	7.6	7.5	7.52	7.42	7.62	7.45				7.38			
24	7.6	7.5	7.45		7.6								
MAY Surface	8.12	8.21	8.15	8.04	7.90	8.15	8.35		7.68	7.68	7.82	7.9	7.68
3	8.2	8.21	8.15	8.10	8.05	8.4	8.4		7.78	7.78	7.95	7.98	7.80
6	8.12	7.85	8.2	7.62	8.05	7.6	7.6		7.70	7.70	7.80	7.78	7.52
9	8.55	7.68	7.48	7.51	7.48	7.52	7.6		7.55	7.50	7.72	7.68	7.42
12	7.52	7.55	7.48	7.40	7.42	7.48	7.6		7.42	7.42	7.58	7.38	7.38
15	7.48	7.48	7.42	7.38	7.38	7.45	7.55		7.40	7.40	7.52	7.35	7.32
18	7.48	7.45	7.42	7.38	7.35	7.42	7.45		7.35	7.32	7.42		7.28
21	7.42	7.40	7.40		7.35	7.38	7.35		7.30	7.28			7.22
24			7.38		7.35	7.32	7.3		7.28	7.20			

CONDUCTIVITY

Specific conductance is another way of looking at the water chemistry of a lake. It is a measure of the resistance of a solution to electrical flow and is expressed in units of μmhos. Since the resistance of a water solution to electron flow is reduced with increased ion content, the purer the water is, the greater its resistance to electrical flow will be. The units, μmohs, is the reciprocal of ohms--defined as the specific resistance of a solution measured between two electrodes 1cm. in area and 1cm. apart. Therefore water with high ionic content (eutrophic water) has higher conductivity measurements than water with low ionic content (oligotrophic water). This relation to eutrophic and oligotrophic conditions does not always hold true. The degree of tightness of the nutrient cycle, that is to say, how fast specific nutrients (ionic materials) are utilized by the biomass when introduced to the water, will have an effect on the actual measurements of conductivity--ions may be present but not measurable. Ruttner (1921) found that Elodea and other plants produce a more or less marked decrease in the electrolyte content of water through their photosynthetic activities.

The pH of the water and temperature will also have an effect on conductivity. The hydrogen ions present in the water will increase conductivity. The temperature of the electrolyte effects the ionic velocities such that conductance increses about 2 per cent per degree centigrade. (Wetzel, 1975).

The measurements taken at Raystown Lake during March and May show some correlation with pH readings; low pH relating to high conductivity readings. The temperature data shows a greater effect on conductivity; March having colder over-all temperatures than May had lower conductivity

measurements. However, when the change in depth is compared with conductivity and temperature there is a discrepancy. Looking at the data in May for stations 16 and 18 it is noted that the surface temperatures for both are relatively high but station 16 has a conductivity of 58 and station 18 has a conductivity of 243. This indicates there are other factors that are effecting the conductivity to a greater extent than temperature. The relative values of conductivity can also be used to determine the relation of mixing of the lake waters with depth and also the source of the waters running into the lake. This is observed in stations 18, 20, and 22 where these waters are effected by streams flowing tnto the lake.

As was previously stated, there are many parameters associated with conductivity of lake waters. The measurements taken in this study were merely to get an idea of the concept of using conductivity as an index of ionic strength of the water.

CONDUCTIVITY μMHOS

STATION

DEPTH (METERS)		1	2	4	6	8	10	12	14	16	18	20	22	Trough Creek
Mar.	Surface						85	78		101	98	49	93	
	3						89	84		98	91	58	71	
	6						87	88		94	89	89	86	
	9						92	72		93	86	90	45	
	12						95	81		91	87	83	43	
	15						95	90		91	93	73		
	18						94	75		92				
	21						94			93				
	24													
May	surface	115	114	118	116	120	110	125		58	242	165	170	118
	3	115	118	111	114	115	110	128		52	234	160	172	112
	6	118	118	112	112	112	96	100		48	200	140	148	112
	9	110	112	112	110	109	94	94		40	176	120	90	112
	12	110	110	109	109	107	93	95		33	152	100	108	100
	15	109	109	109	110	106	93	93		242	160	100	104	80
	18	110	109	109	110	106	96	96		205	150	102		86
	21	105	109	109		110	97	96		209	145			78
	24			109		110	105	96		200	147			

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Soil Study Of The

Raystown Field Station

Michael M. Molesevich
Juniata College
Independent Study
Dr. Robert L. Fisher
Spring, 1977

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Classification Breakdown Of The Field Station Soils (1)

Acknowledgements

I would like to extend my appreciation to the Huntingdon County Soil Conservation Service and Ed Mirkel, Soil Scientist, for their information and assistance.

Introduction

Being a science the study of soils can be very complicated and rigorous. The complexity of the soil is due to the fact that so many different variables affect it and its development. There are both biological and physical parameters to the soil. There is even a wide scale classification system developed for the organization of the many different kinds of soil. Before one can classify a soil, species or geologic formation one must be quite familiar with the system of classification.

The purpose of this study is to study and map the soils of the Raystown Field Station. This includes becoming familiar with the United States system of soil classification and their nomenclature. The end result of this study is this report, my version of a soil map of the Raystown Field Station and a list of soil characteristics of those soils occurring at the field station. These sheets are the type soil characterisics used in classifying soils by the Soil Conservation Service.

History

Throughout the years man's activities have greatly influenced the soil and its development. Before the white settlers had arrived in this country there was a very good and rich soil throughout most of Pennsylvania. With the start of the lumbering industry

in Pennsylvania and the vast removal of virgin forests much if not all of the soil was drastically affected. With nothing to hold the soil in place in this very mountainous region the soil quickly becomes worn away. Farming and cultivating also wears the soil by exposing it to rains, extracting minerals and organics and ingeneral making it more accessible to the elements of the weather. So the soil we see today has gone through considerable changes in a relatively short time as compared to the time it took to form it.

With the Raystown Field Station being a part of the Raystown Dam Project it lies in the Valley and Ridge Province of the Appalachian Mountains. This is characterized by long even crested mountain ridges with rolling valleys. The field station soil has gone through the affects of lumbering years ago and intensive farming more recently.

The climate affecting the study area is continental with warm summers and cold winters. Most winds come out of the west while a few come from the east. Winter winds come out of the west and summer winds from the east bringing moisture. Rainfall averages about forty inches per year. The average frost free season is about five months extending from May to September.

The geology of the field station is very uniform. All bedrock is basically green, gray and chocolate colored shale. There are some areas where the shale is exposed through the soil. The shale also has two local beds of sandstone and conglomeratic

sandstone. The rocks underlying the soil and the parent material of the soil is Upper Devonian in age. The shale formation is known as the Brallier and Scherr Formations. They were formerly known as the Chemung Formation. (Lauderdale, 1977)

Methods and Materials

The first part of this study consisted of researching various sources on soil and soil classification. This was necessary in order to understand the nomenclature used in describing and classifying soils.

The next step was to acquire soil maps, aereal photographs and a soils interpretations book for the soils of Huntingdon County. The interpretations book and a soil aereal photograph of the study area were acquired at the Huntingdon County Soil Conservation Service. After researching the appropriate material the assistance of a soil scientist was needed.

The process of classifying and mapping soils takes years to master and develop. It is only through the assistance of a soil scientist that I could have even attempted classify and map. A day in the field with the soil scientist gave me a small glance at a very complicated classification system. The author of this report does not claim effeciency in this area of classifying and mapping from only a few weeks of study. The soil scientist showed me techniques and characteristics used in the field to name and classify the soils.

The field materials for this study consisted of a tiling spade, soil auger, field notebook and map of the study area. A much more precise study by a soil scientist would require a few addittional materials. These would include a soil color chart, structure and grain chart, and a soil reaction kit. These addittional materials were not needed because of the few soils found at the field station can be distinguished without them.

Basically my procedure consisted of digging a hole in the soil and/or augering it in order to examine it. By knowing the topographical setting, the slope, and general characteristics of the soils in the area you name and therefore classify the soil. Obviously this says alot but being that our study area is relatively small and only a few soils are found a few major characteristics can distinguish a soil. For example, most of the field station's mountains can be one of two soils. The easiest way to tell them apart is by their depth to bedrock which can be done by digging a hole and measuring it to the shale underneath. The Berks shaly loam is 20 to 40 inches while the Weikart is less than 20 inches deep.

Discussion

There are six categories in the United States system of soil classification. The breakdown of the soils of the field station according to these six categories can be seen in Table One. The largest heading is Order and moves to the smallest heading which is used in the field and on the maps- Series.

The six are:

Order
Suborder
Great Group
Subgroup
Family
Series

There are ten orders which are based on the presence or absence of soil horizons and conditions involved in the soil forming process and general climates. There are three of the ten orders represented by the field station soils. Without going into detail the the characteristics of the orders as defined by the Soil Conservation Service (1975) are as follows. The basic concept of Inceptisols have altered horizons and occur in humid areas. The Ultisols are soils of middle to low latitude and horizons have silicate clays in them. Alfisols occur in the East North Central United States, have a high amount of cations, show movement of clay material.

There are also three suborders associated with the soils at the field station which are Ochrepts, Udults, and Aqualfs. Ochrepts are mainly light colored, brownish, more or less freely drained Inceptisols of the mid to high latitudes.(SCS, 1975)

Table 1 Classification Breakdown of the Field Station Soils

Order	Suborder	Great Group	Subgroup	Family	Series	(Legend)
Inceptisols	Ochrepts	Dystrochrepts	Typic Dystrochrepts	Loamy-Skeletal, Mixed, Mesic	Berks	87
Inceptisols	Ochrepts	Dystrochrepts	Lithic Dystrochrepts	Loamy-Skeletal, Mixed, Mesic	Weikart	90
Inceptisols	Ochrepts	Dystrochrepts	Fluvaquentic Dystrochrepts	Coarse-Loamy, Mixed, Mesic	Philo-Basher	9
Ultisols	Udults	Hapludults	Aquic Hapludults	Fine-Loamy, Mixed, Mesic	Blairton	99
Ultisols	Udults	Fragiudults	Aquic Fragiudults	Fine-Loamy, Mixed, Mesic	Ernest	111
Alfisols	Aqualfs	Fragiaqualfs	Typic Fragiaqualfs	Fine-Silty, Mixed, Mesic	Brinkerton	113

The Udults are more or less freely drained, humus poor Ultisols in humid climates in mid to low latitudes that have well distributed rainfall (SCS, p.360). Aqualfs are the gray and mottled Alfisols that have an aquic moisture regime and have other characteristics associated with moisture. (Mottles are spots in certain layers of the soil. For instances there are gray mottles or spots with a brown matrix or background.) Suborders are therefore differentiated on the basis of moisture and temperature. There are forty-seven suborders presently recognized.

Great groups are subdivisions of the suborder. There are 225 great groups which are distinguished by different soil horizons, pans, (layers that block the flow of water, minerals and prevent root penetration.), temperature and differences in the content of such factors as calcium, magnesium, sodium and salts. Again we have four great groups which are Dystrochrepts, Hapludults, Fragiudults and Fragiaqualfs. In short the basic differences are that Dystrochrepts have a low base saturation, Hapludults have minimum horizon development, and the Fragiudults and Fragiaqualfs have differences and similarities asscociated with the fragipans.

The subgroup is the next category. If the term 'typic' is used in the subgroup as in Typic Dystrochrepts then this represents a central type soil group. Typic and Lithic Dystrochrepts also refers to the fact that these soils were on and from sedimentary or metamorphic rocks, are acidic, on steep slopes and are freely

drained. Fluvaquentic refers to the floodplain locale of the soil while aquic means poor drainage or fluctuating water level.

Soil families are divisions of the subgroup and are based on physical soil properties such as texture. Texture refers to the ratio-percentage of the different size particles of the soil. The particles from smallest to largest are clay, silt and sand. Anything larger than sand is coarse. Loam is not a particle size but a certain combination of particle sizes. Other criteria for the family are mineralogy classes (this is what 'mixed' refers to), calcareous and pH classes, along with soil temperature, depth, slope, and consistence. Mixed soils have a combination of minerals in which no single class of mineral(s) is dominant. In short, family = subgroup + adjective.

The lowest heading of the classification system is the series. The soil series is a group of soils having similar characteristics and having those traits arranged in a certain soil profile, except for texture slope and erosion. The name of the series (Berks, Weikert etc.) is usually named for where the type soil profile is located or where it was first recognized.

The slope of the land is associated with the series name. Letters A, B, C, D, EF, refer to the slopes that the series is found on as 0%, 3-8%, 8-15%, 15-25% and 25-70% respectively.

How the slope of the land affects the soil can easily be seen at the field station. Due to the steep slopes soil can not develop as deep and end up being washed down to the foot slopes

to where the soils tend to be alot deeper. A general rule is the soils of the steep slopes tend to be less deep than the soils on flat areas. An exception to the rule is that the Berks soil tends to form in a band along the tops of ridges.

The soils of the uplands also are less moist than the soils on more level areas. This is so for a number of reasons. First, the bedrock is steep and water runs fast, shallow soil cannot retain moisture, there is a comparitively small layer of humus in this area, and the large amount of coarse material in the soil allows for much surface area for water seepage. The erosional capabilities of this area good as can be seen in the result of the steep 'V' shaped valleys which were carved by water.

The reason for a shallow humus layer in the area is that the original thick humus layer from the virgin forests has long been removed and production of detritus material equals the rate at which it is being broken down.

Finally the reaction (pH) of the soil deserves mention. The soils at the field station are generally acidic. There are mainly two reasons for this. One is the general acid condition of the parent shale material. The second reason is the result of organic acids leaching from the original humus when virgin timber still stood. The acids wereformed when the organic material decomposed and being soluble were carried down to the subsoil by water.

Soil Legend For The Map

Soil Type (Soil Series plus Texture Class)	Slope	Legend
Philo and Basher Silt Loam	0	9
Berks Shaly Silt Loam	3-8%	87B
Berks Shaly Silt Loam	8-15%	87C
Berks Shaly Silt Loam	15-25%	87D
weikertShaly Silt Loam	3-8%	90B
Weikert Shaly Silt Loam	8-15%	90C
Weikert Shaly Silt Loam	15-25%	90D
Berks and Weikert Shaly Silt Loam	25-70%	90EF
Blairton Silt Loam	3-8%	99B
Blairton Silt Loam	8-15%	99C
Ernest Silt Loam	3-8%	111B
Ernest Silt Loam	8-15%	111C
Brinkerton Silt Loam	3-8%	113B

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1978

Distribution and Abundance of Zooplankton and Phytoplankton at selected locations on Lake Raystown

by

Linda S. Arentz

Submitted in partial fulfillment
Of requirements for an
Independent Study
Summer 1978

Advisor: Dr. Robert L. Fisher

ABSTRACT

Plankton samples were taken at selected locations on a four year old fresh-water reservoir in Central Pa. . An investigation of species diversity and relative abundance was conducted during the summer months of 1978. Daily vertical migrations of zooplankton were observed at monthly intervals. Data during this study suggested distinct distributional patterns of organisms. Seasonal fluctuations in population densities of Dinobryon s., Asterionella f., Uroglena v., Ceratium h., and Fragillaria c. were evident at all stations. Pronounced patterns of vertical migration was exhibited by Filina l., Daphnia p., and Bosmina c. . Temperature and dissolved oxygen profiles were found characteristic of a stratified lake. Lake temperatures remained constant with the exception of surface fluctuations. Dissolved oxygen curves showed changes at depths over a 24 hour study.

THE STUDY SITE

Lake Raystown is the largest body of water entirely within Pennsylvania. It is a fresh-water reservoir 30 miles long with 118 miles of shoreline and covers 8,300 acres. The reservoir is formed by the Raystown Dam located on the Raystown Branch of the Juniata River, five and one-half miles upstream from the main tributary of the Juniata River. Constructed by the U.S. Army Corps of Engineers between 1968 and 1973, Raystown Dam is a major element in the Susquehanna River Basin Flood Control System. The dam controls a 960 square mile watershed and is designed to provide flood control, recreation, enhanced fishing and downstream flow augmentation. Station 1 was located at the James creek inflow. Its deepest point is approximately 15 meters and the Juniata College Environmental Studies Area is located at this site. Station 2 was located at the Trough Creek confluence 15 miles southwest of the dam and is 23 meters deep at its deepest point. Across from the Seven Points Recreation Area, eight miles south of the dam was the location of Station 3. At this point the lake reaches its widest point of approximately 4,000 feet. The fourth station where samples were taken was at the breast of the dam. The waters at this point reach depths of over 160 feet. The greatest visibility with a Secchi Disk of 20-plus feet was observed at this station Where the waters were quite clear. Secchi visibility was rarely over 15 meters. (See figure 1)

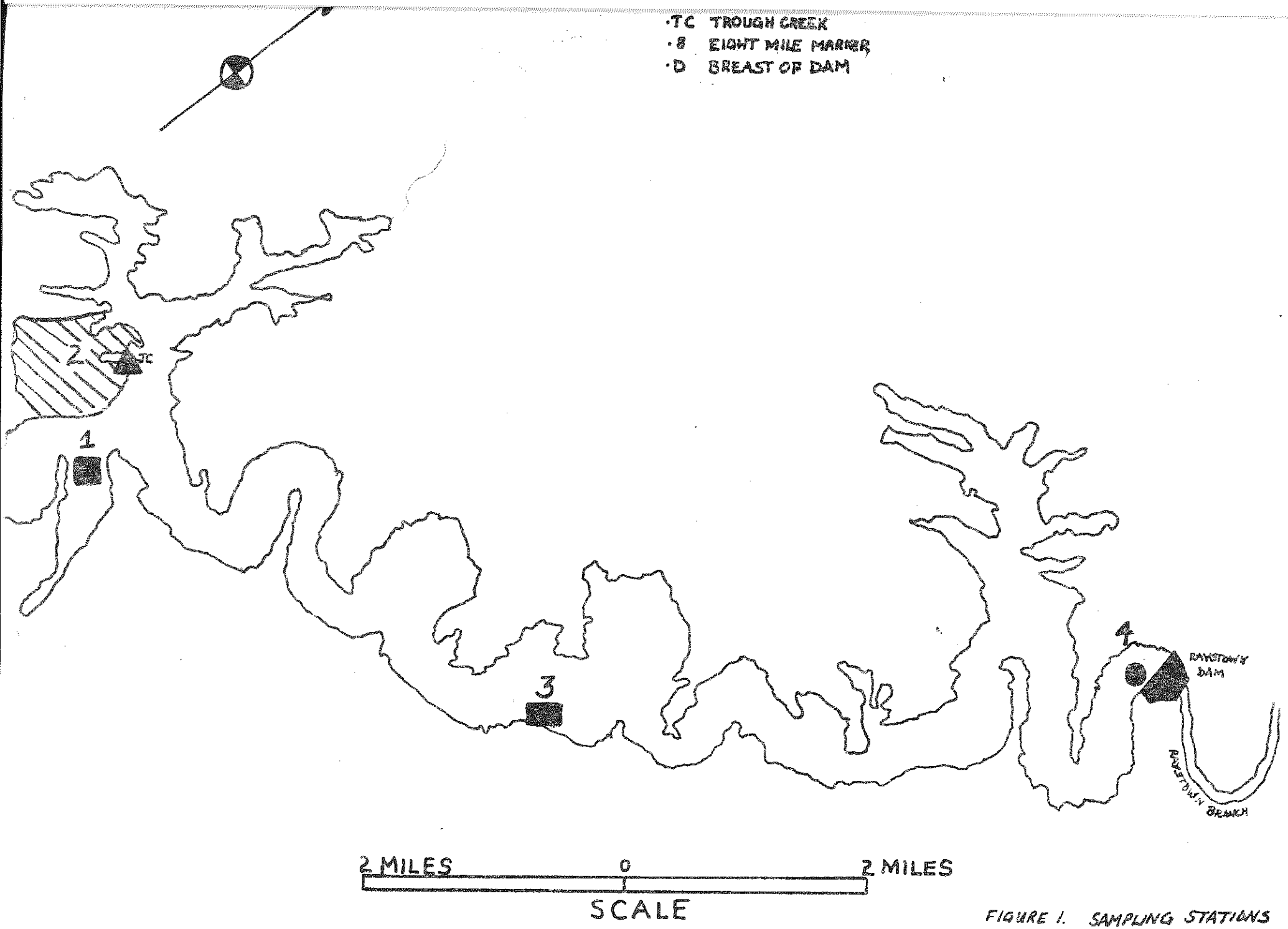


FIGURE 1. SAMPLING STATIONS

METHODS

Samples were taken weekly from June 17 to July 28 on the reservoir between the hours of 10 A.M. and 2P.M. with a Closing Birge Wisconsin Net at three meter intervals from the surface to bottom. Organisms were washed form the plankton net into containers and fixed with Lugol's Iodine (Lind 1974). Temperature and oxygen profiles were obtained once a week at each station when plankton were sampled. A YSI (Model #51) Dissolved Oxygen and Temperature Probe with 150 feet of cable was used to record dissolved oxygen and water temperatures at the corresponding sample depths. Visibility measured in feet, was determined with a Secchi Disk. Air temperature and sky features were also recorded on sampling days. Once during the study samples were taken for 24 hours at each station.

Preserved samples were brought back to the lab at the end of the sampling day. One milliliter of the sample was extracted from each bottle and counted in a Sedgwick-Rafter counting chamber. A compound microscope equipt with a mechanical stage was used to make total counts. Three total counts per sample were averaged for each station. The number of organisms per liter of lake water was determined by the formula:

$$n = \frac{(a1000)c}{1}$$

Welch (1948)

where,

n= number of plankton/liter of original water

a= average number of plankters in all counts in counting unit of cubic mm capacity

c= volume of original concentrate in 1ml.

l= volume of riginal water expressed in liters.

Sample estimates were tabulated for later analysis.

DISCUSSION

A comparison of the data collected from each station indicated that the same species of phytoplankton and zooplankton were present at all four sampling locations. Density differences however, were noted between stations. This variation is shown in figures 2-5 and in the appendix tables.

The sampling period began in mid-June and concluded at the end of July. During this short period fluctuations of several populations were evident. These fluctuations represented in figures 2-5 are; at Station 1, Fragillaria c.and Ceratium h. population counts increased as the summer progressed. Uroglena v.'s numbers increased rapidly but was not detected untill the first week of July. For Station 2 Dinobryon s., Asterionella f., and Staurastrum p. populations decreased while Ceratium h. increased. At Station 3, Fragillaria c. and Staurastrum p. densities exhibited prounced increases from June to July. At Station 4 Dinobryon s. increased and Asterionella f. showed a marked derease. (See figures6-10)

Various Algae are indicators of conditions in which they are found. Anabaena for instance, if found in excess can be an indicator of pollution while Dinobryon species indicate clean water conditions (Palmer 1962). Palmer (1962) found a reasonable number of species of common plankton (which varies from lake to lake) organisms indicates a balanced biological condition. It

is assumed that the chemical and physical environment largely determines the amount of algal production(Hutchinson 1948). Although no nutrient studies were included in this study, the importance of their presence and abundance is not known but should be considered when looking at the different species of organisms present.

Provasoli and his associates (see Hutchinson 1948) found with the provision of light and source of nutrients such as K, C, P, Ca, and Mg, almost any algae should be able to grow. This is possible only when these nutrients are found in the right concentrations and the right physical environment.

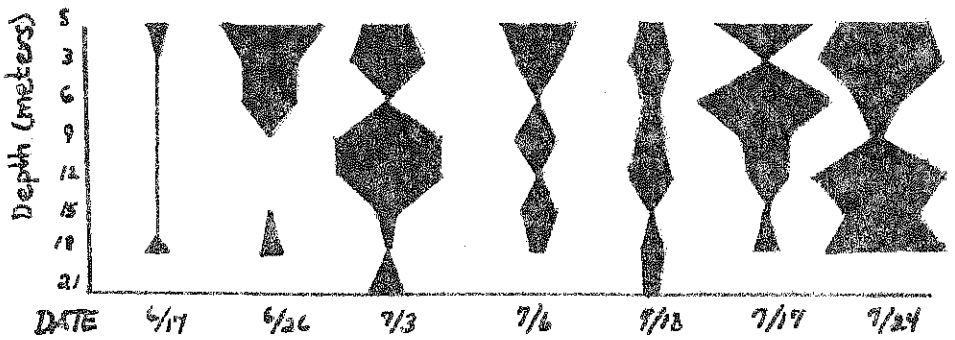
Increases in the populations of algae such as those that tend to develope in temperate regions (such as Chrysophyceans) are indicators of eutrophy. It may be safe to assume that Lake Raystown has characteristics of an oligotrophic lake based on its age and species of plankton present. Lake Raystown is a relatively new lake and Smith (1974) found that the younger the lake, the more oligotrophic, and as young lakes mature they tend towards eutrophy.

In the formation of oligotrophic lakes, certain species of phytoplankton are indicators of such an environment. Species of diatoms such as Tabellaria, Asterionella, and Fragillaria, and species of Dinobryon were present in the lake during the summer of 1978 and are representative of oligotrophic conditions. Listed are some common plankters found in Lake Raystown and characteristic of oligotrophic lake formation.

Desmid types, Dinobryon species
Peridinean types, Ceratium species
Diatom types, Tabellaria species

Hutchinson (1948)

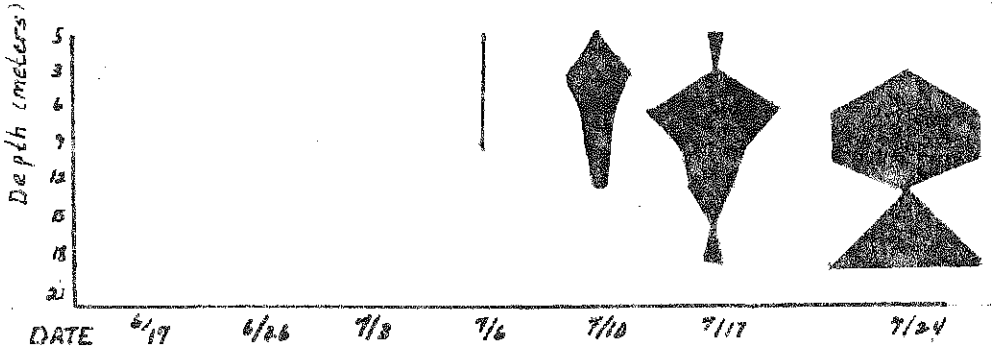
Station 1 Trough Creek



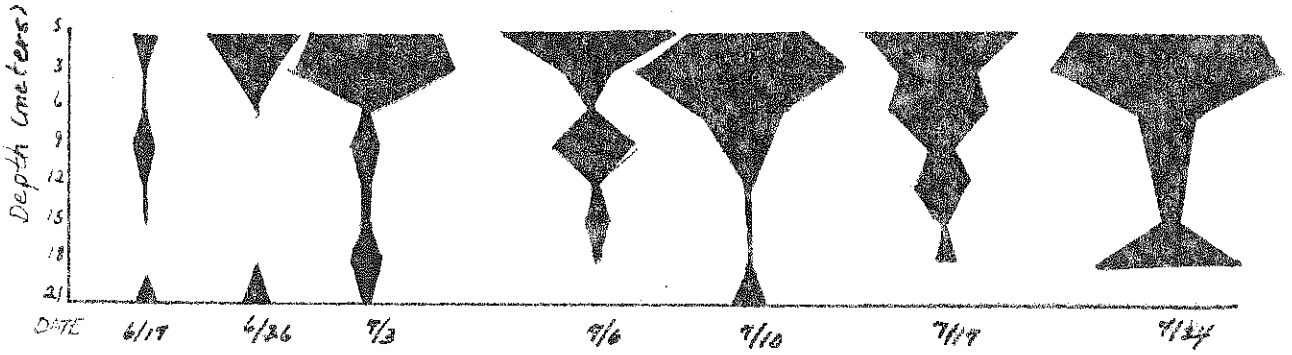
Scale ⌊——⌋ 100 organisms

Fragillaria c.

Scale ⌊——⌋ 100 organisms



Uroglena V.

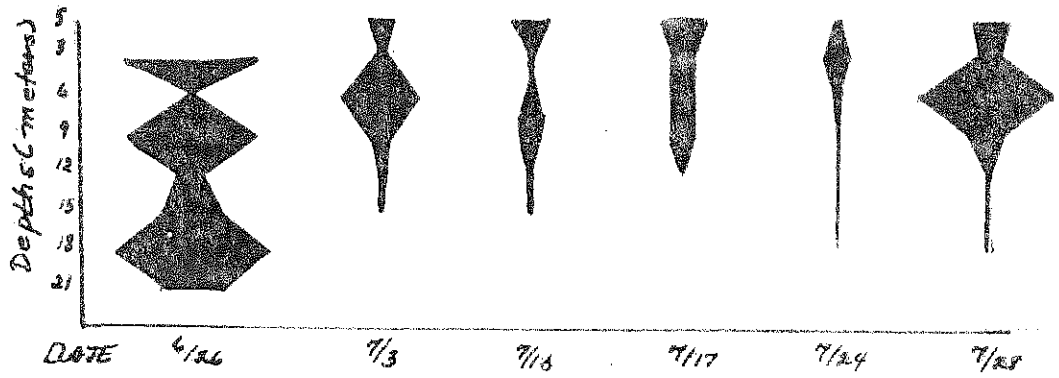


Ceratium h.

Scale ⌊——⌋ 100 organisms

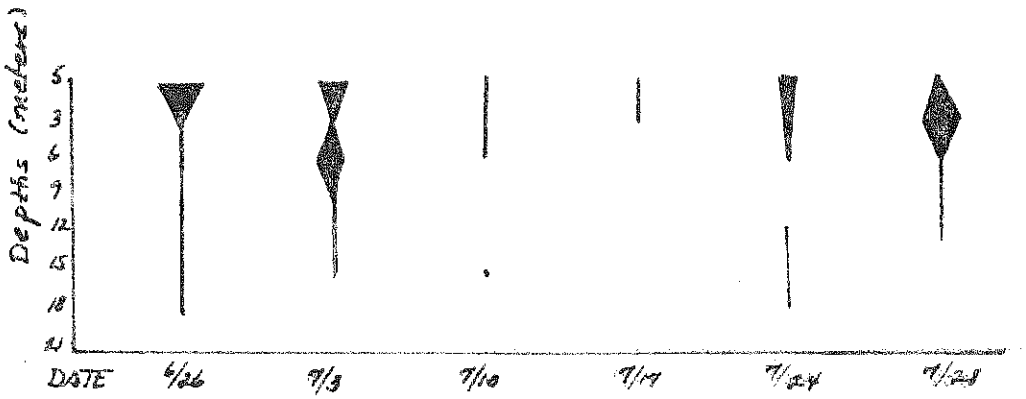
figure 2.

Station 2 James Creek



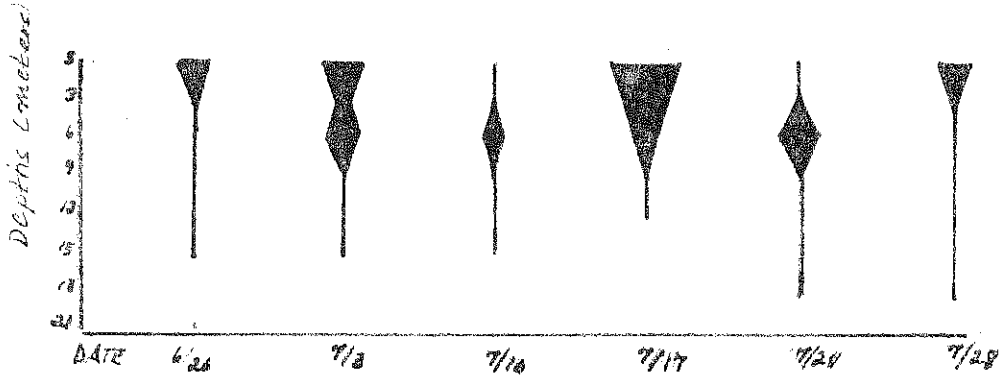
Scale 500 organisms

Asterionella f.



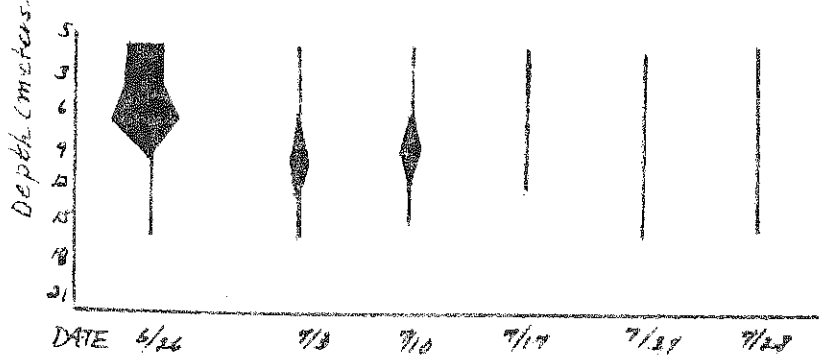
Scale 500 organisms

Dinobryon s.



Scale 500 organisms

Ceratium h.

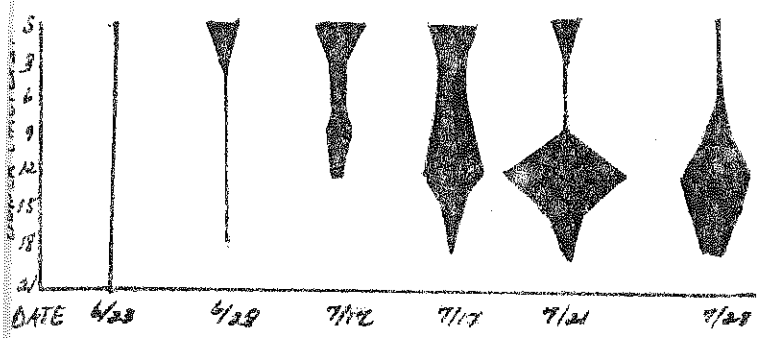


Scale 500 organisms

Staurastrum sp.

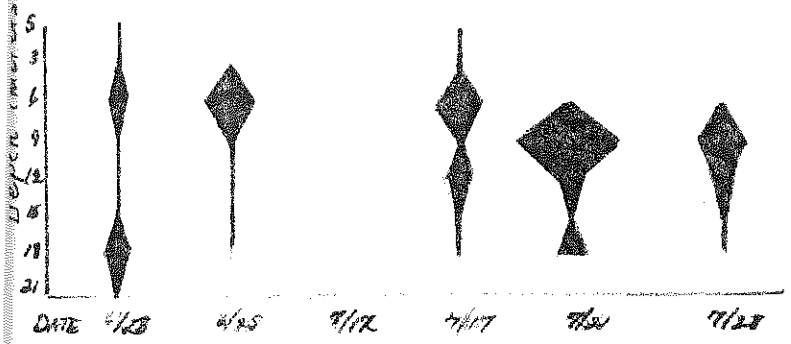
figure 3.

Station 3 7 pts.



Scale ___ 500 organisms

Fragillaria L

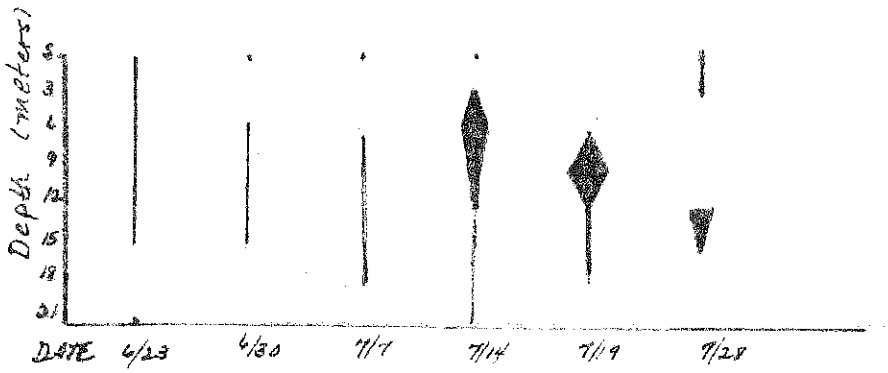


Scale ___ 500 organisms

Staurastrum L.

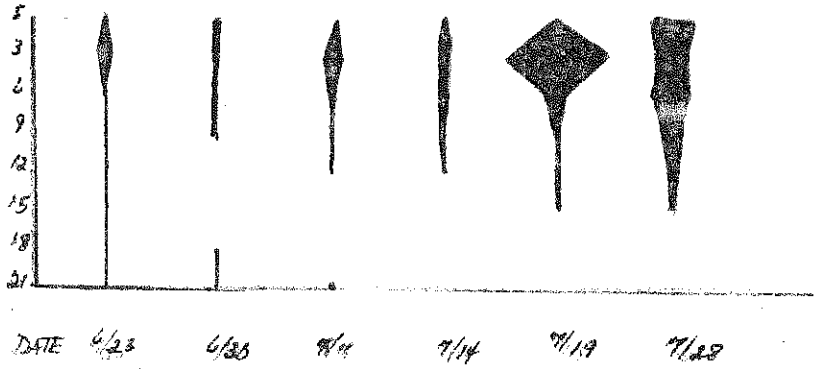
figure 4.

Station 4 Dam



Scale ⌊ 500 organisms

Asterionella f.



Scale ⌊ 500 organisms

Dinobryon S.

figure 5.

Pearsall, when summarizing his own work on three oligotrophic lakes found the dominant algae of net plankton were Desmid types with colonial green algae. These types were found in Lake Raystown with the Desmid Dinobryon s.and colonial Uroglena v. . In earlier work done by Pearsall on a lake considered to be oligotrophic plankton species were found to be intermediate between Desmids and Diatoms, with a spring pulse of Asterionella followed by Tabellaria and Dinobryon during the summer. This particular phenomenon occured at Lake Raystown (figures 2-5). In general, Desmid plankton occurance such as Staurastrum occur in unproductive waters (Hutchinson 1948). This may confirm the assumption that suggests Raystown as oligotrophic. In fresh-water lakes of Europe considered to be oligotrophic, Fragillaria c. was abundant. Also found were species of Dinobryon. Both of these species were present at all stations sampled. This may apply more so to Station 4 than to the others. In large lakes of North America RAwson (1956) concluded that Asterionella and Tabellaria often associated with Dinobryon are the most usual phytoplankton in oligotrophic lakes. Dinoflagellates such as Ceratium, also found in Lake Raystown, are characteristic of oligotrophic waters(Nauman 1977).

VERTICAL MIGRATION

One of the most conspicuous features of the Cladoceran zooplankton and to a lesser extent the Copepods, is the marked vertical migration of these small animals over large distances on a daily basis. The daily movement of zooplankton was first recorded in Lake Constance by Weisman in 1871. Other work was done by Pavisi in 1882. These contributions established the

phenomenon as very widespread.

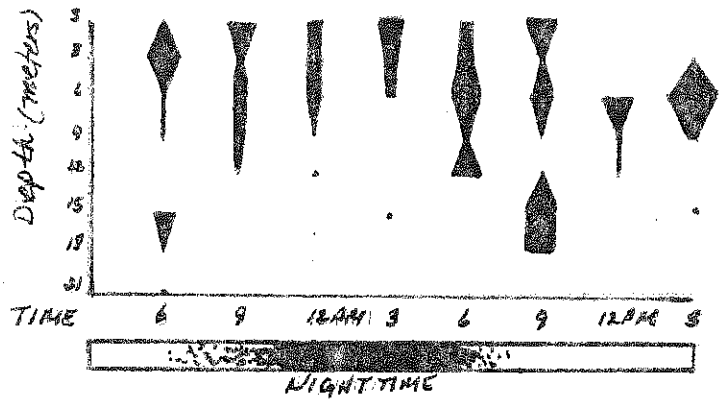
It is generally considered that the stimulus for migration is light (Kamykowski et al. 1976, Duval 1976, Enright 1977 Watson 1970). Most species migrate upward from deep waters toward the surface as darkness approaches (Welch 1975). Maximun numbers of zooplankton were found in the surface layers during nocturnal migrations sometime between sunset and sunrise. In other cases, in twilight migration two maxima occur in the surface layers, at dawn and at dusk. The results of a 24 hour study are represented in figures 7-9. Two species of Rotifers; Filina Filina l. and Keratella c., two Cladocerans; Bosmina c. and Daphnia p., and Copepods exhibited significant migration and are represented in figures 7-9.by estimates in population fluctuations.

Light appeared to be the determining stimulus controling the shifting of populations just before sunrise and sunset. Most of the migrant populations remained at a depth of three meters or deeper during daylight hours. Not all organisms traveled equal distances to raech surface strata. Some organisms were found in upper levels of the lake while others prefered wider depth distributions (figures 7-9).

Station 1 24 hr Study

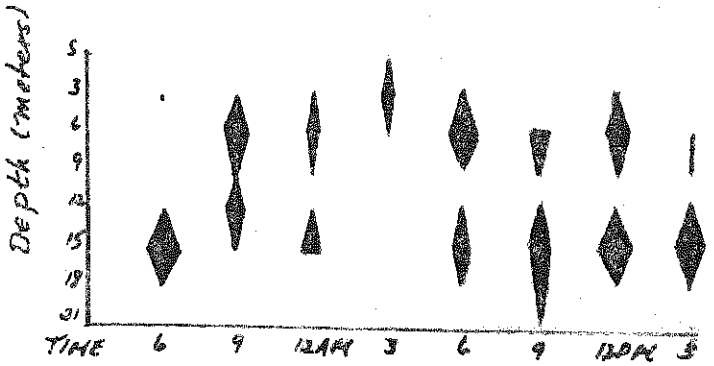
DATE 6/5 to 6/6

figure 6.



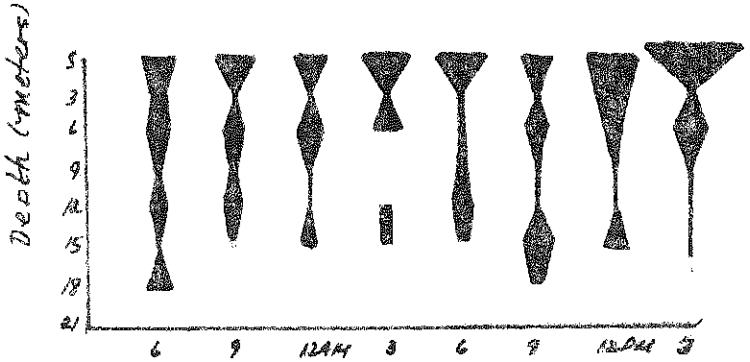
Scale ⌊ 10 organisms

Filina l.



Scale ⌊ 10 organisms

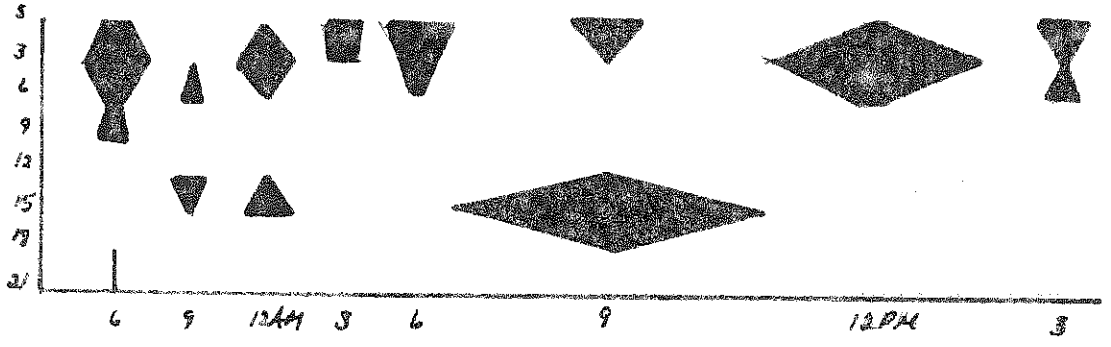
Bosmina c.



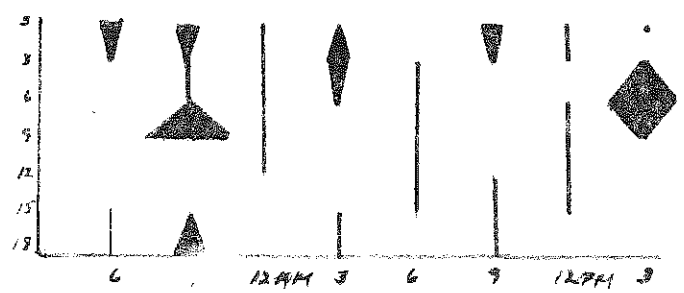
Scale ⌊ 50 organisms

Copepods

Daphnia p.



Scale ⌊ 10 organisms



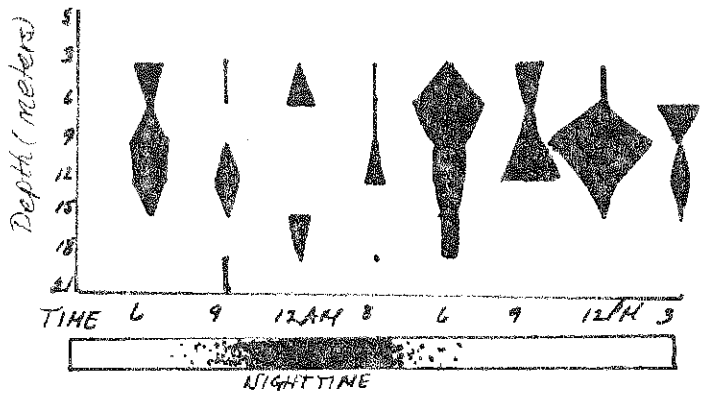
Scale ⌊ 50 organisms

Keratella c.

Station 2 24hr Study

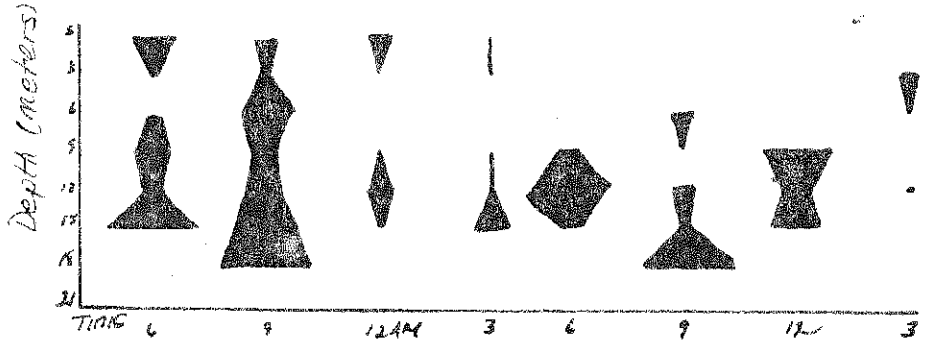
DATE 6/28 to 6/29

figure 7.



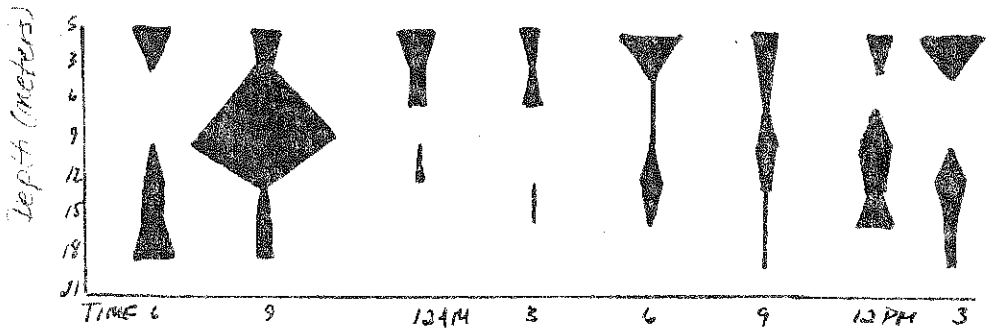
Scale — 10 Organisms

Filina ?.



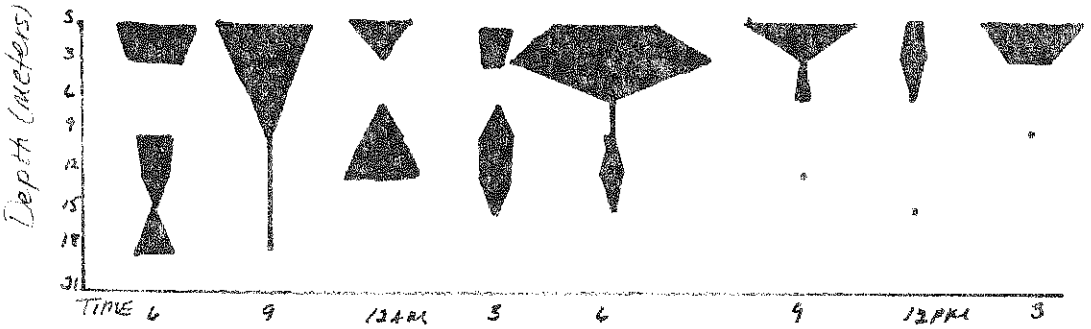
— 10 organisms

Bosmina c.



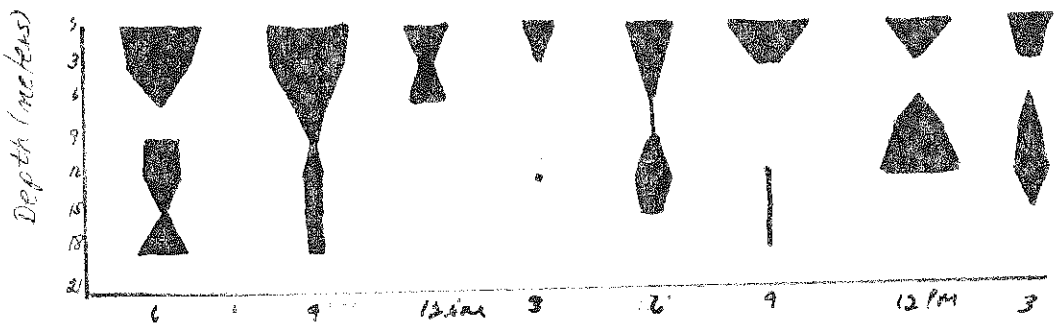
Scale — 50 organisms

Copepods



Scale — 10 organisms

Daphnia. p.



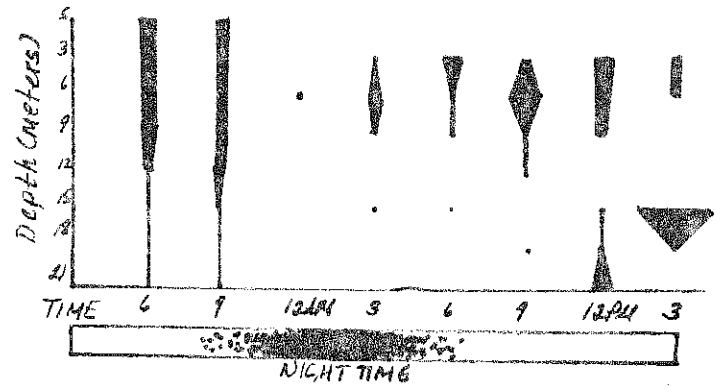
Scale 10 organisms

Keratella L.

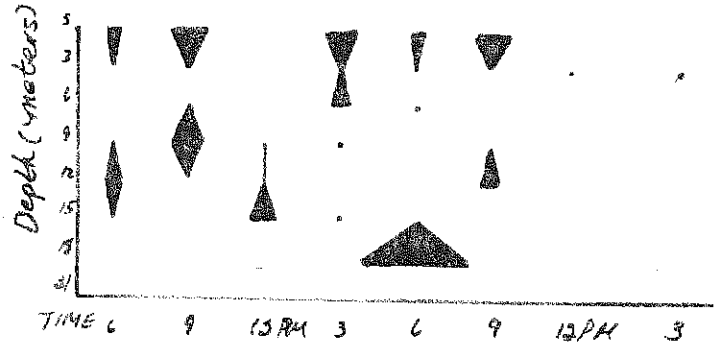
Station 3 — 27th: Steady

Date 7/12 to 7/13

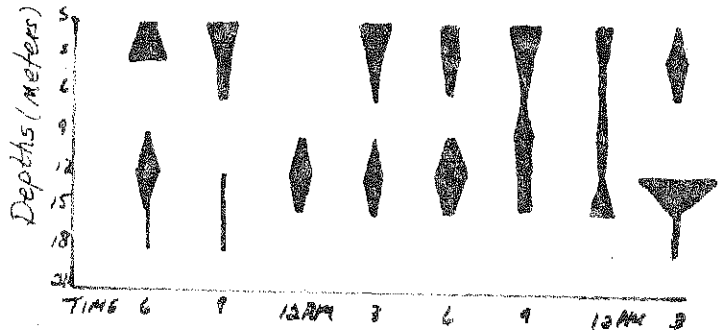
Figure 8.



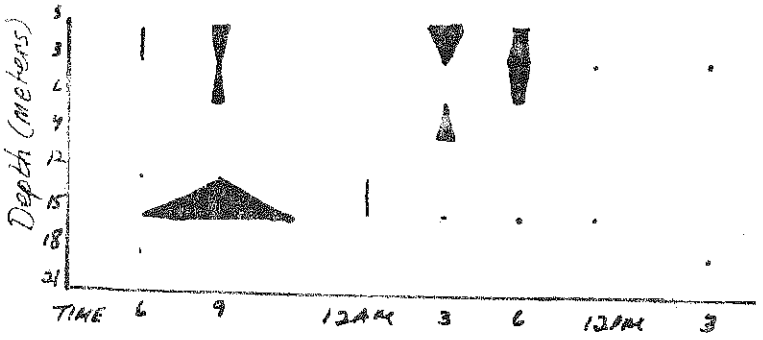
Filina l. Scale ⌊ 50 organisms



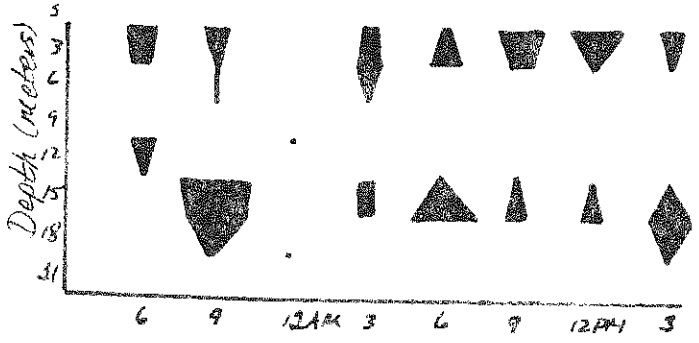
Bosmina C. Scale ⌊ 10 organisms



Copepods Scale ⌊ 50 organisms



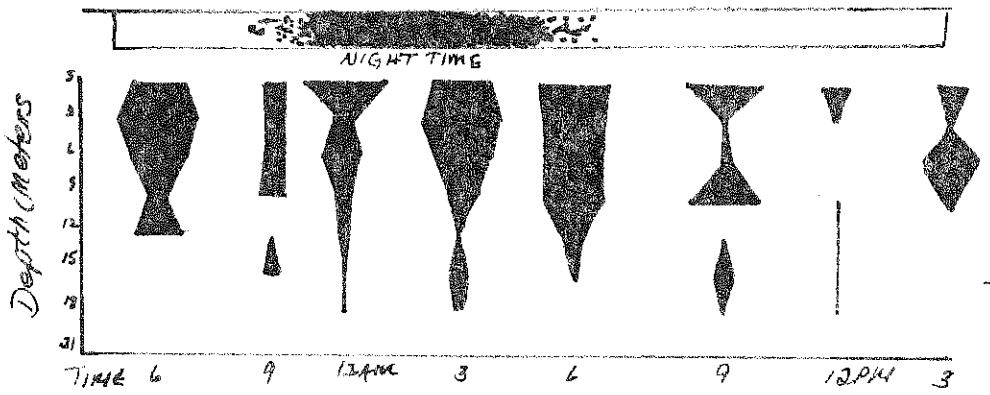
Daphnia D. Scale ⌊ 50 organisms



Keratella C. Scale ⌊ 10 organisms

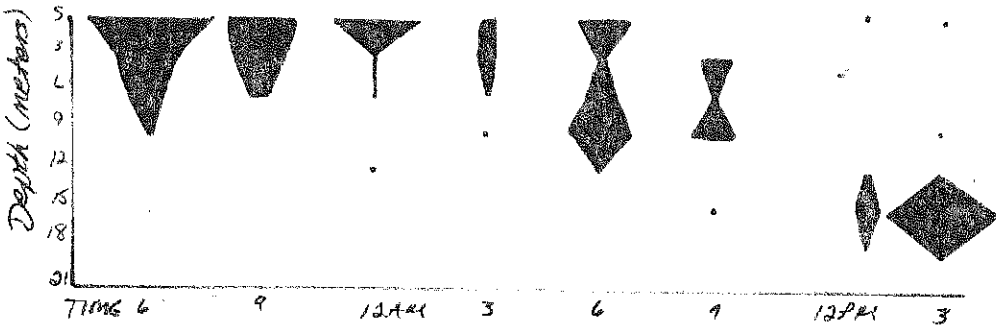
Station 4 24 hr. Study
Date 7/16 to 7/17

figure 9



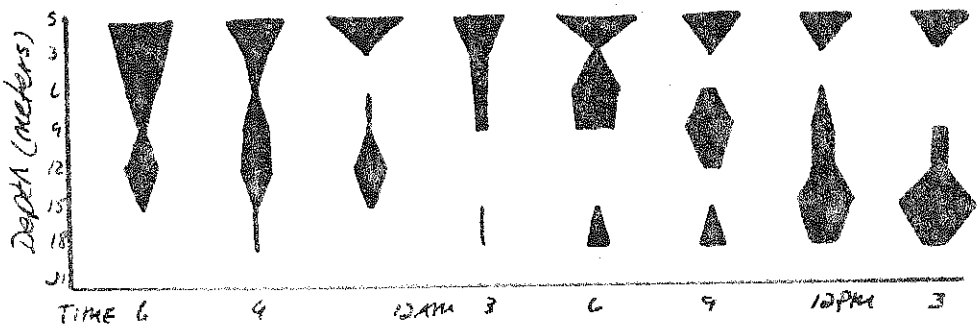
Scale ⊢⊣ 10 organisms

Filina l.



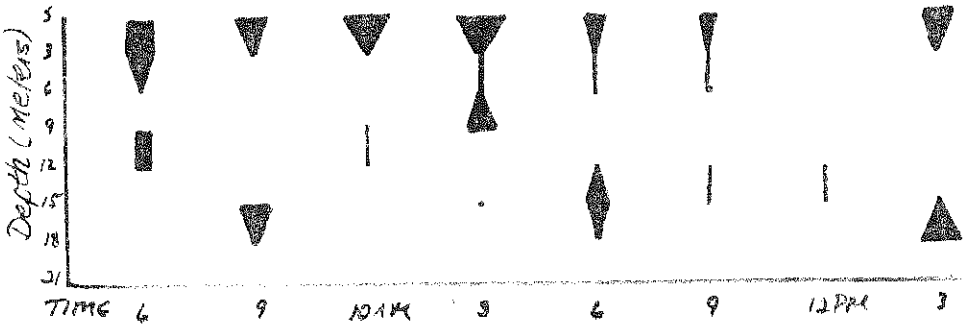
Scale ⊢⊣ 10 organisms

Daphnia p.



Scale ⊢⊣ 10 organisms

Copepods



Scale ⊢⊣ 10 organisms

Keratella c.

At station 1, Daphnia showed marked movement between the hours of 6 P.M. and 3 A.M. between depths of 3 and 6 meters. The Copepods numbers shifted but a part of the population remained at surface depths. For a majority of the populations organisms remained at intermediate depths of 6 meters or more. This pattern followed the same in general for Station 2. Station 3 and 4 however, deviated from Station 1 and 2's pattern in that their distribution was for the Copepods more evenly distributed. The migration of organisms did occur at the same times as the other stations.

Bosmina was found to show pronounced movement at Station 3 and 2 but not as much at Station 1. Its distribution remained evenly distributed between 6 and 18 meters at Station 1.

For the populations of Copepods at all stations numbers were found near the surface. Those Copepods that remained at at lower depths during daylight hours exhibited upward movement during the 6-9 P.M. and 6-9 A.M. rime period.

For Stations 1, 2 and 3 Filina showed distinct movement. At Station 4 the migration patterns were not as defined.

Keratella showed movement similar to Daphnia's at all four stations, from deeper depths during the day to shallower depths at night

LAKE DATA

Water temperatures recorded at all stations during a 24 hour period did not vary drastically from sunup to sunset. They rangeged from 23-25 degrees Centigrade at the surface to 4 degrees at the bottom. As evening approached the surface temperatures cooled down to 21 degrees Centigrade by 6 A.M. and

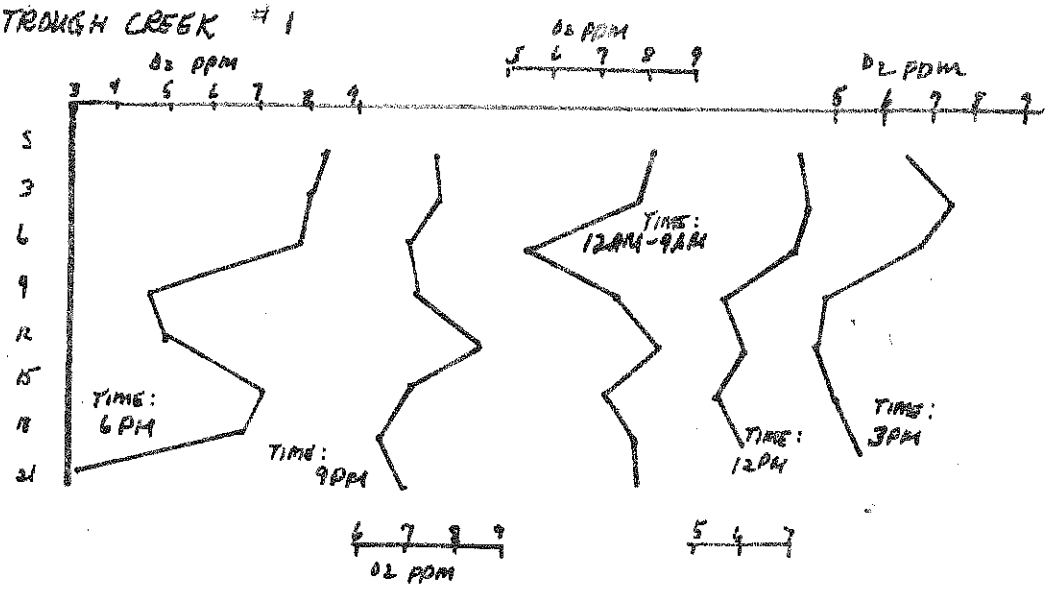
warmed up as the air temperature increased into the day. Below three meters the temperature remained fairly constant throughout the 24 hour study. A thermocline occured between 3 and 9 meters with 3 to 6 meters averaging a temperature of 21 degrees to a drop off of 10-11 degrees at 9 meters (see appendix). Temperatures for Stations 3 and 4 were slightly warmer than those of Stations 1 and 2. This may be attributed to the fact 3 and 4 were located at quiet areas not directly agitated by the inflow of streams like 1 and 2 were.

Dissolved oxygen profiles for Stations 1, 3 and for over a 24 hour period are represented in figure 10, several changes that occured are graphed. Other oxygen and temperature profiles for the regular sampling days are in the appendix.

DISSOLVED OXYGEN IN ppm

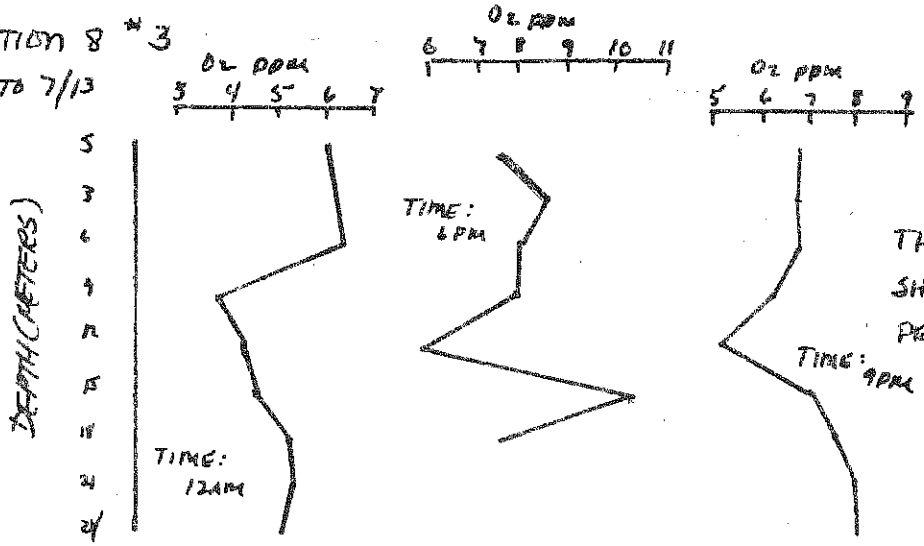
STATION TROUGH CREEK #1

TO 6/6



STATION 8 #3

6/12 TO 7/13

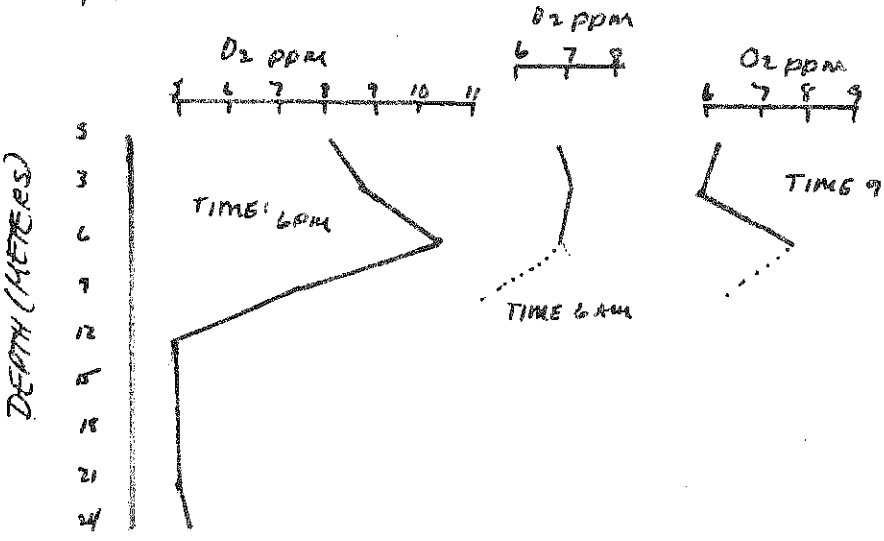


Scale not

THE 6PM CURVE SHOWED THIS SHAPE, BUT THE OTHERS FOLLOWED PRETTY MUCH THE 12 AM AND 9PM CURVES.

STATION DAM #4

7/18 TO 7/19



O2 CURVES FOR 12PM TO 3AM FOLLOWED THE CURVE FOR 6PM EXCEPT FOR 6AM AND 9AM. O2 WERE VALUES LOW AND DOTTED LINES REPRESENT ONLY ESTIMATES.

SUMMARY

1. The same species of phytoplankton and zooplankton were observed at each station in varying densities. At Station 1 the most commonly found species were Asterionella f., Fragillaria c., Dinobryon s., and Copepods. At Station 2; Asterionella f. Dinobryon s., Staurastrum p., Ceratium h., and Copepods. Station 3's representative organisms were, Asterionella f., Fragillaria c., and Ceratium h. . At Station 4; Dinobryon s., Filina l., Ceratium h., Staurastrum p. were representative of the plankton found at the Dam.

2. Light modified by other physical and biological factors appeared to be important in initiating the vertical migration of zooplankton at dawn and dusk.

3. Phytoplankton association may be designated by the name of the dominant or the dominant and one or more suddominant species. This designation may give a good general idea of the phytoplankton and of its principle coaction with zooplankton.

4. Most of the crustacea, some Rotifers and a few of the members of the fresh-water plankton exhibit vertical movement during the course of a 24 hour period. This movement is generally more accentuated in transparent waters and is controlled by light cues. The migratory patterns found in this study were nocturnal and that stimulated by sunrise.

5. Plankton associations (after Hutchinson 1948) Oligotrophic Diatoms- Tabellaria species in association with presence in nutrient poor lakes having a neutral of slightly alkaline pH. The pH for the surface was 7.5 to 7.8 at a depth of 9 meters suggesting almost neutral waters. Chrysophycean plankton such

as Dinobryon is characteristic of nutrient poor waters especially during the warmest temperatures of the year.

Appendix

Table 1.

Station Trough Creek Date 6/17/78

Average number of organisms per liter of original water

Organism	Depth (meters) s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	839		757	178	58	48	114	
Anabaena f.	282		21	3	5	2	30	
Fragillaria c.	10		-	1	1	-	3	
Dinobryon s.	5		-	-	-	-	-	
Tabellaria f.	-		-	-	-	-	-	
Staurastrum p.	40		18	8	6	6	17	
Cerasterias i.	2		1	1	3	2	2	
Oedogonium s.	43		24	7	8	2	33	
Uroglena v.	-		-	-	-	-	-	
Pediastrum b.	10		1	-	3	1	8	
Diatoma v.	2		-	-	-	2	-	
Ceratium h.	14		5	1	4	-	9	
Anacystis c.	-		-	-	-	-	-	
Acanthocystis	-		-	-	-	-	1	
Filina l.	36		21	7	5	1	4	
Copepods	37		5	7	5	1	4	
Daphnia p.	13		1	-	2	-	2	
Bosmina c.	1		2	1	34	11	20	
Keratella c.	10		4	1	-	1	9	
Kellicottia l.	-		-	-	-	1	-	
Leptodora k.	1		-	-	-	-	-	

The 3-6 meters sample was lost.

Table 2. Date 6/26/78

Organism	Depth (meters) s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	5	3	130				137	
Anabaena f.	18	5	7				-	
Fragillaria c.	63	40	30				8	
Dinobryon s.	168	110	8				10	
Tabellaria f.	-	-	-				-	
Staurastrum p.	62	119	91				7	
Cerasterias i.	1	-	-				2	
Oedogonium s.	33	46	101				25	
Uroglena v.	-	-	-				-	
Pediastrum b.	13	6	6				1	
Diatoma v.	6	7	7				4	
Ceratium h.	75	30	6				3	
Anacystis c.	91	57	31				1	
Acanthocystis	9	7	11				-	
Filina l.	13	4	7				-	
Copepods	46	6	11				5	
Daphnia p.	13	2	1				1	
Bosmina c.	1	3	1				3	
Keratella c.	26	12	7				-	
Kellicottia l.	-	-	-				-	

Samples 9-18 meters were also lost.

Table 3.

Station Trough Creek
Average number of organisms per liter of original water.

Date 7/3/78

Organism	Depth (meters) s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	82	161	114	929	203	171	133	102
Anabaena f.	-	2	-	-	-	-	-	-
Fragillaria c.	17	24	2	70	66	10	1	16
Dinobryon s.	8	14	-	-	-	-	-	1
Tabellaria f.	-	-	-	-	-	-	-	-
Staurastrum p.	5	11	5	313	45	30	30	21
Cerasterias i.	-	1	-	6	1	-	-	2
Oedogonium s.	5	10	1	91	13	6	1	5
Uroglena v.	-	-	-	-	-	-	-	-
Pediastrum b.	6	2	-	4	2	1	1	1
Diatoma v.	-	1	-	-	-	-	-	-
Ceratium h.	163	228	2	13	8	8	9	6
Anacystis c.	-	-	-	-	-	-	-	-
Acanthocystis								
Filina l.	5	2	-	2	-	-	-	-
Copepods	28	18	-	10	2	4	2	-
Daphnia p.	7	8	-	3	-	-	-	-
Bosmina c.	-	-	-	3	-	4	-	1
Keratella c.	8	4	-	5	2	2	2	-
Kellicottia l.	2	-	-	-	-	-	-	-

Table 4.

Date 7/6/78

Organism	Depth (meters) s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	48	354		289	100	162	89	
Anabaena f.	27	-		-	-	1	-	
Fragillaria c.	41	33		20	-	19	10	
Dinobryon s.	6	6		6	-	1	1	
Tabellaria f.	-	-		-	-	-	-	
Staurastrum p.	2	10		93	12	14	14	
Cerasterias i.	1	-		1	-	-	-	
Oedogonium s.	85	75		293	19	27	24	
Uroglena v.	2	3		1	-	-	-	
Pediastrum b.	4	2		9	3	7	2	
Diatoma v.	-	-		-	-	-	-	
Ceratium h.	114	34		65	8	14	3	
Anacystis c.	-	12		2	-	1	2	
Acanthocystis	-	-		-	-	-	-	
Conochilus sp.	17	11		-	-	3	-	
Filina l.	4	1		2	2	1	-	
Copepods	34	2		24	5	11	3	
Daphnia p.	-	-		2	-	4	-	
Bosmina c.	-	-		2	-	2	1	
Keratella c.	10	3		3	1	-	3	
Kellicottia l.	-	-		1	-	-	-	
Spirulina m.	1	-		1	-	-	-	

The 6-9 meters sample was spilled.

Table 5.

Station Trough Creek — Date 7/10/78

Average number of organisms per liter of original water

Organism	Depth (meters) s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	441	624	179	135	105	62	59	62
Anabaena f.	2	-	-	1	-	-	-	-
Fragillaria c.	16	25	13	24	32	4	11	13
Dinobryon s.	3	4	-	-	-	4	1	-
Tabellaria f.	-	-	-	-	-	-	-	-
Staurastrum p.	11	8	17	69	16	11	-	8
Cerasterias i.	-	-	-	-	-	-	-	1
Oedogonium s.	-	-	175	54	-	2	18	25
Uroglena v.	2	38	25	14	7	-	-	7
Pediastrum b.	8	-	4	1	6	1	3	3
Diatoma v.	-	-	-	-	-	-	-	-
Ceratium h.	96	223	55	23	6	5	5	7
Anacystis c.	-	-	-	-	-	-	-	-
Filina l.	5	-	-	1	-	-	1	-
Copepods	23	-	13	4	3	5	1	4
Daphnia p.	-	-	-	-	-	-	-	-
Bosmina c.	2	-	-	1	-	-	-	1
Keratella c.	16	4	4	3	2	2	2	1
Kellicottia l.	-	-	-	-	-	-	-	-
Spirulina m.	3	-	-	-	-	-	-	-

Table 6.

Date 7/17/78

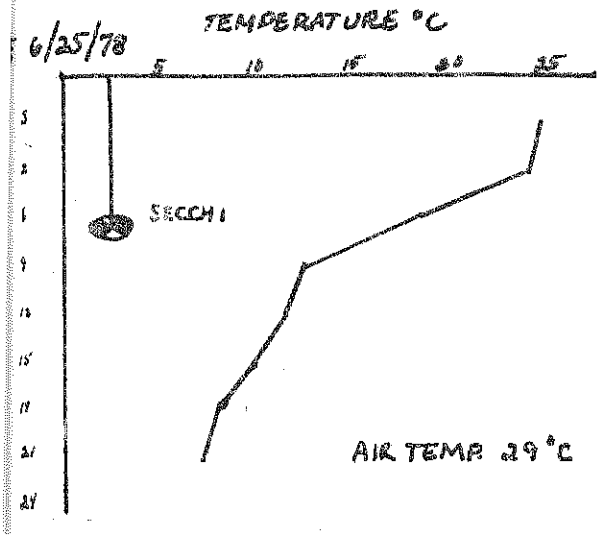
Organism	Depth (meters) s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	363	141	42	73	32	14	17	
Anabaena f.	3	-	-	-	-	-	-	
Fragillaria c.	53	-	143	63	25	9	10	
Dinobryon s.	7	-	-	-	-	-	-	
Tabellaria f.	-	-	-	-	-	-	-	
Staurastrum p.	3	-	25	30	42	8	6	
Cerasterias i.	-	-	-	-	-	-	-	
Oedogonium s.	3	4	365	237	35	10	12	
Uroglena v.	7	-	90	47	34	4	11	
Pediastrum b.	10	-	1	2	1	2	-	
Diatoma v.	-	-	-	-	-	-	-	
Ceratium h.	113	55	58	19	25	3	10	
Anacystis c.	-	-	1	4	-	-	-	
Acanthocystis	28	681	6	-	-	-	-	
Filina l.	12	-	1	1	-	-	-	
Copepods	28	-	58	4	3	2	4	
Daphnia p.	4	-	1	-	-	1	1	
Bosmina c.	-	-	-	-	-	-	3	
Keratella c.	10	-	-	1	2	0	3	
Kellicottia l.	-	-	-	-	-	-	-	
Spirulina m.	38	4	1	4	-	-	-	

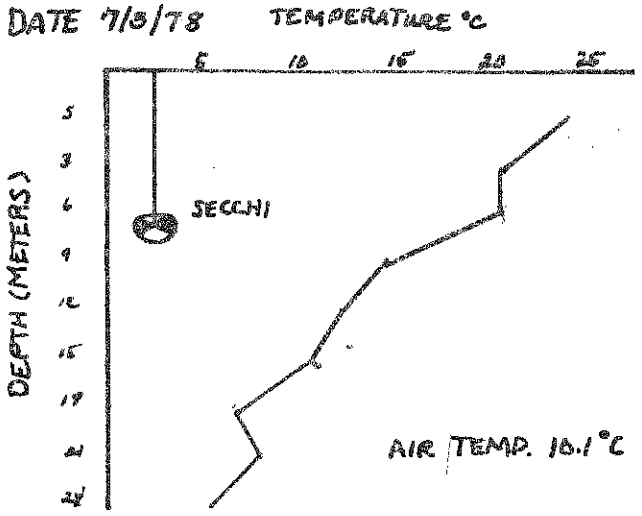
Table 7.

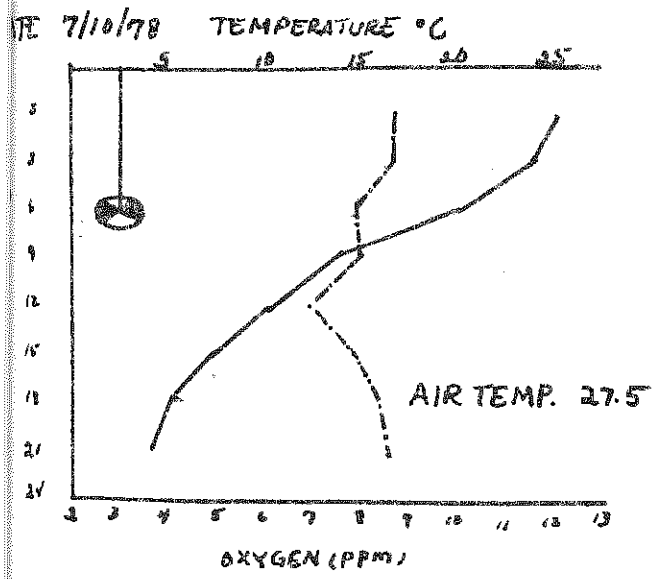
Station Trough Creek Date 7/24/78

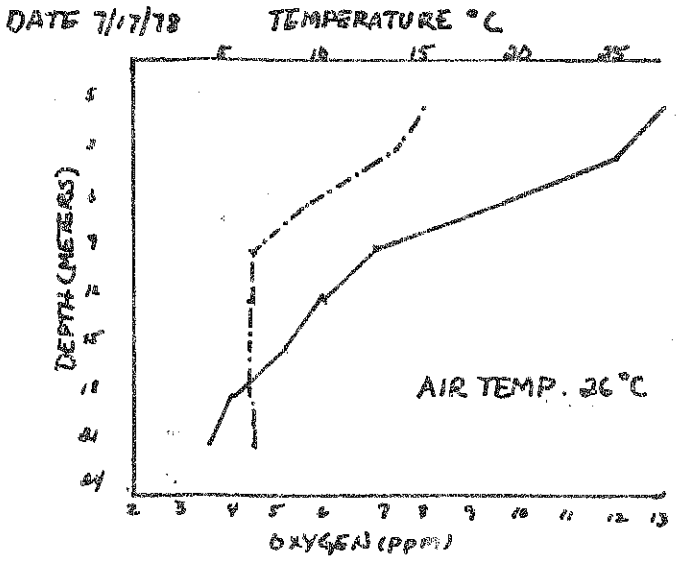
Average number of organisms per liter of original water

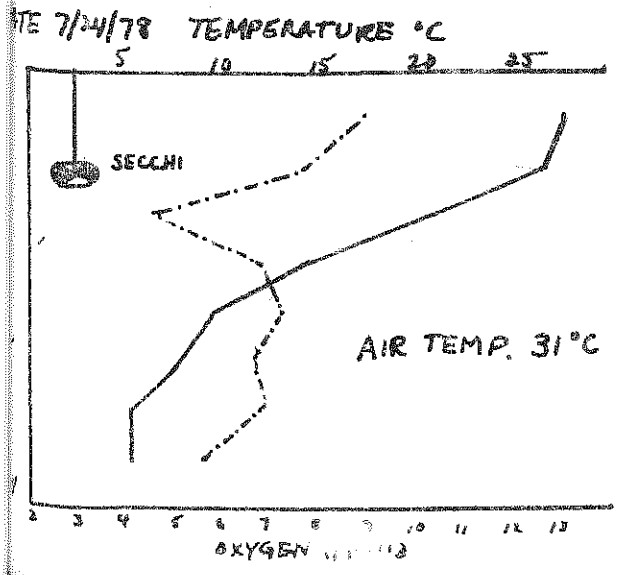
Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	77	372	680	119	195	87	456	
Anabaena f.	30	-	-	-	-	-	-	
Fragilllaria c.	68	72	34	4	82	52	70	
Dinobryon s.	51	55	2	-	4	1	15	
Tabellaria f.	-	-	-	-	-	-	-	
Staurastrum p.	-	-	8	12	62	10	26	
Cerasterias i.	-	-	-	-	-	-	1	
Oedogonium s.	-	-	325	124	118	30	60	
Uroglena u.	-	8	1813	504	2	45	413	
Pediastrum b.	2	-	2	3	-	4	8	
Diatoma v.	-	-	-	-	-	-	-	
Ceratium h.	124	385	42	17	32	17	118	
Anacystis c.	38	145	3	12	1	1	4	
Acanthocystis	-	-	-	-	-	-	-	
Filina l.	-	2	-	4	-	1	4	
Copepods	12	8	2	2	5	3	4	
Daphnia p.	12	8	2	2	5	3	4	
Bosmina c.	-	-	-	-	-	-	-	
Keratella c.	2	-	-	-	-	-	-	
Kellicottia l.	-	-	-	-	-	-	-	
Spirulina m.	38	4	2	-	1	1	4	











TEMPERATURES

DISSOLVED OXYGEN

FIGURE 1.

Table 8.

Station James Creek — Date 6/26/78

Number of organisms per liter of original water (average)

Organism	Depth 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.		873	41	833	178	370	1012	437
Anabaena f.		20	-	31	-	-	.97	-
Fragillaria c.		162	6.7	98	15	9	9	8
Dinobryon s.		365	.97	37	23	12	11	3
Tabellaria f.		4	-	-	-	-	-	-
Staurastrum p.		226	225	448	37	37	39	5
Cerasterias i.		.9	.9	.9	.9	-	2	2
Oedogonium s.		21	4	448	32	7	87	15
Uroglena v.		-	-	-	-	-	-	-
Pediastrum b.		11	.9	31	4	4	4	3
Diatoma v.		5	6	8	3	-	-	-
Ceratium h.		221	-	28	5	3	-	2
Anacystis c.		-	-	-	37	7	9	.9
Acanthocystis		-	-	16	12	3	6	-
Filina l.		4	.9	15	3	-	2	-
Copepods		25	2	30	5	3	11	5
Daphnia p.		11	-	5	-	-	-	-
Bosmina s.		-	.9	11	-	.9	5	-
Keratella s.		6	2	25	2	.9	6	-
Kellicottia l.		-	-	-	-	-	-	-

(Surface sample was lost)

Table 9.

Date 7/3/78

Organism	Depth 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	191	88	478	138	38	15		
Anabaena f.	-	-	-	-	-	-		
Fragillaria c.	121	31	170	107	22	4		
Dinobryon s.	186	23	76	17	5	4		
Tabellaria f.	-	-	167	-	-	-		
Staurastrum p.	26	6	42	81	12	3		
Cerasterias i.	-	-	-	-	-	3		
Oedogonium s.	14	3	64	38	16	3		
Uroglena v.	-	-	-	-	-	-		
Pediastrum b.	8	-	-	3	5	.9		
Diatoma v.	6	-	-	.9	-	-		
Ceratium h.	338	116	167	30	8	4		
Anacystis c.	-	-	-	-	-	-		
Acanthocystis	-	-	-	-	-	-		
Filina l.	6	-	9	.9	2	-		
Copepods	3	11	42	17	5	2		
Daphnia p.	8	.9	12	3.9	.9	-		
Bosmina s.	-	-	-	6	.9	.9		
Keratella s.	10	8	-	6	.9	-		
Kellicottia l.	-	-	2	-	2	-		
Leptodora k.	-	1	-	-	-	-		

Table 10.

Station James Creek Date 7/10/78

Number of organisms per liter of original water (average)

Organism	s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	163	30	22	108	6	18		
Anabaena f.	2	-	.9	-	-	-		
Fragillaria c.	24	32	20	30	151	40		
Dinobryon s.	5	6	18	-	-	9		
Tabellaria f.	-	-	-	-	-	-		
Staurastrum p.	2	5	32	70	17	19		
Cerasterias i.	-	-	-	-	-	-		
Oedogonium s.	-	-	24	60	14	-		
Uroglena v.	5	211	21	37	5	13		
Pediastrum b.	2	4	2	2	3	.9		
Diatoma v.	-	-	-	2	-	-		
Ceratium h.	26	73	126	40	12	11		
Anacystis c.	-	1	-	-	-	-		
Acanthocystis	-	-	-	-	-	-		
Filina l.	5	1	5	2	-	-		
Copepods	31	7	6	3	12	3		
Daphnia p.	4	4	3	-	-	-		
Bosmina c.	-	1	2	-	3	1		
Keratella c.	20	4	2	3	-	1		
Kellicattia l.	-	-	1	-	-	-		

Table 11. Date 7/17/78

Organism	Depth s-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	338	192	186	185	26			
Anabaena f.	-	-	-	-	-			
Fragillaria c.	78	25	-	-	-			
Dinobryon s.	4	9	-	-	-			
Tabellaria f.	-	-	-	-	54			
Staurastrum p.	5	4	13	54	-			
Cerasterias i.	-	-	-	-	16			
Oedogonium s.	-	4	-	2	118			
Uroglena v.	1	864	1373	69	3			
Pediastrum b.	4	3	4	4	4			
Diatoma v.	-	-	-	-	-			
Ceratium h.	426	371	149	65	33			
Anacystis c.	3	-	-	129	-			
Acanthocystis	15	-	-	-	3			
Filina l.	6	4	8	4	8			
Copepods	35	4	4	9	7			
Daphnia p.	20	17	17	4	4			
Bosmina c.	3	4	4	4	4			
Keratella c.	6	4	4	-	-			
Kellicottia l.	-	-	-	-	-			
Spirulina m.	14	-	-	-	-			

Table 12.

Station James Creek — Date 7/24/78

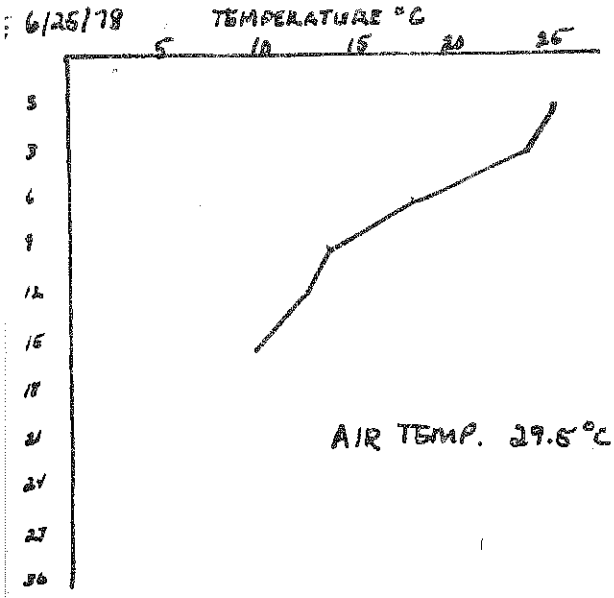
Number of organisms per liter of original water (average)

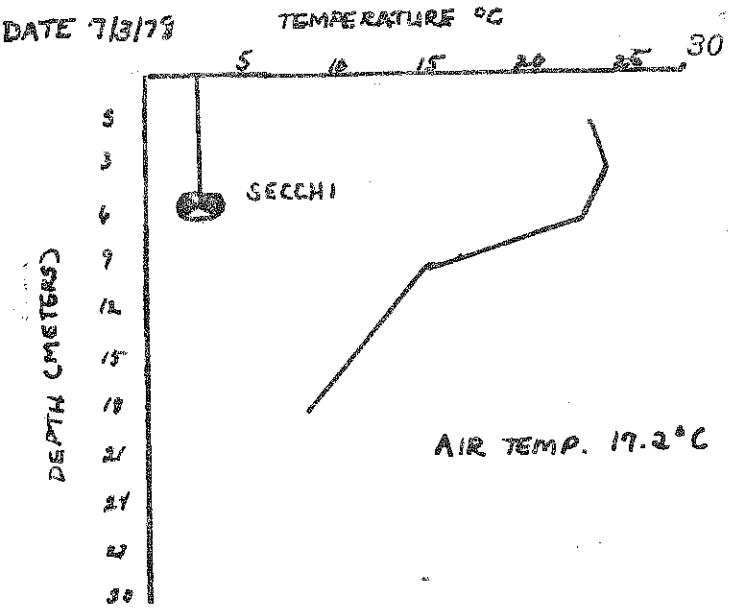
Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	68	192	73	72	66	40	40	
Anabaena f.	4	4	4	-	-	-	-	
Fragillaria c.	21	8	64	55	55	45	15	
Dinobryon s.	38	34	-	-	4	3	3	
Tabellaria f.	-	-	-	-	-	-	-	
Staurastrum p.	4	11	17	8	25	23	8	
Cerasterias i.	-	-	-	-	-	-	-	
Oedogonium s.	4	-	17	38	2	18	6	
Uroglena v.	-	320	1450	3627	408	398	230	
Pediastrum b.	8.5	4	4	-	3	1	1	
Diatoma v.	4	-	-	-	-	-	-	
Ceratium h.	64	11	286	34	39	43	21	
Anacystis c.	30	111	17	17	8	1	3	
Filina l.	4	4	4	-	-	-	3	
Copepods	38	8	8	4	1	4	5	
Daphnia p.	4	8	4	1	4	4	5	
Bosmina c.	-	-	-	-	-	-	-	
Keratella c.	3	4	-	-	6	1	-	
Kellicottia l.	-	-	-	-	-	-	-	

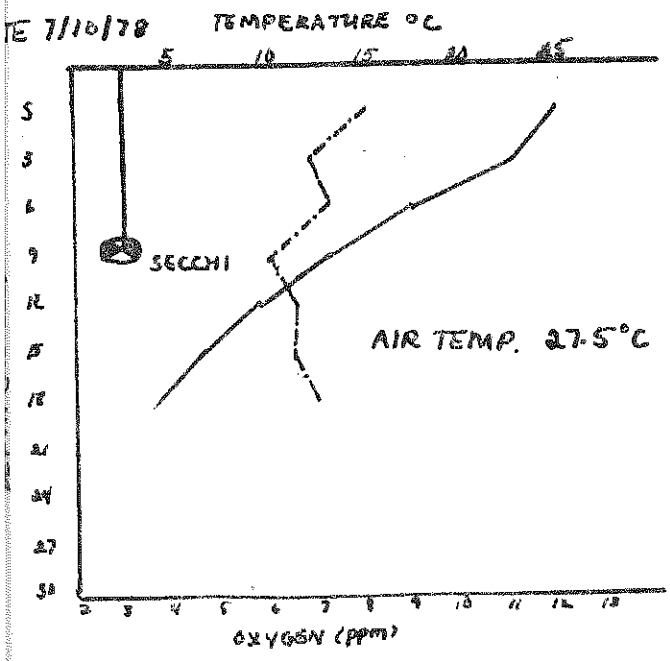
Date 6/28/78

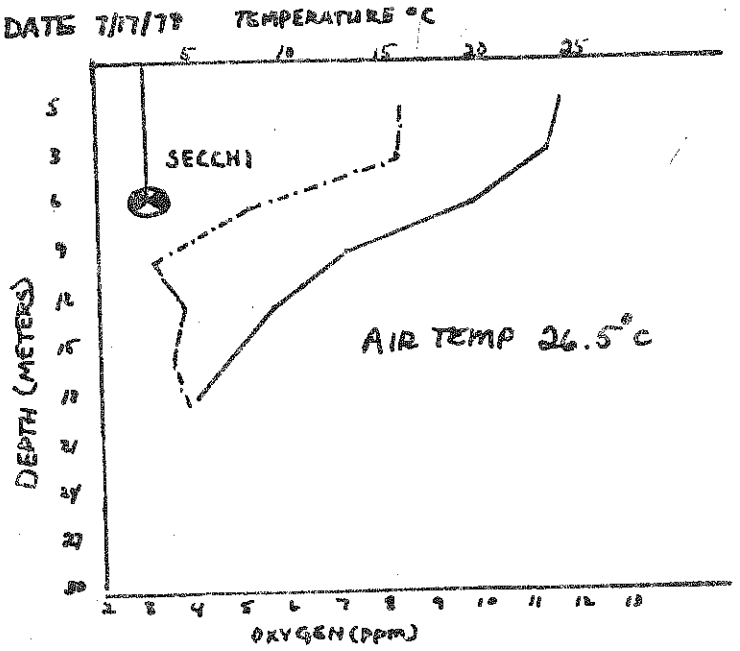
Table 13.

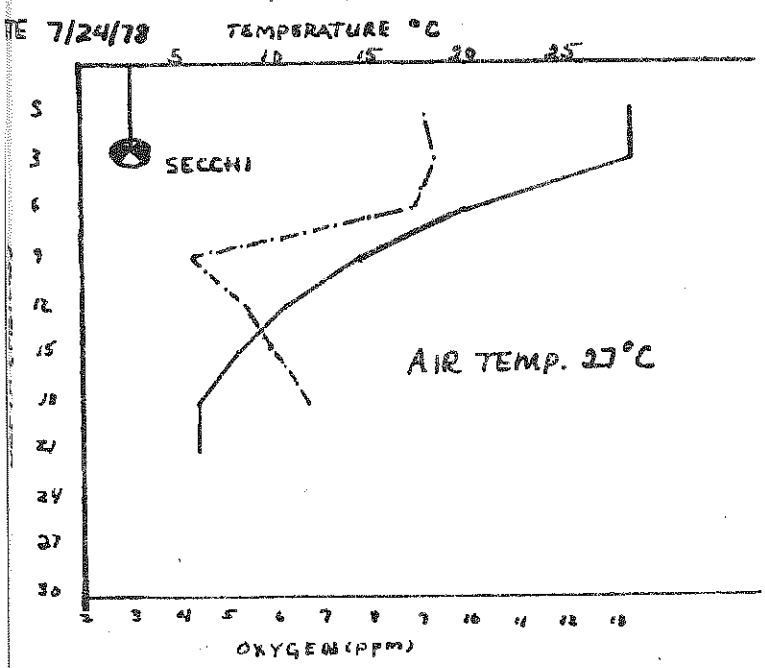
Organism	Depth 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	325	106	938	193	47	32	22	
Anabaena f.	6	1	2	-	1	-	5	
Fragillaria c.	32	18	31	18	-	3	16	
Dinobryon s.	16	169	18	3	2	-	-	
Tabellaria f.	-	-	17	-	-	-	-	
Staurastrum p.	45	8	8	20	15	6	-	
Cerasterias i.	-	-	16	-	-	1	2	
Oedogonium s.	19	20	59	43	10	3	11	
Uroglena v.	-	-	-	-	-	-	-	
Pediastrum b.	9	6	2	2	4	1	1	
Diatoma v.	7	1	2	16	-	1	1	
Ceratium h.	102	41	17	2	1	5	2	
Anacystis c.	-	-	-	-	-	-	-	
Acanthocystis	-	-	-	-	-	-	-	
Filina l.	7	1	3	8	-	-	-	
Copepods	25	29	4	13	6	6	2	
Daphnia p.	16	3	3	1	-	-	-	
Bosmina c.	-	-	2	1	3	2	10	
Keratella c.	10	3	-	-	1	1	1	
Kellicottia l.	1	3	-	-	-	1	1	











STATION: JAMES CREEK

—— TEMPERATURES

-.-.- DISSOLVED OXYGEN

FIGURE 2.

Table 14.

Date 6/23/78

Station 8
Average number of organisms per liter of original water

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	93	94	122	32	9	4	73	19
Anabaena f.	128	10	73	1	12	17	25	9
Fragillaria c.	9	18	7	9	3	4	12	1
Dinobryon s.	10	2	3	1	-	-	1	1
Tabellaria f.	-	-	-	-	-	-	-	-
Staurastrum p.	20	16	78	26	2	13	84	27
Cerasterias i.	17	-	3	2	-	1	4	11
Oedogonium s.	7	6	6	-	-	-	6	1
Uroglena v.	-	-	-	-	-	-	-	-
Pediastrum b.	-	2	7	-	4	1	1	1
Diatoma v.	-	-	-	-	-	-	-	-
Ceratium h.	28	1	22	1	1	3	6	3
Anacystis c.	-	-	-	-	-	-	-	-
Acanthocystis	-	-	-	-	-	-	-	-
Filina l.	24	1	22	1	1	3	6	3
Copepods	39	24	35	4	24	37	26	10
Daphnia p.	32	14	4	-	-	-	10	1
Bosmina c.	-	-	5	1	3	6	6	2
Keratella c.	10	1	3	-	-	7	6	2
Kellicottia l.	-	-	1	-	-	2	-	-
Leptodora k.	1	-	-	-	-	-	-	-

Table 15.

Date 6/30/78

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	187	119	182	32	16	10	2	
Anabaena f.	3	1	3	9	7	1	3	
Fragillaria c.	105	64	15	9	7	1	3	
Dinobryon s.	64	21	4	9	1	5	-	
Tabellaria f.	-	2	-	-	-	-	-	
Staurastrum p.	12	-	343	41	40	17	17	
Cerasterias i.	4	1	-	-	-	-	4	
Oedogonium s.	8	3	-	-	-	1	1	
Uroglena v.	-	-	-	-	-	-	-	
Pediastrum b.	2	-	-	-	3	1	-	
Diatoma v.	-	-	-	-	-	-	-	
Ceratium h.	68	100	48	26	14	8	6	
Anacystis c.	-	-	-	-	-	-	-	
Acanthocystis	-	-	-	-	-	-	-	
Filina l.	-	2	12	-	1	-	-	
Copepods	20	4	20	20	1	7	3	
Daphnia p.	16	7	1	-	1	6	-	
Bosmina c.	-	1	3	-	1	1	-	
Keratella c.	9	-	1	-	1	6	4	
Kellicottia l.	-	3	1	-	1	-	-	

Table 16.

Station 8 Date 7/7/78

Average number of organisms per liter of original water

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	196	100	39	35	45			
Anabaena f.	-	-	-	-	-			
Fragillaria c.	307	121	42	81	75			
Dinobryon s.	13	18	10	13	10			
Tabellaria f.	-	-	-	-	-			
Staurastrum p.	2	12	164	185	166			
Cerasterias i.	-	-	-	-	-			
Oedogonium s.	4	4	3	-	3			
Uroglena v.	-	-	-	-	-			
Pediastrum b.	1	-	1	14	2			
Diatoma v.	-	-	-	-	-			
Ceratium h.	28	51	35	25	27			
Anacystis c.	20	9	1	-	-			
Filina l.	10	2	-	3	3			
Copepods	25	2	3	7	12			
Daphnia p.	2	5	-	-	-			
Bosmina c.	1	2	-	3	2			
Keratella c.	20	-	-	-	-			
Kellicottia l.	-	-	-	-	-			

Table 17. Date 7/12/78

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	127	85	12	25	27	10	29	
Anabaena f.	-	-	-	-	-	-	-	
Fragillaria c.	342	182	169	253	400	92	20	
Dinobryon s.	26	54	12	8	15	3	3	
Tabellaria f.	-	-	-	-	-	-	-	
Staurastrum p.	9	20	372	72	177	57	32	
Cerasterias i.	1	-	-	-	1	-	3	
Oedogonium s.	-	-	-	3	1	-	1	
Uroglena v.	9	12	4	5	1	8	2	
Pediastrum b.	-	-	-	-	-	-	-	
Diatoma v.	2	-	-	-	-	2	-	
Ceratium h.	101	59	38	63	18	12	6	
Anacystis c.	41	33	3	6	6	-	5	
Acanthocystis	-	-	-	-	-	-	-	
Filina l.	7	14	8	3	1	3	-	
Copepods	20	11	4	7	7	7	-	
Daphnia p.	10	5	-	-	-	-	-	
Bosmina c.	2	4	-	-	-	1	-	
Keratella c.	-	5	-	-	-	4	-	
Kellicottia l.	-	-	-	-	-	-	-	

Table 18.

Station 8 Date 7/21/78

Average number of organisms per liter of original water

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	49	29	356	29	42	8	18	
Anabaena f.	-	-	-	-	-	-	-	
Fragillaria c.	83	14	55	44	812	286	83	
Dinobryon s.	31	360	581	94	12	4	8	
Tabellaria f.	-	-	-	-	-	-	-	
Staurastrum p.	-	-	59	590	201	64	106	
Cerasterias i.	2	-	-	-	-	-	-	
Oedogonium s.	-	-	-	1	30	-	1	
Uroglena v.	-	-	132	663	42	256	35	
Pediastrum b.	-	-	-	-	-	-	-	
Diatoma v.	-	-	-	-	-	-	1	
Ceratium h.	127	10	68	42	17	-	2	
Anacystis c.	13	1	42	-	-	4	4	
Acanthocystis	8	-	1	-	-	-	-	
Filina l.	1	5	-	-	-	-	1	
Copepods	9	4	-	4	-	-	-	
Daphnia p.	2	-	13	-	-	-	1	
Bosmina c.	-	-	-	-	-	-	-	
Keratella c.	2	2	-	-	-	-	-	
Kellicottia l.	-	-	-	-	-	-	-	
Spirulina m.	6	-	-	-	-	-	-	

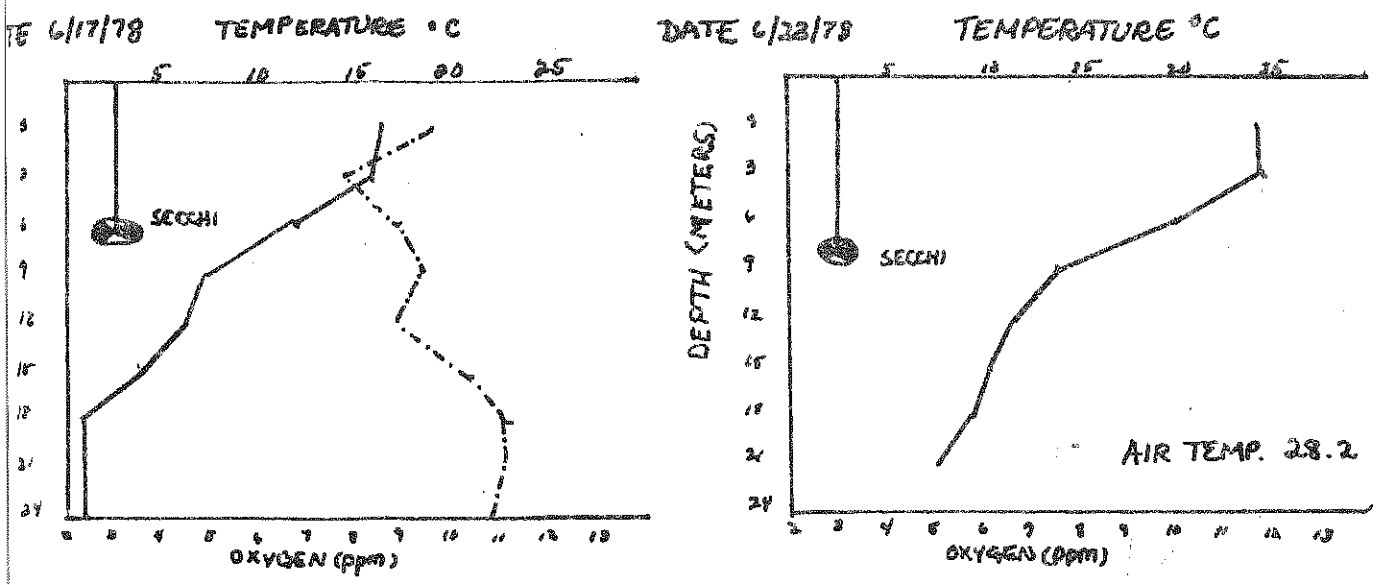
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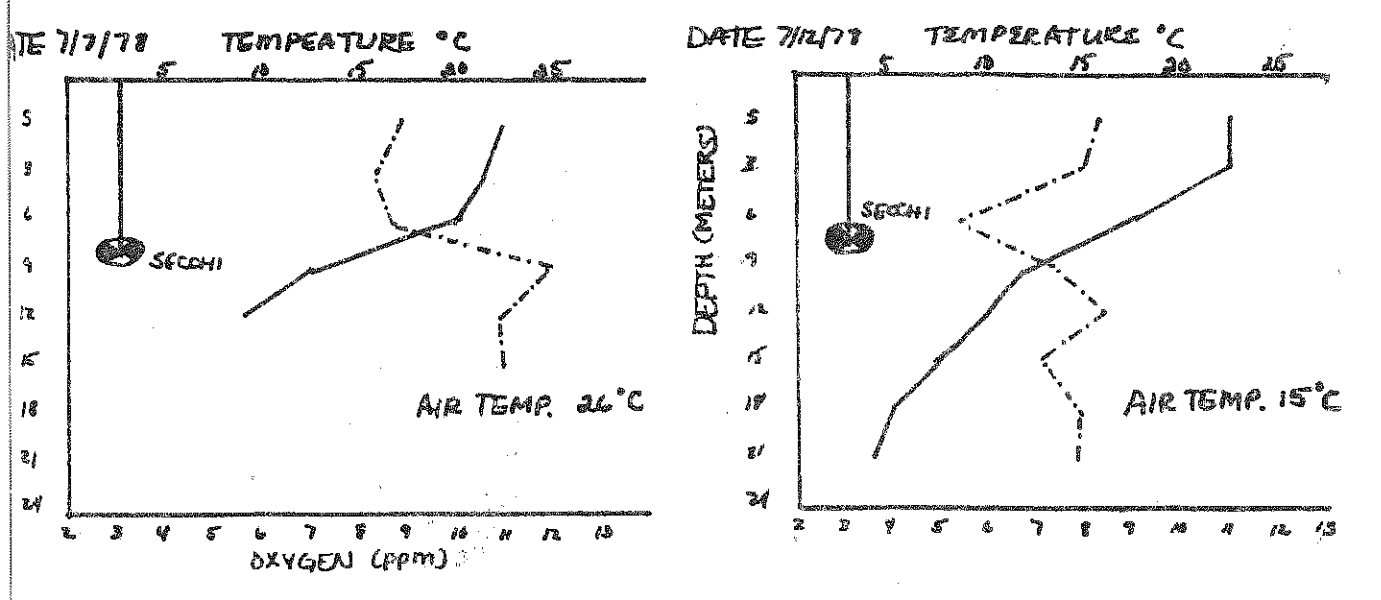
Date 7/28/78

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	4	4	47	21	17	12	-	
Anabaena f.	-	-	-	-	-	-	-	
Fragillaria c.	25	8	34	128	487	325	89	
Dinobryon s.	359	162	534	68	42	8	-	
Tabellaria c.	-	-	-	-	-	-	-	
Staurastrum p.	-	-	1	320	132	51	12	
Cerasterias i.	-	-	-	-	-	-	-	
Oedogonium s.	-	-	-	-	12	8	-	
Uroglena v.	8	-	-	132	4	-	4	
Pediastrum b.	-	-	-	-	-	-	-	
Diatoma v.	-	-	-	-	-	-	-	
Ceratium h.	38	8	175	38	8	4	8	
Anacystis c.	8	34	17	4	4	4	4	
Acanthocystis	-	-	-	-	4	-	-	
Filina l.	-	-	-	-	-	-	-	
Copepods	-	-	4	-	-	-	-	
Daphnia p.	-	-	-	-	-	-	-	
Bosmina c.	-	-	4	-	-	-	-	
Keratella c.	-	-	-	-	-	-	-	
Kellicottia l.	-	-	-	-	-	-	-	

STATION : EIGHT

—— TEMPERATURE
-.-.- DISSOLVED OXYGEN





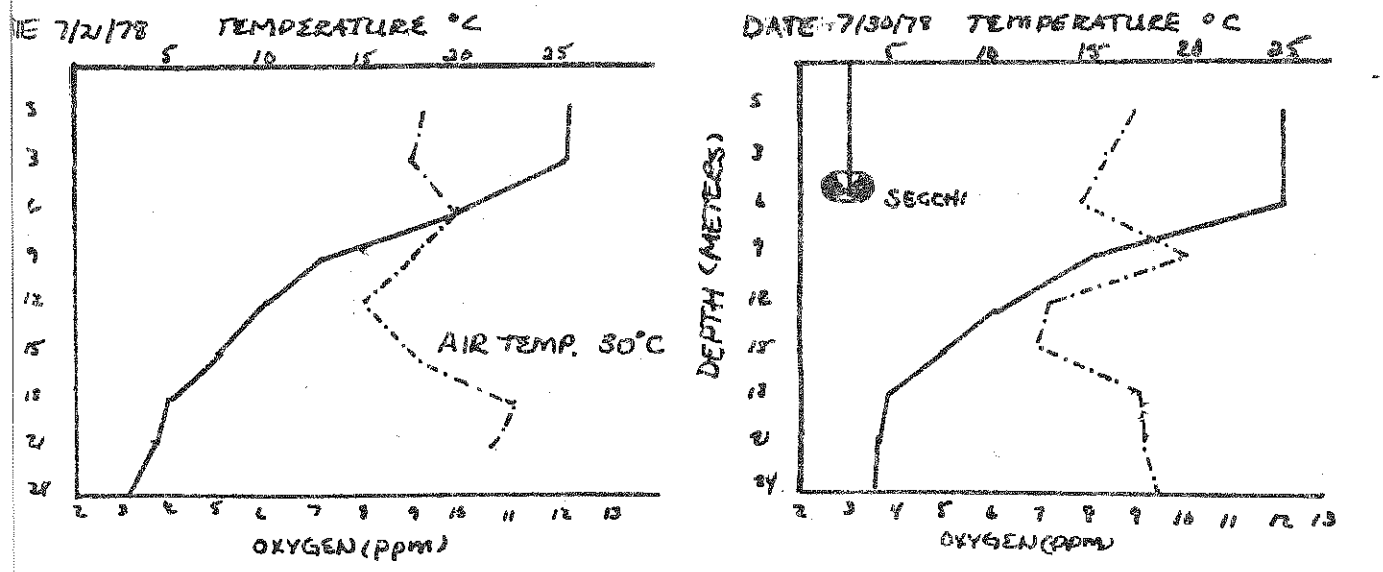


FIGURE 3.

Table 21.

Date 6/23/78

Station Dam
Average number of organisms per liter of original water

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	50	41	24	6	6	3	3	4
Anabaena f.	3	41	-	3	13	3	2	1
Fragillaria c.	14	3	3	1	1	-	1	2
Dinobryon s.	4	55	11	3	23	5	4	2
Tabellaria f.	1	-	.8	-	.8	-	2	-
Staurastrum p.	1	4	13	3	3	2	-	4
Cerasterias i.	6	3	3	1	2	6	-	2
Oedogonium s.	-	3	3	-	2	-	.8	.8
Uroglena v.	-	-	-	-	-	-	-	-
Pediastrum b.	-	-	-	-	-	-	.8	.8
Diatoma v.	-	-	-	-	-	-	-	-
Ceratium h.	6	106	17	3	40	6	5	3
Anacystis c.	-	-	-	-	-	-	-	-
Acanthocystis	-	-	-	-	-	-	-	-
Filina l.	14	18	6	6	6	1	2	2
Copepods	16	7	4	16	18	12	20	10
Daphnia p.	4	23	14	1	2	-	-	-
Bosmina c.	-	-	1	-	4	-	-	-
Keratella c.	2	2	-	-	-	2	3	3
Kellicottia l.	-	-	-	-	-	-	-	-

Table 22.

Date 6/30/78

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	4	5	9	3	1	-	1	1
Anabaena f.	-	1	2	5	6	-	-	-
Fragillaria c.	5	4	5	1	1	-	-	-
Dinobryon s.	30	32	21	3	-	-	4	2
Tabellaria f.	-	-	-	-	-	-	-	-
Staurastrum p.	5	-	13	3	1	1	-	-
Cerasterias i.	4	-	-	1	2	-	1	3
Oedogonium s.	3	-	1	1	-	-	-	-
Uroglena v.	-	-	-	-	-	-	-	-
Pediastrum b.	-	-	-	-	-	1	-	-
Diatoma v.	1	-	-	-	-	1	-	-
Ceratium h.	20	70	31	10	2	-	2	1
Anacystis c.	-	-	-	-	-	-	-	-
Acanthocystis	-	-	-	-	-	-	-	-
Filina l.	17	10	4	8	4	2	2	-
Copepods	12	3	10	6	8	2	6	6
Daphnia p.	7	2	2	1	3	1	1	1
Bosmina c.	-	1	-	-	1	-	-	-
Keratella c.	3	-	-	-	-	-	2	-
Kellicottia l.	-	2	1	2	-	-	-	-

Table 23.

Station Dam

Date 7/7/78

Average number of organims per liter of original water

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	20	20	12	16	6	1	-	5
Anabaena f.	-	-	-	-	-	-	-	-
Fragillaria c.	26	26	21	9	4	1	-	4
Dinobryon s.	20	52	23	7	1	-	-	4
Tabellaria f.	-	5	6	-	-	-	-	-
Staurastrum p.	5	-	28	14	2	2	2	-
Cerasterias i.	-	-	-	-	-	-	-	-
Oedogonium s.	-	-	-	-	-	1	-	-
Uroglena v.	-	-	-	-	-	-	-	-
Pediastrum b.	1	1	-	-	1	1	-	-
Diatoma v.	-	-	-	-	-	-	-	-
Ceratium h.	31	82	57	45	14	2	3	1
Anacystis c.	-	8	3	1	1	-	1	1
Acanthocystis	-	-	-	-	-	-	-	-
Filina l.	14	5	6	2	6	1	6	-
Copepods	2	-	-	12	4	-	4	1
Daphnia p.	15	3	2	2	1	1	1	-
Bosmina c.	3	-	3	-	-	-	2	-
Keratella c.	2	1	-	-	-	-	2	-
Kellicottia l.	-	-	-	-	-	-	-	-

Table 24.

Date 7/14/78

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	20	18	20	100	45	3	-	2
Anabaena f.	-	-	-	-	-	-	-	-
Fragillaria c.	171	74	103	153	63	18	8	10
Dinobryon s.	17	66	55	11	3	-	-	-
Tabellaria f.	-	-	-	-	-	-	-	-
Staurastrum p.	85	27	134	90	54	22	6	4
Cerasterias i.	3	1	3	-	-	2	-	-
Oedogonium s.	10	-	-	2	1	-	-	-
Uroglena v.	-	1	-	-	-	-	-	-
Pediastrum b.	1	-	1	-	-	-	-	-
Diatoma v.	-	-	-	-	-	-	-	-
Ceratium h.	141	98	135	33	30	11	2	1
Anacystis c.	11	4	-	2	-	3	1	-
Acanthocystis	-	1	-	-	-	-	-	-
Filina l.	17	3	2	-	2	1	-	2
Copepods	9	6	5	1	3	1	1	3
Daphnia p.	5	2	3	-	4	2	-	-
Bosmina c.	1	-	1	-	-	-	-	-
Keratella c.	9	3	-	-	-	-	-	-
Kellicottia l.	-	-	-	-	-	-	-	1

Table 25.

Station Dam
Average number of organisms per liter of original water

Date 7/19/78

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	17	1	9	21	11	9	2	
Anabaena f.	-	-	-	-	-	-	-	
Fragillaria c.	43	1	3	111	41	32	3	
Dinobryon s.	47	564	113	26	37	25	4	
Tabellaria f.	-	-	-	-	-	-	-	
Staurastrum p.	1	-	23	279	38	63	13	
Cerasterias i.	-	-	-	-	-	-	-	
Oedogonium s.	-	-	-	-	1	-	-	
Uroglena v.	-	-	-	-	-	-	-	
Pediastrum b.	-	-	-	-	-	-	-	
Diatoma v.	-	-	-	-	-	-	-	
Ceratium h.	78	17	141	171	40	33	4	
Anacystis c.	8	-	2	11	8	2	4	
Acanthocystis	7	-	-	-	-	-	-	
Filina l.	10	-	2	8	-	2	1	
Copepods	8	-	2	4	3	-	1	
Daphnia p.	-	4	1	6	-	1	-	
Bosmina c.	-	-	-	-	-	-	-	
Keratella c.	2	-	1	-	1	1	-	
Kellicottia l.	-	-	-	-	-	-	-	

Table 26.

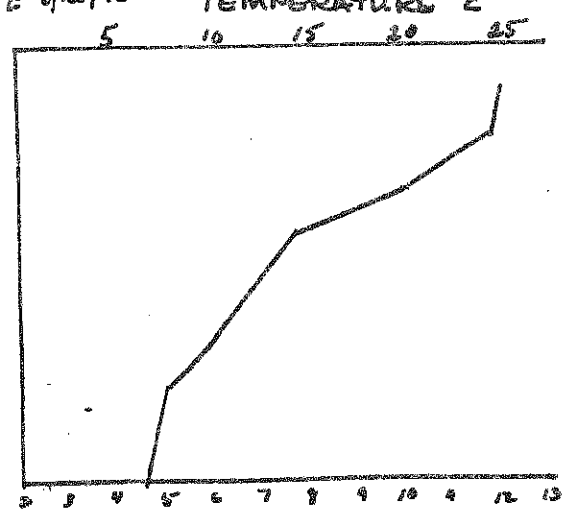
Date 7/28/78

Organism	Depth (meters) 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Asterionella f.	1	8	8	4	4	17		
Anabaena f.	-	-	-	-	-	-		
Fragillaria c.	16	14	1	4	12	231		
Dinobryon s.	268	184	226	162	72	12		
Tabellaria f.	67	76	-	-	-	-		
Staruastrum p.	9	8	-	-	98	51		
Cerasterias i.	3	-	1	298	-	-		
Oedogonium s.	1	1	-	-	-	-		
Uroglena v.	4	7	3	-	-	-		
Pediastrum b.	-	-	-	-	-	-		
Diatoma v.	-	-	-	-	-	-		
Ceratium h.	108	142	119	158	68	38		
Anacystis c.	39	150	115	94	72	42		
Acanthocystis	-	-	1	1	-	-		
Filina l.	1	2	1	-	-	-		
Copepods	10	9	-	4	-	-		
Daphnia p.	4	5	1	-	8	4		
Bosmina c.	2	1	-	-	-	-		
Keratella c.	-	-	-	-	-	-		
Kellicottia l.	-	-	-	-	-	-		
Spirulina m.	12	-	-	-	-	-		

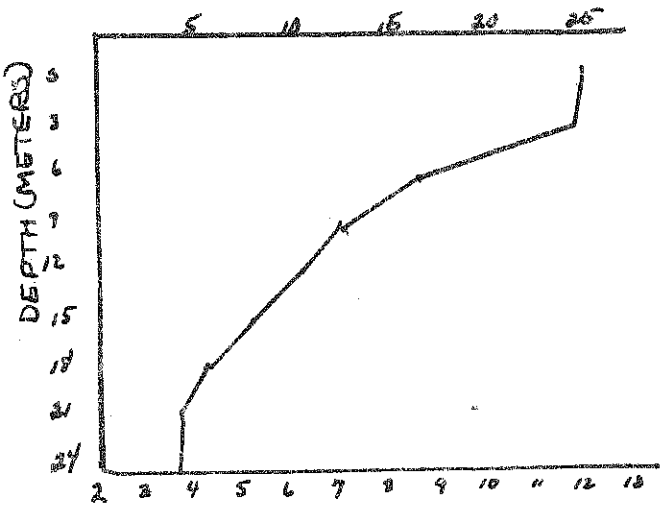
TION : DAM

— TEMPERATURE
-·-·- DISSOLVED OXYGEN

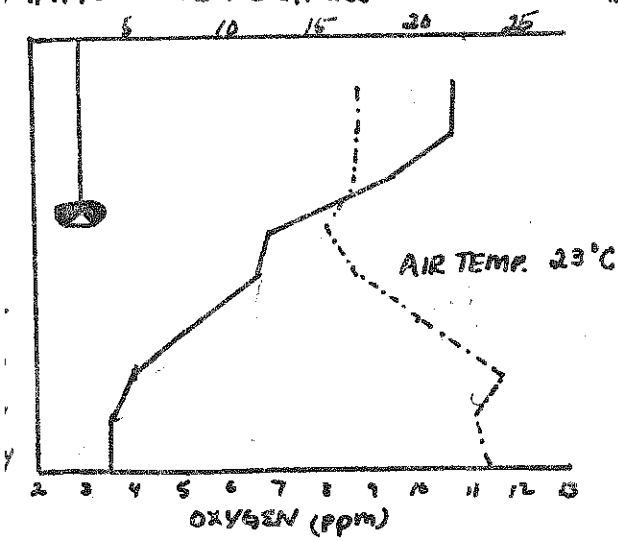
E 6/23/78 TEMPERATURES °C



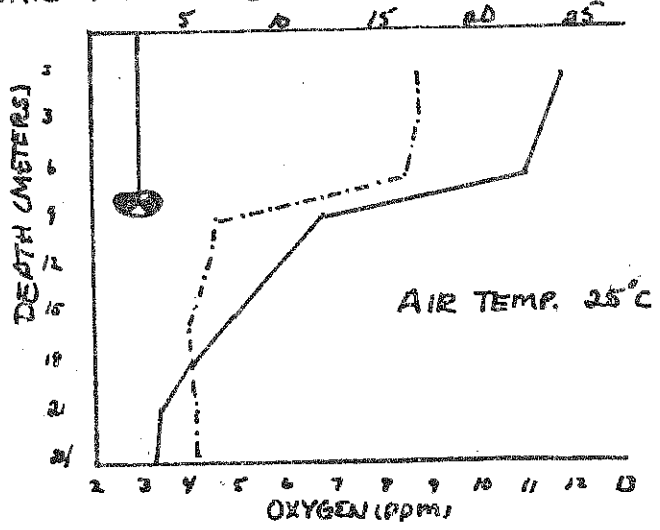
DATE 6/30/78 TEMPERATURE °C



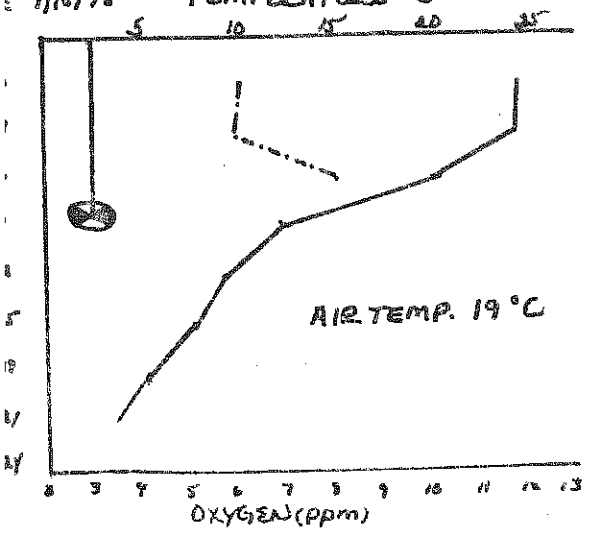
7/7/78 TEMPERATURE °C



DATE 7/14/78 TEMPERATURE °C



E 7/18/78 TEMPERATURE °C



O2 LEVELS DROPPED OFF SHARPLY AND RAN OFF THE SCALE

DATE 7/30/78 TEMPERATURE °C

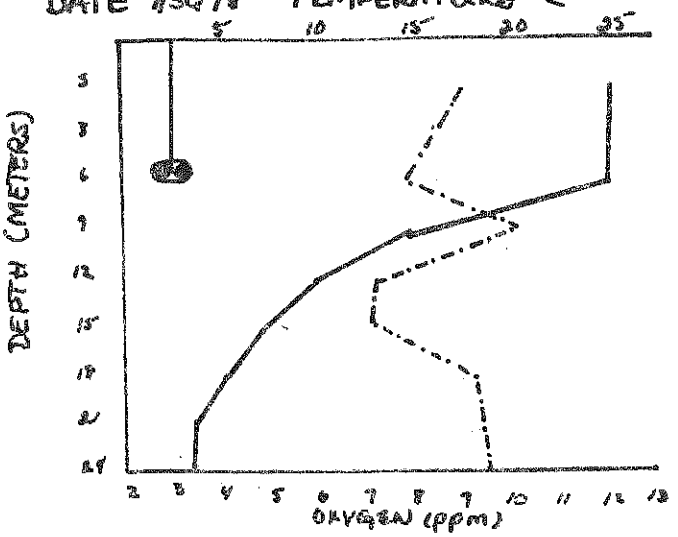


FIGURE 4.

LITERATURE REVIEW

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RAYSTOWN FIELD STATION
JUNIATA COLLEGE

Forest Ecology--A Characterization of Forest Communities at the Raystown Field Station

by
Tom Phillips and Eric Hauenstein
Adviser: Dr. Todd Gustafson
(a three term study during 1977-78 school year)

Introduction

The purpose of this study is to obtain both qualitative and quantitative data on the trees, shrubs and various ecological relationships which exist at Raystown Field Station. Upon verification from these observations, the field station will be divided into distinct communities according to tree dominance. In each community trees will be classified according to species, number of points of occurance and number of individuals of each species, total and average basal area for each species, average tree height for each species, and relative rankings of density, frequency, dominance and importance value. Qualitative observations of shrub and sapling cover, slope aspect, light penetration and other biotic and abiotic factors will be related to these quantitative findings in an attempt to explain the ecology of each community. A section considering soil measurements and interpretations is also included.

The learning goals of this independent study are dual in nature. The primary objective is to gain practical insight into all aspects of forest ecology. This includes plant community-environment relationships, succession, morpho-physiological characteristics, hybridization of species, and any other relevant biological phenomenon which are found to be worth reporting during the course of our investigation. The second aim of this project is to learn how to utilize some common sampling techniques and a few basic forestry tools. This knowledge will give us a foundation of understanding for the future in both graduate school and in practical field work.

Due to the use of slow and overly-accurate measuring techniques in the early stages of sampling, a lack of time, and poor weather, we were unable to sample as much of the field station using the quarter method as we had originally intended. The entire northern peninsula and the maple grove, representing approximately one-third of the station, were completed during the fall term. Within this area we have identified three distinct forest communities based on the dominant tree species (see Map 1, page 8). These three communities were initially observed from field observation during the summer and were later confirmed and clarified from the quantitative data collected during sampling of trees in the autumn. The edaphic measurements

taken, combined with the numerous environmental observations reported, also add support to the division of the northeastern portion of the field station into three separate communities, as will be elaborated on later.

Before going further, perhaps a valid question can be raised in the following: is it justifiable to classify an entire plant community depending entirely on its dominant tree species? And what exactly determines "dominance"?

Dominance in a community, upon which most community types are classified, is a concept which is often misnamed, if not misunderstood, by the layman. The dominant species is that plant species which exerts the most overall influence on each of the other species and on the physical environment of that community. In this broad sense, dominance is ranked according to importance values, a calculation made for each species which uses relative density, relative frequency and a narrowly-defined relative dominance component in equal parts (to be discussed later in more detail). The dominant species is well-adapted to the ecological conditions present within the community; due to changing environmental conditions and successional sequences, though, dominance by one species, unless it is in a climax state, often does not last long in biological terms. For example, a mid-successional tree species may dominate an area for only 60 or 70 years until it is crowded out by a later species in the successional continuum. It is obvious, then, that dominance for a community is often a transient condition.

The general term for dominance in forest communities (as measured by importance values) such as we are studying represents itself in the form of a number of plant traits of which basal area (directly related to tree height for most trees), canopy spread, nutrient and water uptake capacity and physiological tolerances to light, wind, temperature, etc. are the most important. These factors all directly effect the relative rankings for density, frequency and dominance of the vegetation in a community. In other words, the plant which exerts the most influence in a forest community is often the tree species which maximizes one or a combination of the factors of height, leaf cover, mineral and water absorption, and physiological tolerance to environmental stress. For example, by being on the average the tallest

member or else the member with the most widespread canopy cover within a community, a tree species maximizes the sunlight that reaches its leaves and in so doing reduces the light received by all the other species living within the community. This competitive factor of sunlight distribution is a very important single element determining dominance in a forest. The amount of sunlight received by the community helps also to determine moisture and temperature microenvironments besides the crucial light intensity factor. Thus, within a forest community, the species which most controls the sunlight received will often be the dominant species. The next most important factor in these communities is probably moisture availability, particularly in areas of young vegetation where wind and sunlight play more of a role in edaphic conditions. Subdominant tree species, shrub cover, and ground layers may also be important determiners when classifying a forest stand, but in this study tree dominance based on quantitative data will be the prime criteria for classifying the plant communities observed.

In some circumstances light may not be the highest priority--the limiting factor, in other words--in a forest community. For example, on the side of many mountains where high winds are a factor, the dominant trees are usually those with low, stout stems and often limited canopy cover. In these communities the loss of plant and soil moisture due to the desiccating effects of the wind is a priority for each tree and not the maximum amount of sunlight that it can absorb. In other situations, the available nutrients, fire, temperature or other factors may be the limiting influences.

Savannas and deserts are dominated by the species that is merely in the most abundance. Neither height nor canopy spread are important dominance traits since moisture plays more of a role in determing plant distribution and abundance than does the amount of sunlight. That species with the greatest density which is best able to utilize the limited water resources in these ecosystems will exert the most influence on their communities. This is quite different from the forest communities where the leaf area index (LAI) of each species--directly related to the percentage of sunlight

that each species is able to control--and tree height are more important factors in determining dominance than is the actual density of individuals of a particular species.

The four relative values which were calculated for each species, of which importance value is the most significant since it is a ranking of overall species influence on the community, were computed using the following equations:

$$\text{Frequency} = \frac{\#\text{ sampling points of occurance}}{\text{total }\#\text{ of sampling points}} \times 100$$

Species that are scattered throughout the forest have more influence than when in a tight little clump.

$$\text{Rel. Frequency} = \frac{\text{frequency of a species}}{\text{sum of frequencies of all species}} \times 100$$

$$\text{Rel. Density} = \frac{\#\text{ trees per species}}{\#\text{ trees of all species}} \times 100$$

Usually # trees/hectare

$$\text{Rel. Dominance} = \frac{\text{species basal area}}{\text{all species basal area}} \times 100$$

Determined by the area of the trunk (BA)

$$\text{Importance Value} = \frac{\text{Rel. Freq.} + \text{Rel. Den.} + \text{Rel. Dom.}}{3}$$

Overall influence ranking of species compared to every other species in a specific community

Methods and Materials

For the fall term we used the quarter method in our analysis of the northern section of the field station. The quarter method is a plotless vegetation sampling technique which varies from the older plot methods in that the sampling area is not boxed off into carefully measured squares, circles or other geometric shapes; instead, random points are located within the sampling area--in this case, each of the three communities. At each point an imaginary four-cornered box is created by the intersection of two perpendicular lines in the box's center; the nearest sampleable tree (minimum sampling size is a basal area of 1.05 dm^2) in each quarter of the box is then recorded for species, basal area, distance from the center sampling point, and height.

To insure random and therefore fully representative sampling points, the northern peninsula was divided into parallel north-south transects at a 127° angle. Sampling was begun at the field-oak forest boundary above the maple grove and to the left of the last road hill going down to the farmhouse (see Map 2). A jeep trail runs along the ridge of the peninsula for most of its length. This trail was used as a focal

point for operations throughout the sampling; the parallel transect lines were basically drawn perpendicular to it from the start of the oak forest (at the field boundary) until the jeep trail cuts sharply to the north near the eastern end of the peninsula.

The first several transect lines were spread 50 meters apart, and the figures used from the table of random numbers to locate sampling points were halved in order to accomodate the 50 meter limit. This method was found to be too slow and resulted in much overlapping of sampling areas due to the small area covered during each sample. As a result, 100 meter distances between lines were maintained. This facilitated less sampling overlap and resulted in much faster work with little loss of accuracy in the data. As shown in Map 2 describing our transect lines, we reverted back to 50 meter intervals between lines when we got to the maple hollow due to the fact that this area represents a compact but very important community of its own (due to its usefulness to man as a maple sugar source in the spring) and as accurate data as possible was thus desired.

Another major change in the procedure at an early stage in the sampling which speeded up sampling immensely involves our shift from accurately measuring out all distances to sampling points with tapes to the more practical method of merely pacing off lengths. This slightly less accurate technique increased the efficiency of our sampling a great deal.

Actual sampling points along each transect line were found using a table of random numbers. Once we converted to 100 meter intervals, the numbers in the table could be used without alteration since we were working with a base ten scale. Four random numbers were used from the random numbers table to locate each sampling point (each sampling point contained four sampled trees since it was quartered in accordance with the quarter method). The first two numbers indicated how many meters (paces) to go along the transect line; the second pair of numbers told how far to go to the right or left of the transect line depending upon whether the number was odd or even. Consistency was maintained using the random numbers. When moving north along a transect line, if the second two numbers were an odd number combination, then this indicated

an eastward sampling point (to the right of the transect line) and a westward (left) sampling point for an even number. Opposite directions were taken when moving south along the next parallel transect line.

The instruments used during the collection of data were relatively simple--though very functional--elements of any sampling study. A flexible metal cylinder tape was used for a dual purpose. On one side it measures length in meters and was used to determine the distance from the central sampling point to the sampled tree in each of the four quarters. This length was ultimately used to determine relative densities for each of the species in each community. The other side of the tape measures basal area in squared decimeters. Basal area is a measure of the actual horizontal area occupied by the trunk of a tree; it is proportional to the volume of living wood present and mathematical calculations can rapidly estimate wood volumes from basal areas by treating the tree as a cone (adjustments are then made for canopy, branches,etc. for specific groups of species--ie. hardwoods vs softwoods). The minimum basal area for a tree to be sampled was 1.05 dm^2.

A forester's compass was used to keep our transect lines true as we stayed on a reading of 127^0 for each of the parallel lines. The compass also aided in keeping our lines to the sampling points perpendicular to the transect lines by using its peep sight.

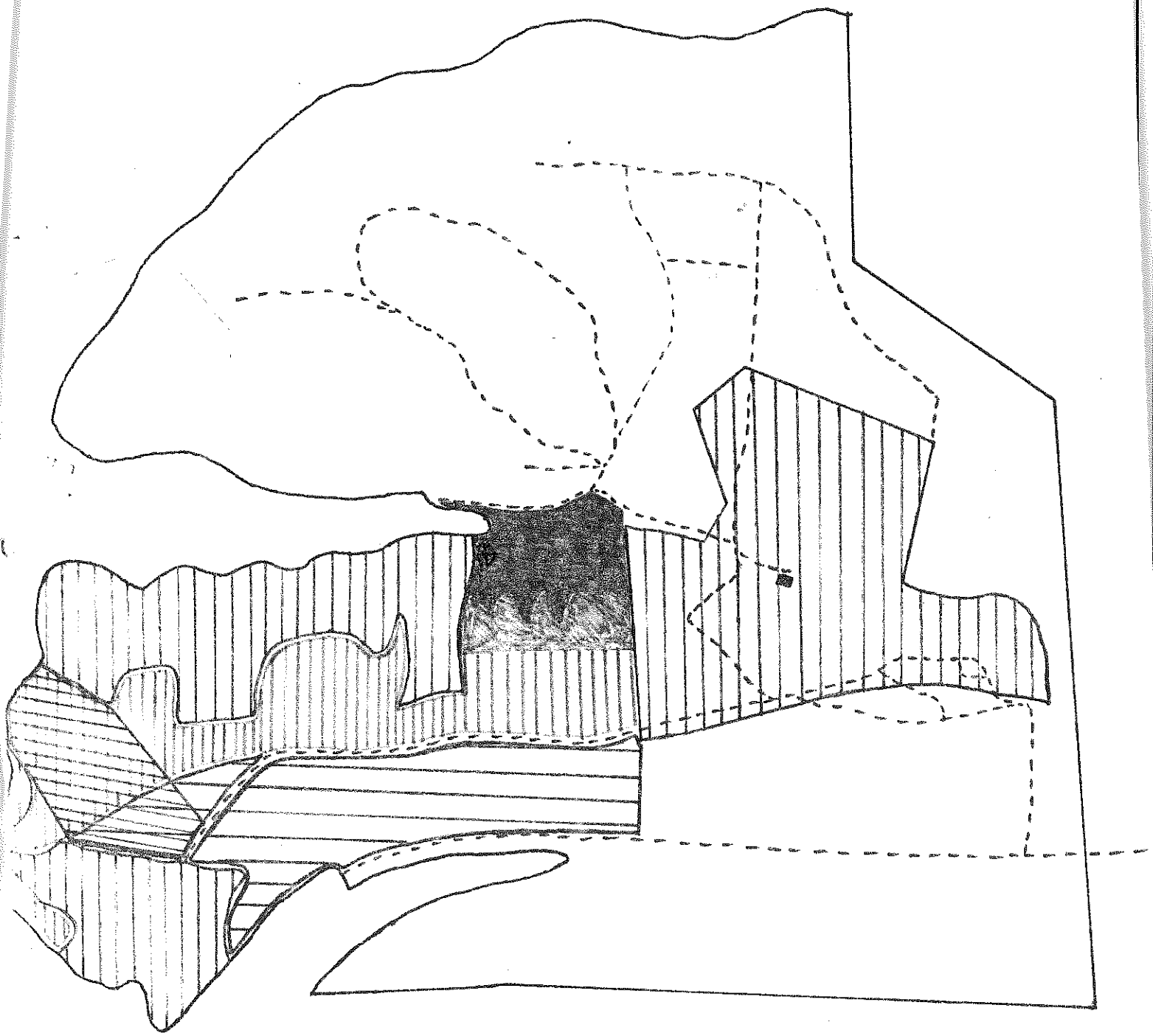
A clinometer was extensively used in this study to measure tree height. This convenient instrument, calibrated to estimate heights of trees in meters, uses angles and simple geometric principles for the basis of its measurements.

A range finder was used initially for measuring relatively short distances, but its function was found unnecessary as the study proceeded. Plant presses, a Jacob's staff, and tree identification books filled out the rest of the equipment list utilized throughout the study.

The most important source of error during the sampling was probably in the determination of each of the sampling points. When each sampling point was being paced off, we tried to maintain as perpendicular a path from the transect line as possible.

This was at times difficult to do because of irregular terrain and numerous obstacles in the way of a straight perpendicular line, but we attempted at all times to maintain the randomness and accuracy of our sampling points. This does not suggest that a certain amount of bias will not be included in this study. On the contrary, due to the less accurate but more efficient method which we adopted of pacing off the distances and approximating the direction of the perpendicular lines to the transect lines, a degree of bias is unavoidably inherent in the process of sampling. The easiest route around an obstacle, perhaps a few steps unconsciously taken closer to a clump of closely-spaced "sampleable" trees, differing pace lengths depending on the number of obstacles and steepness of the slope--all of these influences and others suggest that errors will inevitably (be a NOT SO significant part) of the results of this study. All other possible sources of error are concerned with (the identification of HYBRIDS species) and in the use of measuring instruments. Mistakes in identification and with the measuring tape, clonometer and forester's compass would be slight and most probably insignificant as we attempted to be accurate and honest in all of our measurements and observations. Although there is no way for us to quantitatively determine the level of significance of the error in this study, we feel that all mistakes and biases have been minimized and that the data collected is a good representation of the communities sampled.

Fig 1 - Community Boundaries, Grass Fields, Jeep Trails and 2 "Special" Vegetation Stands



Key

- Grass Field Boundary
- Young Area of pine, red maple & hickory (last cut in 1955)
- Community 3 Boundary (North Slope)
- Community 2 Boundary (South Slope)
- ⊕ Maple Hollow Region with very young red & sug maple saplings
- Ecotone area (sampled as part of Community 2)
- Community 1 (Maple Hollow)
- Jeep Trail
- Field Station Boundary

Map 2 - Transect Line Layout For Quarter Method
(The maple hollow was sampled independently of communities 2 & 3)

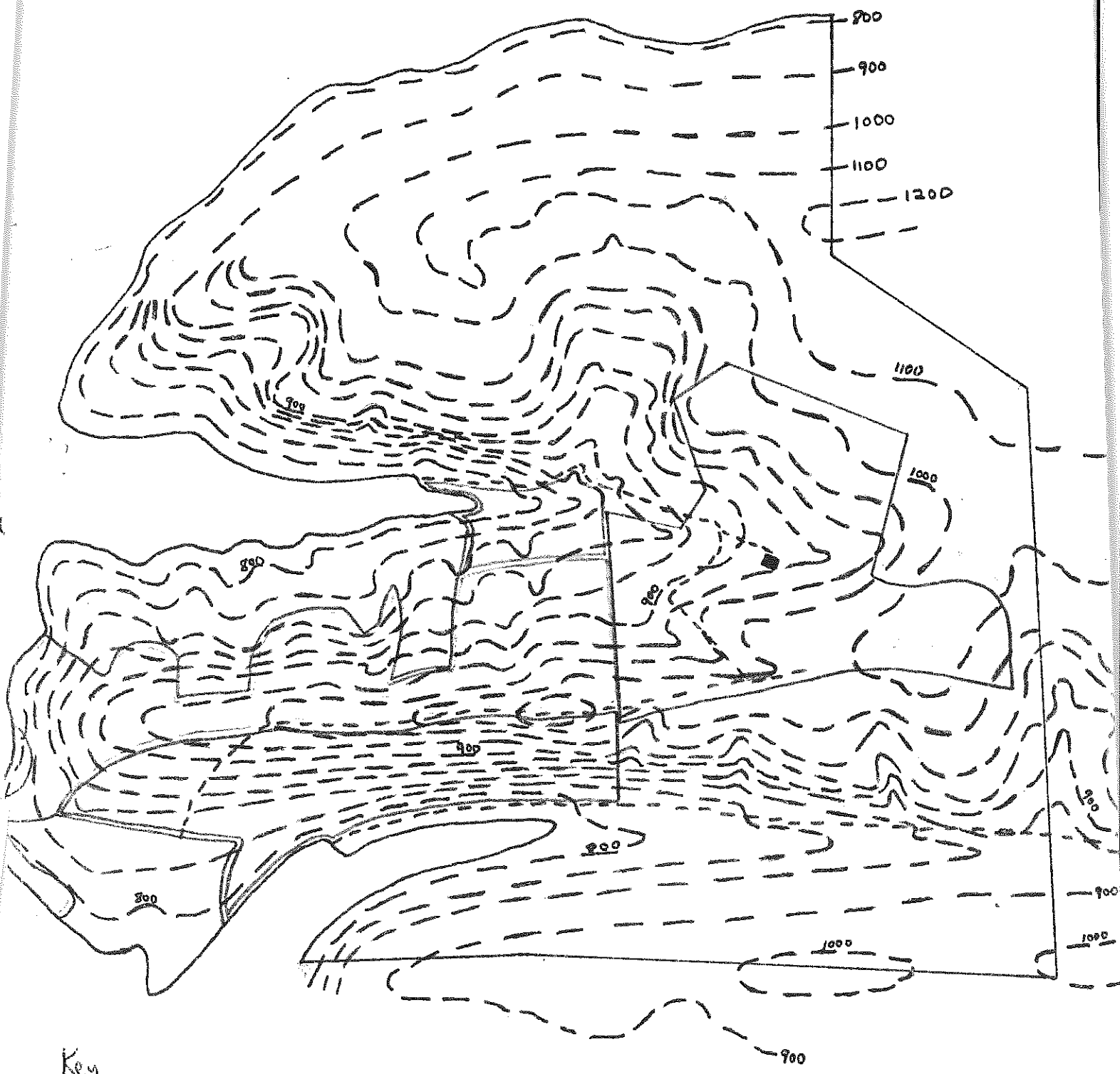


Key

① Point where sampling was begun for north & south slope communities (2 & 3)
② Point where sampling was begun for maple hollow community (1)

——— Grass fields boundary
——— Community 2 boundary (south slope)
——— Community 3 boundary (north slope)
——— Field Station boundary
- - - - → Transect line used for quarter method
- - - - - - Jeep trail

ap 3 - Topographic Map of Field Station



Key

——— Community 1 Boundary (Maple Hollow)
——— Community 3 Boundary (north slope)
- - - - Jeep Trail
——— Grass Fields Boundary
——— Community 2 Boundary (south slope)
- - - - - } Contour Lines
- - - - -

Results

Maple Hollow--Community 1

As shown in Map 1, three plant communities within the northeastern portion of the field station were identified. Community 1 is the maple hollow. This community of highly dominant sugar maples is essentially in a climax condition; according to Clair Grove, former resident and owner of this farming tract, the trees in the hollow have not been disturbed by man through three generations of his family and as far as he is aware, have never been seriously interfered with by anybody.

This area is down in a depression and as such is a water drainage basin for much of the runoff from the slopes above. A small stream runs down through the hollow parallel to the road on its way to the lake. At the boundary region between communities 1 and 2 (the northern sloping border of the maple hollow), runoff gullies are noticeable as depicted on Map 1 by the red projections extending from the maple hollow. These small drainage valleys share many characteristics that are common to both communities. The runoff coming down the slope from community 2 is more excessive than would be expected under natural conditions due to the lack of topsoil and minimal litter in community 2 caused by relatively recent farming of the higher-elevated land.

Several other factors aid in the retention of moisture in the maple hollow. The hills bordering the hollow help to keep the wind rather calm within the depression. These surrounding slopes also shade the community from sunlight during certain times of the day. The dominant sugar maple trees are themselves an important factor in retaining moisture, also; the extensive canopy spread--both vertically thick and horizontally widely-enveloping--typical of this species helps create a microenvironment for the community which strongly influences the nature of both its biotic and abiotic aspects. The canopy of the maples is a microenvironmental (abiotic) influencer with regard to its effects on screening the sunlight that reaches lower levels of the community and also as a windbreaker. Both of these functions combine with the previously-mentioned moisture accumulation functions of the surrounding slopes to produce an environment of high soil moisture content and relatively high humidity. A kind of

moisture greenhouse effect which serves to conserve ground water and air humidity is maintained under the protective maple canopy layer and between the steeply sloping boundaries of the maple hollow community.

A biotic factor resulting from the vast maple canopy is the large amount of leaf litter which falls to the forest floor. Maple leaves are rich in nutrients and contain no toxic substances like some other species (walnut, for example). Over the years a rich, porous topsoil layer develops due to the decomposition of fallen leaves. Thus, the nutrient-filled, brown forest podzolic soil observed in the maple hollow community is in a large part due to the biotic influence of the dominant species on its own abiotic environment. More on soils will be discussed later.

A second biotic influence exerted by the maples helps in a competitive sense to insure the continued dominance of the community by the sugar maples. This controlling mechanism again takes us back to the sugar maple species' overwhelming control of the sunlight penetration into the lower levels of the forest. By absorbing the vast majority of available light energy, the sugar maples are limiting and in most areas of the hollow entirely disallowing the germination of seeds and the growth of saplings of other competing tree species. Thus, the sugar maples, representing the dominant climax species of this community, are able to successfully control possible competing species which are more shade intolerant than themselves. At the same time, by maintaining maximum light absorption efficiency--in other words, by having the canopies of the maples cover as much horizontal surface area as the trees can afford to maintain--the photosynthetic capabilities of this dominant species remain as high as possible. Continued growth and maintenance (and therefore dominance) by the climax sugar maples is insured as a result, an enviable position for any species to be in. Sugar maples respond to both interspecific and intraspecific competition from other trees in the following morphological manner. In crowded woods they normally have long, branchless trunks; in the open, shorter trunks and long, rounded crowns are most often adopted.

The typical ecology of the sugar maple species is closely parallel to the

relationships observed in its role as dominant species within the maple hollow community. Sugar maples require rich, deep soil with a lot of moisture. The adaptation value for this species (a relative ranking from 1.0 [xeric conditions] to 10.0 [mesic--most moist] describing the behavior of trees along a moisture gradient) is 10.0 for upland trees; this proves the sugar maple's high dependence on moisture availability. In a successional sense, sugar maples are a classic climax species. This species is relatively shade tolerant during seed germination and sapling growth; in the maple hollow community the sugar maples outcompeted the earlier-established Virginia pines (a pioneer species) by growing up under them initially and eventually growing taller than the shade intolerant pines. The average height of the Virginia pines in the maple hollow is 10.33 meters while the average height for the sugar maples is 16.97 meters. Although the relative density of the Virginia pines ranks second behind the sugar maples, the pine species has been generally overtaken by the red maples, also. The relative frequency, relative dominance and importance value of the red maples are higher than the Virginia pines. This fact suggests that the surviving Virginia pines in the hollow are only remnants of an earlier successional state during which the pioneer pines were the dominant species. Virginia pines are very shade intolerant. The red maples, a mid-successional species, are often the trees that choke out the pines by shading them, thus setting the stage for the sugar maples to grow. Sugars can grow beneath red maples but not vice versa. Through this process of succession, each stage creates the conditions for the next stage until the climax species--in this community the sugar maple--becomes established. Actually the Virginia pines and red maples produce conditions which serve to limit their own numbers by helping the sugar maples to become dominant.

Clair Grove thinks (but is not positive) that the maple hollow has not been farmed or cut by man for at least three generations (approximately 90 years). Due to the presence of these pines, though, I suggest that some kind of disturbance in the past 200 years or so must have provided the opportunity for their establishment. Perhaps a natural fire burned off a portion of the hollow, thus exposing an area with

enough sunlight for the pine seeds to germinate. Or maybe Clair is unaware of some timbering which took place in this area sometime in the past 100 to 200 years. The soil profile of the hollow, as will be discussed later in more detail, shows a marked lack of development for a stand which supposedly has never been farmed or burned. Early settlers may have even cleared this area and farmed it long before Clair's family got ownership of the land.

A projection into the future would suggest that in a number of years (perhaps 50) all of the remaining Virginia pines in the maple hollow will die off and not be replaced. The high moisture content of the soil and lack of sunlight being reached by the pines due to maple competition make this projection a reasonable assumption. It is also reasonable to suggest that if no new cuttings are undertaken in this community, then no new pine saplings will ever have a chance to become a dominant element due to their shade intolerance. Few if any pine seeds will ever even germinate since pines are a pioneer species and cannot compete against established sugar maples.

The center of the maple hollow is very clean as far as shrubs and sapling entanglements are concerned due to this low light penetration factor caused by the thick maple canopy. Low grasses and spring ephemerals are distributed lightly throughout most areas of the forest floor. This clean understory is a common characteristic of mature deciduous forests, but as the community gets older, more large litter may accumulate in the form of branches and trunks than is presently the case.

Most of the red maples and shagbark hickories present in the community are located in the rear of the hollow (north side) near the community 1-community 2 boundary. Only a very few red maples and no hickories remain in the center of the hollow where the sugar maples are highly dominant. Since both of these species are mid-successional and also since they can tolerate lower moisture (more xeric) conditions and thinner soil than the sugar maples, this outcome of horizontal distribution in the hollow is logical. Also, shagbarks are often found in between many communities and often on sloping terrain. The back portion of the hollow near its border with community 2 has drier and thinner soil and a much steeper aspect than the central areas of the hollow.

Thus, the ecological relationships observed in this community coincide well with the general characteristics of red maples and hickories.

Both of these two species will probably survive for many years in their present niches within the boundary area. Community 2 above the hollow is still far from maturing and contains conditions which, though tolerable for the continued existence of these two species, as yet will keep the sugar maples from moving in and taking a dominant role. Community 2 is much younger than the maple hollow and thus has poorer soil and is still in a very early successional stage; both of these conditions limit sugar maple growth beyond the maple hollow for the time being. Even in the far future, though, it might be impossible for the sugar maples to ever dominate beyond their present confines within the maple hollow due to the steepness of the slope and the subsequent lack of water in the soil (mainly because of runoff) as is the case in the more mature community 3 where oaks dominate.

A final gradient to be considered in this community is that of the vertical distribution of tree species based on the heights of the canopies. In many deciduous forests the canopies are arranged in fairly regular vertical strata; in the maple hollow these canopy layers consist of one overwhelmingly dominant sugar maple stratum (at approximately 17 meters), a scantily-developed red maple canopy height (at 14.6 meters), and an equally scanty dispersal of Virginia pine canopies at 10.3 meters. Most of the other tree species composing the maple hollow flora fall somewhere close in canopy height to one of these three vertical strata, though in less significant and widely dispersed distributions. These three hypothetical canopy layers (as indicated in the ensuing raw data table) exist due to niche differentiation by the species involved. Though poorly developed in this community, the strata are caused mostly by plant responses to the varying light factor at different heights within the forest. The fact that the sugar maples dominate to such a high degree explains why the vertical canopy levels are not more well-defined in this hollow; only the sugar maples themselves constitute a fairly homogeneous canopy layer at the top of the forest.

A small area of the hollow near the boat dock consists primarily of small red

maples intermixed with sugar maple saplings (see Map 1), mostly all of which were too small in basal area to be sampled as trees. This area extends up to community 2 at the rear of the maple hollow boundary; where the saplings of maples intergrade across the community boundaries, there is no evident ecotone like there is in the western area of this back boundary. Presumably, this small section of the maple hollow was farmed at the same time as community 2 and thus its vegetation is the same age as that of the south slope. Greater diversity in the vegetation is the most significant change in the flora as you proceed up the slope of this sapling area from its maple hollow extension until it disperses in the middle of community 2.

Maple Hollow Raw Data--Community 1

Species	# pts. of occurrence	# ind.	total basal area (dm^2)	ave. basal area (dm^2)	Rel. Density	Rel. Frequency	Rel. Dominance	Importance Value	Ave. Tree Height (m)
saccharum (sugar maple)	13	25	259.04	10.36	41.67	32.50	69.36	47.8	16.97
rubrum (red maple)	8	8	38.65	4.83	13.33	20.00	10.35	14.6	14.63
virginiana (Virginia pine)	6	9	23.39	2.60	15.00	15.00	6.26	12.1	10.33
pseudoacacia (black locust)	4	5	8.15	1.63	8.33	10.00	2.18	6.8	8.67
ovata (shagbark hickory)	2	5	20.85	4.17	8.33	5.00	5.58	6.3	12.40
virginiana (common chokecherry)	2	2	4.25	2.13	3.33	5.00	1.14	3.2	15.00
triacanthos (honeylocust)	1	2	5.20	2.60	3.33	2.50	1.39	2.4	15.00
alba (white oak)	1	1	5.80	5.80	1.67	2.50	1.55	1.9	15.00
rubra (slippery elm)	1	1	5.00	5.00	1.67	2.50	1.34	1.8	12.00
americana (American elm)	1	1	1.50	1.50	1.67	2.50	.40	1.5	10.50
cinerea (butternut)	1	1	1.65	1.65	1.67	2.50	.44	1.5	9.00
11 species	40	60	373.48		100	100	99.99	999	

Maple Hollow Calculations

60 Distances

436.97m = Total Distance

7.28 m = Mean Distance

53.00m = Mean Area

All Species Density = $\frac{10{,}000\ m^2/ha}{53.0\ m^2/tree}$ = (189 trees/ha) or $\frac{4046.85\ m^2/acre}{53.0\ m^2/tree}$ = 77 trees/acre

Ave. Basal Area/Tree $= \frac{373.48\ dm^2}{60\ trees} =$ (6.22 dm^2/tree)

All Species BA/Hectare $= 6.22\ dm^2/tree \times 189\ trees/ha =$ (1176 dm^2/ha)

Density of Each Species:

	(Density/ha)(Ave. BA)
Sugar Maple: $\frac{41.67}{100} = \frac{x}{189} \Leftrightarrow x = 78.8$ trees/ha	(78.8)(10.36) = 816.4
Red Maple: $\frac{13.33}{100} = \frac{x}{189} \Leftrightarrow x = 25.2$ trees/ha	(25.2)(4.83) = 121.7
Va. Pine: $\frac{15.0}{100} = \frac{x}{189} \Leftrightarrow x = 28.4$ trees/ha	(28.4)(2.60) = 73.8
Black Locust: $\frac{8.33}{100} = \frac{x}{189} \Leftrightarrow x = 15.7$ trees/ha	(15.7)(1.63) = 25.6
Shagbark Hickory: $\frac{8.33}{100} = \frac{x}{189} \Leftrightarrow x = 15.7$ trees/ha	(15.7)(4.17) = 65.5
Com. Chokecherry: $\frac{3.33}{100} = \frac{x}{189} \Leftrightarrow x = 6.3$ trees/ha	(6.3)(2.13) = 13.4
Honeylocust: $\frac{3.33}{100} = \frac{x}{189} \Leftrightarrow x = 6.3$ trees/ha	(6.3)(2.60) = 16.4
Wt. Oak: $\frac{1.67}{100} = \frac{x}{189} \Leftrightarrow x = 3.2$ trees/ha	(3.2)(5.80) = 18.6
Slippery Elm: $\frac{1.67}{100} = \frac{x}{189} \Leftrightarrow x = 3.2$ trees/ha	(3.2)(5.00) = 16.0
Am. Elm: $\frac{1.67}{100} = \frac{x}{189} \Leftrightarrow x = 3.2$ trees/ha	(3.2)(1.50) = 4.8
Butternut: $\frac{1.67}{100} = \frac{x}{189} \Leftrightarrow x = 3.2$ trees/ha	(3.2)(1.65) = 5.3

Σ All Species BA/ha = (1177)

Checks out with calculation above for tot. dm^2/ha; error due to significant figures.

10% Rule:

Variance (s^2) = 543.79

$s = 23.32$

$s\bar{x} = 6.03$ $\qquad \frac{6.03}{77} = .0783$

* Complies with 10% rule.

South Slope--Community 2

Community 2 is the most immature of the three areas which we studied; it was first farmed between 1855 to 1860 and was used for agricultural purposes continuously until sometime between the years 1910 and 1920. Due to the youth of this presently-dominated white oak stand, a large number of diverse tree species with generally low importance value components (rel. freq., rel. den., and rel. dom.) are typified. Many of the species present are pioneer and mid-successional types, which is reasonable considering the poorly developed soil and high light availability factors within the community.

This stand is highly affected by man's recent intrusion in the area. The thin soil contains numerous fine shale particles and is very low in organic content from qualitative observations; virtually no topsoil covers it since not enough vegetation debris has yet been able to accumulate and decompose on top of the poor soil. This lack of litter decay and subsequent humic formation in the soil is due to several factors: (1)the vegetation has not yet matured enough to produce as extensive a leaf fall as is present in the maple hollow, for example, (2)the dryness of the upper areas of the slope have slowed decomposition of the litter to a large degree, and (3)the high wind factor of this relatively unsheltered community may blow many of the leaves down the slope into the depressions at the upper boundary area of the maple hollow, especially since less vegetation of this area is present to help control the wind and keep the litter in place.

This stand is predominantly a xeric area, though toward its lower boundaries at the base of the slope it becomes more mesic by degrees. The reasons for this lack of moisture in the soil are closely comparable to many of the factors controlling the lack of good soil--largely due to the immaturity of the community but also to a large degree because of the steep slope and exposure of the area. Specifically, more wind, light and temperature effects limit the moisture availability down this slope than they do in the other two communities. In the two other stands, better developed tree canopies and soil conditions (older soils have generally higher water holding capaci-

ties than recently cultivated soils due to deeper topsoil and more organic content in the upper layers) serve to maintain more stable community microclimates as far as edaphic conditions are concerned--the canopies control wind, temperature and light penetration to the forest floor while the soil controls moisture retention, and both organic and inorganic nutrient flow.

The steepness of the slope is another major contributor to the xeric conditions as evidenced by significant precipitation runoff down a number of observable depressions leading into the maple hollow. Of course, the compact, basically grass/herb/litter-free character of the soil would not present much of an obstacle to the moisture in its downward movement. This extensive runoff will serve to erode some of any organic material or topsoil which does accumulate and will also greatly deplete the sloping community of much of its mineral nutrient supply which is weakly bound by the poor soil.

Thus, it is a reasonable assumption that many years must elapse before the soil of this community can regenerate itself to a state of stability. Numerous factors are presently interacting to shape the future edaphic nature of this community; most of them seem to be working against its rapid development. The major criterion that this soil requires before it can support a more productive forest, though, is further development of its vegetation. This demonstrates how succession is a two-way interaction between plants and their environment. The trees of this community aid in the development of the soil, while these improving edaphic factors in turn effect the nature of the vegetation growth which they support.

At present this community is adding many more valuable resources (water, minerals, organic debris, etc.) to its lower areas and to the maple hollow community than it will continue to contribute in the future. Certainly some resources will always be lost to neighboring communities, but this outflow should continually decrease with increased maturation of the stand. Due to all of the environmental drawbacks associated with this community, though, it will probably never be as productive as a more favorable area such as the maple hollow. The more highly developed north slope stand (community

3), similar in many environmental qualities to the south slope, may be a good indication of what this community will be like in a later stage of succession.

One final comment about the edaphic nature of this stand. Most of the more mesic plants which were sampled were found in the ecotone between communities 1 and 2. There are several less steeply sloped areas near the maple hollow border which were considered as parts of the south slope community, whether justly or not. The species which compose parts of this intergrade region (indicated on Map 1 by purple with lines drawn across the maple hollow depressions to represent species diversity and overlap) include most of the sugar maples, red maples, hickories and dogwoods that were sampled for community 2. Thus, due to the poor quality and moisture content of the soil as a whole, only the hardier xeric-adapted species are located throughout the upper areas of the stand, while most of the more mesic species are scattered in the lower slope regions.

The disturbance of much of this community has occurred at its borders with the cleared fields along the inlet. The extensive cuttings done by man along this boundary has resulted in a very irregular shape to the stand with pioneer species irregularly spaced near the forest edge. Thus, this stand is not fully representative of a natural community, particularly near its edges, but within its interior some interesting successional transitions are taking place.

The Virginia pines were probably the first species to naturally dominate following farming operations. A significant number of Scotch pines also inhabit areas along the slope, mostly above the fields bordering the lake, but it is assumed that they were planted by man since this species is not native to the United States. Short, scrubby trees, mostly pines with some small oaks, are scattered throughout the upper areas of the community. By "upper areas" is meant all of the community (in a vertical direction) from its intersection with the fields along the lake up to the top of the ridge and in a horizontal direction along the entire ridge from the beginning of the community (at its western side) all the way to the eastern tip of the ridge before it slopes steeply down to the lake (see Map 1 for a graphical representation). A major

part of the community being avoided in distinguishing this upper area of the south slope is the unique mesic ecotone area at the bottom where community 2 intergrades into the maple hollow. Returning to the subject, the scrubby vegetation is thick to such a high degree as to make walking through parts of the upper community very difficult; barbed shrubs and thickets of closely spaced saplings, all resultants of the disturbed soil and xeric conditions, are quite prevalent.

Numerous young saplings (too small to be sampled) of red maple and dogwood are located in the small ecotone area of semi-mesic, though still very shaley and poorly developed, soil above the maple hollow. This area has fewer scrubby thickets than most of the rest of community 2 but is nevertheless difficult to traverse due to the high density of the saplings. The high number of red maple saplings suggest that perhaps due to the higher moisture content of this area compared to farther up toward the ridge, more red maples (which are often successional preludes to the climax sugar maples) became established early and skipped the usual pioneer and diverse species stage which is the phase that the upper slope is just beginning to come out of with the increasing dominance by the white oaks. Red maples are more mesic than pines and oaks but require more xeric conditions than sugar maples. Further reasoning would suggest that this small area, upon future maturation of the present red maples and consequent soil changes, will be replaced by sugar maples. An expansion of the present maple hollow community would be the result of such a replacement.

The liklihood of this sugar maple takeover is high since (1)the area is in close proximity to the sugar maples in the hollow and (2)the area has already proved its favorableness to maples as a result of the red maple establishment. Thus, in this possible successional situation, the red maples are presently creating a micro-environment for themselves which could eventually result in their extinction by the sugar maples.

A final qualitative vegetation observation should be made. At the point of the peninsula there is a very steep drop from the end of the ridge down to water's edge. This area and other less-steep land above the cleared field at the northeastern end

of the peninsula, comprise the youngest forested section of the entire field station. It overlaps across the boundary between communities 2 and 3 and was last farmed in 1955 (see Map 1 for an area with striped red lines). Saplings of pine, red maple and scattered hickories, accompanied by increased quantities of grasses and herbs, are located on this relatively rich soil. This area, though it contains many diverse and somewhat uncharacteristic flora for the two communities in which it is included, has been considered a part of both communities mainly because of environmental correlations with aspects of both communities 2 and 3 which it represents. After this area matures, it will be interesting to see if its climax vegetation does indeed justify its inclusion into both of these communities or if it represents a separate community with unique characteristics. This area is relatively small and secluded at the tip of the peninsula; it is not representative of the majority of these two communities and, though included in sampling, will not be mentioned again.

The three species with the largest importance values are white oak, Virginia pine and common chokecherry in decreasing order of importance. This result is not surprising since each of these species is representative of a major development in the maturation of this young community. The third most important tree of the community, the common chokecherry, is a pioneer species which is largely represented along the borderline of community 2 with the grass fields above the lake inlet. This species is also dotted throughout most of the interior of the community but with far less frequency. These trees are often indicators of land which has been disrupted by man either by cultivation or cutting, both of which apply in this community. Other than serving as an indicator, the common chokecherry's significance in this stand is limited (except perhaps for its role in providing food for birds in the way of berries during summer and autumn months).

The Virginia pine, another pioneer species, probably was the earliest dominant of this south slope due to its tolerance of a harsh, recently-disturbed environment as well as its need for a high light factor. As a result of overshadowing by oaks and other taller trees as the community progresses, these pines, like the chokecherries,

will probably become less and less important members of the community. Only near the top of the ridge where the soil is most xeric and where tree densities of other species are thin do the pines have a good chance to survive for a long time. The white oaks, by far the most influential trees in this community, will probably remain the dominants for many years and could represent the climax species for the majority of the south slope. The only tree species presently posing a threat to the future domination by white oaks are the maples; as previously discussed, the red maples are establishing themselves in many of the lower areas of the slope next to the maple hollow. The degree to which these maples encroach upon the white oaks of the upper slopes will depend on a number of environmental developments of this community which only the future can answer. Both the biotic and abiotic components of the south slope are too underdeveloped at present to make any definite conclusions as to how far up the slope the maples will settle. This is a dynamically interacting area between a mature lowland sugar maple stand and a young upland white oak-dominated stand. Numerous factors are involved in this classic phytosociological encounter; it will be interesting to see what has happened in 75 or 100 years after the soil of the south slope becomes more developed (assuming that man does not disturb the area again).

My prognostication about the maple hollow/white oak community struggle is as follows. Either one of two things will happen depending on the exact way in which the red maples and the sugar maples respond to the ever-changing edaphic qualities of the ecotone. In both cases, one or the other of the two species of maple will advance part way up the slope--probably not more than half way up--by outcompeting the oaks for available resources; the edaphic conditions will be continuously improving on the slope as the vegetation on it matures and the maples will have little problem with light availability since they are more shade tolerant than the oaks which will be dominant. The gradually increasing dryness and underdevelopment of the soil from lower to upper levels of the slope will determine how far the maples will advance. In other words, moisture and nutrient availability will be the two main limiting factors of the maples.

My first theory is that the red maples, since they are more xeric-tolerant than sugar maples, could form a horizontal strip of dominance between the upper oaks and the lower sugar maples along the length of the slope. Depending on how variable the sum of environmental conditions become as you proceed up the slope and whether or not the red maples can find their own specific niche within this gradient, then perhaps they could become the climax species in this present ecotone region. Numerous red maple saplings are already established within parts of this region suggesting that changes are already underway. The second possibility is that the red maples will move into this area and then be eventually replaced by sugar maples, the climax species, in a typical successional sequence (the same continuum which probably took place in the initial development of the maple hollow). The factor which will decide which of these two species takes control of this area is the degree of niche differentiation of the slope. If the red maples are able to outcompete the sugar maples in this area by specializing in unique edaphic and environmental characteristics which are present, then the area could someday represent three climax communities instead of the two present communities which are separated by a diversely populated ecotone.

The unlikely outcome of the two communities--white oak and sugar maple--with the same boundaries as presently exist should also be mentioned. The only way this situation could take place is if the agricultural disturbance of the south slope had caused permanent soil effects to the point that only oaks could subsist on it. However, the soil of community 2, particularly in the lower slope areas, has a high probability of once again becoming fertile and of developing a good profile which will support the nutrient requirements of maples. This soil development is going to take much time, but it is likely to occur due mostly to the effects of the developing vegetation on it. Also, the fact that red maple saplings are already becoming established on the lower part of the slope (in the ecotone region) adds evidence to the idea of relatively rapid soil improvement.

No obvious vertical stratification of vegetation is yet apparent in this com-

munity. Of significance, though, is the fact that the range of tree heights for the diverse stand is quite homogeneous. The majority of trees average between 10 and 12 meters high. For a comparison, in the maple hollow there exist a number of widely scattered tree heights and several poorly developed canopy strata which are dominated by the single extensive sugar maple canopy. Part of the reason for this close range of heights in community 2 is obviously due to the immaturity of the stand. The role that the environment plays in this phenomenon is not completely clear; a general statement would suggest that the harshness of the edaphic conditions and the steepness of the slope are the two major contributing factors to the relatively low and homogeneous tree heights of all of the species.

A final consideration needs mentioned concerning north-south orientation of this slope. South-facing slopes are typically much drier than north slopes due to sunlight effects and consequent moisture limitations. This xeric-nature characteristic of south slopes is indicated by the lack of presence of any hemlock in community 2, whereas it was found to a small degree in community 3 where moisture is less limiting due to shading by the mountain.

South Slope Raw Data--Community 2

Species	# pts of occurrence	# ind.	total basal area (dm^2)	ave. basal area (dm^2)	Rel. Density	Rel. Frequency	Rel. Dominance	Importance Value	Ave. Tree Height (m)
Quercus alba (white oak)	16	27	66.96	2.48	23.68	23.53	21.43	22.9	10.33
Pinus virginiana (Virginia pine)	6	18	44.40	2.47	15.79	8.82	14.21	12.9	11.03
Prunus virginiana (common chokecherry)	8	15	33.30	2.22	13.16	11.76	11.16	12.0	11.53
Oak$_1$ (hybrid)	7	10	31.80	3.18	8.77	10.29	10.18	9.7	12.50
Pinus sylvestris (Scotch pine)	4	10	26.80	2.68	8.77	5.88	8.58	7.7	10.51
Acer rubrum (red maple)	6	9	17.80	1.98	7.79	8.82	5.70	7.5	11.94
Acer saccharum (sugar maple)	4	6	25.05	4.18	5.26	5.88	8.02	6.4	17.53
Cornus florida (flowering dogwood)	3	3	4.20	1.40	2.63	4.41	3.78	3.6	8.13
Oak$_5$ (hybrid)	3	4	6.00	1.50	3.51	4.41	1.92	3.3	9.63
Quercus coccinea (scarlet oak)	2	2	8.60	4.30	1.75	2.94	2.75	2.5	16.25
Carya ovata (shagbark hickory)	2	3	5.50	1.83	2.63	2.94	1.76	2.4	10.43
Pinus pungens (table-mountain pine)	1	1	8.20	8.20	.88	1.47	2.62	1.7	11.00
Oak$_3$ (hybrid)	1	1	8.50	8.50	.88	1.47	2.72	1.7	15.50
Oak$_4$ (hybrid)	1	1	6.50	6.50	.88	1.47	2.08	1.5	17.50
Fagus grandifolia (american beech)	1	1	4.05	4.05	.88	1.47	1.30	1.2	16.0
Oak$_2$ (hybrid)	1	1	1.60	1.60	.88	1.47	.51	1.0	11.00
Quercus ilicifolia (bear oak)	1	1	1.35	1.35	.88	1.47	.43	.9	11.00
Carya tomentosa (mockernut hickory)	1	1	11.8	11.8	.88	1.47	.45	.9	17.3
totals: 18 species	68	114	312.41		99.9	99.97	99.6	99.8	

South Slope Calculations

14 Distances

071.86 m = Total Distance

9.40 m = Mean Distance

88.36 m^2 = Mean Area

All Species Density = $\frac{10{,}000\ m^2/ha}{88.36\ m^2/tree}$ = (113 trees/ha) or $\frac{4046.85\ m^2/acre}{88.36\ m^2/tree}$ =

(46 trees/acre)

Ave. Basal Area/Tree = $\frac{312.41\ dm^2}{114\ trees}$ = (2.74 dm^2/tree)

All Species BA/Hectare = 2.74 dm^2/tree × 113 trees/ha = (310 dm^2/ha)

Density of Each Species (calculated using proportions as done for maple/hollow) (Density/ha)(Ave. BA)

wt. Oak:	26.8 trees/ha	(26.8)(2.48) = 66.5
Va. Pine:	17.8 "	(17.8)(2.47) = 44.0
Com. Chokecherry:	14.9 "	(14.9)(2.22) = 33.1
Oak$_1$:	9.9 "	(9.9)(3.18) = 31.5
Scotch Pine:	9.9 "	(9.9)(2.68) = 26.5
Red Maple:	8.8 "	(8.8)(1.98) = 17.4
Sugar Maple:	5.9 "	(5.9)(4.18) = 24.7
Fl. Dogwood:	3.0 "	(3.0)(1.40) = 4.2
Oak$_5$:	4.0 "	(4.0)(1.50) = 6.0
Scarlet Oak:	2.0 "	(2.0)(4.30) = 8.6
Shag. Hickory:	3.0 "	(3.0)(1.83) = 5.5
Table-Mt. Pine:	1.0 "	(1.0)(8.20) = 8.2
Oak$_3$:	1.0 "	(1.0)(8.50) = 8.5
Oak$_4$:	1.0 "	(1.0)(6.50) = 6.5
Am. Beech:	1.0 "	(1.0)(4.05) = 4.1
Oak$_2$:	1.0 "	(1.0)(1.60) = 1.6
Bear Oak:	1.0 "	(1.0)(1.35) = 1.4
Mock. Hickory:	1.0 "	(1.0)(11.8) = 11.8

10% Rule:

S^2 = 51.41

S = 7.17

$S\bar{x}$ = 1.34

$\frac{1.34}{113}$ = .012

* Complies with 10% rule.

Σ All Species BA/ha = (310)
Checks out with calculation above for total dm^2/ha

North Slope--Community 3

The forest community located on the north slope presents a fairly stable situation well adapted to a poor site. This stand contains some very large trees and is probably comparable in age to the maple hollow. The only known evidence of man's recent disturbance was aperiod of selected timbering around 1900, but the area was never clear-cut or farmed. One area on the eastern tip of the stand by the lake was known to have been clear-cut in 1955 (map #1, red hatched area) but sampling in this area did not significantly affect the data.

The geography of this site indicates a xeric-mesic transition although on the whole should be considered a xeric site. The slope here is more gradual than the one of community 2 suggesting that drainage is not as rapid as in community 2. Attempts at making soil core samples were greatly hindered by the presence of many rocks, some fairly large, in the soil. This rocky soil supports the fact that chestnut oak (sometimes called rock oak) is the most important species here (I.V. = 37.64). Throughout the Northeast chestnut oak is found on rocky hillsides. Since chestnut oak is well adapted to xeric, disturbed (rocky) sites it is assigned an adaptation value of 3.5 and is not considered a major contributor to the forest types of Pennsylvania. The other two most important species on this site are white oak (I.V. = 21.03) and Virgina pine (I.V. = 11.97). White oak appears to behave similarly to chestnut oak (also 3.5 adaptation value) and Virginia Pine is filling its usual niche as a pioneer species. The Virginia pines were sampled at the top of the slope and could be considered propagations from community 2 possibly in the area where early timbering occured. The very large

oaks (heights up to 20 meters and basal areas of 10 dm^2) were found halfway down the hill. The presence of eastern hemlock (I.V. = 1.49) and sugar maple (I.V. = .89) indicate a mesic habitat, and in fact these trees were sampled at the bottom of the hill.

This community was refered to as being stable because it appears that the most important species, chestnut and white oaks, have a fairly good hold on the environment. Diversity is fairly low on this site with other species (chokecherry, shagbark hickory, and oak hybrids) having low importance values. At many places on the site ground cover is very scarce with the tall oaks recieving most of the sunlight. Observations like this prompt the use of such terms as "climax" or "near climax" which are safe to use here. Where understory was evident the small trees consisted of more chestnut oaks and white oaks along with sapplings of the oak hybrids. With large trees producing a lot of litter over a long period, the soil could be considered to be somewhat fertile. A soil profile revealed that the upper layers were darker than those of community 2 and soil analysis proved the soil to have the highest water holding capacity of the three stands. Perhaps with an increased organic content and a mesic habit this site would give way to the more mesic red oak-like hybrids. The fact still remains that the soil is very rocky (which imposes a bias on the test for water holding capacity of a rock-free sample) and is well adapted to by chestnut oak, which will probably predominate for some time. There appears to be substantial evidence to refer to this stand as a stable chestnut oak-white oak community.

North Slope Raw Data--Community 3

species	# pts. of occurrence	# ind.	total basal area (dm^2)	ave. basal area (dm^2)	Rel. Density	Rel. Frequency	Rel. Dominance	Importance Value	Ave. Tree Height (m)
Quercus prinus (chestnut oak)	26	65	331.24	5.10	44.21	30.59	44.12	39.64	12.23
Quercus alba (white oak)	14	27	212.25	7.86	18.36	16.47	28.27	21.03	16.08
Pinus virginiana (Virginia pine)	14	18	54.20	3.01	12.24	16.47	7.22	11.98	10.76
Oak$_2$ (hybrid)	8	12	59.45	4.95	8.16	9.41	7.92	8.50	13.76
Pinus strobus (white pine)	8	9	32.75	3.64	6.12	9.41	4.36	6.63	11.41
Oak$_4$ (hybrid)	5	5	12.35	2.47	3.40	5.88	1.64	3.64	12.70
Oak$_3$ (hybrid)	3	4	28.75	7.19	2.72	3.53	3.83	3.36	14.38
Tsuga canadensis (eastern hemlock)	2	2	5.70	2.85	1.36	2.35	.76	1.49	10.00
Prunus virginiana (common chokecherry)	2	2	2.40	1.20	1.36	2.35	.32	1.34	8.75
Quercus ilicifolia (bear oak)	1	1	3.00	3.00	.68	1.18	.40	.75	13.00
Acer saccharum (sugar maple)	1	1	6.05	6.05	.68	1.18	.81	.89	17.50
Carya ovata (shagbark hickory)	1	1	2.70	2.70	.68	1.18	.37	.74	14.00
12 species	85	147	750.84		99.97	97.99	100.02	99.9	

North Slope Calculations

147 Distances

784.44 m = Total Distance

5.34 m = Mean Distance

28.52 m^2 = Mean Area

$\frac{10{,}000\ m^2/ha}{28.52\ m^2/tree}$ = 351 trees/hectare or $\frac{4046.85\ m^2/acre}{28.52\ m^2/tree}$ = 142 trees/acre

Ave. Basal Area/Tree $= \frac{750.84\ dm^2}{147\ trees} =$ (5.11 dm^2/tree)

All Species BA/Hectare $= 5.11\ dm^2/tree \times 351\ trees/ha =$ (1794 dm^2/ha)

Density of Each Species (calculated using proportions as done for maple hollow)

		(density/ha)(Ave. BA)
Chestnut Oak:	155.2 trees/ha	~~(155.2)(5.1) = 791.5~~
White Oak:	64.4 trees/ha	(64.4)(7.86) = 506.2
Va. pine:	43.0 trees/ha	(43.0)(3.01) = 129.4
Oak_2:	28.6 trees/ha	(28.6)(4.95) = 141.6
Wt. Pine:	21.5 trees/ha	(21.5)(3.64) = 78.3
Oak_4:	11.9 trees/ha	(11.9)(2.47) = 29.4
Oak_3:	9.5 trees/ha	(9.5)(7.19) = 68.3
E. Hemlock:	4.8 trees/ha	(4.8)(2.85) = 13.7
Com. Chokecherry:	4.8 trees/ha	(4.8)(1.20) = 5.8
Bear Oak:	2.4 trees/ha	(2.4)(3.00) = 7.2
Sugar Maple:	2.4 trees/ha	(2.4)(6.05) = 14.5
Shagbark Hickory:	2.4 trees/ha	(2.4)(2.70) = 6.5

Σ All Species BA/ha = (1792)

Checks out with calculation above for total dm^2/ha; difference due to significant figures.

10% Rule:

$S^2 = 1945.26$

$S = 44.11$

$S\bar{x} = 1.20$

$\frac{1.20}{351} = .003$

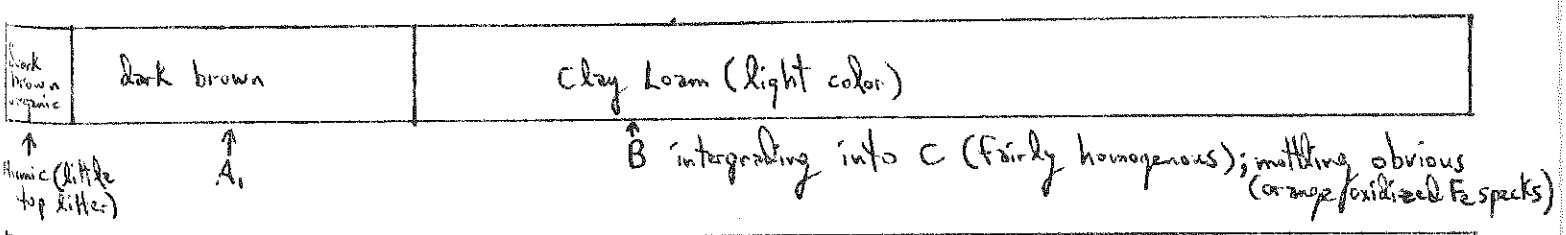
* Complies with 10% rule.

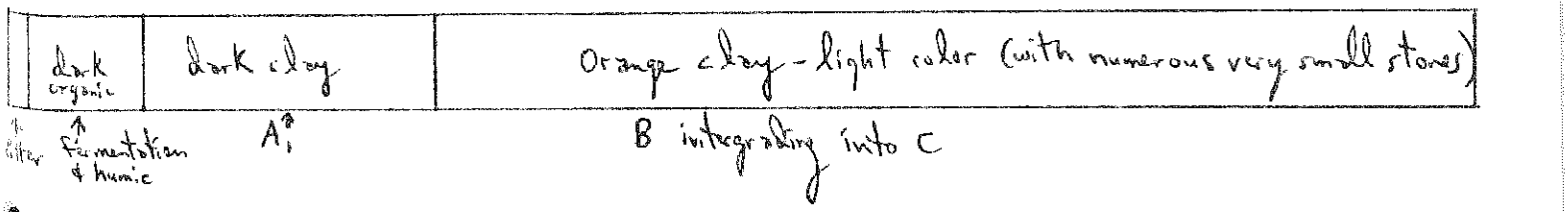
Quantitative Soil Analysis and Interpretation

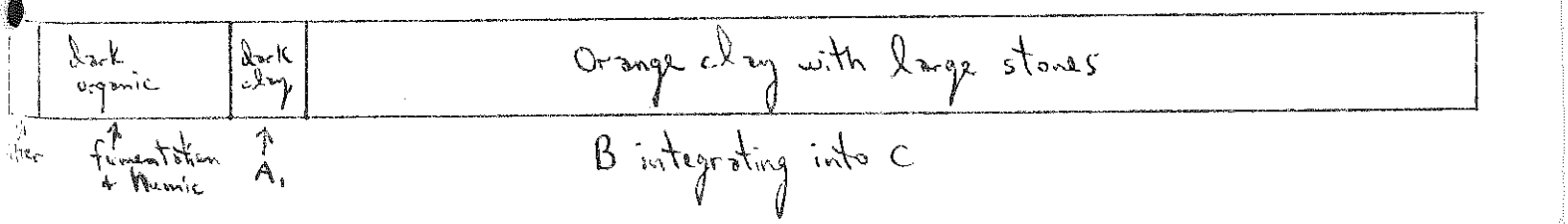
A soil study was carried out for each of the three communities from which we compiled the data below (calculations have been excluded). Intermixed with previous discussions of the three separate communities we have often made mention of their edaphic qualities, but only in a qualitative sense. From the quantitative information below, some concrete conclusions relating vegetation to soil can be drawn. In making these edaphic comparisons it is important to remember that the soil samples analyzed in each community were taken from one location only--one which we considered as representative-looking for that stand. Thus, even though the results below are correct for the soil samples studied, there is nevertheless a relatively high probability of bias concerning the location selected for the sample.

Community	Fresh Wt. Moisture Content (% H_2O FW)	Organic Content (% organic)	Water Holding Cap. (% WHC)	% Relative Water Content	pH
1 - Maple Hollow	31.52%	7.22%	55.33%	56.97%	4.5
2 - South Slope	21.71%	7.17%	27.03%	80.30%	4.6
3 - North Slope	24.96%	11.21%	45.26%	55.15%	4.3

Soil Profiles







The percent moisture content of the three communities turned out as expected with the maple hollow most mesic followed by the next most disturbed and highly elevated area--Community 3--and then followed by the youngest and most exposed community of the three, Community 2. Since south-facing slopes tend to be more xeric than cool, moist north-facing slopes, it could be that the fresh weight moisture contents of these three stands will stay the same relative to one another; it is obvious that the maple hollow, due to its low, enveloped topographic position, will always be the most mesic of the three. But whether the two slope communities converge toward similar moisture conditions as the years proceed is not altogether clear. The determiner will be the degree of environmental and vegetational differences which develop as the two communities mature.

The percent organic content of the soils is also a reasonable result in relative terms, though the high north slope value was a bit surprising in absolute terms. The maple hollow has the largest litter fall of the three communities due to its expansive canopy of leaves and the mere bulk of the dominant sugar maples. But due to the higher moisture content of the maple hollow soil, the litter decomposes more rapidly than on the slopes; the organic material gets cycled much more rapidly, in other words (this also implies that the maple hollow may have quite fertile soil). Also, sugar maples have relatively high nutrient uptake capacities which aid in the rapidity of this organic cycling. As a result, the maple hollow has a low organic content. This is partially verified by the community's soil profile in which the fermentation/humic layer is very small compared to the two other communities. As for Community 3, it is an old community as far as organic accumulation is concerned since its vegetation was only thinned and never farmed. Its more xeric conditions (and subsequent slow organic decomposition), coupled with the extensive leaf fall from some of the large oaks residing there, give it a higher organic content than the maple hollow. Also, this north slope has many more shrubs and herbs than the maple hollow which add much to its organic component. Community 2 is too underdeveloped at present to have a high organic content. This community's litter fall is relatively small due to its vegeta-

tional immaturity and, though it is xeric which implies slow decomposition and high organic content, the soil is so bare that much of the little litter which does fall gets blown down the slope and out of the upper areas of the community. It should be noted that the soil sample for Community 2 was taken 50 meters or so from the top of the ridge. Thus, it is "upper slope" soil in contrast to the more mesic ecotonal soil which is found near the maple hollow community boundary.

An adequate explanation for the present water holding capacity values becomes difficult since such an interpretation depends in part on the texture and mineral characteristics of the various soil levels, the analysis of which we are quite inexperienced with. The maple hollow has the highest water holding capacity of the three communities. Each of the three has a similar clay B layer with shale particles mixed throughout. The clay quality of soil is an important determinant of water holding ability due to its cation exchange capacity, but we are unable to draw any precise comparisons between the clay properties of the three stands from mere qualitative observation. An interesting qualitative comparison can be drawn between water holding capacity and the size of shale particles that were present in the soil, however. The maple hollow had the smallest stone particles, followed by the north slope and the south slope, respectively, in increasing size of shale fragments. This coincides exactly with the relative order of water holding capacity values that we calculated. Obviously, stones do not contribute much to a soil's ability to hold water; thus, the size of the shale particles present seem to represent one of the major factors influencing these relative water holding capacities.

Percent relative water content relates how much water is present in the soil compared to how much it is capable of holding. Thus, it is easy to understand why the south slope--the most xeric community and the one with the lowest percent water holding capacity--has the highest percent relative water content. Since it has a very low water holding capacity, much less moisture is required to reach a given level of saturation than is required in the other two communities with higher water holding capacities. The south slope has the lowest fresh weight moisture content of the

three, but this is more than offset in the percent relative water content calculation by the large differences in water holding capacity between community 2 and the other two communities.

pH is another result which coincides nicely with the known conditions within each community. Though the pH readings were close in all three stands, the north slope has the most acidic soil; this would be a result of its high organic content which lowers pH through the leaching out of organic acids. The maple hollow, ranking next in organic content, also ranks second in pH. Finally, the south slope has the highest pH due to its underdeveloped organic content.

Unfortunately we were unable to obtain reasonable results of plant available phosphorus for the three stands. Thus, no measure of mineral fertility has been determined.

The soil profiles do not show any unique or very exciting layer differentiation like we observed in the hemlock forest at Alan Seegar, but this is to be expected due to the shaley and podzolic nature of the field station soil. The maple hollow soil seems to represent the best profile for tree growth due to its deep A layer. Typical of brown forest podzolic soils, each of the three stands had no A_2 layer and a poorly differentiated B layer consisting of clay and shale fragments, the latter actually being one relatively homogenous B-C layer with little difference as you got deeper instead of two distinct B and C layers. The humic and litter layers varied in expected ways between the communities depending mostly on the rate of litter decomposition. Limited leaching has occurred in all of the three soils due to the lack of a greyish A_2 layer and also since the plants in these communities, particularly in the maple hollow, are taking up nutrients so rapidly.

The edaphic component of any vegetation stand interacts in an indeterminable number of ways with each of the other biotic and abiotic elements of the area. These complex matrices of interrelatedness are no exception in the three communities examined here. It is impossible that every factor can ever be considered even after years of research, but we have tried to related a few of the most basic and obvious interactions

which we observed in order to gain a rough understanding of why things are as they are at the field station. This goes for all of our other interpretations in this paper as well. Our assumptions and conclusions may not all be correct, but they are at least honest attempts aimed at reasoning through the jumble of relationships which we have viewed.

Species Characteristics

The section is devoted to an explanation of the behavioral characteristics of the most important species sampled throughout this study. Where possible, experimental data on a given species' physiological mechanisms is provided. This type of information verifies why certain trees are successful where they grow because of utilization of environmental factors. The one major factor which influences a species' distribution, which crops up throughout this study, is moisture availability and a trees tolerance to a lack of it. Where concrete physilogical data is not available descriptions are made according to known behavior or research done on an ecologically equal species. Discussion is also provided here of the oak hybrids which occur at the field stations. These trees are considered intergrades between red oak types with known behavior.

The ability of a tree to maintain a suitable internal moisture level on a dry site will determine its success on that site. To avoid dessication in dry habitats stomatal openings must be very limited, but not so much as to impede movement of carbon dioxide to chloroplasts and thus hinder productivity. Important factors in this relationship are the diffusion gradient of water vapor from the plant to the atmosphere and the diffusion gradient of carbon dioxide from the atmosphere to photosynthetic sites in the chloroplasts. Important in both of these diffusion gradients is stomatal resistance, mesophyl tissue resistance, and leaf temperature. A competant study of these mechanisms was performed by J.E. Wuenscher and T.T. Kozlowski (1971) at the University of Wisconsin. A graph of water use efficiencies as influenced by light intensity (at a leaf temperature of 30°C.) and leaf temperature

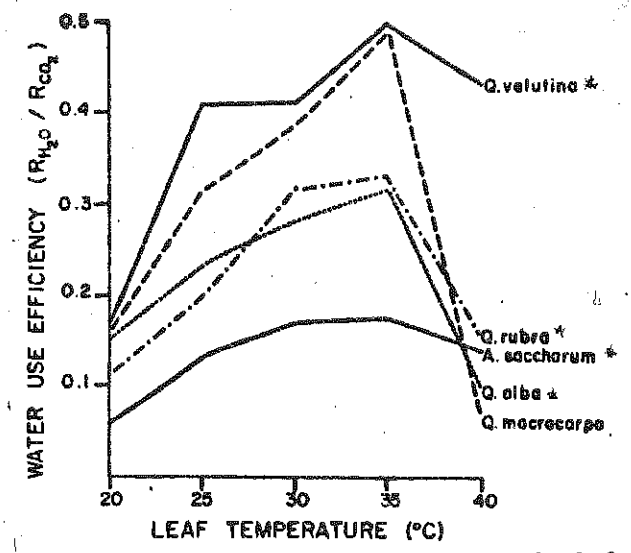


FIG. 15. Water-use efficiencies as influenced by leaf temperature at a light intensity of 0.24 cal cm^{-2} min^{-1}.

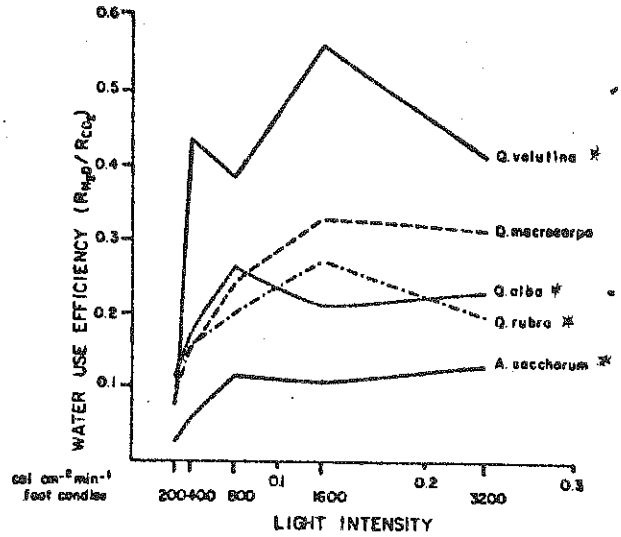


FIG. 16. Water-use efficiencies as influenced by light intensity at a leaf temperature of 30°C.

Both after Wuenscher and Kozlowski (1971)

(at a light intensity of .24cal.cm^{-2}min^{-1}) is provided from this study with the starred species relevant to the field station study. Quercus rubra and Q. velutina are included because they are considered intergrades in the oak hybrids. References to the Wisconsin study are made where applicable to the following species descriptions.

Acer saccharum

The sugar maple is a very successful species and the most mesic of the trees sampled. Sugar maples have the lowest water use efficiency of the species sampled which follows from an examination of its habitat. Existing on ~~wet~~ moist sites, the sugar maple can afford to have its stomates open for maximum photosynthesis without ~~fear~~ DANGER of desication. It is interesting to note that stomatal resistance and internal CO_2 concentration increases and mesophyl resistance decreases along the environmental gradient from mesic to xeric (Wuenscher, 1971). High mesophyl resistance, indicating large amounts of mesophyl tissue, should be expected for this maple because of its good productivity (leaf biomass). High concentrations of mesophyl can be seen in the fleshiness of the leaves which lack a high amount of scleretized tissue. Along with being fleshy, the leaves are not highly dissected like oaks, which adds to their high water loss (more surface area). Also very interesting about sugar maple leaves is that their orientation is for the most part horizontal. This feature allows for maximum light use and inhibition of understory species because of this light use. This DEEP SHADE vivacity of the sugar maple on mesic sites allows it to establish itself under mid-successional species like red maple but prevents other species from coming in underneath it..

Acer rubrum

The red maple is many times found in association with sugar maple but has a wider environmental tolerance. In northern Wisconsin forests a bimodality is expressed in this tree achieving high levels of dominance in dry-mesic and wet-mesic environments (Curtis, 1959). The red maple exhibits an intermediate dgree of shade tolerance which allows it to come in underneath several canopy trees, except A. saccharum. Red maple is also known to rapidly infiltrate disturbed or burned over areas. Red maple is usually never established as the primary dominant (because sugar maple usually takes over) and individuals do not attain great sizes due perhaps to susceptability to diseases. The leaves of red maple, although of similar morphology to sugar maple (with fine serations), are not situated horizontally which accounts for them not being equal light competitors. The main ecological significance of this species is its range of distribution between wet-mesic and dry-mesic stands and its ability to establish itself below others.

Quercus alba

Of the oaks one usually thinks of two major types: the red oak group, characterized by pointed lobes on leaves, and the white oak group, characterized by round-lobed leaves, of which Q. alba is a member. The variation of white oak found in field station stands is called latiloba, with leaves whose invaginations go less than half way to the midrib. Oaks in general are considered a xeric group, although the water use efficiency of white oak falls in the range of the more mesic oaks. Found mainly on xeric sites, the white oak must have a mechanism for dealing with water unavailability. This mechanism ~~is to have~~ involves a high stomatal resistance, making the internal concentration of CO_2 very low (almost to zero) facilitating a high

diffusion gradient of CO_2 into the leaf. (Wuenscher, 1971) This high diffusion gradient means that ~~on the few occasions of~~ even with a narrow stomatal opening a good deal of CO_2 will be delivered to the chloroplasts and productivity will be maintained adequately. This is a general feature of oaks along with the fact that they all have very deep root systems for water uptake.

The morphology of white oak leaves is of similar consequence to all oaks as xerophytes and will be dealt with here. Oak leaves are considered sclerophylous, which means that unlike the fleshy maple leaves, oak leaves are rather thin and rigid. Sclerophylous refers to the fact that cells of the leaf tissue is scleretized, or has a secondary layer of cellulose laid down, facilitating the rigidity and preventing wilting in dry spells. The other feature aiding oaks as xerophytes is the highly dissected nature of their leaf margins. The dissected leaf avoids water loss simply by having less surface area that other leaves but more importantly the dissection breaks up the boundary layer of stagnant air around the leaf. This very thin air layer, held by an adhesive force, is important in temperature control. A large boundary layer area (ie. maple) may heat up considerably under the suns radiation causing evaporation , whereas a broken boundary layer of a dissected leaf will not heat up rapidly, can be more easily colled by wind, and will avoid evaporation. It is these xeromorphological features of oak leaves that aid in their adaptation to xeric habitats.

Quercus prinus

The chestnut oak is considered to belong to a sub-division of the white oak group. The leaves of chestnut oaks are shallowly lobed compared to other white oaks but still maintain the sclerophylous nature of these xerophytes. Chestnut oaks are found on dry

rocky soils and are sometimes refered to as rock oak. These trees may reach dominance on rocky terrain and will usually be less significant on better sites. Chestnut oak is important in preventing erosion on these poor sites so that other species may grow.

Prunus virginiana

The common chokecherry is a prolific contributor to the dry forests of our area. The chokecherry is a small spindly tree which is known for dominating in sapling size classes, and when breaks in the canopy occur they can mature to sizeable trees. Chokecherry sprouts abundantly yielding sapplings which have a high shade tolerance but whose tolerance drops as the tree grows in height. It is known that birds which eat fruits aid in the wide distribution of chokecherry, especially along hedgerows. Comparitively, Prunus virginiana is not as important a tree as other hardwoods, but it does fill a significant niche in filling a "gap phase" of succession following a disturbance, and can be refered to as a pioneer species.

Pinus virginiana

Virginia pine is a scrubby tree which is very important as a pioneer species, much like the chokecherry. It is considered a pioneer species because of its good ability to grow on poor dry soils especially after disturbance, and many abandoned farmlands eventually support pure stands of this species. The tree is characterized by a fast growing shoot which extends to the canopy where a scrubby bole of needles sprouts.

Quercus Hybrids

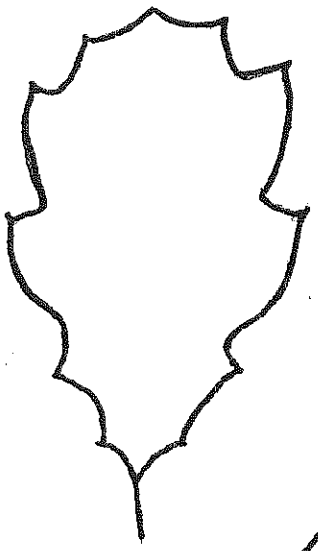
Oaks are hardy trees important to our xeric forests, and are known to transcend through mesic gradients (ie. swamp chestnut oak). Within the distinct oak groups, white oaks and red oaks, it is

known that species become less well defined. Many oaks found in the field may be considered intergrades between similar species, results of introgressive hybridization along an environmental gradient. Many times leaves may appear like one species but the bark or twigs may seem like another on the same individual. Researchers in Wisconsin forests believed to have found Q. alba types which were endowed with a certain fire resistance through introgression with Q. macrocarpa (Curtis, 1959). In this study of the Raystown Field Station several trees were sampled which were believed to be intergrades between several red oak types.

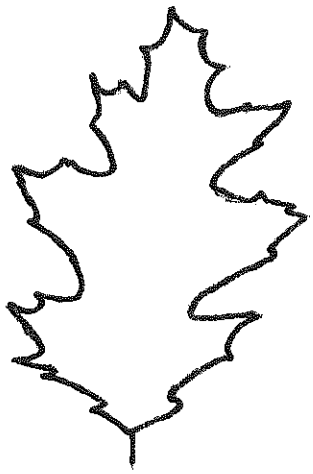
The oak hybrids sampled were believed to be intergrades of black oak (Q. velutina), red oak (Q. rubra), and bear oak (Q. ilicifolia). One tree was found that was believed to be pure black oak (by verification of fruit and twig) and one supposedly pure bear oak was found. All of the hybrids sampled had leaves like the red oak, with many variations, but usually the bark and stance of these trees could not satisfy these investigators in deeming them red oaks. The reason for assuming hybridization with black oak and bear oak deals with the invaginations of the leaf margins. Blask oak leaves are characterized by deep invaginations while bear oak has shallower invaginations and typically the leaf is very broad toward the top. Leaves of the sampled hybrids showed varied degrees of these features, especially of being broad toward the top. These assumptions arise from purely qualitative observations, leaving much room for further examinations of barks and tissues or even biochemical analysis.

The remaining support, that most significant to this study, for this assumed hybridization is that the distribution behavior of the hybrids seems introgressive of the three species believed

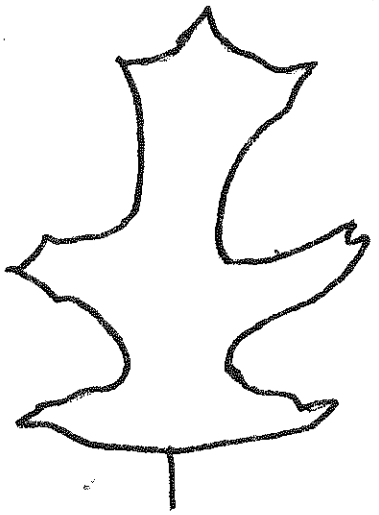
Oak Leaves



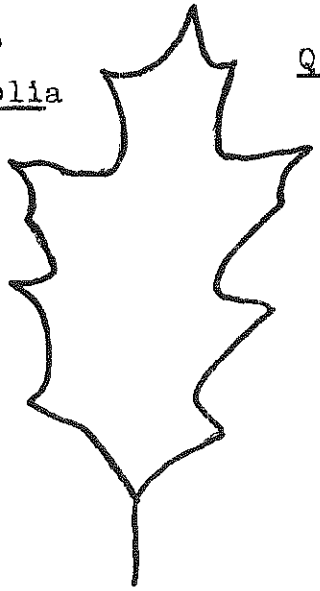
Q. ilicifolia



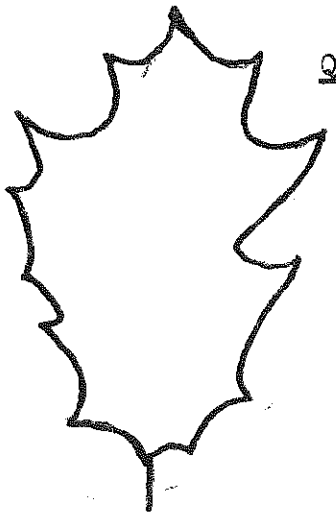
Q. rubra



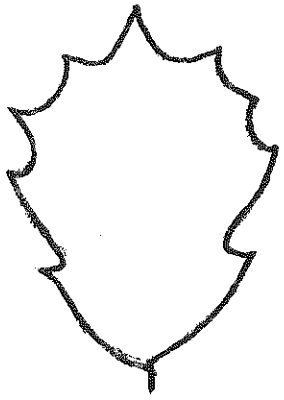
Q. velutina



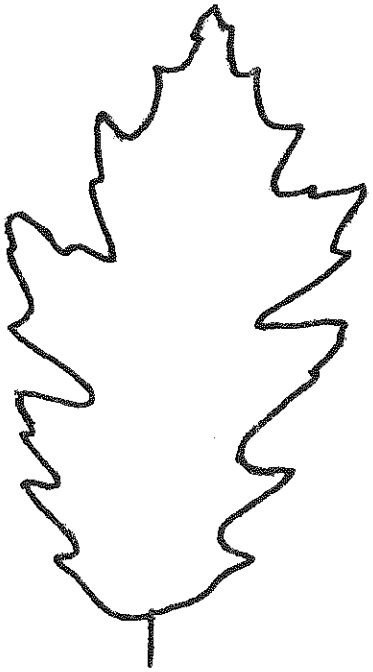
Oak_1



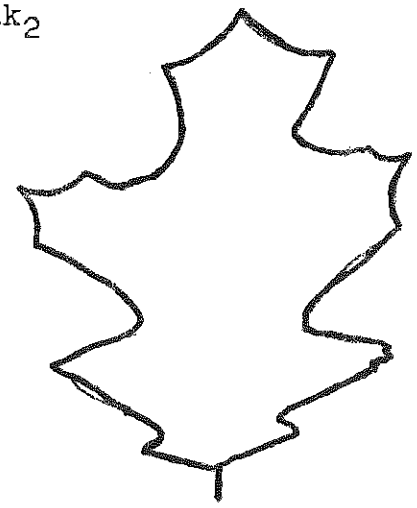
Oak_2



Oak_3



Oak_4



Oak_5

to have hybridized. From the water use efficiency data of Wuenscher and Kozlowski one sees that Q. rubra is the most mesic of the oaks and Q. velutina is the most xeric. Q. ilicifolia is also known to grow well on sandy or rocky soils. The hybrids sampled were found at all points along a hillside, although primarily toward the top. Upon walking other unsampled sections of the field station these types were found abundantly along ridgetops and down the sides. For the sake of consistancy all five hybrids were considered ecological equals and were assigned an adaptation value of 3.5 on a scale from xeric (1.0) to mesic (10.0). It is felt that these hybrid oaks have a range of xeric tolerances and that they have the potential for dominance on poor hillside sites.

Closing Discussion

At this point all of the vegetation data has been expressed and analyzed for each community. It is appropriate to now discuss the relationship that these three stands have with one another. A statistical test to determine if enough points were sampled was performed (the 10% rule) and proved that each stand was sampled adequately to give significant results.

A test for similarity between communities was performed following the example of Sørensen (1948) in computing similarity indices. Similarity was determined by the number of species common to two stands and the total number of species in each stand (diversity) by the equation IS = 2c/A+B (100) where c is the number of species common to two stands, A the total number of species in stand A and B the total number of species in stand B. For the Raystown Field Station the maple hollow and the south slope were 48% similar, the maple hollow and the north slope were also 48% similar, and the north slope and south slope were 58% similar. These numbers seem very nice and appear to follow from what is now known. The north slope and south slope are both oak forests and it would be expected that their similarity to the maple forest would be the same, as it is. Also the fact that both the north and south slopes are oak forests supports the fact that they are the most similar of the three stands at 58% similarity. There are seven species in common to these two slopesof which there are ten total for the north slope and 14 on the south slope.

Another way of ordinating sample stand data is by computation of the compositional index for each stand. The compositional index is calculated by multiplying the importance value for a species by its adaptation value and then summing all of the products

Community Compositional Indices

species	Adaptation value	Composition numbers & Importance Values					
		Stand 1		Stand 2		Stand 3	
Acer saccharum	10.0	47.8	478	6.4	64	.89	8.9
Acer rubrum	7.0	14.6	102.2	7.5	52.5	-	
Carya ovata	5.0	6.3	31.5	2.4	12.0	.74	3.7
Carya tomentosa	5.0	-		.9	4.5	-	
Cornus florida	3.0	-		3.6	10.8	-	
Fagus grandifolia	9.5	-		1.2	11.4	-	
Gleditsia triacanthos	7.0	2.4	16.8	-		-	
Juglans cinerea	7.0	1.5	10.5	-		-	
Pinus pugens	2.0	-		1.7	3.4	-	
Pinus sylvestris	*	-		7.7		-	
Pinus virginiana	1.0	12.	12.1	12.0	12.0	12.0	12.0
Quercus alba	3.5	1.9	6.7	22.9	80.2	21.3	74.6
Quercus ilicifolia	1.0	-		.9	.9	.75	.75
Quercus coccinea	3.0	-		2.5	7.5	-	
Quercus prinus	3.5	-		-		39.6	138.6
Quercus Hybrids	3.5	-		13.9	48.7	15.5	54.3
Robinia pseudoacacia	7.0	6.8	47.6	-		-	
Tsuga canadensis	9.0	-		-		1.5	13.5
Ulmus americana	7.5	1.5	11.3	-		-	
Ulmus rubra	7.5	1.8	13.5	-		-	
Prunus virginiana	3.5	3.2	10.2	12.0	42.0	1.3	4.6
Compositional Index:			740.4		349.9		311.0

* An introduced species, not to be considered here.

for each species to obtain the index. Adaptation values are assigned according to how well a species adapts to a mesic habitat. Thus sugar maple is assigned a value of 10.0 and virginia pine a value of 1.0 following the ecological gradient from mesic to xeric. In light of this it can be seen that the compositional index is a general description of a community according to how many well adapted dominant species are found there (important species). A community which has a few mesic species with high importance values will have a high compositional index. In this case the most mesic stand, the maple hollow, has the highest compositional index at 740.4. The other stands show typically lower indices for xeric sites. It is significant for these xeric stands that the north slope has a lower value than the south, attributed probably to the lowere diversity on the north slope.

The information presented in this study is significant in better understanding the vegetation of the Raystown Field station. This study also gave a great deal of enlightenment to the investigators on Pennsylvania forests in general. The authors wish to acknowledge Todd D. Gustafson, Robert L. Fisher, and Clair Grove for their help in dealing with two would-be foresters.

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1979

LIMNOLOGICAL CHARACTERISTICS AND ALGAL RESPONSES TO NUTRIENT ADDITIONS IN WATERS OF RAYSTOWN LAKE

by

Elaine D. Keithan

Presented to the Faculty of

Bucknell University

in Partial Fulfillment of

the Requirements for the Degree

of Master of Science in Biology

Approved: Wayne F. McDuffett
Advisor

Wayne F. McDuffett
Department Chairman

September, 1979

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A limnological investigation was carried out on Raystown Lake, Huntindgon County, Pennsylvania, from February through December, 1978. To the author's knowledge, no comprehensive investigation of this lake has been performed to date. In addition to providing needed base line information on this system, a primary objective was to determine the effect of nutrient enrichment on growth of natural algal populations in the lake. It is hoped that information obtained in this study may be used to determine the effect on the lake system of nutrient loading from the surrounding watershed.

Many studies have been carried out to determine the effect of excessive nutrient input, for example, sewage effluent on algal growth in lakes (Schindler, 1971; Maloney, Miller and Shiroyama, 1972; Miller and Maloney, 1972; Powers, Schults, Malveg, Brice and Schuldt, 1972). A number of investigators have concluded that phosphorus is the most limiting element to the growth and abundance of phytoplankton in most fresh water lakes (Maloney, Miller and Shiroyama, 1972; Vanderhoef, 1974; Schelski, 1974; Allen and Kramer, 1972; Powers, Schults, Malveg, Brice and Schuldt, 1972).

Raystown Lake, located in Huntingdon and Bedford Counties, south-central Pennsylvania, was constructed under the authorization of the Flood Control Act of 1962. The lake is formed by the Raystown Dam, located in the Raystown Branch of the Juniata River. The Raystown Dam was constructed between 1969 and 1973 and designed to provide flood control in the Susquehanna River Basin system, recreation, enhanced fishery, and downstream flow augmentation. Raystown Dam is a rock

and earthfill embankment, 1,700 feet in length and 225 feet in height. The area surrounding the lake is predominantly mixed deciduous forest with small areas of cultivation. The lake is underlain mainly by Devonian shale, sandstone, and highly fertile soils with silt-loam and sandy-loam textures (U. S. Department of Agriculture, 1972).

MATERIALS AND METHODS

Samples for physical-chemical analyses were taken every three weeks (except monthly for February and March) for the period February through December, 1978. Water was collected from eight sites located throughout the reservoir in areas where major streams with perennial flow enter: Hawns Run, James Creek, Coffee Run and Shy Beaver Creek entering the west shore of the lake at 6.4 km, 30.1 km, 40.2 km, and 44.2 km, respectively, above the dam; Great Trough Creek and Tatman Run enter the east shore of the lake at 31.4 km and 32.2 km, respectively, above the dam; also at mile marker 24 (farthest upstream site sampled) and at the breast of the dam (see Figure 1 for sample site locations). Surface samples were collected at these sites to determine the effect of allochthonous materials entering the lake basin. A Boston Whaler was used for transportation to the sites, the samples being taken well up into the stream areas in order to sample water that was a result of the stream inflow before being completely mixed with the major body of water. In addition, vertical series of samples were collected at a ninth site located in Juniata Harbor.

Samples for dissolved oxygen were collected in 125 ml glass, ground-stoppered bottles and were fixed in the field with the first two Winkler reagents. Conductivity, pH and temperature were measured with the aid of portable instruments. Samples were collected at the Juniata Harbor site every three meters to a depth of 18 meters using a Kemmerer sampler. Laboratory determinations of alkalinity and free CO_2 were performed on samples within 2 to 3 hours of collection. Samples for determination of nitrate-nitrogen, ammonium-nitrogen, total phosphorus (T.P.), total

dissolved phosphorus (T.D.P.), and dissolved inorganic phosphorus (D.I.P.) were also collected. All samples collected for subsequent laboratory analyses were stored on ice in the dark until taken to the laboratory.

Standard analytical procedures were employed in chemical analyses (Standard Methods--American Public Health Association, 1975). Dissolved oxygen was determined by the azide modification of the Winkler method; alkalinity by titration with .05 N H_2SO_4. Various forms of N and P were determined by colorimetric procedures; NH_3-N by direct Nesslerization; NO_3-N by cadmium reduction to NO_2-N followed by dizaotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine; PO_4-P by reduction of the molybdophosphoric acid with stannous chloride preceded by persulfate digestion in analysis for organically bound and condensed forms. Samples analyzed for N, inorganic-P and total dissolved-P were first filtered with 0.45 µm Millipore filters. Extinction coefficients for the water column were determined by Secchi disk measurements.

Chlorophyll a and Productivity

Samples for determination of chlorophyll a were analyzed using the Turner fluorometry technique (Turner, G. K. Associates, 1973). Samples were filtered through a glass fiber filter, ground with a hand tissue grinder and extracted in 90% acetone saturated with magnesium carbonate. After an extraction period in the dark, the samples were then centrifuged and the fluorescence of the supernatant solution measured.

Primary productivity estimates were made using a ^{14}C technique (Lind, 1974). B.O.D. bottles (300 mls) were used to incubate samples innoculated with 1 ml of solution containing $NaH^{14}CO_3$ (activity-1 µCi/ml) and suspended at the original sample depths for four hours. All productivity

experiments were carried out at approximately the same time of day (10 AM-2 PM). Following incubation the samples were stored in a black box for transfer to the laboratory. Samples were then filtered (100 to 200 mls, depending on density of suspended material in the water column) onto Millipore (0.45 μm) filters and desiccated in glass scintillation vials for approximately one week. Filters were covered with a toluene-based fluor and counted with a Packard (Model 3320) liquid scintillation spectrometer.

Total inorganic carbon was estimated by performing acid and base titrations on subsamples of water used in the ^{14}C experiments.

Nutrient Enrichment

Nutrient enrichment bioassay experiments were carried out using a modification of the algal assay procedure bottle test, developed by the Joint Industry/Government Task Force on Eutrophication (EPA, 1971). Surface water was passed through a plankton net (No. 20 mesh nylon) to remove zooplankton, placed in 3 liter culture jars and enriched so that the final concentration of nutrients was as follows: .5 ppm phosphate, 7.5 ppm nitrate, .5 ppm phosphate plus 7.5 ppm nitrate and 5% sewage effluent. Duplicate jars of each concentration were started. Cultures were incubated for 5 days at ambient temperatures and lighted with 6-14 watt soft white fluorescent bulbs. Air was pumped into the cultures to facilitate water circulation.

Nutrient enrichment bioassays were conducted monthly to determine variations in seasonal response to enrichment. Beginning in July cultures of various concentrations of phosphate (KH_2PO_4) were used to examine the possibility of a dosage response to phosphate additions. Cultures

receiving only nitrate (KNO_3) were discontinued after no response was noted in several experiments.

Algal response was analyzed by determining ^{14}C-fixation rates at the beginning and end of a 5-day incubation period and estimating chlorophyll *a* concentration on days 0, 2 and 5 of the experiments.

RESULTS AND DISCUSSION

PHYSICO-CHEMICAL

Vertical profiles

The data collected throughout the water column at the Juniata Harbor site during the year showed a definite stratification of the waters from early April through early November and during winter ice cover. Overturns occurred in mid-March and mid-November. Figure 2 shows the temperatures at various depths throughout the year. Summer stratification was characterized by warm water in the epilimnion ranging between 20 and 30°C. The hypolimnion water stayed fairly constant around 5 to 6°C. Inverse stratification was found during the winter months of ice cover. Temperature profiles measured in February and March show that the temperature ranged from 0°C at the surface to 2.3°C at the bottom.

Raystown Lake may be classified as a dimictic lake circulating freely twice a year in the spring and fall and directly stratifying in the summer and inversely stratifying in the winter. This classification was introduced by Hutchinson (1957) and is generally accepted as most useful and as having the least ambiguity.

Table 1 shows the average values and range of values for the water column of various physical and chemical data and Figure 3 illustrates depth profiles of selected data during summer (August) and winter (February) stratification. The decrease in dissolved oxygen that is seen for the water column during the summer months is evidence that stratification resulted in the concentrations of oxygen in the hypolimnion being very reduced due to oxidation of organic matter. Also during the summer, pH's at the surface tended to be relatively high due to photosynthetic

activity and low values at greater depths reflecting decomposition, resulted in low average values for the water column. In the epilimnion during the summer months, the dissolved oxygen reached saturation levels. At the height of summer stratification, dissolved oxygen decreased to as little as 0.4 mg O_2/l in September in the hypolimnion. Any surface runoff bearing oxygen may not have contributed oxygen to depths due to the fact that it is warmer and flows above the thermocline.

During the winter months of February and March, abundant oxygen was found at all depths. The dissolved oxygen of the water decreased with depth, however, indicating that any oxygen produced by phytoplankton occurred in the near surface waters where light was available. Although the ice prevents aeration of the water by wind, a flow of influent water through the lake could help maintain the dissolved oxygen in the dark hypolimnetic water. The inflowing water being warmer than the $0^{o}C$ surface water sinks to the bottom, carrying dissolved oxygen with it. The average thickness of ice cover was measured between 15 and 17 inches. Snowfall generally was swept away by the wind and therefore did not contribute greatly to the blockage of light through the ice; however, the ice was cloudy and contained trapped air bubbles which probably limited light transmission.

Seasonal variations in the concentrations of nutrients (nitrogen and phosphate) are shown in Table 1. During late winter (March) total dissolved phosphate, nitrate and ammonia reached relatively low concentrations perhaps due to algal utilization. Total dissolved phosphate and nitrate concentrations increased somewhat with depth in winter (Fig. 3). After spring overturn in mid-March these nutrients (NO_3 and T.D.P.) increased in concentration through the month of May. Dissolved phosphate

declined to very low levels in June through September, probably due to increased productivity at this time. NO_3 concentrations generally remained high throughout the sampling period. Ammonia concentrations varied throughout the year, being most abundant during winter ice cover in February (Fig. 3). The sources of nitrogen to a lake system are terrestrial runoff (considered to be a major source), precipitation, nitrogen-fixing blue-green algae and bacteria, and excretion of nitrogenous waste compounds by plants and animals.

PRODUCTIVITY AND CHLOROPHYLL *a*

Vertical profiles

Chlorophyll *a* and productivity data are shown in Table 2. Chlorophyll *a* concentration and ^{14}C-fixation rates are relatively low in early spring with increasing values for both throughout the summer period. Sharp decreases with depth were noted during the stratified periods (Fig. 4). Productivity was highest during summer months and generally limited to the upper six meters of the lake (Fig. 4). The depth distribution generally corresponds to light availability. The average depth of 1% surface illumination during the same period was calculated to be seven meters. The warm temperatures during the summer months and the light availability together undoubtedly stimulate growth of algae and rates of photosynthesis. Figure 4 shows seasonal variation with depth of planktonic productivity (^{14}C-fixation and chlorophyll *a* concentration) and the depth of 1% surface illumination for the period February, 1978, through December, 1978. June and September showed the greatest depth of 1% surface illumination of 12 and 18 meters, respectively.

Not all variations in photosynthesis can be attributed to light. The

photosynthesic rate will depend upon the quantity and kind of phytoplankton and the nutrients available in the surrounding environment. Seasonal stratification during the course of the year also will determine depths at which phytoplankton can grow. The epilimnion may become nutrient depleted in the near surface water where light is available to support photosynthesis (see phosphate data, Table 1). Surface inhibition of phytoplankton by intense light was evident with a greater abundance of phytoplankton at greater depths, generally between 3 and 6 meters (Fig. 4).

Chlorophyll a and productivity/m^2 declined markedly from February into March (Table 2). This may be attributed to the previously mentioned decreased nutrient supply and also less available light for photosynthesis with the greater thickness of ice. During the winter months the average depth of 1% surface illumination was 3.5 meters as compared to 7 meters during summer months. There was also a marked decrease in chlorophyll a concentration and ^{14}C-fixation with depth. In February chlorophyll a concentration ranged from 175 mg/m^3 at the surface to 1 mg/m^3 at the bottom and in March ranged from 5 to 6 mg/m^3 from surface to bottom. In February ^{14}C-fixation at the surface was .91 mg/m^3/hr and decreased to .28 mg/m^3/hr at 15 meters. In March ^{14}C-fixation was greatest at a depth of 6 meters at 16 mg/m^3/hr and ranged from .07 at the surface to .09 mg/m^3/hr at 15 meters.

The stream data (Table 3) show that site 24, the site farthest upstream from the dam, had the highest chlorophyll a content with values of 240 mg/m^3 compared with 90.13 mg/m^3 at the dam site. As noted earlier, the upstream waters have more dissolved solids that can be utilized by plankton.

Many factors contribute to the productivity of a lake. The amount

of turbidity and hence light penetration is very important in limiting plankton growth. Latitude and altitude, in relation to incident light, plays a part in how productive a body of water is. The lakes with the lowest productivity are either at high altitudes or high latitudes (Brylinsky and Mann, 1973).

Stream samples

The effects of runoff of streams into Raystown Lake can be seen in the data taken during the ice-free period (Table 3). There is evidence to indicate that streams located more towards the headwaters of the reservoir may contribute more to nutrient input. Although no particular pattern is evident with respect to inorganic nitrogen and phosphate, the highest productivities were observed farthest upstream from the dam. Streams entering further upstream from the dam drain primarily cultivated areas where soil erosion may contribute large amounts of phosphate and nitrate to streams. The streams that enter the lake nearest the dam site (see Fig. 1) originate from wooded areas where cultivation does not contribute to additions of nutrients into the lake. Total phosphate averages were highest in two streams furthest from the dam--Coffee Run (16.11 µg/l) and Shy Beaver (15.33 µg/l). Conductivity was also found to be higher in the headwater stream areas than downstream areas. The average conductivity measured at site 24 (furthest site from dam) was 229 µmhos/cm and the dam site average is 131 µmhos/cm. This indicates that there are more ionized substances dissolved (inorganic acids, bases and salts) in the water the farther upstream from the dam one travels. Conductivity varies seasonally at all sites, but not to a great degree.

Alkalinity showed the same general increase in concentration as the conductivity from the dam site to site 24. Alkalinity is primarily a

function of carbonate, bicarbonate and hydroxide content of the water. Photosynthesis and decomposition processes occurring in aquatic environments tend to cause changes in alkalinity.

The pH values for the stream sites compare with the chlorophyll a data in that both are higher at the upstream sites than at the dam site. This indicates the influence of photosynthesis as an important factor in affecting pH. Plants absorb CO_2, eliminate bicarbonate, precipitate carbonates and form hydroxyl ions, thereby raising the pH. Wetzel (1975) states that the range of pH of a majority of open lakes is between 6 and 9, being mainly the "bicarbonate type" regulated by the CO_2-HCO_3^--$CO_3^=$ system of buffering capacity.

The nitrate and ammonia concentrations in Raystown Lake were found to be fairly uniform throughout the system. Nitrates in the stream areas ranged from a maximum and minimum of .78 to .95 mg/l and ammonia ranged from .20 to .31 mg/l with no particular pattern evident from one end of the reservoir to the other.

A major factor is that nutrients that are supporting primary productivity are probably allochthonous. The runoff from soils in surrounding areas of streams is of major importance and determines amounts and kinds of nutrients that eventually flow into the lake.

Nutrient enrichment

The data obtained from nutrient enrichment experiments are shown in Figure 5. The data show that the greatest responses occurred with additions of .05 sewage effluent in every experiment except that carried out in April. The highest values observed after enrichment for both ^{14}carbon-fixation and chlorophyll a occurred in August and September. In December cultures enriched with sewage effluent were the only ones which showed a response.

Most frequently phosphorus cycling rates appear to be most important in sustaining productivity (Wetzel, 1975). During March, May and July the addition of phosphorus alone elicited a productivity response second only to that of sewage enrichment. Interestingly, in April phosphorus alone resulted in the greatest response of all treatment. Phosphorus enrichment (0.5 mg/l) in many cases also resulted in higher responses than nitrate and phosphates in combination. This is particularly curious since the same concentration of phosphorus was used in the combination enrichment. Since nitrogen concentrations in the lake were found to be high, the additions of phosphorus in successively higher concentrations were expected to result in higher productivity. In several experiments (July, August, September), the addition of various concentrations of phosphorus alone resulted in marked productivity increase in the cultures as the concentration of phosphorus was increased from 0.5 ppm to 1.0 ppm. However, phosphorus added in concentrations above 1.0 mg/l generally did not result in correspondingly higher response. The concentration of phosphorus added with the sewage effluent was approximately equivalent to the 0.5 ppm phosphorus enrichment used in experiments. During October none of the phosphate cultures showed any response; only slight responses were found in the nitrate-phosphate combination and sewage effluent cultures.

Maloney, Miller and Shiroyama (1972) conducted algal assays on waters from nine Oregon lakes of varying quality and found that addition of phosphorus alone stimulated algal growth rates. No correlation was found between algal growth rates and concentrations of nitrogen and carbon. Vanderhoef (1974) found in a study at Green Bay, Lake Michigan, that PO_4-P appeared to be the element limiting growth of nitrogen-fixing algae; fluctuations in PO_4-P concentration were closely correlated with fluctuations

in growth of nitrogen-fixing algae. Studies done by Powers, Malveg, Bruce and Schuldt (1972) on Burntside River and Shagawa Lake show similar results to those observed in Raystown Lake. Schelski (1974) concluded in a study on Lake Michigan that phosphorus was a limiting element and that carbon fixation and chlorophyll concentration were enhanced by additions of various response concentrations of phosphorus.

Nitrogen alone gave no response during the first four months of experimentation and was eliminated from the enrichment regime. This lack of response indicated that nitrogen alone is not a limiting nutrient in the growth of the natural algal population of the lake. These results correlate with findings by Schindler (1971) where, in experiments performed to determine nutrients responsible for eutrophication of freshwater lakes, nitrate added alone caused no increase in primary production in ^{14}C bioassay experiments. In the case of Raystown Lake it was found that nitrogen (NO_3-N) occurs in relatively high concentrations ranging from .38 to 2.22 mg/l.

The normal nitrogen-to-phorphorus ratio in algal cells is about 15:1 by atoms (Allen and Kramer, 1972). The addition of nutrients in this ratio (7.5 ppm NO_3-N to .5 ppm PO_4-P) showed an algal response above controls during each month except December where all the cultures showed a decline in productivity except for those enriched with sewage effluent. A combination of nitrate and phosphorus generally showed a lower response than enrichment with phosphorus alone. This response is curious and perhaps is indicative of nitrogen inhibition.

Vollenweider (1968) stated that nitrogen and phosphorus appear to be the most important nutrients responsible for eutrophication but indicated that phosphorus was usually the initiating factor. Crane and Sommerfeld

(1976) have reported in an *in situ* study in Lynx Lake, Arizona, that the phytoplankton standing crop was significantly influenced by additions of nitrogen-phosphorus and nitrogen-phosphorus-carbon combinations, but that the addition of nitrogen, phosphorus or carbon individually as well as nitrogen or phosphorus in combination with carbon did not significantly influence phytoplankton standing crop.

Some of the variations in response seen during the year may be due to seasonal changes in algal populations in the lake. During the duration of the study the algal populations in the lake underwent a succession (Table 4). In general, the succession went from a predominance of greens in April, May and June to blue-greens in July and August, to diatoms and greens in September, to blue-greens and diatoms in October, to green flagellates and diatoms in November and December. These differences in response to nutrient enrichment are probably due in part to the varying nutrient requirements of algal populations that occur seasonally.

SUMMARY

A limnological study was conducted on Raystown Lake from February through December, 1978, to provide information on this system and attempt to determine the effect of nutrient loading from the surrounding watershed on the lake system.

Raystown Lake, being a dimictic lake circulating freely in the spring and fall, showed a definite stratification of the waters from early April through early November and during winter ice cover.

Seasonal variations in the concentrations of nutrients (nitrogen and phosphorus) and productivity were observed and a correlation of the two is possible.

The effects of runoff of streams into Raystown Lake were found to be greatest more toward the headwaters of the reservoir where the highest productivities and chlorophyll a concentrations were observed. This leads to the conclusion that the nutrients most effectively supporting primary productivity in Raystown Lake are probably allochthonous.

The vertical profile study showed the productivity was highest during summer months and generally limited to the upper six meters of the lake. Two periods of increase in chlorophyll a concentration in the water column were found during April to May and June to November with sharp decreases in chlorophyll a concentration with depth during the stratified period. Chlorophyll a concentration and productivity/m^2 declined markedly from February into March, probably due to decreased nutrient supply and less available light for photosynthesis during ice cover.

The nutrient enrichment experiments showed that sewage effluent, containing high concentrations of phosphorus, quite obviously has a marked

effect in terms of increasing growth of the algal populations in the lake. The enrichment experiments do demonstrate the importance of phosphorus in supporting significant increases in algal growth. Phosphorus, in many cases, resulted in higher algal growth response than nitrate and phosphorus in combination. The lack of algal response to nitrate indicates that nitrate alone was not a limiting nutrient in the growth of the natural algal populations of the lake. The seasonal changes in algal populations in the lake may account for the variations in enrichment response seen during the study period due to varying nutrient requirements of algal populations. Clearly, these results indicate that phosphorus is the most frequently limiting nutrient in Raystown Lake.

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Figure 1. Sampling sites in the Raystown Lake study area.

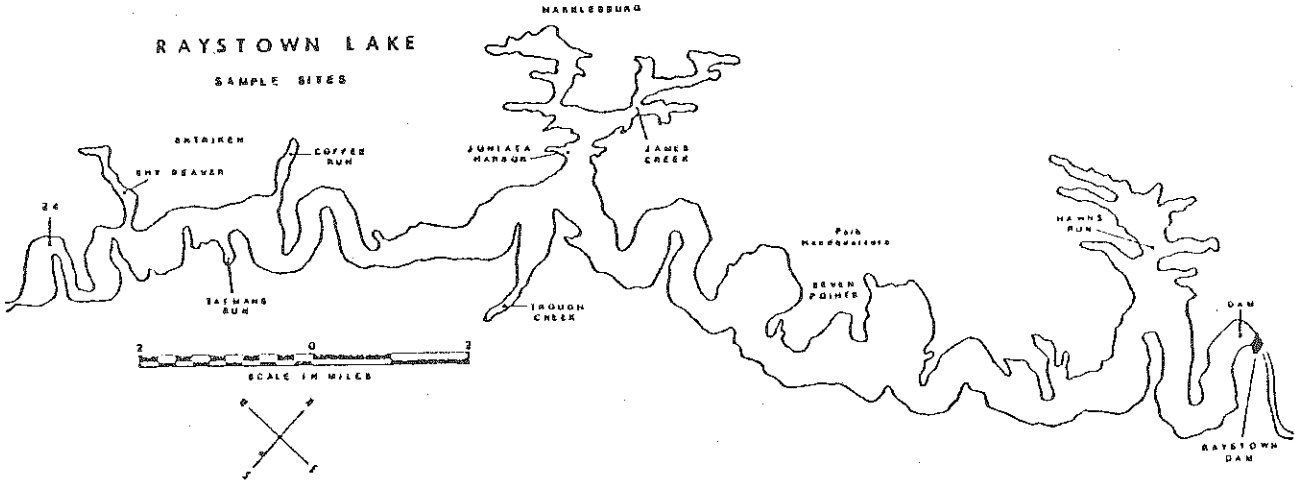

RAYSTOWN LAKE
SAMPLE SITES
MARKLESBURG
ONTARIOH
COPPER RUN
SHY BEAVER
SUMLATA HARBOR
JAMES CREEK
24
TASMANS RUN
IROQUOIS CREEK
Pork Headquarters
BEVAN POINTE
HAWNS RUN
DAM
RAYSTOWN DAM
2 0 2
SCALE IN MILES

Figure 2. Depth-time isotherms-^{o}C.

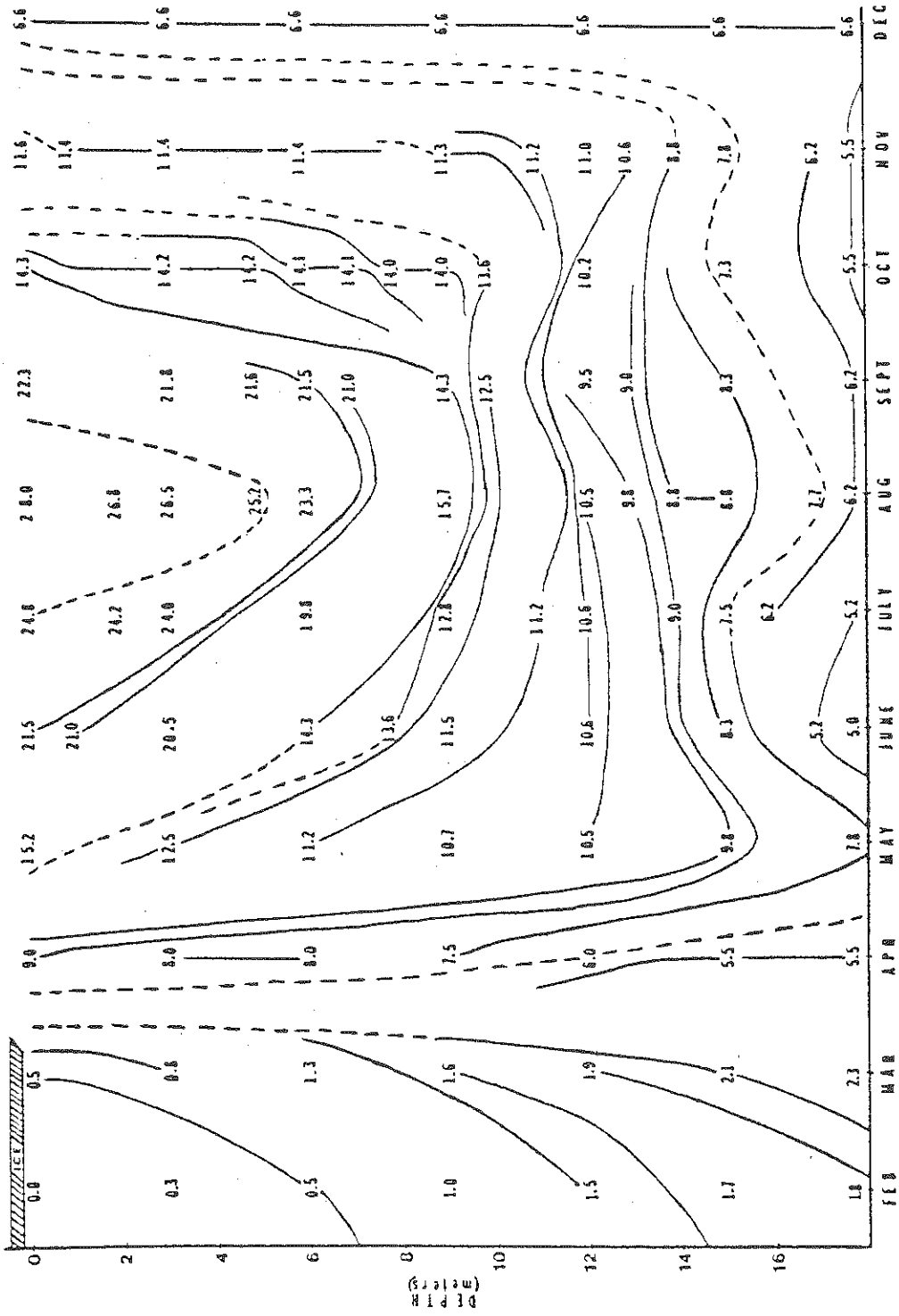

DEPTH - TIME ISOTHERMS °C
DEPTH (metres)
0
2
4
6
8
10
12
14
16
ICE
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
1978

Figure 3. Seasonal variations of depth profiles of physico-chemical characteristics for Raystown Lake; summer (August) and winter stratification (February). Samples taken at Juniata Harbor site.

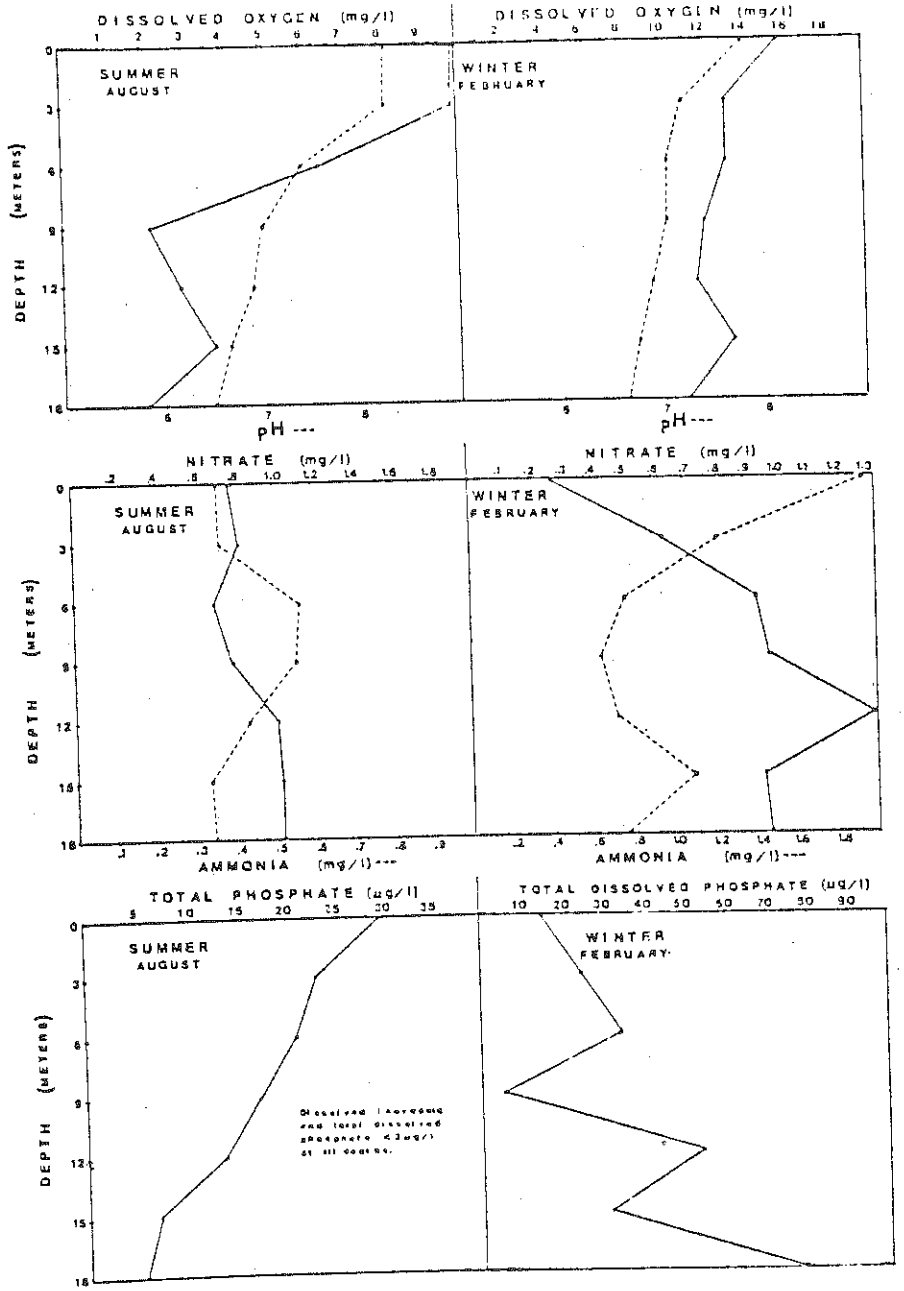

DISSOLVED OXYGEN (mg/l)
SUMMER
AUGUST
WINTER
FEBRUARY
DEPTH (METERS)
pH ---
NITRATE (mg/l)
AMMONIA (mg/l)---
TOTAL PHOSPHATE (µg/l)
TOTAL DISSOLVED PHOSPHATE (µg/l)

Figure 4. Profiles of seasonal variation with depth of planktonic productivity (^{14}C-fixation and chlorophyll *a*) and depth of 1% surface illumination for the period February, 1978 - December, 1978.

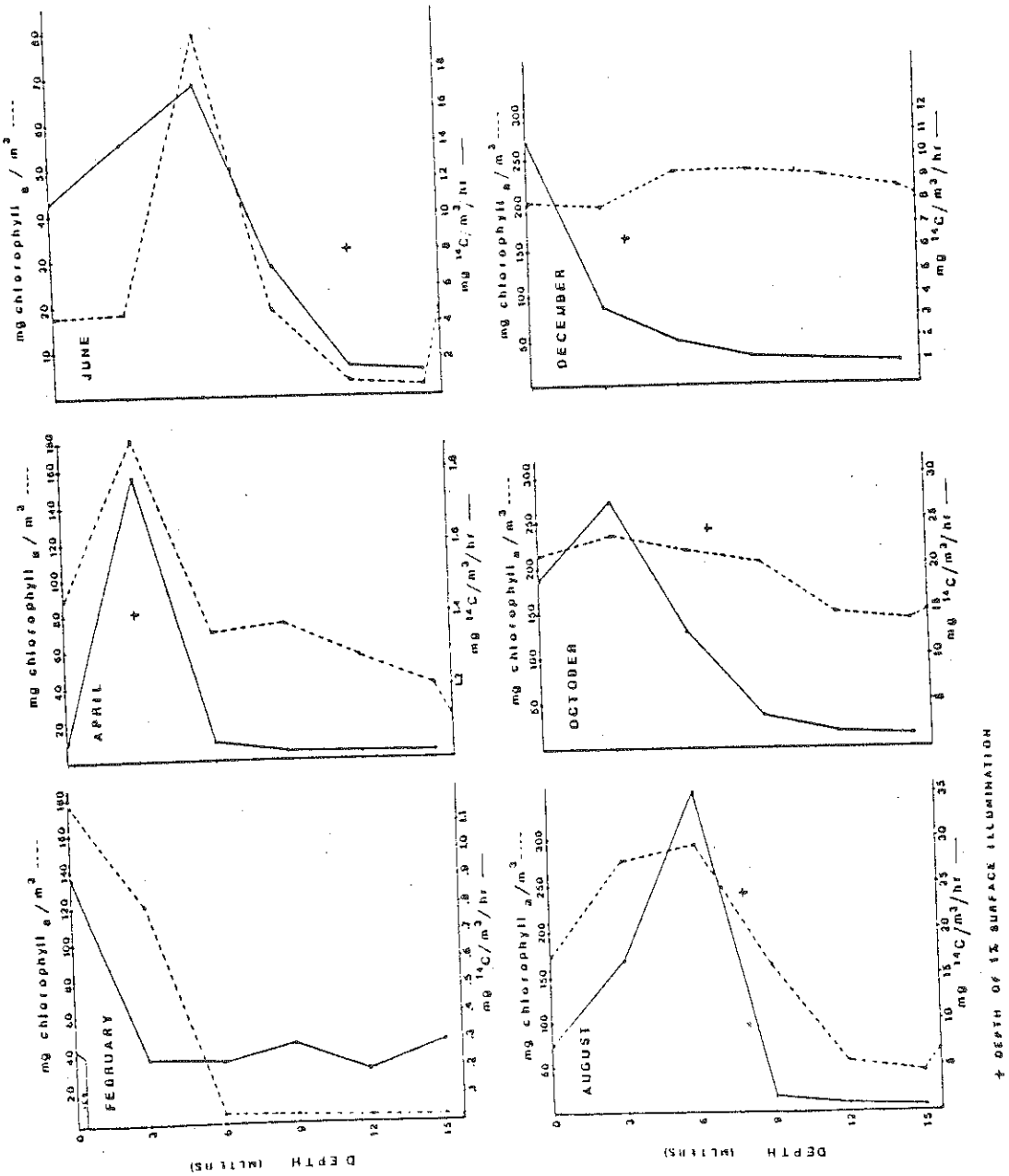
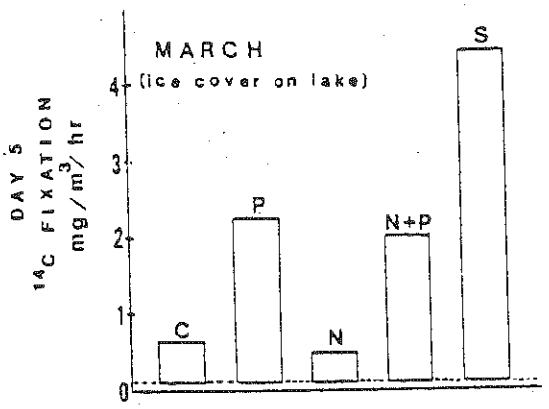
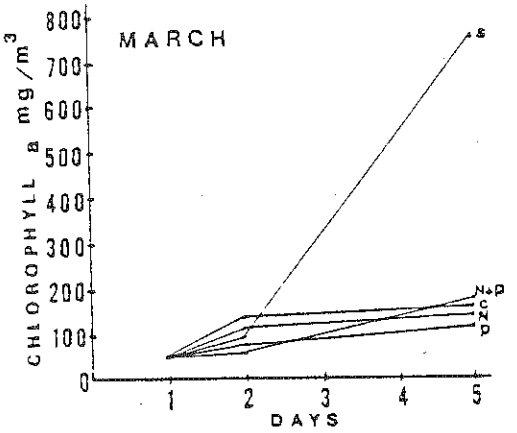
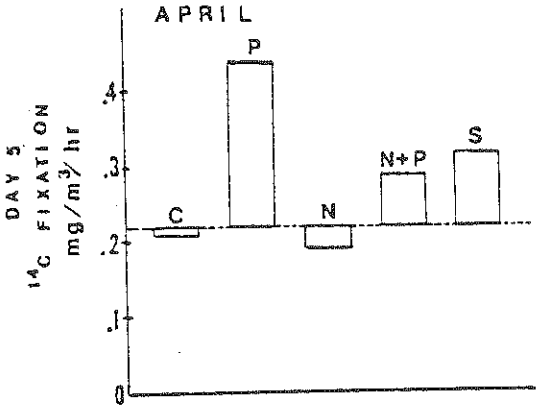
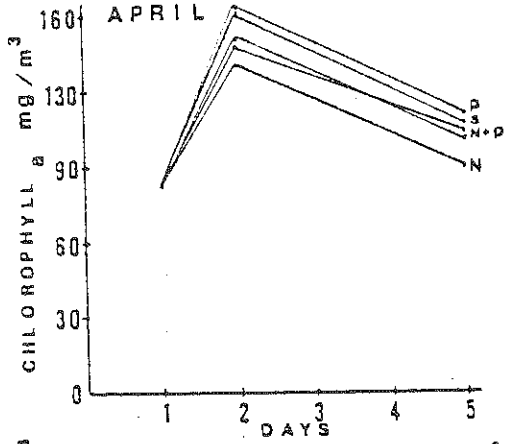

JUNE
DECEMBER
APRIL
OCTOBER
FEBRUARY
AUGUST
mg chlorophyll a / m³
mg ¹⁴C/m³/hr
DEPTH (METERS)
+ DEPTH OF 1% SURFACE ILLUMINATION

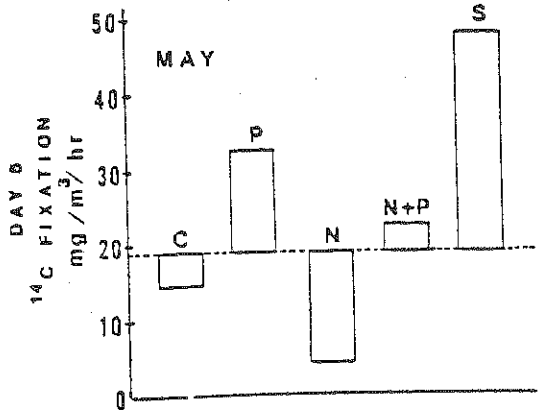
Figure 5. Algal response to enrichment cultures shown by ^{14}C fixation ($mg/m^3/hr$) and concentration of chlorophyll *a* (mg/m^3) for March through December.

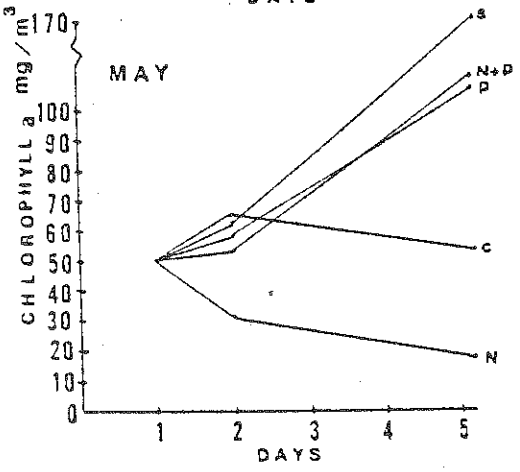




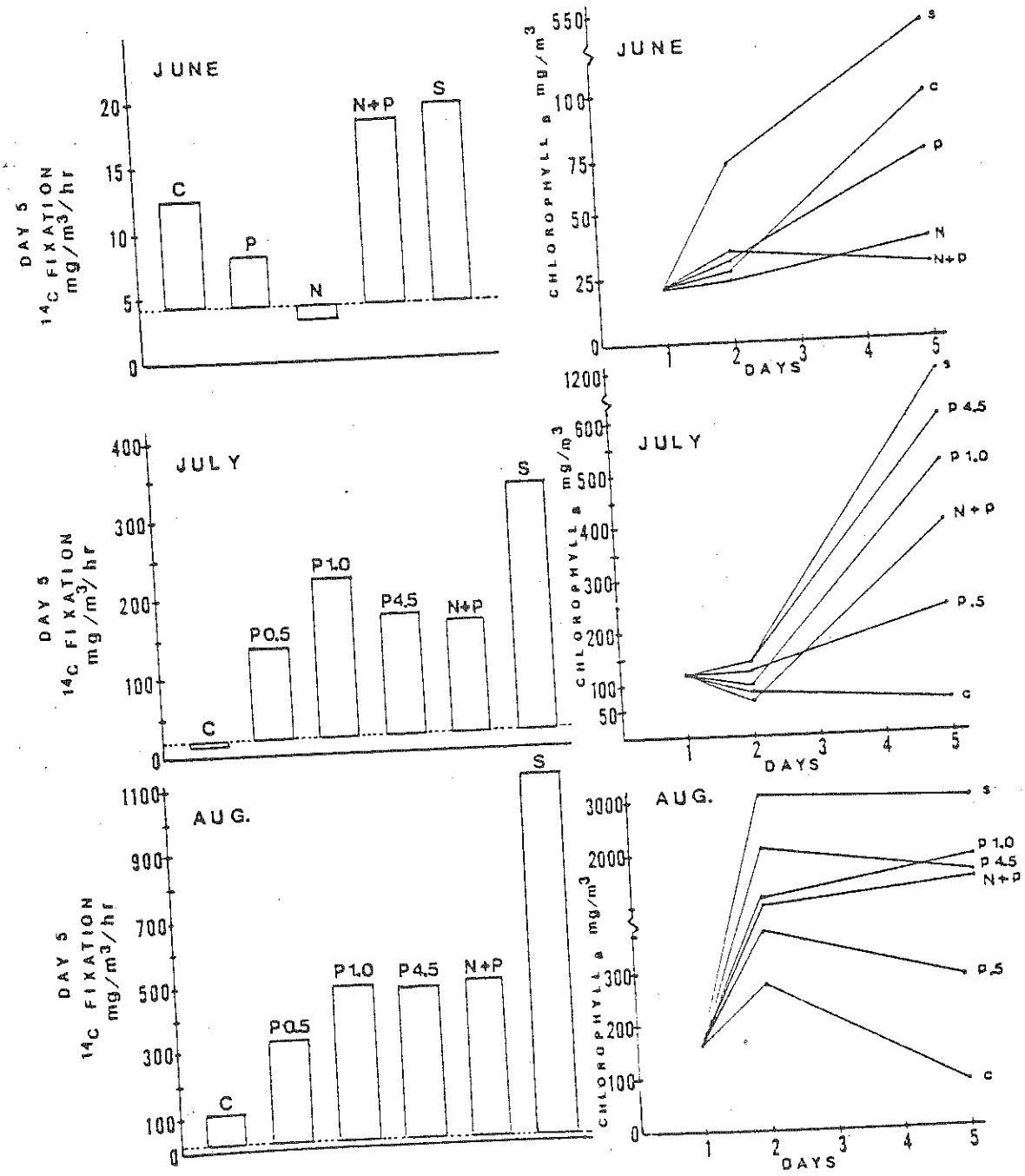


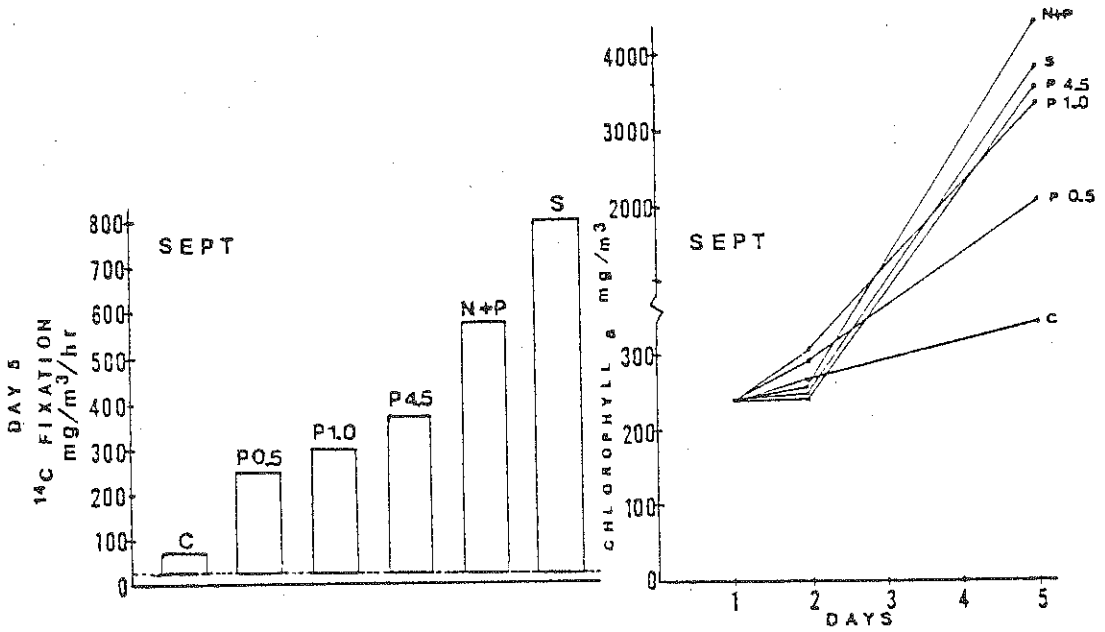


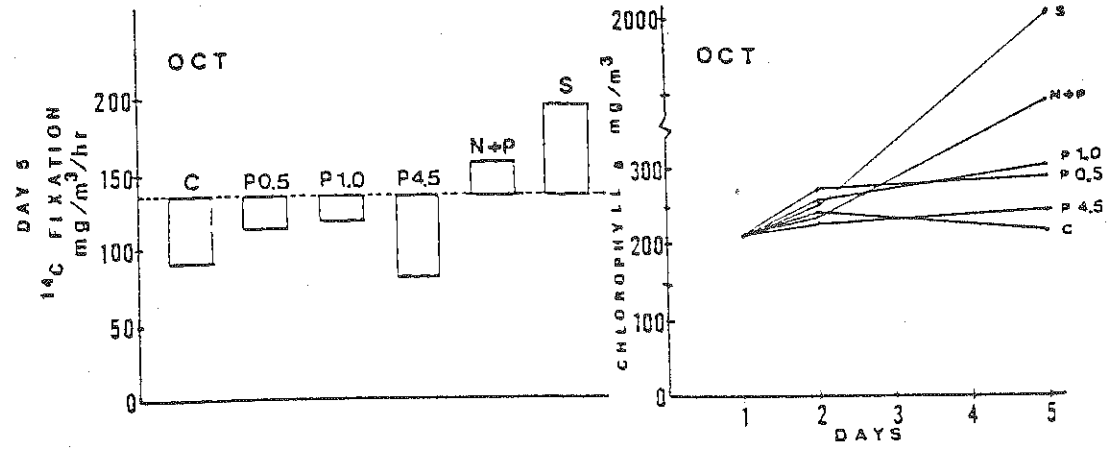


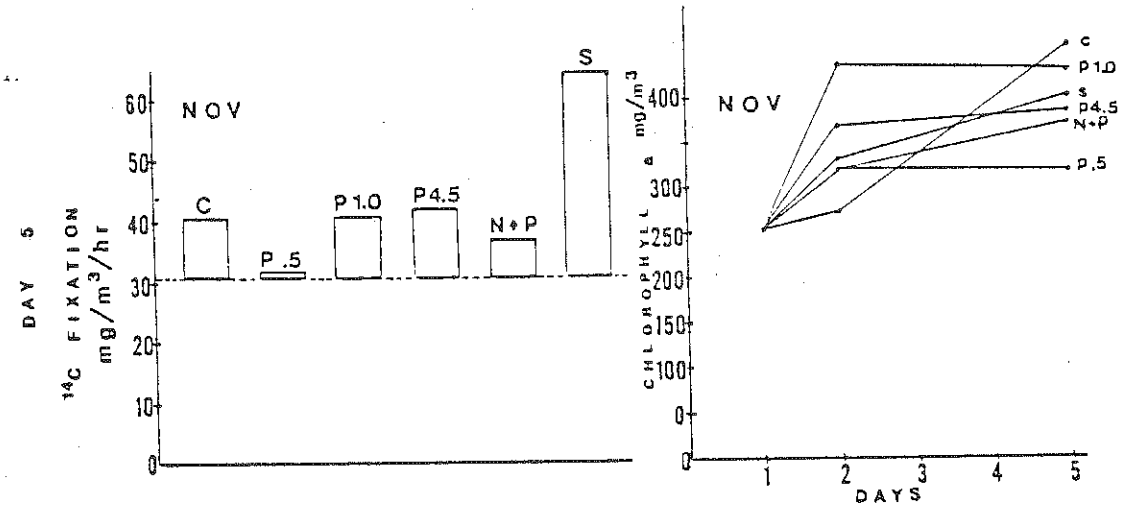


P= 0.5ppm KH_2PO_4
N= 7.5ppm KNO_3
N+P=15:1
S= 5% sewage effluent
C= control


JUNE
DAY 5
^{14}C FIXATION
mg/m^3/hr
C
P
N
N+P
S
JUNE
CHLOROPHYLL a mg/m^3
DAYS
s
c
p
N
N+p
JULY
C
P0.5
P1.0
P4.5
N+P
S
JULY
CHLOROPHYLL a mg/m^3
DAYS
s
p 4.5
p 1.0
N+p
p.5
c
AUG.
C
P0.5
P1.0
P4.5
N+P
S
AUG.
CHLOROPHYLL a mg/m^3
DAYS
s
p 1.0
p 4.5
N+p
p.5
c


SEPT
DAY 5
^{14}C FIXATION
mg/m^3/hr
C
P0.5
P1.0
P4.5
N+P
S
CHLOROPHYLL a mg/m^3
DAYS
N+P
S
P 4.5
P 1.0
P 0.5
C


OCT
DAY 5
^{14}C FIXATION
mg/m^3/hr
C
P0.5
P1.0
P4.5
N+P
S
CHLOROPHYLL a mg/m^3
DAYS
S
N+P
P 1.0
P 0.5
P 4.5
C


DAY 5
^{14}C FIXATION mg/m^3/hr
NOV
C
P .5
P1.0
P4.5
N+P
S
CHLOROPHYLL a mg/m^3
NOV
c
P1.0
s
P4.5
N+P
P.5
DAYS

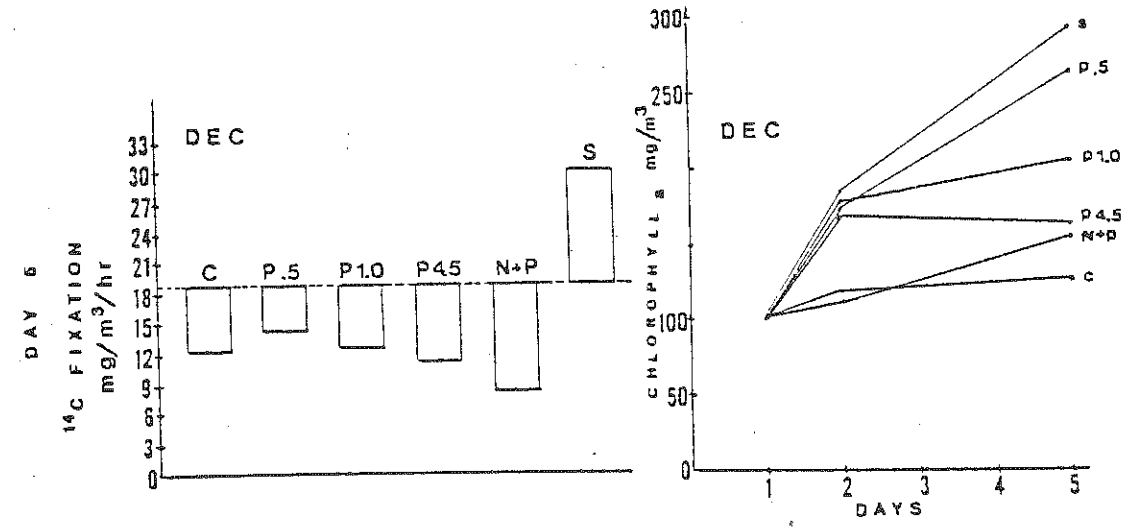

DAY 6
^{14}C FIXATION mg/m^3/hr
DEC
C
P.5
P1.0
P4.5
N+P
S
CHLOROPHYLL a mg/m^3
DEC
s
P.5
P1.0
P4.5
N+P
c
DAYS

Table 1. Seasonal variations of physical-chemical characteristics for Raystown Lake at Juniata Harbor. Mean values for the water column and range of values in parentheses.

SEASONAL VARIATIONS OF PHYSICAL-CHEMICAL CHARACTERISTICS FOR RAYSTOWN LAKE AT JUNIATA HARBOR[1]

	pH	Conductivity µmhos/cm	Alkalinity mg/ℓ	Dissolved Oxygen mg/ℓ	NH_3-N mg/ℓ	NO_3-N mg/ℓ	Dissolved Inorganic Phosphate µg/ℓ	Total Dissolved Phosphate µg/ℓ	Total Phosphate µg/ℓ
Feb.	7.06 (6.65-7.80)	166 (90-190)	28.45 (6.63-36.25)	12.92 (11.20-15.80)	1.02 (.63-1.94)	.92 (.27-1.68)	----	33.6 (6.0-70.8)	-----
Mar.	7.31 (7.20-7.35)	151 (95-175)	31.04 (9.00-37.50)	11.84 (10.30-14.80)	.31 (0.0- .45)	.49 (.32- .64)	----	8.5 (4.0-14.0)	-----
Apr.	7.57 (7.40-7.70)	183 (170-200)	25.86 (25.00-26.75)	11.39 (11.00-11.80)	.67 (.42-1.18)	.67 (.62- .71)	8.94 (7.0-15.0)	15.43 (11.0-20.0)	-----
May	7.63 (7.40-7.85)	175 (170-200)	30.21 (28.25-31.75)	10.03 (9.60-10.70)	.41 (.30- .51)	.82 (.68-1.05)	5.97 (3.0-12.0)	18.29 (16.0-34.0)	53.36 (25.0-75.5)
June	7.24 (6.40-7.70)	147 (120-190)	30.74 (27.00-35.50)	8.05 (7.80- 9.80)	.17 (.07- .32)	.91 (.86-1.08)	<4	<4 (<4- 8.0)	12.56 (4.5-71.5)
July	7.18 (6.50-8.05)	187 (160-200)	42.43 (30.00-50.00)	6.46 (3.60- 9.30)	.51 (.24- .92)	.97 (.82-1.18)	<4	<4	14.71 (1.5-38.0)
Aug.	7.28 (6.50-8.25)	164 (140-190)	44.43 (32.50-49.75)	5.36 (2.10-10.20)	.41 (.33- .52)	.89 (.70-1.08)	<4	<4	14.21 (5.5-29.5)
Sept.	7.35 (6.60-8.05)	186 (155-215)	43.82 (27.50-58.50)	4.97 (.40- 8.30)	.19 (.08- .36)	.90 (.70-1.16)	<4	<4	21.91 (6.3-29.5)
Oct.	7.32 (6.65-7.80)	171 (150-180)	47.50 (32.50-56.00)	5.97 (.60- 9.25)	.35 (.12- .65)	.83 (.72-1.20)	<4	(<4-23.0)	(<4-24.6)
Nov.	7.72 (7.55-8.50)	184 (160-200)	48.21 (40.00-52.50)	7.44 (.50-10.60)	.26 (.12- .54)	.76 (.72- .81)	<4	(<4-22.5)	26.57 (9.0-41.0)
Dec.	7.13 (7.05-7.20)	135 (135-135)	56.04 (52.25-68.75)	9.27 (9.20- 9.30)	.26 (.20- .31)	.75 (.72- .78)	<4	<4	<4

[1]Mean values for the water column; range of values in parentheses.
---- = Data not available.

Table 2. Seasonal rates of planktonic primary production and chlorophyll a concentration at Juniata Harbor. Mean values for water column and range of values in parentheses.

SEASONAL RATES OF PLANKTONIC PRIMARY PRODUCTION AND CHLOROPHYLL *a* CONCENTRATION AT JUNIATA HARBOR[1]

	Chlorophyll *a* mg/m^3	^{14}C fixation $mg/m^3/hr$	Chlorophyll *a* mg/m^2	^{14}C fixation $mg/m^2/hr$
Feb.	44.43 (1.00-175.00)	.35 (.19- .91)	777.50	5.30
March	50.11 (5.40- 51.00)	.11 (.07- .16)	446.00	1.65
April	74.71 (23.00-171.00)	.44 (.12- 1.78)	1307.50	6.55
May	136.00 (90.00-170.00)	5.59 (.40-25.25)	2385.00	83.85
June	24.93 (2.50- 80.00)	6.13 (1.34-17.01)	396.25	129.08
July	120.00 (74.00-200.00)	12.62 (.44-25.51)	2107.50	189.23
Aug.	151.14 (42.00-296.00)	10.35 (.46-35.29)	2645.00	155.30
Sept.	168.43 (138.00-246.00)	23.84 (.67-34.03)	3120.00	210.08
Oct.	185.43 (140.00-232.00)	10.76 (1.21-27.07)	3245.00	319.73
Nov.	246.28 (136.00-330.00)	26.39 (6.58-56.05)	4310.00	395.95
Dec.	216.00 (196.00-232.00)	3.13 (.84-10.88)	3777.50	47.00

[1]Mean values for water column; range of values in parentheses.

Table 3. Physical-chemical characteristics of stream inlets of Raystown Lake. Mean values for the period April, 1978 - December, 1978, and range of values in parentheses.

PHYSICAL-CHEMICAL CHARACTERISTICS OF STREAM INLETS OF RAYSTOWN LAKE[1]

Site	Temp. °C	pH	Cond. µmhos/cm	Alk. mg/ℓ	D.O. mg/ℓ	NH_3-N mg/ℓ	NO_3-N mg/ℓ	D.I.P. µg/ℓ	T.D.P. µg/ℓ	T.P. µg/ℓ	Chlorg. mg/m
Dam	16.46 (7.40-28.00)	7.84 (7.40-8.20)	131 (120-155)	32.81 (26.25-37.50)	10.06 (9.40-11.80)	.23 (.06-.52)	.81 (.72- .92)	(<4- 5.5)	(<4-16.0)	(<4-22.0)	90.13 (35-170)
Hawns Run	17.32 (7.20-28.00)	7.75 (7.20-8.20)	144 (110-205)	31.75 (21.75-37.00)	10.06 (8.80-12.10)	.24 (.08-.38)	.95 (.70-2.22)	(<4-14.5)	(<4-37.5)	(<4-22.5)	96.33 (46-170)
James Creek	17.79 (6.60-28.80)	7.97 (7.40-8.35)	168 (120-200)	41.83 (20.00-55.75)	10.30 (9.40-11.90)	.27 (.14-.45)	.79 (.66-1.29)	(<4- 5.5)	(<4-19.0)	(<4-29.0)	184.11 (88-264)
Trough Creek	17.40 (6.60-29.20)	7.86 (7.35-8.40)	176 (140-200)	41.81 (18.75-57.50)	9.96 (8.70-11.50)	.23 (.12-.36)	.78 (.57-1.00)	(<4- 5.5)	(<4-12.5)	(<4-34.0)	138.67 (60-242)
Coffee Run	18.23 (6.60-29.70)	8.04 (7.50-8.40)	195 (140-235)	56.28 (32.50-71.75)	10.08 (8.70-12.20)	.30 (.14-.55)	.84 (.52-1.10)	(<4-10.5)	(<4-22.0)	(<4-32.0)	216.00 (88-420)
Tatman Run	18.54 (6.60-28.60)	8.06 (7.50-8.40)	189 (150-245)	54.50 (25.00-74.50)	10.21 (9.00-11.65)	.28 (.07-.53)	.81 (.48- .98)	(<4- 5.0)	(<4-16.5)	(<4-21.0)	190.67 (76-324)
Shy Beaver	18.14 (6.20-28.70)	8.19 (7.65-8.70)	196 (90-260)	56.33 (27.50-80.50)	10.43 (9.30-11.50)	.31 (.15-.44)	.83 (.38-1.07)	(<4- 4.5)	(<4- 9.5)	15.33 (5.5-36.0)	210.00 (130-380)
24	18.98 (6.30-29.00)	8.24 (7.60-8.85)	229 (195-280)	57.53 (25.00-86.50)	10.37 (8.90-11.70)	.20 (0.0-.35)	.83 (.30-1.14)	<4	(<4-13.0)	(<4-23.0)	240.00 (99-430)

[1]Mean values for the period April, 1978-December, 1978; range of values in parentheses.

Table 4. Dominant algal forms present in Raystown Lake during the sampling period.

Plankton Identification (Ward and Whipple, 1959)

April	*Scenedesmus-g	Cymbella-d	
	Closterium-g		
	Anabaena-bg		
May	*Scenedesmus-g	Synedra-d	
	Navicula-d	Closterium-dm	
	Diatoma-d		
June	*Scenedesmus-g	Synedra-d	
	Navicula-d		
	Diatoma-d		
July	*Anabaena-bg	*Nitzchia-d	
	*Coelastrum-g	Stauroneis-d	
	Scenedesmus-g	Cyclotoma-d	
August	*Oscillatoria-bg	Anabaena-bg	Synedra-d
	Ankistrodesmus-g	Dinobryon-f	Stauroneis-d
	Scenedesmus-g	Cyclotella-d	
September	*Micratinium-g	Phytoconis-g	Nitzchia-d
	Scenedesmus-g	*Fragilaria-d	Anabaena-bg
	Chlorella-g	Cyclotella-d	Oscillatoria-bg
October	*Fragilaria-d	Diatoma-d	Chlorella-g
	*Oscillatoria-bg	Stauroneis-d	Akistrodesmus-g
	Dinobryon-f	Pediastrum-g	
November	*Dinobryon-f	Coelastrum-g	
	*Fragilaria-d		
	Selanastrum-g		
December	*Dinobryon-f	Stauroneis-d	
	Fragilaria-d	Closterium-g	
	Tabellaria-d		

* -- showed greatest response to enrichments

g -- green algae

bg -- blue-green algae

d -- diatom

f -- flagellate

dm -- desmid

1980

FOREST ECOLOGY
AT
LAKE RAYSTOWN FIELD STATION

by

Tim Albaugh
and
Linda Williams
5/15/80

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Introduction:

This study is being used as an introduction to Forest Ecology. In this study two forest areas, a pine forest and an oak forest, have been chosen and sampled. The data obtained has been used to generate some phytosociological parameters which have been in turn used to provide a description of these forests. From this, conclusions have been drawn from the acquired information on the successional possibilities of these areas and the possible management schemes needed for resources, wildlife, and aesthetics in these forest stands.

Methods and Materials:

This section of the paper will present a description of the sampling method used and other pertinent information related to the collection of data. Also there will be some discussion of problems encountered and ideas for better methods in the future. Finally, this section will give some information about the results obtained.

This study was done on two forest areas at the Lake Raystown Field Station. The quarter point method was used for this study with random stratified sampling. First the areas were decided upon and the boundaries were measured and marked. When sampling in the oak forest 10 meter intervals were used; while in the pine forest, because of its homogeneity, 15 meter intervals were used. Intervals were at right angles, checked by a compass bearing, to the road in the oak forest and to the top of the hill in the pine forest (see Fig.). The distance A-B was measured and assumed as 100%, then with a table of random numbers a portion of this distance was measured and this was used as the first data point. From this point (C in Fig.) another compass bearing parallel to the road in the oak forest,

and to the top of the hill in the pine forest was taken. With another random number a distance was measured as a portion of 10 meters in the oak forest and of 15 meters in the pine forest, and another point was found for taking data. This was done twice for each interval in both forests. The only materials needed for this were a measure and a compass. At each point the distance to the nearest tree in each quarter was measured along with the circumference at breast height, also the species of tree was recorded. 15 centimeters was used as a cut off between a tree and a sapling. Also noted in each forest area was the soil, the drainage, ground cover, slope, protection (wind), and relation and number and kind of scrub growth and young trees.

Some of the difficulties encountered in sampling were as follows. The biggest problem was the keying of the trees in the oak forest. This study was done when there were no leaves or buds on the trees. With the great variance in bark and the possibility of hybridization in the oaks this task was a very difficult one for the younger trees and for the scrub. In the pine forest the greatest difficulty was the slope of the ground. It was difficult to climb around on, and once a data point had to be rechosen because the workers could not get at the original one. If, in the future, a choice is possible it would be wise to stay on fairly level ground. It was also difficult to stay on a compass bearing in a straight line with the undergrowth present. This became somewhat easier as time went on so practice is the only help here. There was also a transportation problem of actually getting to the site. In the future it would be wise to choose a site closer to the school for study.

Result of the compilation of data can be found on pages 10-12. These values were obtained by various calculations and examples of these can be found on page 13.

The only special note here is in the calculation of density. Since the quarter point method was used, there was no definite area involved for each quadrat. Thus, the values given are relative ones.

Discussion:

This section will consist of two major parts. One will be a presentation of what these forest areas are like and the second part will be a comparison of the two forests and why they are the way they are today. Also some mention will be made in reference to the various phytosociological measurements obtained from studying these forests.

One of the most obvious characteristics of the pine forest is its homogeneity. It can be seen just by looking at the area that it is nearly a pure stand. This is also backed up by the data and measurements taken on this forest. Virginia pine is found in all the quadrats sampled and has very high relative frequency, density, and dominance values. An important note here is that red maple is present and is present mostly as small saplings or young trees. The only other species from the data is one very large (largest tree in area) white pine. Its overall influence on the area is probably rather small since it shades little and is characterized by sparse reproduction.

This forest is also obviously in an early successional stage. Most of the trees are small ones about the same age—being about the same in circumference. There is little large deadwood. These two facts are indicative of a young forest. Virginia pine is a good tree for growing over old farmland and this area was once used for grazing. There is even evidence of this grazing in that hawthorne is abundant in the open areas. Hawthorne is usually one of the species last eaten by grazers because other more edible plants exist. When these other species are eaten away hawthorne can become a dominant. Apparently, the area was clear cut;

except for that one white pine, as there are many stumps still present.

Other parameters were also noted. The stand is located on a very steep slope and much of the ground is rock instead of dirt. This very rocky condition was probably caused by erosion of the soil after clear cutting and grazing of the hillside. This leaves very poor soil on which to grow—soil that Virginia pine is well suited for. Under the pines there is very little growth amounting to not much more than a few lichens and some moss. There is also a heavy carpet of fallen needles. In more open areas there is either bare rock or there is some stabilization occurring. Areas that have been stabilized are controlled mostly by Pennsylvania sedge, and many small red maple trees. The slope is relatively well protected with little wind and a south-west exposure. A final note is that the seed species for this forest consist of the Virginia pine, and red oak and red maple which are abundant at the top of the hill above the slope.

Homogeneity is not one of the characteristics of the oaf forest. It has six different species present in it with no one type really overwhelming all the others at present. Chestnut oak is the most dominant at the present although from the phytosociological measurements on it one can see that it is not controlling the forest. White oak and Virginia pine are also relatively influential in the area with large Virginia pine being rare. Both black and red oak are present but are probably being out-competed by other plants because black is not a good competitor and red grows better in wetter areas.

This forest is probably relatively old. There are many large trees over one meter in circumference and there is a good deal of large deadwood both standing and on the ground. There is no evidence of grazing, farming, or lumbering in this forest so it has not really been disturbed for quite some time. The understory consists of many raggedy Virginia pine and a large number of oak saplings. The exact species of sapling was difficult to establish, as mentioned before.

Again, this forest is located on the top of a ridge. It is more exposed and the area is very windy. This could help account for many of the broken branches found lying about and for the poor condition of the very young trees. The soil was dry and fairly well drained with some rocks. There was also a very large amount of leaf litter and in some areas it was well over ankle deep. This along with the previously mentioned abundance of deadwood might indicate a lack of soil organisms although no measurements of this factor were made.

In comparison, then, these two forest areas are quite different. The one forest is a rather homogeneous pine stand while the other is dominated by mostly chestnut oak with white oak and Virginia pine being very influential. One has been recently cut and grazed with much surface erosion; while, the other is relatively advanced successionally and has a stabilized floor. The pine forest has little undergrowth while the oak forest has many oak and pine saplings. Also the pine forest is not heavily weathered and located on a steep slope while the oak forest is on a flat surface on top of a hill and receives much wind and weather.

Conclusions:

This section will present some ideas on the future of the stands that have been studied. Specifically, successional trends and some ideas on management in relation to resources, wildlife, and aesthetic possibilities will be presented.

Succession predictions are difficult to make because of the tremendous number of different factors which could have an effect. Trees vary greatly in their needs for soil, water, light, nutrients and space and they may be able to vary one need against the others. There are root and leaf interactions along with the possibility of allelopathy. Most unpredictable of all is the kind of disturbance that might occur on the stand—from pathogens to fire to wind storms. With this

in mind this writer will present a rudimentary view of the successional trends which could occur on these sites.

The pine forest is at present nearly homogeneous but there are red oak and red maple seed sources and saplings available. Also there is a stabilization and enrichment of the rocky soil going on. These two factors are very important. Virginia pine has few enemies, insect or plant, but it easily affected by fire because of its thin bark. Hardwoods are also destroyed by fire so it is doubtful that this kind of catastrophe could change the area much. However, with the continuing stabilization of the soil in and around the stand the Virginia pine has a poor chance of surviving successionally. Virginia pine is easily out-competed on good soils and red oak is an exceptionally fast growing species and is moderately tolerate of most conditions. So if there are any openings or clearings formed by falling trees (that one very large white pine) red oak and red maple could eventually take hold on the hillside. Also without any other slight disturbance there will probably still be a very slow take over by red oak and red maple as the soil condition improves. Should the area again be clear cut or if something major would happen which could erode the soil the Virginia pine would probably again control the area.

In the oak forest the associations are much more complex due to the increased number of species. There seems to be some evidence that this area was once a Virginia pine forest. It was at one time farmed or at least cut (a long time ago) and Virginia pine probably took over the area at that time. Also, now, Virginia pine is found in small clumps or as single trees which is often the case when it has been out-competed in an area. White oak, one of the more dominant species, is probably on the way out. White oak does best in deep rich soil--like in valleys. It is also a long lived tree so that its presence will still be felt for some time

to come. It will probably loose out because of the chestnut oak. This species has few pathogens and is somewhat fire resistant due to its thick bark. It does well on rocky ridges with dry soil (the conditions of the area) because it can develop strong, widely branching lateral roots in these situations so as to firmly anchor itself and have a wide area in which it can obtain nutrients. Black oak is present in few trees and will probably not have any major affects on the area as it is usually easily out-competed. The red oak, although it is a fast growing species, appears to never have been abundant as there are only two of the species in the area. If there are no major disturbances, then chestnut oak will become more dominant and could with time form a pure stand. With some disturbance such as lumbering or a major disaster where most of the oaks were wiped out then Virginia pine could regain its foothold because it grows well in disturbed areas and can reproduce readily.

Keeping in mind some of the above discussion suggestions for the management of these stands will be given for useable resources, wildlife, and for pure aesthetics.

In both of these stands the most important resource is the wood from the trees. The pine forest in being mostly Virginia pine could be utilized for the paper industry as pulp wood. There are some problems with this idea. One would be feasibility as this writer doubts that it would be economically worth it to use these trees for pulp wood because of the small area involved and the distance from any paper mills. Another major problem with this is that the stand is situated on a very steep slope. This would present problems in harvesting and in replanting as complete erosion of what little soil is there could easily take place. In the oak forest there are also possible uses for the wood if harvested. Chestnut oak is a hard, strong, tough wood which is used for rough construction. White oak is noted for its long lasting strength and is often used for cabinets,

floors, and furniture. Black oak also can be used for construction purposes. Again there is the problem of feasibility with similar difficulties as encountered with the pine forest. Also if the oak forest were harvested one would have to be careful to reseed the area with oak as there is a possibility of a Virginia pine take over of the area. So these areas are potential resources but the small size and the isolation of these areas probably make them impractical to use.

For wildlife management these areas probably have little use. The major types of animals found in this area would consist of squirrels, rabbits, deer, wild turkey and other kinds of birds. Squirrels have been shown to be important with white oaks because in their collecting and burying of nuts increases the probability that the white oak seeds will germinate. No study on their importance in this area has been done. Rabbits and deer would feed on the young trees and shrubs if there were a shortage of food. Since there are large fields of grass, which these animals prefer, near the pine and oak stands there is little chance of interaction between these animals and the forests. Wild turkey and other birds would probably only be interested in these stands for nesting purposes. They usually eat fruit, grain, or insects. The oak forest is well exposed to wind and weather and would be a poor site for the nesting of any bird. In the pine forest small birds were observed there (black capped chickadee) and probably found suitable nesting sites; however, turkeys because of their size and poor flight could probably not nest on a steep slope with trees so close together. It appears, then, that in either area there is little interaction between the wildlife and the forest stands so there is no need for any real management here.

Aesthetically, the best management would be no management. This means that it would be best to simply leave these areas alone and let them take on their own natural beauty, whatever form that may be. There are some suggestions if one desires

that these areas remain as they are today. The pine forest will have to be protected from the possible encroachment of the hardwoods. This could be accomplished simply by removing some of the red oaks and the young red maples, the major hardwoods in the area. Some selective thinning in the pine forest would result in much larger and healthier trees as there would be fewer organisms after the same amount of nutrients. This writer can think of no suggestions for keeping the oak forest as it is other than simply leaving it alone.

This report has given various phytosociological data, and general observations on an oak forest and a pine forest. These parameters were then used as a basis for a description of these areas. Finally, some conclusions were made about these areas in relation to successional trends and the management of the areas for resources, wildlife, and aesthetic purposes.

RESULTS: The Pine Forest

	Pinus virginiana	Pinus strobus	Acer rubrum
1. # of trees	51	1	6
2. Basal Area (dm^2)	560	118	48.8
3. Frequency (%)	100	6.25	31.25
4. Density (see below)	3.18	.0625	.375
5. Relative Frequency (%)	72.73	4.55	22.73
6. Relative Density (%)	87.93	1.72	10.34
7. Relative Dominance (%)	77	16	6.7
8. Importance Value	79.22	7.4	13.25

Note: Density values represent relative figuires due to type of sampling; see discussion for more explanation.

Check for sufficient sample size:

1. Σx = 13059 cm
2. Σx^2 = 4129335 cm^2
3. Number (N) = 58
4. Variance (S^2) = 21399.8
5. Standard Deviation (S) = 146.1
6. Standard Error ($S_{\bar{x}}$) = 19.0
7. Mean ($\bar{x}$) = 221

Use 10% rule: $S_{\bar{x}} / \bar{x}$ = .085 which is less than .1, so sample size was sufficientl large.

Confidence Interval at 95% level:

$t_{.05}$ = 1.671 $\quad 221 \pm 31.7$ or 221 (189.3-252.7)

RESULTS: The Oak Forest

	Species #1	Species #2	Species #3	Species #4	Species #5	Species
1. # of trees	60	25	13	2	21	7
2. Basal Area (dm^2)	4670	1385	577	92	353	93
3. Frequency (%)	87.5	46.8	34.1	6.25	53	18.7
4. Density (see below)	1.87	.78	.40	.062	.656	.21
5. Relative Frequency(%)	35.5	18.9	13.8	2.5	21.5	7.6
6. Relative Density (%)	46.8	19.5	10.2	1.6	16.4	5.5
7. Relative Dominance(%)	65.1	19.3	8.0	1.3	4.9	1.3
8. Importance Value	49.1	19.3	10.7	1.8	14.3	4.8

Species #1: Quercus prinus

Species #2: Quercus alba

Species #3: Quercus velutina

Species #4: Quercus rubra

Species #5: Pinus virginiana

Species #6: Pinus strobus

Note: Density values represent relative figuires due to type of sampling; see discussion for more explanation.

Check for sufficient sample size:

1. Σx = 31722 cm

2. Σx^2 = 10557112 cm^2

3. Number (N) = 128

4. Variance (S^2) = 21223.4

5. Standard Deviation (S) = 145

6. Standard Error ($S_{\bar{x}}$) = 12.8

7. Mean ($\bar{x}$) = 247.8

Use of 10% rule: $S_{\bar{x}} / \bar{x}$ = .051 which is less than 0.1, so sample size was sufficiently large.

RESULTS: The Oak Forest (con't)

Confidence Interval at 95% level:

$t_{.05} = 1.658$ $\quad 248 \pm 21.25$ or $248\ (226.75\text{-}269.25)$

CALCULATIONS:

BASAL AREA = $(\text{circumference})^2 / 4\pi$

FREQUENCY = # of QUADS species found in / TOTAL # of QUADS

DENSITY = total # of trees / # TOTAL # of QUADS

RELATIVE FREQUENCY - add up all frequency values = F; RF = frequency of species / F ⊗ 100%

RELATIVE DENSITY = # of individuals of one species / total # of individuals of all species ⊗ 100 %

RELATIVE DOMINANCE = BA of one species / total BA for all species ⊗ 100%

IMPORTANCE VALUE = RF + RD + RDo / 3

VARIANCE = $S^2 = \dfrac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1}$

Σx = SUM OF DISTANCES

Σx^2 = SUM OF THE SQUARE OF THE DISTANCES

n = NUMBER OF VALUES

STANDARD DEVIATION = $S = \sqrt{S^2}$

2) STANDARD ERROR = $S_{\bar{x}} = S / \sqrt{n}$

3) 10% RULE = $S_{\bar{x}} / \bar{x} < .1$ $\quad \bar{x}$ = MEAN OF VALUES

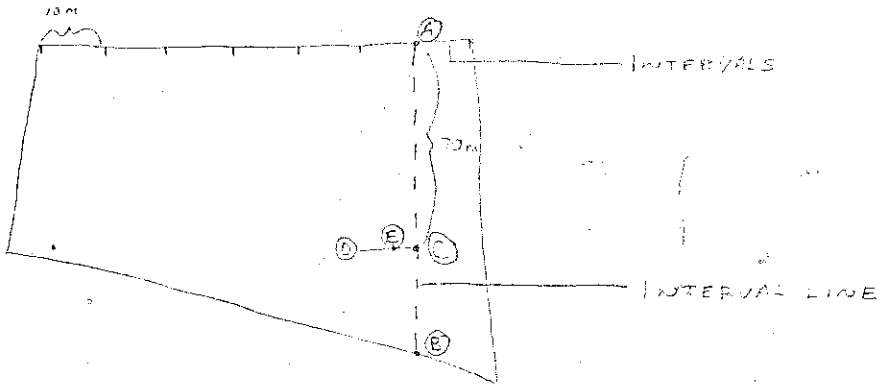
4) CONFIDENCE INTERVAL = (at 95% level) $S_{\bar{x}} \otimes (t.05)$

- $t.05$ - from STUDENT T TABLE

MAPS AND SAMPLING INFORMATION:

IPE 1: EXAMPLE FOR EXPLANATION OF SAMPLING

SAMPLE AREA LAYOUT



① DISTANCE A-B = 100m. With a number, say 70 from a table of random numbers, go down interval 70m (70% of 100m).

POINT C IS A SAMPLING POINT.

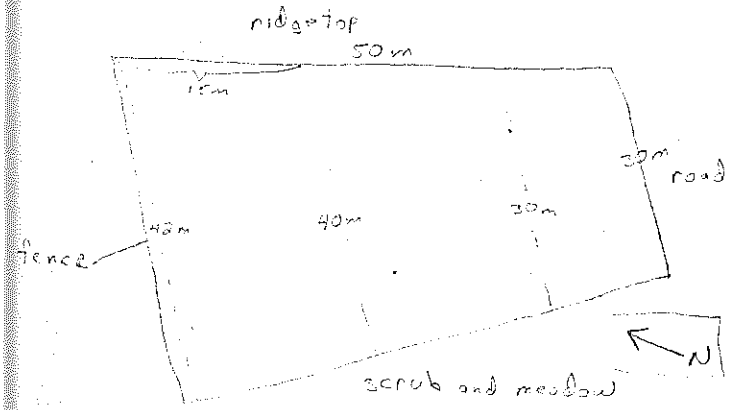
② DISTANCE C-D = 10m. With another number, say 35 from a table of random numbers, go across C-D 3.5m (35% of 10m).

POINT E IS A SAMPLING POINT.

③ REPEAT this twice for each interval line giving four (4) sampling points per interval line.

IGUIRE 2: MAP AND SAMPLING NOTES ON PINE FOREST

- sampling was [illegible] directly across from house at Lake Paxtown Field Station.



① area studied 7/8/80

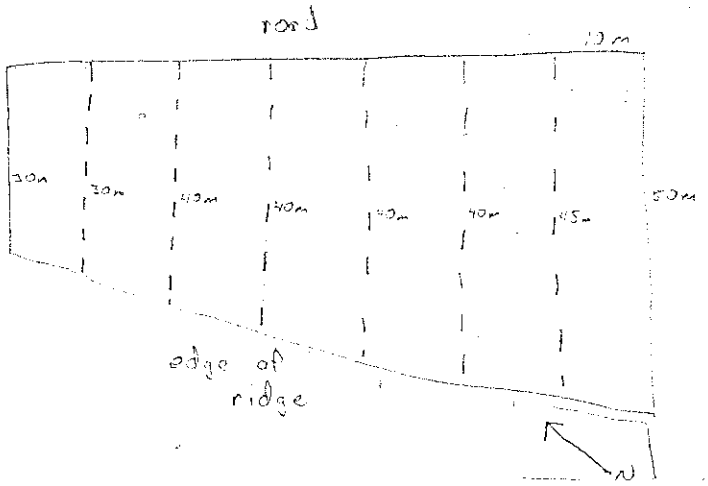
② weather overcast

③ young leaves out on trees

MAPS AND SAMPLING INFORMATION:

FIGURE 3: MAP AND SAMPLING NOTES ON OAK FOREST.

- sampling area located on ridge behind the house about 20 m off of road at Lake Raystown Field Station



- ① area studied 4/18/19/90
- ② weather clear
- ③ no leaves out

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FIELD DATA

Location OAK

Date 4/18/80

PLE

SPECIES	
	210 — distance in cm
	17.5 — circumference in cm
	2.43 — basal area in dm^2

INTERVAL LINE ①

QUAD #										
1	① CHESTNUT OAK	215 33 8.66	② WHITE OAK	348 45.5 16.4	③ CHESTNUT OAK	320 62.5 31.0	④ VIRGINIA PINE	370 46.5 17.2	35 m dist. down INTERVAL	50 m total dist. of INTERVAL
2	① BLACK OAK	335 35.5 10.0	② Virginia Pine	113 35.5 10.0	③ WHITE OAK	242 23.5 4.39	④ Virginia Pine	6 17.5 2.43	73 dist down from point at 35m	
3	① CHESTNUT OAK	587 19 2.87	② Virginia Pine	134 23.5 4.39	③ CHESTNUT OAK	145 15 1.79	④ BLACK OAK	50 105 87.7	33 m dist. down INTERVAL	
4	① BLACK OAK	410 73 42.4	② CHESTNUT OAK	149 32 8.14	③ Virginia Pine	285 18.5 2.72	④ Virginia Pine	190 47 17.5	4.4 dist away from POINT AT 33m	
5	① CHESTNUT OAK	117 66 34.6	② CHESTNUT OAK	116 28.5 6.46	③ CHESTNUT OAK	180 37.5 11.1	④ CHESTNUT OAK	85 17.5 2.43	25m	45m
6	① WHITE ~~PINE~~ OAK	133 118.5 111	② CHESTNUT OAK	323 22.5 4.02	③ WHITE OAK	330 40 12.7	④ Virginia PINE	362 28 6.23	3.5m	
7	① BLACK OAK	204 103.5 85.2	② CHESTNUT OAK	109 37 10.8	③ CHESTNUT OAK	261 27.5 6.0	④ CHESTNUT OAK	74 22.5 4.02	28 m	
8	① BLACK OAK	65 103 84.4	② CHESTNUT OAK	241 30 11.5	③ CHESTNUT OAK	362 27.5 6.0	④ CHESTNUT OAK	43 22.5 4.0	1.4 m	
9	① WHITE OAK	387 21.5 3.67	② CHESTNUT OAK	630 38 11.4	③ RED OAK	163 106 89.4	④ Virginia Pine	339 16 2.03	14 m	40 m
10	① WHITE OAK	440 39 12.0	② Virginia Pine	446 22 3.85	③ BLACK OAK	319 21.5 3.67	④ CHESTNUT OAK	419 35 9.74	3.8 m	
11	① CHESTNUT OAK	49 19.5 3.02	② Virginia Pine	470 25 4.97	③ WHITE OAK	137 29 6.69	④ CHESTNUT OAK	429 30 7.1	89 m	
12	① CHESTNUT OAK	220 16.5	② CHESTNUT OAK	123 133 140	③ CHESTNUT OAK	348 30 7.16	④ CHESTNUT OAK	91 41.5 13.7	5.4m	

INTERVAL LINE ②

INTERVAL LINE ③

% canopy cover_____

Light outside forest stand_____

Light inside at forest floor_____

Shrub layer_____

Herb layer_____

Depth of litter_____

Type of litter_____

Depth of A_____

pH of A_____

Other_____

FIELD DATA

Location OAK

Date 4/28/20

QUAD #												
INTERVAL LINE ④	13	① CHESTNUT OAK	500 102" 82.7	② VIRGINIA PINE	160 55" 24.0	③ CHESTNUT OAK	140 35" 9.74	④ WHITE OAK	231 29 6.64	11m	40m
	14	① CHESTNUT OAK	357 44.5" 15.7	② CHESTNUT OAK	443 103 84.4	③ WHITE OAK	92 158 198	④ WHITE OAK	560 47.5" 17.9	7.6m	
	15	① CHESTNUT OAK	418 84" 56.1	② BLACK OAK	380 65.5" 34.1	③ CHESTNUT OAK	218 35" 9.74	④ CHESTNUT OAK	55 29 6.69	38m	
	16	① CHESTNUT OAK	424 17 2.29	② CHESTNUT OAK	95 100 79.5"	③ CHESTNUT OAK	445 30 7.16	④ BLACK OAK	420 21 35"	7.4m	
INTERVAL LINE ⑤	17	① CHESTNUT OAK	370 22.5" 4.02	② CHESTNUT OAK	35" 100 79.5"	③ CHESTNUT OAK	531 30.5" 7.4	④ CHESTNUT OAK	468 21.5" 3.67	39m	40m
	18	① CHESTNUT OAK	109 23 4.2	② BLACK OAK	303 40.5" 13.0	③ BLACK OAK	454 31.5" 7.89	④ CHESTNUT OAK	300 100 79.5"	2.9m	
	19	① WHITE OAK	322 21.5" 3.67	② WHITE OAK	259 153 186	③ WHITE OAK	351 36.5" 10.6	④ WHITE OAK	238 ~~247~~ 247 485	7m	
	20	① CHESTNUT OAK	275 15" 1.79	② VIRGINIA PINE	314 31 7.64	③ VIRGINIA PINE	146 42 14.0	④ CHESTNUT OAK	178 63.5" 32.0	8m	
INTERVAL LINE ⑥	21	① CHESTNUT OAK	31 96.5" 74.1	② VIRGINIA PINE	504 19 2.87	③ CHESTNUT OAK	91 18.5" 2.72	④ BLACK OAK	148 155" 191	14m	40m
	22	① WHITE OAK	233 122 118	② WHITE PINE	214 62 30.5"	③ WHITE OAK	269 19 2.87	④ CHESTNUT OAK	104 87.5" 60.9	9m	
	23	① WHITE OAK	154 21.5" 3.67	② VIRGINIA PINE	60 19 2.87	③ WHITE OAK	677 117 108.9	④ CHESTNUT OAK	389 95.5" 72.5"	19m	
	24	① CHESTNUT OAK	298 35"	② CHESTNUT OAK	90 77 77.1	③ RED OAK	457 19 2.87	④ WHITE PINE	323 64.5" 33.1	7m	

% canopy cover_____

Light outside forest stand_____

Light inside at forest floor_____

Shrub layer_____

Herb layer_____

Depth of litter_____

Type of litter_____

Depth of A_____

pH of A_____

Other_____

FIELD DATA

Location OAK Date

INTERVAL LINE (7)

INTERVAL LINE (30)

Quad #										
25	① CHESTNUT OAK	58 15 1.79	② WHITE OAK	282 45 16.1	③ Virginia Pine	123 79 49.6	④ CHESTNUT OAK	307 63 31.5	32m	30m
26	① CHESTNUT OAK	260 81.5 52.8	② CHESTNUT OAK	166 99 77.9	③ CHESTNUT OAK	194 66 34.6	④ CHESTNUT OAK	151 86 58.8	5m	
27	① CHESTNUT OAK	290 56 29.9	② BLACK OAK	224 30 7.16	③ CHESTNUT OAK	130 83 54.8	④ BLACK OAK	139 29 6.69	8m	
28	① WHITE OAK	112 59 27.7	② CHESTNUT OAK	314 59 27.7	③ WHITE PINE	88 37 10.9	④ WHITE OAK	209 25.5 5.17	5m	
29	① CHESTNUT OAK	54 36.5 10.6	② CHESTNUT OAK	230 68 30.5	③ WHITE PINE	190 36 10.3	④ Virginia Pine	128 59.5 28.1	15m	30m
30	① WHITE PINE	207 26 5.37	② CHESTNUT OAK	49 35.5 10.0	③ Virginia Pine	123 59.5 28.1	④ Virginia Pine	52 65.5 34.1	1m	
31	① Virginia Pine	145 59.5 28.1	② WHITE PINE	252 20 3.18	③ WHITE OAK	423 18.5 2.72	④ Virginia Pine	245 59 29.7	12m	
32	① WHITE OAK	163 19 2.87	② Virginia Pine	342 65.5 39.1	③ WHITE OAK	145 40 12.7	④ WHITE OAK	307 35 9.74	4m	
9										
10										
11										
12										

% canopy cover

Light outside forest stand

Light inside at forest floor

Shrub layer

Herb layer

Depth of litter

Type of litter

Depth of A

pH of A

Other

FIELD DATA

Location PINE

Date 5/2/80

	QUAD #										
INTERVAL LINE ①	1	① FENCE (IN WAY, no SAMPLE)		② Virginia Pine	50 18 2.57	③ Virginia Pine	63 16 2.03	④ FENCE		18m	42m
	2	① Virginia Pine	179 21.5 3.6	② Virginia Pine	195 22.5 7.0	③ Virginia Pine	174 20 3.18	④ Virginia Pine	13 22 3.85	4m	
	3	① Virginia Pine	185 22 3.85	② Virginia Pine	460 17 2.99	③ RED MAPLE	386 17 2.99	④ FENCE		38m	
	4	① Virginia Pine	92 23 4.2	② Virginia Pine	200 31 7.64	③ Virginia Pine	169 25 4.97	④ Virginia Pine	275 32 8.1	7m	
INTERVAL LINE ②	5	① Virginia Pine	415 26 5.39	② Virginia Pine	241 29 6.69	③ Virginia Pine	216 15 1.79	④ Virginia Pine	568 26 5.37	21m	40m
	6	① Virginia Pine	87 31 7.64	② Virginia Pine	289 28 6.33	③ Virginia Pine	305 49 19.1	④ Virginia Pine	335 19 2.87	12m	
	7	① Virginia Pine	78 37 10.8	② Virginia Pine	76 24 4.58	③ Virginia Pine	481 19 2.87	④ WHITE PINE	291 122 118	28m	SHIFTED POINT DUE TO TERRA
	8	① Virginia Pine	183 40 18.3	② Virginia Pine	175 50 19.8	③ Virginia Pine	206 16 2.03	④ Virginia Pine	130 17 2.09	14m	
INTERVAL LINE ③	9	① Virginia Pine	111 34 9.19	② Virginia Pine	103 49 19.1	③ Virginia Pine	96 32 8.14	④ Virginia Pine	240 52 21.5	15m	30m
	10	① Virginia Pine	313 38 11.5	② Virginia Pine	336 18 2.57	③ Virginia Pine	727 45 16.1	④ Virginia Pine	183 96-25 TEMP 73.3	4m	
	11	① Virginia Pine	400 20 3.18	② Virginia Pine	338 31 7.64	③ Virginia Pine	272 50 19.8	④ Virginia Pine	70 50 19.8	19m	
	12	① Virginia Pine	329 18	② RED MAPLE	174 41 133	③ Virginia Pine	572 54 23.2	④ Virginia Pine	347 15 1.79	10m	-area open with lots of scrub

% canopy cover_____

Light outside forest stand_____

Light inside at forest floor_____

Shrub layer_____

Herb layer_____

Depth of litter_____

Type of litter_____

Depth of A_____

pH of A_____

Other_____

FIELD DATA

Location PINE

Date 5/2/80

QUAD #										
13	① RED MAPLE	108 34 9.19	② Virginia Pine	213 29 6.69	③ Virginia Pine	71 75 44.7	④ RED MAPLE	182 33 866	14 m	30 m
14	① SCRUB MEADOW - NO TREES		② SCRUB MEADOW		③ Virginia Pine	43 42 14.0	④ Virginia Pine	90 28 6.23	4 m	
15	① Virginia Pine	87 26 5.37	② RED MAPLE	139 36 10.3	③ Virginia Pine	162 63 31.6	④ Virginia Pine	194 42 14.0	17 m	
16	① RED MAPLE	96 25 4.97	② Virginia Pine	156 35 9.74	③ Virginia Pine	285 24 4.58	④ Virginia Pine	121 47 17.5	12 m	
5										
6										
7										
8										
9										
10										
11										
12										

PATTERSON CREEK

% canopy cover_____

Light outside forest stand_____

Light inside at forest floor_____

Shrub layer_____

Herb layer_____

Depth of litter_____

Type of litter_____

Depth of A_____

pH of A_____

Other_____

LIMNOLOGICAL ANALYSIS OF THE JAMES CREEK WATERSHED OF RAYSTOWN LAKE

Submitted By

George J. Mack

May 1980

I would like to thank Dr. Todd Gustafson for his advice, patience, and lasting faith in this project, without which this independent study could not have been completed. I am indebted to Dr. Robert Fisher for his help and use of the Juniata College field station, and the assistance in the field by Peter Davis and James Angstadt, which I gratefully acknowledge.

A physical-chemical investigation of the James Creek watershed of Raystown Lake, Huntingdon County, Pennsylvania, from March through May 1980 was undertaken to examine the limnological variations existing among the contributing streams and within the lake itself. The purpose of this study is to provide comparative baseline data concerning the various streams entering the watershed and the resulting effects upon confluent water.

The James Creek watershed drains a 20.38 square mile area (before inudation) of Penn Township forming the headwaters of Raystown Lake. The 30 mile long, 8,300 acre lake was authorized in 1962 under the Flood Control Act. The lake is formed by the Raystown Dam, located in the Raystown Branch of the Juniata River. Constructed between 1969 and 1973, the dam provides flood control, recreation, enhanced fishery, and downstream flow augmentation.

The actual testing of the streams and lake was carried out over a two day span in mid-May. This method of sampling afforded the unique advantage of equalizing the effects of atmospheric conditions at all testing sites. The sampling was done approximately four days after significant rainfall had occured. In this manner, all testing sites had been exposed to the same amount of environmental fluxuations and should therefore have been recovering at their natural rate. A total of 16 streams and 8 lake sites were analyzed (See Figure 1). The Juniata College Houseboat was used for transportation to these sites. The creek samples were taken well upstream so as to insure accuracy of the individual streams contribution without backflow from the lake. Lake samples were collected using a Kemmerer water-bottle. The parameters actually tested were dissolved oxygen content, conductivity, pH, temperature, and millivolts (simply to correlate with pH). Also, any unique physical characteristics of the streams were noted. All testing was done on location via the use of portable instruments. This eliminated the concern over whether or not the water samples were fixed or stored properly.

The YSI Model 33 Salinity-Conductivity-Temperature Meter was used to test the conductivity and temperature. The YSI Thermo-Oxygen Probe was used to analyze the dissolved oxygen content and temperature. In most instances the two different meters yielded the same temperature readings, if not, the temperatures were averaged. A standard portable pH meter was used to test the pH and millivolts. It was calibrated using standard 7 and 10 ph buffers.

DISSOLVED OXYGEN

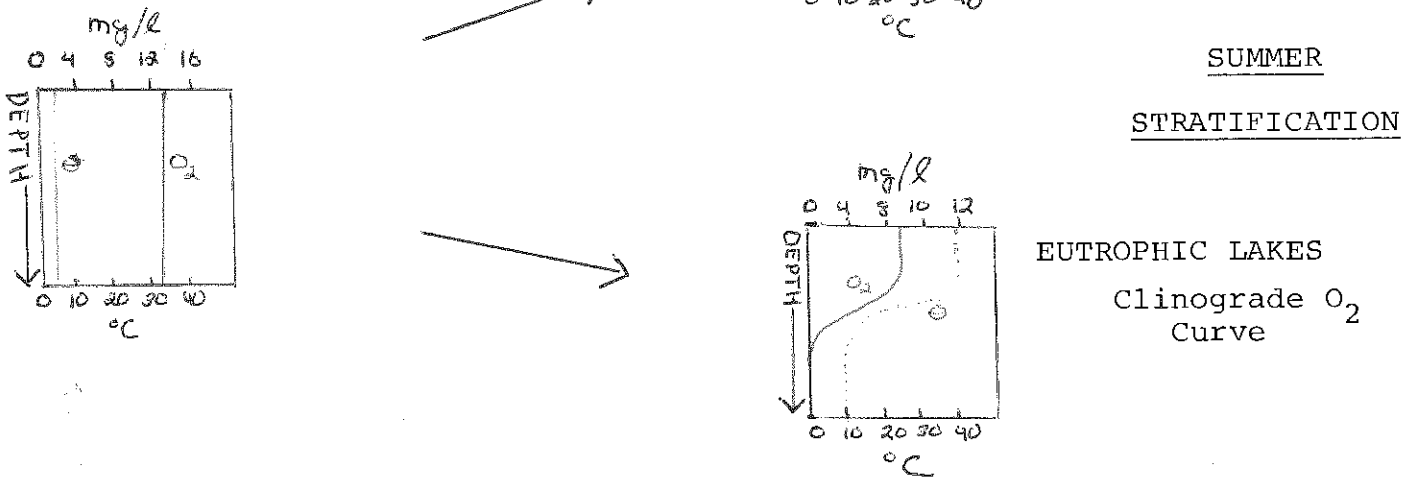
The dissolved oxygen content of lakes and streams is one of the most important parameters governing the aquatic ecosystem. The dynamics of oxygen solubility and distribution affect the behavior and physiological growth of all aquatic organisms. Factors which affect the dissolved oxygen content are depth, temperature, light, metabolic utilization, other dissolved gases, turbulence, and pressure.

Solubility of oxygen is affected nonlinearly by temperature and increases considerally in cold water. The solubility for oxygen decreases approximately one-half as the temperature rises from the freezing point to 30 C.[2] As a gas, oxygen reacts to the atmospheric pressure as well as to the partial pressure of other gases. Hence the elevation of the lake or stream will have an effect upon the maximum saturation of oxygen in water. The combined atmospheric and hydroststic pressures at a particular depth is called the absolute saturation.[3] The diffusion of gases in water is a tedious process, therefore the degree of turbulence will affect the equilibrium between oxygen in the atmosphere and that dissolved in the water.

Lakes can be classified according to the seasonal stratification of dissolved oxygen which is directed related with photosynthetic activity. Eutrophic or "well nourished" lakes exhibit a deep layer or hypolimnetic loss of oxygen. The curve of the oxygen distribution drops sharply through the metalimnion (that

thermal region bordering the thermocline) and is termed as clinograde. It seems that temperature and oxidation of organic matter are the mafor factors causing oxygen depletion in the hypolimnion.[4]

Oligotrophic or "poorly nourished" lakes represent the other extreme of oxygen distribution. These lakes are usually clear for considerable depths with low turbidity. The light transmission or euphotic zone is deep and photosynthesis may occur at some distance below the surface. The oxygen curve may increase through the metalimnion with a high oxygen content in the hypolimnion. This type of curve is termed an orthograde or vertical oxygen curve. An example of both clinograde and orthograde oxygen distribution curves follows: (For Test Period)



The basic physical and chemical relationships between dissolved gases in streams follow the same fundamental laws as those in lakes. However, temporal and spacial relations of dissolved gases are affected by special physical features unique to streams. Factors such as inherent turbulence, land-water interfaces, velocity and volume variations alter streams in a special way. There are three primary sources of oxygen in streams, each with unique contributions. Ground water and surface run-off represent the most insignificant source of dissolved oxygen. Water originating from springs or from subterranean channels is typically low in dissolved oxygen, often to the point of being anaerobic. If however, subsurface water flows over broken rocks shortly before reaching the surface, the turbulence may increase the oxygen content.

Photosynthesis in less turbid streams contributes oxygen to the water during the daylight hours. Of course, this may be counterbalanced by respiration occuring at night. In gereral, those slow moving streams permit more photosynthetic activity than slightly more turbulent systems.

Finally, the most influential factor which serves to increase the dissolved oxygen content is physical aeration. Physical aeration is the process by which streams secure oxygen directly from the atmosphere.[5]

In this specific project dissolved oxygen in both streams and the lake was measured via the Clark type oxygen sensor which measures oxygen pressure. Oxygen is consumed at the cathode caus-

ing a pressure drop across the membrane. Inside the membrane next to the cathode the oxygen pressure is zero because the oxygen is consumed as it reaches the cathode. Outside the membrane the oxygen pressure is the ambient pressure to be measured. Oxygen diffuses through the membrane due to this pressure differential. The flow of oxygen through the membrane is directly proportional to the differential oxygen pressure across the membrane. The chemical reaction within the sensor produces a current which is in direct stoichiometrical relation to the amount of oxygen being consumed. Hence, the cell current is directly proportion to the oxygen pressure to which the sensor is exposed. With this instrument field calibration was necessary due to changing membrane properties.[6]

In examining the specific oxygen profile of Lake Raystown, one factor clearly stands out-- increasing depth decreases dissolved oxygen content. At ever station tested there was a significant drop in the amount of oxygen dissolved in the water. This occured despite the fact that the deeper water was between one to five degrees centigrade cooler than the surface water. The apparent reason for this gradation of oxygen content is the degree of photosynthesis which is most likely occuring in the eutrophic zone. The phytoplankton in the upper two meters (5 feet test sample) are apparently undergoing significant photosynthesis, causing an increase in oxygen content. It should be noted that while there seems to an inconsistency beteeen temperature and degree of solubility, the change in temperature is probably not so

great so as to offset the amount of photosynthetic activity. It seems apparent from the temperature and dissolved oxygen data that the lake existed in a condition between the spring overturn and summer stratification. This state can best be catagorized as a 'mixed conkition state.' By this I simply mean that the physio-chemical properties of the lake are transgressing from the older winter state, yet have not reached the stable summer condition. Further references will be made to support this contention in following scetions. Since summer stratification has not yet been attained it is impossible, based solely upon the oxygen profiles, to ascertain whether Lake Raystown is an oligotrophic or eutrophic body of water. However, based upon the clinograde as opposed to orthograde O_2 curves seen for all sites, it is presumed that Lake Raystown will exhibit eutrophic characteristics.

The dissolved oxygen content of the contributing streams elicits an entirely different set of concerns. As mentioned earlier, variability among small streams seems to be the order of the day. The experimentally obtained results seem to verify this. The dissolved oxygen content among the 16 tested streams ranges from a low of 4.8% ppm to a maximum of 17.5% ppm. The key factor which seems to dictate the oxygen content is the turbulence of the stream. Sites 1,2,and 3 (% O_2: 4.8, 4.5, 4.6) feed slow moving, almost stagnant marshes. Samples of streams 9, 10, and 11 (% O_2: 16.0 17.0 17,5) of the Aitch boat launch area were taken just downstream of small 6 to 10 inch waterfalls. Thus the primary means of stream solubility-- physical aeration, most likely contributed to these high dissolved oxygen contents. Had time permitted, it would have been interesting to go back and analyze thes streams above the sudden turbulence interjected by waterfalls. The fundamental conclusion discerned from the dissolved oxygen content of the streams of the James Creek watershed is that variability is indeed the key word.

TEMPERATURE

The thermal properties of water are one of the most important factors in determining the fitness of water as a natural environment and in regulating the interacting relations among aquatic organisms. The two most unique and fundamentally important characteristics of water are its extremely high cacacity for heat absorption and the fact that pure water reaches its maximum density at 3.98 C, rather than its freezing point, 0.0 C.

The temperature of natural waters is dependant upon two factors, the heating effects of solar radiation and the cooling effects of evaporation. Lambert's Law states that light absorption by water increases exponentially with the length of the light path: in a column of water one meter in length, 91 percent of light with wavelength of 820 nm is absorbed and only 9 percent transmitted; at a depth of 2 meters, the amount absorbed increases to 99 percent.[7] More than 50 percent of all solar radiation is absorbed within this region, the upper one or two meters below the surface of the water.

The basic thermal characteristics and processes in the water in streams are not different from those of lake waters. Penetration of light, absorption, specific heat, and other factors which affect the nature of the water molecule determine the characteristics of streams just as they do with lakes. The major factor affecting the temperature of streams is once again solar radiation. However, the considerable land-water interelationships manifest

other thermal effects on the water. The degree of shade due to trees, the cooling effects of the various substrates, and the volume and velocity of the water as it transcends toward the lake, all affect the temperature of the water. Also, the dinural and seasonal temperature follows the atmospheric temperatures more closely in streams as opposed to lakes. A general rule is that the smaller the stream, the greater the temperature variation and the more rapid the response to environmental fluctuations.

A unique factor which affects many streams, especially those of the James Creek watershed, is the affect agriculture has upon the thermal properties of the water. The spring run-off from cultivated fields greatly increases the amount of silt present, which in turn enables the stream to absorb more heat-- increasing its specific heat capacity.

Returning to the discussion of lakes, we can now discuss the process of thermal stratification, specifically its affects during the March through May testing period.

As winter yields to spring, solar radiation increases due to a higher sun and increased day length, resulting in the melting of the ice. As the surface water warms up to approximately 4 C, it becomes more dense producing a slight temporary stratification which sets up convection currents. These currents, aided by the wind, serve to mix the lake so as to approach uniform water temperature. This process is known as spring overturn.[8]

As summer approaches, the usual pattern is then to establish a stable, three layered thermal system. The top layer or epilimnion

is the zone of summer circulation; changes in the atmospheric temperature affect that of the water. The second layer, termed the thermocline is defined by a sudden drop in temperature with increasing depth. A subsidiary term, the metalimnion, represents a gradient of either side of the thermocline. The bottom layer or hypolimnion is a cold, relatively undisturbed region, low in dissolved oxygen and high in carbon dioxide.

Analysis of the specific depth-temperature data of Lake Raystown seems to support the aforemention concept that the lake, during the testing period, was in a state of flux following spring overturn and prior to summer thermal stratification. Spring overturn had obviously occured since the ice had melted at least two months prior to the actual testing period. The contention that summer stratification did not yet exist is provided by the definition of thermocline which refers to a sudden drop in temperature over a short distance. Analyzing the data, specifically sites D and E, it should be noted that the maximum drop in temperature is only 5 C, occuring over the maximum depth range. All other sets of data include a lesser degree of change, regardless of the change in depth. Based upon this evidence it seems improbable that summer stratification has occured.

Once again, analysis of streams shows a tremendous range of temperature. Numerous streams registered a low of 12 C while streams 10 and 11 recorded highs of 22 C. This data is somewhat perplexing. It should be recalled that streams 9, 10, and 11 also recorded the highest dissolved oxygen content. It was noted that the readings

were taken downstream of small waterfalls. This water seemed to be somewhat turbulent which would account for the high oxygen content but would seem to indicate the presence of cooler water. However, since both the conductivity meter and the oxygen probe were used to test temperature and since the oxygen probe was tested, calibriated and consistantly employed throughout the days operation, it would seem that the water was in fact, turbulent yet warmer. The final conclusion reached involves the land-water interactions. The small streams were totally exposed to the bright sunlight. There were no trees to provide shade along the banks of streams 10 and 11; this would provide an adequate answer to the question of high temperature in these waters. Also, it was stated that the dissolved oxygen was tested below the waterfalls; it now seems likely that if tested upstream , the oxygen content would be more in line with the remaining streams.

It can be seen from this analysis that the temperature of small streams is affected vigorously and more quickly by the environment on a day to day basis while the lake seems to function thermally on a more consistent seasonal pattern.

pH

The pH of natural waters is governed to a large extent by the interaction of H^+ ion arising from the dissociation of H_2CO_3 and from OH^- ions, resulting from hydrolysis of bicarbonate. The range of pH of most open lakes is between 6 and 9. Most of these lakes are the 'bicarbonate type'- containing varying amounts of carbonate and are regulated by the CO_2-HCO_3^--$CO_3^=$ system of buffering capacity. Calcareous hardwater lakes commonly are buffered strongly at pH values above 8. Seepage lakes and lakes of igneous rock catchment areas are less well buffered and more acidic, with pH values somewhat less than 7.[9]

The hydrogen ion activity is extremely important in its relation to the total CO_2 content of the water. The CO_2 content is derived by the equilibria established between atmospheric CO_2, the bicarbonate-carbonate system, contributions from metabolic respiration, and utilization in photosynthesis. It has been shown that the vertical pH distribution in lakes exhibits approximately the inverse pattern of total CO_2 content.[10] A biologically mediated example of this correlation is the photosynthetic utilzation of CO_2 which reduces CO_2 content and increases pH. The pH of a given stream or lake provides a rough estimate of the stresses on the bicarbonate-carbonate system which in turn affects aquatic metabolism of microorganisms.

As the spring overturn occurs in lakes, mixing of dissolved materials distributes CO_2 and other gases evenly, producing a

rather uniform pH from surface to bottom. As warmer temperatures occur, eutrophic lakes exhibiting a clinograde oxygen curve, show a carbon dioxide-carbonate concentration in a general inverse relationship to oxygen. The concentration of carbon dioxide and bicarbonate increases with depth, therefore the pH should decrease accordingly. Orthograde oxygen distribution is usually accompanied by a very slight, if any , increase in CO_2-- or slight decrease in pH.[11]

The bicarbonate buffer system and pH of streams are determined primarily by current. Thus, the chemical composition of streams is subject to considerable change. The outstanding factor which influences streams more so than lakes is the substrate from which streams emanate-- the mineral- bearing rocks of the streambed. For example, in limestone regions a high concentration of CO_2 is not apt to develop in a stream because any excess in gas would enter into combination with lime in the substrate to give carbonate. The direct, strong influence of the substrate rests primarily upon the solubility of the buffer substance in rocks.[12]

The period of mixing tends to disrupt any pattern of stratification according to depth in Lake Raystown. The majority of testing sites on the lake seem to exhibit pH readings with no depth correlation. If however, one examines sites C and B, there is a slight decrease in pH, this would correlate with an increased level of dissolved CO_2 (decreasing O_2). However, the decrease in pH is so slight while the accuracy of the pH meter is not that great so as to invalidate any steadfast conclusions.

The pH of the streams is a direct product of the streambeds upon which they flow. The variations in pH in the different test streams can be directly attributed to this factor. Further geological analysis of the streambeds would be required to postulate the specific influences upon the individual streams.

CONDUCTIVITY

The specific conductance of water is a measure of the resistance of a solution to electrical flow. The resistance of the water solution to electrical current is reduced with increasing content of ionized salts. By definition, specific conductance of an electrolyte is the reciprocal of the specific resistance of a solution measured between two electrodes 1 cm^2 in area and 1 cm apart. The resistance is expressed in umhos cm^{-1} (reciprocal of ohms). The temperature of the electrolyte affects the ionic velocities; conductance increases about 2 percent per degree C. Increasing pH also increases the conductivity.[13]

The specific conductance of the common bicarbonate type lake is closely proportional to concentrations of the major ions. Assuming Lake Raystown fits this catagory, the concentration of ions, greatest to least, should be: Ca, Mg, Na, K, CO_3, SO_4, Cl.

Obviously, water with high ionic content (eutrophic) should have higher conductivity measurements than water with low ionic content (oligotrophic).

In a general sense, the quanity and quality of dissolved solids determines the variety and abundance of aquatic organisms. The chemical density of the environment of aquatic plants and animals is a function of the total dissolved solids. Also, as the only source of nutritionally important ions availible to phytoplankton is that matter dissolved in the water, the entire aquatic community is directly limited by the availibility of a given set of ions.

The main differences between lakes and streams with respect to dissolved solids are the relative concentrations, composition, and longitudinal distribution of the substance. Seasonal variations in rainfall and surface runoff, and the geochemical nature of the drainage basin, strongly influence the composition of waters of small streams, thereby imparting considerable individuality to streams even within a restricted region. Variability becomes the key word in any attempt to catagorize small streams.[14]

Examining the specific conductance data of Lake Raystown reveals that there does in fact exist a direct correlation between temperature and conductivity; an increase in temperature increases the concuctivity. Throughout all samples, except site H, there was a decrease in conductivity with decreasing temperature (decreasing depth). The increasing depth itself may or may not be a determining factor upon the ionic concentration of dissolved solids. Based soley upon the availible thermal data, it is impossible to distinguish between increased conductivity due principally to increased temperature or due to an increase in amount of dissolved solids. No doubt both factors contribute to some extent. The effect pH had upon conductivity seemed to vary inconsistantly both in depth profiles across the same depth and across the same depth at varying sites across the lake.

Once again, the variation in conductivity among the 16 different streams seems to verify the concept of different nutrient inflows to the various streams.

FOOTNOTES

(1.) Army Corps Of Engineers Raystown Project Office Reprint-General Information, Raystown Lake Project, 1975. p.4.

(2.) R. Wetzel, Limnology (Phila.: Saunders, 1975), p.124.

(3.) Wetzel, p.125.

(4.) G. Reid, Ecology Of Inland Waters and Estuaries (New York: Nostrand, 1976), p. 197.

(5.) Reid, p. 210.

(6.) Yellow Springs Instrument Co., YSI Oxygen Meter Computer, (Yellow Springs, Ohio: 1967), p. 1.

(7.) Reid, p. 143.

(8.) Reid, p. 152.

(9.) Reid, p. 174.

(10.) Wetzel, p. 177.

(11.) Reid, p. 207.

(12.) Reid, p. 217.

(13.) Wetzel, p. 148.

(14.) Reid, p. 247.

(15.) Reid, p. 210.

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Wetzel, R., Limnology, W.B. Saunders Co., Phils., 1975.

Yellow Springs Instrument Co. Inc., YSI Oxygen Meter Computer, yellow Springs, Ohio. 1967.

TABLE 1

PHYSICAL-CHEMICAL CHARACTERISTICS OF LAKE RAYSTOWN

Site ft	Temperature C	Conductivity umhos/cm	Dissolved O_2 ppm	pH	mv
A15	14	120	17.0	9.1	-1.2
A5	15	123	11.0	8.6	-0.9
B25	14	120	10.5	8.7	-1.0
B5	15	125	11.5	8.6	-1.0
C25	13	110	7.5	8.4	-0.6
C15	15	120	10.5	8.1	-0.7
C5	15	123	11.25	8.2	-0.8
D50	9	110	7.5	8.4	-0.8
D25	11	113	10.0	8.2	-0.8
D5	14	115	10.5	8.4	-0.8
E45	10	110	6.5	8.5	-1.0
E25	13	109	8.0	8.4	-0.9
E5	15	111	10.25	8.4	-0.9
F45	11	107	6.5	8.3	-0.7
F25	12	107	8.25	8.3	-0.7
F5	14	109	9.2	8.3	-0.8
G30	14	107	10.0	8.2	-0.7
G15	14	111	10.5	8.3	-0.8
G5	15	111	11.0	8.3	-0.8
H16	15	134	9.5	8.3	-0.7
H5	16	125	11.5	8.3	-0.8

TABLE 2

PHYSICAL-CHEMICAL CHARACTERISTICS OF

JAMES CREEK WATERSHED STREAMS

Site	Temperature C	Conductivity umhos/cm	Dissolved O_2 ppm	pH	mv
1	12	40	4.8	7.4	-0.2
2	13	44	4.5	7.5	-0.1
3	12	48	4.6	8.2	-0.5
4	13	65	11.2	8.2	-0.7
5	14	70	8.75	8.0	-0.6
6	14	75	7.0	8.1	-0.7
7	14	80	10.0	7.7	-0.4
8	13	49	6.25	9.0	-1.1
9	19	100	16.0	8.9	-1.0
10	22	110	17.0	9.1	-1.2
11	22	110	17.5	9.2	-1.3
12	22	120	14.0	8.1	-0.7
13	16	70	13.0	8.1	-0.7
14	13	50	9.0	8.0	-0.7
15	12	45	9.25	8.4	-0.9
16	12	55	8.5	8.4	-0.8

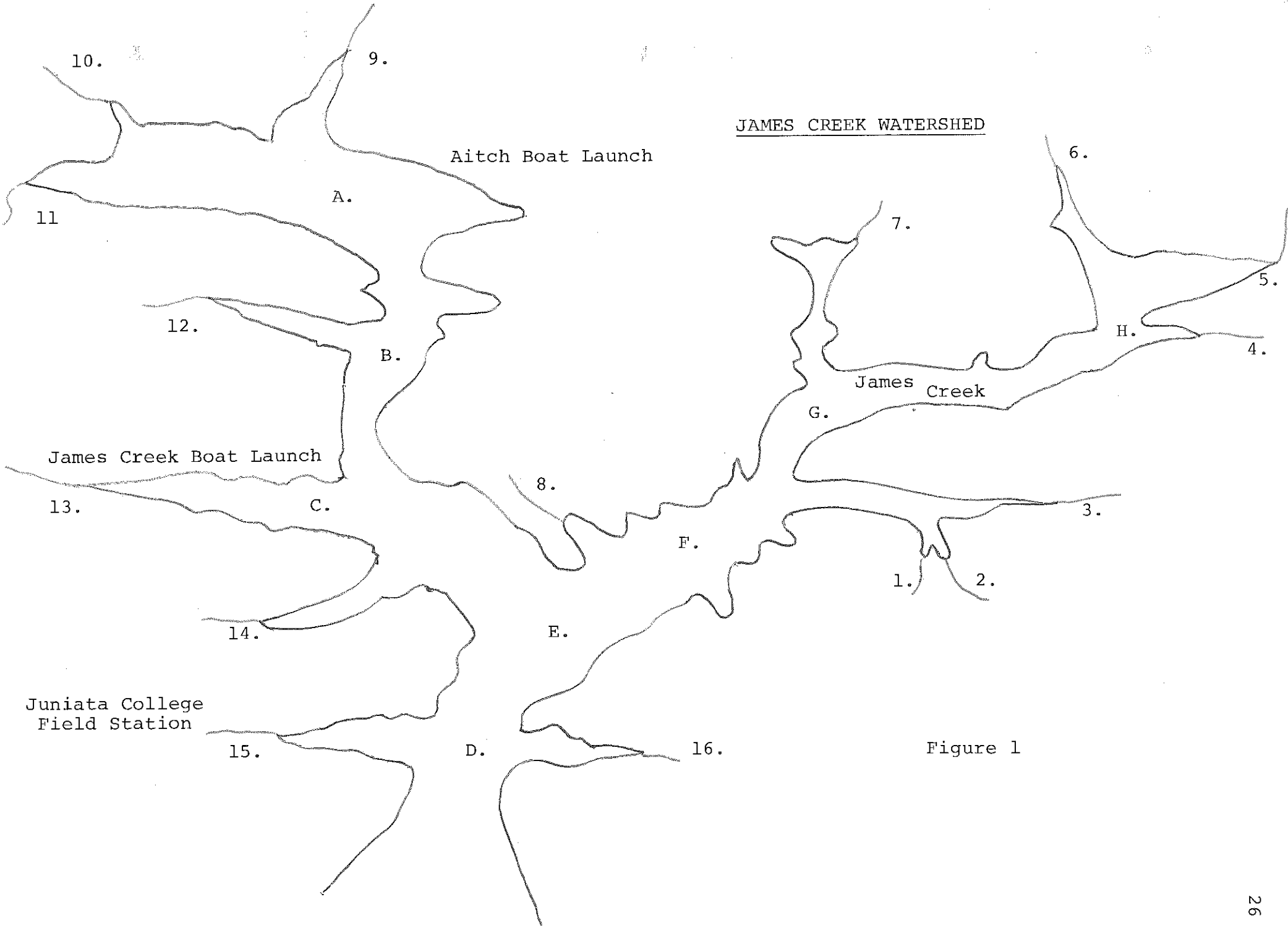

JAMES CREEK WATERSHED
10.
9.
Aitch Boat Launch
A.
11
12.
B.
James Creek Boat Launch
13.
C.
14.
E.
Juniata College
Field Station
15.
D.
16.
8.
F.
7.
6.
5.
H.
4.
James Creek
G.
3.
1.
2.

Figure 1

1985

OXYGEN CONSUMPTION OF THE SOUTHERN BOG LEMMING, *SYNAPTOMYS COOPERI*, AND A BRIEF DISCUSSION OF HABITAT REQUIREMENTS.

John Gibble
September 1985

Research under
Robert L. Fisher, Ph.D
Juniata College

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ABSTRACT

The oxygen consumption of **Synaptomys cooperi** at a temperature of 25 degrees Celcius was observed to be 4.Ø4 cc O2/g/hr. Oxygen consumptions at other temperatures ranging in five degree increments from Ø5 degrees to 3Ø degrees Celcius were observed. Because the least value for oxygen consumption was found at 25 degrees Celcius, it is assumed that this temperature fell within the thermal neutral zone. The oxygen consumption at 25 degrees conforms to the "Mouse to Elephant" curve derived by Scholander et al (195Ø).

In three areas where more than one Synaptomys was live-trapped, a brief vegetational analysis revealed that of three classes of vegetation, discriminated by heighth (Class 1: less than .7Ø meters; Class 2: greater than .7Ø meters and less than 2.Ø meters; and Class 3: greater than 2.Ø meters), Orchard Grass, Dactylis glomerata; Privet, Ligustrum vulgare; and Sugar Maple, Acer saccharum were the most abundant species of vegetation.

INTRODUCTION

The Southern Bog Lemming, Synaptomys cooperi, is a small microtine rodent found from Eastern Quebec, south to Arkansas, and east along the Atlantic Seaboard (Hoffmeister et al, 1972). In regards to feeding and nesting habits, this species is similar in many respects to the larger Meadow Vole, Microtus pennsylvanicus.

Because Synaptomys is relatively rare throughout the southern limits of its range of occurence (Connor, 1959, reports that in Canadian sphagnum bogs Synaptomys is quite common), very little study has been dedicated to this small microtine. The most notable works have been accomplished by Paul Connor (1959) and Alicia Linzey (1982,83). Connor has produced an extensive dissertation on the life history of the bog lemming in Southern New Jersey; detailing feeding, breeding, and seasonal shifting of habitat. Linzey (1982) produced a doctoral dissertation on the relationships between Synaptomys and Microtus pennsylvanicus. In 1983, Linzey also authored a paper for the American Society of Mammalogists reviewing in general the scientific data thus far compiled on Synaptomys.

Currently there are seven subspecies recognized by the American Society of Mammalogists (Linzey 1983). According to Cushing (1945 through Linzey 1983) the range of the bog lemming once

extended as far south as Nuevo Leon, Mexico and to Dallas, Texas. Guilday et al (1977 through Linzey 1983) has produced evidence from a cave in Pennsylvania that suggest that Synaptomys cooperi replaced Synaptomys borealis in that area about 11,000 years ago. Linzey (1983) suggests, drawing upon other references that Synaptomys is a transitional form between the genus Lemmus and the genus Microtus. Furthermore Linzey (1982) suggests that Microtus pennsylvanicus and Synaptomys cooperi evolved separately (giving rise to her thesis on the interactions of Synaptomys and Microtus habitat), while Microtus ochrogaster and Synaptomys evolved simultaneously as these latter two compatibly inhabit similar habitat without any definite trend of aggession or exclusion.

According to Connor (1959) and Linzey (1983) Synaptomys feeds primarily on coarse grasses. Several researchers claim an exclusive genus or species of grass as being important, though the appetite for coarse grasses is probably a result of the varied habitats which Synaptomys frequents; the result is a diet of varied grasses, fungi, fruits, and bark (Connor 1959, Linzey 1982, Gaines et al 1979 through Linzey 1983). A life span of not more than three years might be attributed to this vole. Bog lemmings are a prey species for a variety of predators including foxes, skunks, raccoons, opposums, raptors, larger snakes, and shrews (all of which were observed in the study areas). Also, many parasites have been found on Synaptomys including ticks (Acarina) and lice (Bots) (Hamilton and Whitaker, 1979).

The interest in oxygen consumption of various forms of life was heightened after Odum's conclusion that energy was the currency of life forms (Smith 1980). Pearson (1960) concluded that 4.8 calories of energy are liberated for each cubic centimeter of oxygen that is consumed. In calculating the efficiency of trophic levels, many researchers have used oxygen consumption to found their assumptions (Smith 1980, Dalby and Heath 1975, Scholander et al 1950).

The ambient temperature at which an animal is kept seems to have an impact on the amount of maintenance energy requried by the animal (Hart, 1952). For each animal at a particular time of year there is a zone of thermal neutrality, or a temperature at which the least amount of energy must be utilized for heating or

cooling the body, circulation, digestion, and other functions which the animal must maintain. In determining trophic level efficiencies and other related factors this zone of thermal neutrality figures into calculations in energy flow. Some of the studies concerning these factors include: Dalby and Heath, 1975; Mann, 1966; Pearson, 1960; Hart, 1952; Morrison and Ryser, 1951; and Morrison, 1948.

METHODS

The animals used in this experiment were obtained from a wild condition from habitats in proximity to the Raystown Field Station maintained by Juniata College, Huntingdon, Pennsylvania. This area is situated near Raystown Lake in the "Ridge and Valley" section of Southcentral Pennsylvania. A trap line was established and records were kept from June 9 through August 9, 1985. Animals were trapped in 6x2x2 inch aluminum, and 8x3x4 inch galvanized box traps, based on the widely recognized Sherman models. Traps were baited with rolled oats, peanut butter, and apple; in combination or singly. 70 traps were maintained on the study areas during the duration of the study.

Animals were housed singly (except in the case of a birth where the female and young were kept together) in commercial plastic cages with metal lids. The animals were fed a diet of coarse grasses, rootstocks, rolled oats, guinea pig food (pellet form), apple, and fresh native fruits. Water was supplied with commercial drip-type bottles, ad libitum. Cages were lined with cut grasses, live grasses, damp sawdust, and soils. The dages were kept damp, necessitated by the deaths of two captive specimens from apparent heat stress. The cages were kept on a screened in porch, facing North-east. Ambient daytime temperatures often exceeded thirty degrees Celcius and at night temperatures dropped to near ten degrees Celcius.

Oxygen consumption testing began around May 30, with Peromyscus leucopus and Microtus pennsylvanicus being used to establish the system. Synaptomys were tested from July 1 through August 9, 1985.

Oxygen consumption was measured in a closed-circuit system, using the Med-Science Model 160 Volumeter (see Figure 1). A one liter chamber was prepared with Soda lime and Drierite. A heavy-meshed screen was suspended in the circular chamber to prevent the animal from coming in contact with the Soda lime and Drierite. A loose fitting lid was attached as a cover. The lid was sealed by a water bath, which also served to maintain a constant temperature within the chamber. Two gas ports on the lid allowed for the input of oxygen and for analysis by the volumeter. The volumeter operated on a vaccuum piston, to which a graphing arm was attached. The piston was activated with the input of oxygen. As the animal respired, carbon dioxide and water were respectively absorbed by the Soda lime and Drierite. The piston was drawn down as a result. Consequently, the graphing arm moved one millimeter for each 2/3 cubic centimeter of oxygen that was

consumed. At one minute intervals the graphing arm was "bumped". The resultant graph allowed the researcher to determine how much oxygen was consumed each minute, or conversely how many minutes were required to consume a certain amount of oxygen. All tests were conducted between 1600 and 2200 hours. Equipment was checked prior to each trial. Mann (1966) using similar equipment forwarded that the volumeter he used produced only one tenth of one-percent error.

Oxygen consumption trials were run at various temperatures: 05, 10, 15, 20, 25, and 30 degrees Celcius. A thermal neutral zone was determined to be the temperature at which the animal consumed the least amount of oxygen. Each of four animals was tested two times at each temperature interval, yielding 48 trials. Each trial lasted at least one hour, while some trials lasted up to two and one-half hours. Data is based on the respective times required for two cubic centimeters of oxygen to be consumed. Therefore, from 48 trials, 309 replicates were examined. Animals were placed in the sealed chamber fully 20 minutes prior to the collection of data. In most instances the animals quieted themselves after ten or fifteen minutes in the chamber, and simply slept or remained stationary. Food and water were not provided in the chamber to reduce activity. In relation to this absence of food (since Synaptomys is a grazer its bulk food requirements may be rather demanding) Dalby and Heath (1976) and Scholander (1950) mention that post-absorbitive weight loss does not affect the basal metabolic rate. Subsequently, all data is calculated in terms of the weight of the animal when it was put into the sealed chamber.

A generalized vegetational analysis was begun and completed during the middle of August, 1985. Each analysis was expressed as a circular plot with a cluster of successful traps as the focus of each circle. The diameter of the plot was 12 meters. Vegetation was placed in three classes: (1) less than .70 meters in heighth; (2) greater than .70 but less than 2.0 meters; and (3) greater than 2.0 meters in heighth. Class (1) vegetation was measured in terms of abundance or relative dominace, where results tended to reflect the most abundant species or genus of grasses and forbs. Three 0.5 meter squares were randomly selected as being typical of class (1) vegetation, and the plant life falling within these squares was categorized. Class (2) vegetation was measured on a point/quarter-point basis, with points being established at one, three, and five meters from the origin or focus, with 90 degrees separating each of set of points relative to the perimeter and focus of the circle. Class (3)

vegetation was measured in terms of a similar point/quarter-point method with points being established at the origin or focus of the circle, and a three, and six meter intervals, each separated by a distance relative to the circle, of 90 degrees. This method was devised not so much to give an intensely detailed view of the habitat requirements of Synaptomys, but to deliver a general categorization of the plant species present relative to the trapping area. Data was expressed in terms of occurence. This method is vaguely similar to the vegetational plots monitored by Linzey (1982), though her plots were designed more in terms of microhabitats and other factors pertaining to the animals she studied.

A trap line consisting of 70 traps was maintained for 51 days, yielding 3570 trap nights. During the course of the study, the absence of Synaptomys necessitated the movement of some traps to other areas. The successful areas are designatedin Table 6 along with the number of trap nights and subsequent captures in those areas.

RESULTS

Between June 22 and August 9, 1985, fifteen bog lemmings were captured on the study areas. Of these, six specimens were kept alive; four individuals were tested. Pregnant females were excluded from the testing. The four individuals were tested two times at each temperature interval. 309 replicates resulting from these tests were examined. The mean values for these animals' oxygen consumption for each temperature were as follows:

05 degrees	**8.08 cc/gm/hr**
10 degrees	**7.85 cc/gm/hr**
15 degrees	**6.10 cc/gm/hr**
20 degrees	**5.43 cc/gm/hr**
25 degrees	**4.04 cc/gm/hr**
30 degrees	**5.21 cc/gm/hr**

The least amount of oxygen was consumed at 25 degrees Celcius, where 4.Ø4 ccO2/gm/hr were consumed. This temperature was determined to be within the thermal neutral zone. Consequently, this value was considered to be the basal metabolic rate.

In relation to the projection for basal metabolic rates, Morrison et al (1959 through Packard 1968) established a formula for which an animal weighing 23.5Ø grams (the average weight of animals used in this experiment) should consume 3.36 ccO2/gm/hr. The deviation of the calculated value from the experimental value for this experiment is 16.4%. This is an acceptable difference considering the high metabolic rates of microtine rodents (Scholander et al, 195Ø).

Vegetation analysis took place on three areas: two analyses of the Upper Brook Plot (plot a, plot b) where a total of nine bog lemmings were captured, and one analysis of Locust Plot where four bog lemmings were captured. The data presented in Table 7 reflects the information obtained from the analysis. The most abundant species by far in each class were :Class (1)-Orchard Grass, Dactylis glomerata; Class (2) Privet, Ligustrum vulgare; Class (3) Sugar Maple, Acer saccharum. From observations made in the field, both Synaptomys and Microtus seemed to feed heavily on Orchard grass. Synaptomys was also observed to feed heavily on Carex sp. and Andropogon sp., evidenced by cutting in runways and feeding platforms.

Synaptomys was found only in areas with a prominent leaf canopy. Sugar maples with diameters of 1Ø to 2Ø centimeters were abundant on the Upper Brook Ploys, and Black Locust, Robinia pseudoacacia, was abundant on the Locust Plot. In addition a shrubby cover seemed to be important as Privet and Rubus sp. were noticeably common on both plots.

Other small rodents caught during the course of the study include Peromyscus leucopus, Microtus pennsylvanicus, and Zapus hudsonicus. Blarina brevicauda and Sorex cinereus were also captured. A counting of areas trapped and resultant captures is detailed on Table 8.

CONCLUSIONS

From this study it appears that the metabolic rate of Synaptomys cooperi is (in relation to other small mammals) within the bounds expected, based upon references to other metabolic studies. The deviation from a calculated value for metabolism (using weight and standard equations) from the actual value for metabolism was only 16.4%. This deviation seems quite reasonable in that allowance must be made for error in the equations, stemming from a reliance on surface area but using weight as a substitute in the equation. In addition, this value, though higher than the calculated value, might be due to the high metabolic rates of microtine rodents observed by other researchers (Scholander 1950, Mann 1966). Most researchers have found that the metabolic rate is slightly higher than the "mouse to elephant" curve described by Scholander et al (1950).

In comparison the metabolic rate of Synaptomys cooperi was 4.04 cc/gm/hr, while the rate for Microtus pennsylvanicus was determined to fall between 2.9 to 4.1 cc/gm/hr (Morrison 1948); and Clethrionomys sp. was found to be between 3.1 and 3.9 cc/gm/hr (Morrison 1948). Mann (1966) found the basal metabolic rate of Microtus pinetorum to be 3.4 cc/gm/hr, and Packard (1968) found the metabolic rate of Microtus ochrogaster to be 2.65 cc/gm/hr with a thermal neutral zone between 26 and 31 degrees Celcius.

According to Hart and Heroux (1953) natural acclimation to the ambient temperature is important because pelage development affects the basal metabolic rate. Accordingly the basal metabolic rate is higher in non-acclimated individuals exposed to unseasonal temperatures. The basal metabolic rates put forth here would then be subject to seasonality and pelage development.

In regards to habitat, Synaptomys was found only in areas with a prominent leaf canopy. On this aspect two speculations could be made: (1) a leafy canopy shaded out species of grasses favored by Microtus. Linzey (1982) describes Synaptomys habitat as typically "sub-marginal meadow vole habitat". (2) The leafy canopy provided suitable conditions for the growth of species preferred by Synaptomys.

Concerning relationships with other small mammals caught during this study; Linzey (1982) presents a dissertation concering the relationship of Synaptomys with Microtus pennsylvanicus. In this paper Linzey shows that there is a definite partitioning of

habitat and microhabitat, and that the more aggressive meadow vole in some instances tends to exclude Synaptomys from favorable habitat. Coincidentally, Synaptomys populations would be subject to the fluctuations of Microtus populations. This seemed true in at least one instance where several lemmings were caught until meadow voles started regularly appearing in those trapping areas. In addition, Peromyscus leucopus and Blarina brevicauda were quite common in these areas. Certainly these animals had some affect on the Synaptomys population, though from these observations no conclusive relationship could be inferred.

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TEMPERATURE VS. OXYGEN CONSUMPTION
IN Synaptomys cooperi

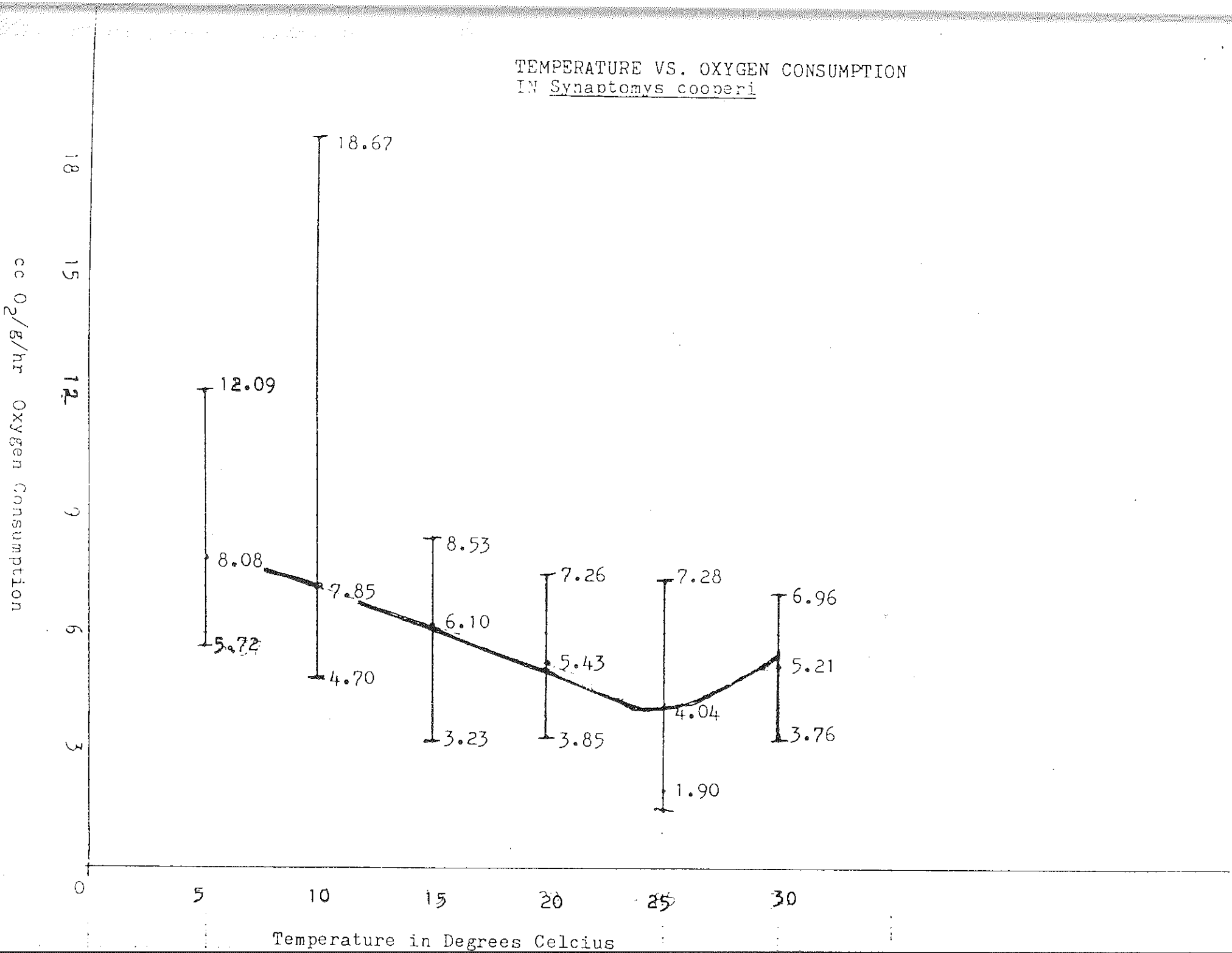


figure two

STATISTICS OF OXYGEN CONSUMPTION VALUES OBTAINED FROM FOUR INDIVIDUALS

Temperature: 5 degrees
Number of Tests: 7 tests
Mean O2 consumption:8.Ø8 cc/gm/hr
Variance: 3.13
Standard Deviation: 1.77
Standard Error: .245
Minimum: 5.72
Maximum: 12.Ø9
Range: 6.37
Sum : 419.96

Temperature:1Ø degrees
Number of Tests:8 tests
Mean O2 Consumpton:7.85 cc/gm/hr
Variance:13.5
Standard Deviation:3.67
Standard Error:.5ØØ
Minimum:4.7
Maximum:18.67
Range :13.93
Sum:456.Ø3

Temperature: 15 degrees
Number of Tests:8 tests
Mean O2 Consumption: 6.1Ø cc/gm/hr
Variance:2.4Ø
Standard Deviation:1.55
Standard Error:.224
Minimum:3.23
Maximum:8.53
Range:5.3Ø
Sum:293.Ø5

Temperature: 20 degrees
Number of Tests:7 tests
Mean O2 Consumption:5.43 cc/gm/hr
Variance:1.22
Standard Deviation:1.10
Standard Error:.177
Minimum:3.41
Maximum:7.26
Range:3.85
Sum:211.93

Temperature:25 degrees
Number of Tests:8 tests
Mean of O2 Consumption:4.04 cc/gm/hr
Variance:1.42
Standard Deviation:1.19
Standard Error:.156
Minimum:1.90
Maximum:7.28
Range:5.38
Sum:234.59

Temperature:30 degrees
Number of Tests:8 tests
Mean of O2 Consumption:5.21 cc/gm/hr
Variance:.690
Standard Deviation:.831
Standard Error:.105
Minimum:3.20
Maximum:6.96
Range:3.76
Sum: 328.8

Figure Three

VEGETATIONAL ANALYSIS / PERCENTAGE OCCURENCE OF PLANT SPECIES ON THREE PLOTS

Class 1	Locust Plot	U.B. Plot A	Plot B*
Dactylis g.	55.9%	18.4%	18.2%
Phleum pratense	8.9	---	---
Andropogon sp.	14.7	18.4	18.1
Carex sp.	---	15.8	31.7
Juncus sp.	---	2.6	4.5
Panicum cl.	---	13.2	13.6
Rubus sp.	14.7	10.5	---
Glechoma h.	2.9	---	---
Others	2.9	13.2	13.6
Class 2			
Robinia ps.	10.4%	10.4%	---
privet	---	66.7	80.3
Acer sac.	---	---	10.4
Rubus sp.	37.5	16.7	---
Ceanothus am.	2.1	6.2	6.0
Solidago od.	50.0	---	---
Class 3			
Robinia ps.	93.8%	9.4%	---
Acer sac.	---	90.6	100
Quercus rub.	6.2	---	---

*U.B. abbreviation for Upper Brook Plots A and B.

Figure Four

TRAPPING SUCCESSES IN FIVE AREAS

	S.cooperi	Microtus pe.	Peromyscus sp.	Blarina
Upper Brook Plot 949 trapnights	9	12	38	8
Locust 364 trapnights	4	18	17	3
Spicebush 428 trapnights	1	4	Ø	3
Lower Brook 257 trapnights	1	6	12	Ø
BackRoad 435 trapnights	1	2	33	Ø
Overall Results Including Captures from Other Areas	16	97	211	58

*In addition, one Zapus hudsonicus, and two Sorex cinereus were captued during the course of the study.

1998

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Abstract

We compared the composition of small mammal communities in abandoned field habitats to the data collected by Dr. Robert Fisher 25 years ago. Our goal was to determine the effect of time and corresponding vegetation succession on small mammal communities. We established 2 study plots in each of the two field habitats and sampled small mammal communities using a 25 unit live trapping grid. Each plot was sampled five times during late winter of 1998. We determined the species composition and population density for each plot in order to compare habitat types as well as evaluate temporal changes in the small mammal community over the past 25 years.

Introduction

Animal communities possess a very close relationship with the environment and habitat they live in. It has been found that animal communities change as the habitat changes. Thus when a habitat succession occurs, the animal community that lives within this community would be expected to change in some way. Species abundance, density, and diversity are some of the most common elements within a community that experience changes with the succession of habitat.

Habitat succession of the Juniata College Raystown field station has been occurring since the fields were abandoned in 1974. Factors playing in the succession of this habitat are both natural and man-made changes. The man-made changes in these habitats include the creation of a recreational lake and the removal of abandoned materials left behind before the lake was filled. The natural succession of this area can be found in the maturation of the habitats as a result of succession related to the natural processes of succession found at the Raystown field station.

Dr. Robert Fisher surveyed the small mammal communities 25 years ago in a variety of different habitats throughout the field station property. By use of snap traps and live traps, Dr. Fisher was able to collect small mammals to show species abundance and diversity in all microhabitats contained within the field station.

Our goal was to revisit two of the habitats surveyed by Dr. Fisher and examine the changes in the community ecology of small mammals with the past twenty five years of succession. The purpose of this project was to successfully make several conclusions about species abundance and diversity within two different habitats at the Raystown Field Station by using a series of live trapping grids.

We hypothesized that....

The Study Area

Juniata College's Raystown Field Station is 365 acres of mostly forest and field habitat with streams and shale-banked hillsides assimilated throughout. The field station is located 20 miles south of Huntingdon off of Route 26. Juniata College leased the Raystown Field Station from the U.S. Army Corp of Engineers 25 years ago. This was during the construction of the Raystown Dam. The station house is a remodeled 19th Century farmhouse surrounded by fields and a newly established pond.

The Raystown Field Station consists of many different habitat types. Of these, there are two different sorts of fields. One of which is lakeside. These fields have some small shrub growth with intermittent patches of lowland forest. The other type of field habitat is that which is 'land-locked'. These are the fields surrounding the station house and the hills nearby. These fields also contain some small shrubs with a small grove of saplings growing into one of them.

Another major habitat type is that of the oak forest. These forests cover a great number of acres at the field station. They are found over much of the hillsides throughout the area. They consist mostly of white and red oak trees along with some hickory species. Some pine trees and shrubs as well as other tree and sapling species inhabit these forests as well.

The maple forest is yet another habitat type at the field station. Constituting much of the stream valleys, these forests consist mostly of sugar maple trees. However, other tree and sapling species do occupy this area. The maple forest has less underbrush than the oak forest.

The last type of forest habitat at the Raystown Field Station is the pine forest. Virginia and white pine trees dominate this habitat. Yet some deciduous underbrush does occupy this forest.

The final habitat present at Juniata College's Raystown Field Station is the Raystown Lake. The lake is a great aquatic environment housing many species of fish.

These habitats house many plant and animal species. However, trapping small mammals was the object of our research. This is the reason we chose only to study the field habitats.

Materials and Methods

The traps used in this experiment were Sherman non-folding live traps(1"x2"x6" & 3"x3"x15"), Sherman folding live traps(1"x2"x6" & 4=3"x4"x18"), and Small wooden live traps constructed by Dr. Fisher. Our trapping setup consisted of a total of 100 live traps distributed in two grids of 25 traps per microhabitat per trapping night. Each grid set was 80'x80' square containing 25 traps that had an equidistant relationship with each other at 20 feet between traps(See figure 1). The trapping grids were also oriented in a North to South manner that would provide data from specific localities within each grid. This orientation of the trapping grids allowed for a numbering system identifying each trap→ 1A through 5E(See figure 1). The trapping grids were set in a manner to encompass both the lakeside and station fields(See figure 2). Each trap was flagged with marking tape to establish an easier manner in which to find the traps from day to day and in case of snow fall.

When setting the traps, each trap was checked to ensure good working condition. Each trap was then baited with approximately a teaspoon of a 1 to 1 mixture of peanut butter to Corn Flakes. The peanut butter was used because it had proven to be an adequate attractant/food in a preliminary trapping effort conducted 1 month prior to this project. The Corn Flakes were used to make the bait easier to work with and to provide alternate carbohydrates to keep the small mammals alive in the traps. Also a small amount of Polyfil®, a form of pillow stuffing, was placed inside each trap to provide nesting material to keep the trapped animals warm, therefore decreasing the amount of energy used for maintaining body temperature and at the same time increasing the survivability of the animals between trap setting and checking times.

When checking the traps, the traps that were empty were checked for bait, Polyfil, and working condition. The empty traps were then closed until the traps were reset. The traps that contained small mammals were handled accordingly with gloves. For each occupied trap, the small mammal was emptied into a plastic bag and weighed. After weighing the individual, it was then removed from the plastic bag by grasping the scruff of the neck. The individual was then identified to species and sex, and marked by our selected toe clipping scheme(See figure3).

Through some preliminary research we found that trapping should be limited to those days in which there was no threat of rain or snow. Also, the temperature had to be above freezing at night, and no snow could be on the ground. These days with adverse conditions prove to be "bad trapping days".

Results

The following are the results of our mark-recapture, small mammal survey at the Raystown Field Station. All data in this section is stated briefly and a detailed explanation of the data is contained within the discussion section.

We captured a total of four different species and a total of fifty two individuals. Eight of the fifty two individuals were recaptures in our mark-recapture study. Our study showed the following in respect to designated habitat : at the lakeside field(See Table 1), three *M. pennsylvanicus* and ten *P. leucopus*... at the station field(See Table 1), thirteen *M. pennsylvanicus*, twelve *P. leucopus*, three *Sorex fumeus*(smoky shrew), and one *Microtus pinetorum*(pine vole). A total of four species were found in both habitats during this study, which was started on Feb 10th and ended on April 14th of 1998

Lakeside field data taken by our group revealed .00406 small mammals caught/ trap/ day with a total capture percentage of 3.25%(See Table 1). Station field data taken by our group revealed .00906 small mammals caught/ trap/ day with a total capture percentage of 7.25%(See Table 1). Possible explanations for the discrepancies in this data could lie in climactic, successional, or seasonal factors. The correlation of species similarity showed little to no similarity between the two data sets shown. All explanations will be shown in the discussion section of this paper.

The imbalance of numbers in this case shows that there is a difference in the day to day capture data. The statistical significance of species similarity is somewhat stronger between these two data sets(See table 1). The explanation for all findings for these data sets will be stated in the discussion section of this paper.

The temperature in this project ranged from a nighttime high 50°F / low 15°F and a daytime high 84°F / low 35°F . Data taken in our study had a slight correlation to the trapping success in both the station field and the lakeside field(See table 2).

Discussion

The species diversity between Dr. Fisher's data(See Appendix) and our data(See Table 3) can readily be seen. In the lakeside field our group caught two species whereas Dr. Fisher caught five species. In the station field our group caught four species while Dr. Fisher also had four species(See Table 2 for specific species findings) For explanations of this occurrence we must look at each individual species caught between both studies.

Zapus hudsonius, also known as the Meadow jumping mouse, usually inhabits lowland meadows. They primarily nest in the summer under logs and brush. They also hibernate about 2 to 3 feet below ground during the winter. This particular species was found in both lakeside and station field data for Dr. Fisher. This species did not appear in our data collection and can be eliminated from this project's data for reason of seasonality. Seeing as Z. hudsonius hibernates until early to mid April, our collection of this species would have been nearly impossible and should not be considered when looking at the data.

Peromyscus maniculatus, also known as the Deer mouse, tends to inhabit all dry land, with little preference for grassland or forest. They have been found to nest in burrows, trees, and buildings. They are very adaptable to different habitats, but they usually cannot coexist with the similar species *Peromyscus leucopus*, or the white-footed mouse. Even though these two species are not usually found to coexist, neither species seems to be dominant over the other for particular habitats. Both the Deer mouse and the White-footed mouse were present in Dr. Fisher's study, yet only the white-footed mouse was found in our study. The explanation for this can probably be attributed to the filling of Raystown Lake in the year prior to Dr. Fisher's study. This dramatic flooding event would have pushed the habitats and species communities together for these two species, making them compete with each other for the territory. No data has been found for which species was originally the dominant species prior to the flooding event, but as seen in our data, the white-footed mouse is the only species found in either habitat.

Microtus pinetorum, also known as the pine vole, usually inhabits the forest floor. They nest under stumps and logs as well as other objects used as shelter. One meadow vole was captured in our Station field data. This could be explained by the vole being captured on the edge of the habitat where the forest and field met.

Mus musculus, also known as the house mouse, inhabits fields and buildings. This species has come to depend on broken down structures and any food edible that have been made available by humans. There was a presence of abandoned structures and human impact in the area of the survey at the time of Dr. Fisher's survey. Now the abandoned structures and other related items of human impact have been removed. This may be the explanation for the presence of the house mouse in Dr. Fisher's lakeside and station field data and the lack of this species in our data.

Sorex fumeus, also known as the smoky shrew is found in birch or hemlock forests or in an area of deep leaf mold. They nest in dry vegetation and make their own burrows. This species was not present in Dr. Fisher's studies, but was present in our station field data. All individuals collected of this species were within feet of a small pine section on the fringe of the station field. This area was somewhat moist and would act as suitable habitat for this species. The appearance of this species was probably due to the growth of the pines to yield a suitable moist habitat where they could survive..

Microtus pennsylvanicus, also known as the meadow vole, inhabits low wet areas or high grass lands. They are territorial and can nest either above or below the ground. This species seems to have had no change in population structure or distribution as far as the contained data has shown.

When looking at the density data between both studies, the trapping effort to species caught must be examined. Dr. Fisher's trap lines were not configured in a way to make density a valid calculation. Considering, the trapping effort similar for both cases, we must look at the capture percentage. The data for the lakeside field shows Dr. Fishers capture percentage to be 12.8%. In comparing our data containing a capture percentage of 3.25%, we might suggest that the densities in this particular habitat were slightly larger 25 years ago. This slightly larger density in Dr. Fisher's data can possibly be explained by the filling of Raystown Lake one year prior to his study. The filling of Raystown Lake would, in effect, force separate communities together into a smaller area. After one year with a filled lake, the communities may not have had an opportunity to completely stabilize, and thus are found with more individuals and more species per allotted area. A second hypothesis for this occurrence may be that the energy provided by the habitat at the time of Dr. Fisher's experiment may have been enough to hold an increased number of species. But with the succession of this habitat, the energy content has dropped to a level that allows for a only a decreased amount of species and density of these individuals.

Temperature is the final factor examined in our data(See Table 2). Dr. Fisher did his study on small mammals during the summer months. Our data was collected over the late winter and early spring. This alone could have a major effect on the outcome of our data collecting. For example, the case of *Z. hudsonius* hibernating during winter would distort our data. Also, it has been found in our research that when temperature conditions limit the food supply, many species of small mammals enter a torpor in order to conserve energy. Without going into a torpor, many of these small mammals would starve to death.

As for the overnight freezing effects, we came to some conclusions that are not entirely statistically significant, but are strong arguments. The temperature ranged from below 15°F to nearly 50°F for night time lows during this study. However, the amount of small mammals trapped during this time period barely fluctuated per night, making this data poor for a correlation to a nighttime freeze and activity levels during this time(See Figure 4).

The study done in the station field showed a sharp rise in temperature, with a drop following. After this, another temperature increase occurred. Over this time, the amount of small mammals caught only rose during the first rise in temperature(Table 2). After that, the number caught declined and leveled off. This situation could be due to the small mammals coming out of torpor. After coming out of torpor, the small mammals would then have to feed veraciously in order to regain the weight and energy lost during their period of inactivity. After this burst of activity there should potentially be a stabilization of feeding behavior and activity rates to a point where normal seasonal rates apply.

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We would like to extend our appreciation to Chuck Yohn our research advisor, Juniata College, and all fellow Juniata students(Amanda Maurer, Sue Anestis, Sean Collins, Lance Eisenhower, Erin Letrick, and Melissa Hicks) who donated their time to make this research project possible.

Appendix

- In order to facilitate near future studies for this project, we decided to start a mark and recapture study of the small mammals in these communities that could also be comparable to Dr. Fisher's study 25 years ago.
- The following are the data results from Dr. Fisher's survey taken 25 years ago. Dr. Fisher caught the following: at the lakeside field(figure A), four *Microtus pennsylvanicus*(meadow vole), twenty *Peromyscus leucopus*(white-footed mouse), eighteen *P. maniculatus*(deer mouse), thirty six *Mus musculus*(house mouse), and two *Zapus hudsonius*(meadow jumping mouse)... at the station field(figure A), thirteen *M. musculus*, two *M. pennsylvanicus*, one *Z. hudsonius*, and eight *P. leucopus*. A total of five species were found during this survey from July 23rd to Aug 4th of 1973.
- Dr. Fisher's mammals captured in the lakeside field consisted of .0256 small mammals caught/ trap/ day with a total capture percentage of 12.8%. Dr. Fisher' s mammals captured in the Station field consisted of .0341 small mammals caught/ trap/ day with a total capture percentage of 4.51%.

Appendix - Dr. Fisher data
Table 1 - Comparative species
Table 2 - Temperature relations
Table 3 - Raw data for 1998
Figure 1 - Trapping grid
Figure 2 - Grid placement and station map
Figure 3 - Toe clipping scheme
Figure 4 - Night time low lake and station capture rate/temperature graphs

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1999

EFFECT OF SOIL NITRATES, PH, AND ORGANIC CONTENT ON *ACER SACCHARUM* SEEDLING DISTRIBUTION

Dana A. Hornyak

ABSTRACT

I examined the relationship between distributions of sugar maple (*Acer saccharum)* seedlings and soil characteristics at Juniata College's Raystown Field Station. I compared soil pH, nitrate and percent organic content in three areas of high seedling density to three areas of low seedling density. I found no significant differences in pH, nitrate, or percent organic content between soil collected from areas of high sugar maple seedling density and areas of low density.

INTRODUCTION

The sugar maple (*Acer saccharum*) is a common tree inhabiting moist valley soils of Central Pennsylvania. It's optimal environment consists of well drained loamy soil abundant in organic matter, with a pH ranging from strongly acidic (pH 3.7) to slightly alkaline (pH 7.3) (Burns, 1990). They do not grow well in dry, shallow soils. Sugar maple's leaf litter tends to modify the pH and nutrient status of soil to conditions optimal for seedling establishment, and plant growth (Burns, 1990). Leaching by rain and runoff however removes nutrients from the soil, and such leaching may inhibit establishment of maple seedlings (Bennett et al., 1988).

To produce optimal growth, all essential plant nutrients must be present in adequate quantities within the soil. Nitrogen is the most common element to be deficient from the soil (Bennett et al., 1988). Nitrogen is used in relatively large quantities by plants to produce amino acids, protein, and chlorophyll (Bennett et al., 1988).

I observed that there were distinct areas at the Raystown Field Station in which sugar maple seedlings grew in large dense patches. Surrounding these areas of dense seedlings few, if any sugar maple seedlings grew. Because soil nutrients can vary enormously over relatively short distances (Perry, 1994) I hypothesized that soils differed in nutrients and composition between the high density and low density patches therefore resulting in the patchy distribution of maple seedlings.

METHODS AND MATERIALS

I conducted this experiment in the maple grove adjacent to Lake Raystown at Juniata College's Raystown Field Station, Entriken quadrangle Huntingdon County Pennsylvania (North 40^{o} 21'29", West 78^{o} 09'01"). The maple grove is approximately fifty years old, with an over story dominated by sugar maples, with red maples (*Acer rubrum*), and white oaks (*Quercus alba*) mixed in.

I randomly established 3 plots among areas of high sugar maple seedling density (>50 seedlings/m^2), and 3 plots among areas of low maple seedling density (<10 seedlings/m^2). I randomly

selected three 1 m^2 subplots within each plot and counted all the living sugar maple seedlings and took a soil sample within each of these subplots.

I measured percent organic content of the soil by drying about 30 grams in an oven to constant weight to remove any moisture. A known weight of each soil sample was placed in a crucible in a 600^o C furnace until all organic material contained in the sample was burned away. I then calculated percent organic content for each sample based on the original sample weight and the weight after burning.

To extract nitrogen from the soil, I first calculated the amount of moist soil needed to obtain 10 g of dry soil, based on my previous calculations. To this soil I added 0.10 g calcium sulfate, and 20 ml deionized water. I removed water from the soil by vacuum filtration. I then analyzed the water for nitrate content using a cadmium reduction method (HACH, 1992).

I determined the pH of the soil by taking10 g of each soil sample and adding 20 ml of deionized water to it. It shook it and let it settle three separate times. After the third time the soil was removed from the water by vacuum filtration, and the water was tested for pH concentration using a pH meter.

To compare the percent organic matter, pH, and the nitrate concentration of soil collected from high density areas to those collected in low density areas, I used a two sample T-test (Ambrose et al., 1995). I used an α level of 0.05 and considered differences to be significantly if $p<0.05$.

RESULTS

Mean percent organic matter did not significantly differ between high density plots (9.48%) and low density seedling plots (8.69%) (t=0.85, df=14, p=0.41). Similarly the mean soil nitrate did not significantly differ between high density plots (0.0357 g/ 10 g soil) and low density plots (0.0318 g/10 g soil) (t=0.3, df=15, p=0.76). The same was true of the pH content of the soil, the mean soil pH of high density plots (3.85) and that of low density plots (4.16) did not significantly differ (t=-1.42, df=15, p=0.17).

DISCUSSION

I found no significant differences between the mean percent organic matter, pH, or nitrate content of the soils of high and low seedling density. These factors are not causing the patchy distribution of sugar maple seedlings which I observed at the Raystown Field Station.

If I was to continue investigating the relationship between the differences in sugar maple seedlings at the field station I would test for a variety of different factors. The density differences might be a result of different light intensities coming through the canopy. It may be the result of seed distribution. Or possibly the difference between the areas where seedlings are growing where they are not is related to some other soil factor that I did not test for. It is possible that an essential nutrient, other than nitrogen, is the limiting factor. There is something which is limiting the distribution of sugar maple seedlings in the maple grove, but it may take a lot of trial and error before the cause is determined.

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THE EFFECTS OF MOISTURE AND NITRATE LEVELS ON SOIL INVERTEBRATES IN THE MAPLE GROVE OF THE RAYSTOWN FIELD STATION

Cara J. Kelly

ABSTRACT

I investigated the effect of elevation and soil moisture on the distribution of soil macrofauna at the Raystown Field Station. I compared macrofauna densities, along with soil nitrate levels and percent moisture between Upper and Lower regions. I found the mean number of macrofauna, along with species richness, to be significantly higher in the Lower regions. Of the five most common occurring species tested, only julids were significantly more abundant in the Lower grove than in the Upper grove. The percent of moisture in the soil of the Lower grove was significantly greater than that in the Upper grove soil, while no significant difference existed in nitrate levels between the regions. These findings show that elevation affects soil invertebrate distribution as well as percent soil moisture.

INTRODUCTION

According to Connelly (unpublished), the distribution of macrofauna within the maple grove of the Raystown Field Station is unevenly distributed. Several factors are known to affect soil macrofauna distribution, including food diversity and abundance, variability of vegetation, and percent moisture (McBrayer et al., 1977). To investigate the factors contributing to distribution in the sugar grove, I determined how macrofauna richness and abundance, soil nitrate levels, and percent moisture varied with elevation. I hypothesized that high and low elevations would contain different levels of: 1) macroinvertebrate distribution, 2) soil nitrate concentrations, and 3) percent soil moisture.

METHODS AND MATERIALS

I conducted my study in the sugar maple grove of the Juniata College Raystown Field Station (Entriken Quadrangle N40° 21'29'' W78° 9'01''), located in Huntingdon County, Pennsylvania. A small intermittent stream bed runs through the foot of the ridge on which the grove is located, and overstory vegetation consists mainly of sugar maple trees (*Acer saccharum*), along with a scattering of oaks (*Quercus* sp.) and Virginia pines (*Pinus virginiana*).

I divided the grove into two regions, Upper (>880ft) and Lower (<840ft) elevations. I randomly selected ten study sites from each region, which consisted of a mixture of both pine boards and asphalt shingles. The boards and shingles were randomly placed in 1997 as part of a previous study (Kelly & Wolf, unpublished). On two different dates, I recorded the number and species of macrofauna under each of the twenty sites.

I collected soil adjacent to the boards/shingles within 6 centimeters, and stored each soil sample in a plastic bag. Samples were kept in a cooling unit prior to analysis in order to preserve the nitrates. I weighed half of each sample to obtain a wet weight, and then dried each to a constant mass, obtaining a dry

weight. Subtracting the two weights provided the percent moisture in each sample. I then calculated the amount of moisture (in grams) per ten grams of each sample, which I used as a correction factor in order to determine ten grams of each fresh sample. I extracted nitrates from the soil and measured nitrate levels in each sample by using a cadmium reduction method (Hach, 1992).

I compared macrofauna richness, percent moisture, and nitrate levels between the top and bottom of the grove using a Two-sample t-test (Heath, 1995). I also compared the number of macrofauna in the Upper grove to that of the Lower, as well as the five most abundant species using a Mann Whitney Confidence Interval (Heath, 1995). For all tests, I set $\alpha = 0.05$, and considered differences to be significant if $p < 0.05$.

RESULTS

The Lower grove had significantly greater diversity (4.95) than the Upper (2.55), (t=3.75, df=18, p=0.0018)(Table 1). Also, I found a greater number of macrofauna overall in the Lower region (10.00) than in the Upper region (5.50), (w=140.0, df=18, p=0.0088). Of the five most common occurring species, only julids were significantly more abundant in the Lower grove (3.25) than in the Upper grove (0.00), (w=144.0, df=18, p=0.0029). The Lower region contained a greater percent of moisture in the soil (19.10%) than the Upper (8.30%), (t=-6, df=18, p=0.0001). There was no significant difference in nitrate levels between the Lower (1.45) and Upper (1.197) regions, (t= -0.47, df=18, p=0.64).

Table 1. Type and number of fauna, pooled between two samples, found in the Upper and Lower Regions of the grove.

	Top of grove	**Bottom of grove**
Isopods	1	11
Lithobiids	6	7
Cryptopsids	2	2
Millipedes	0	1
Julids	15	154
Snails	1	3
Lycosid spiders	2	3
Crab spiders	0	2
Small spiders	6	10
Spring tails	18	19
Wood roaches	17	22
Crickets	1	2
Beetles	0	4
Ants	12	18

DISCUSSION

I found that while macrofauna diversity varied with elevation, it was unaffected by soil nitrate levels. Thus, nitrates are not a direct factor contributing to the greater species richness and greater overall number of macrofauna found in the bottom of the grove. However, according to Ohtonen et al. (1997), nitrates govern distribution indirectly. Macrofauna, mainly arthropods, contribute to nutrient cycling by breaking down organic matter through comminution and dissemination (Moore, 1987). Comminution involves digestion of organic substrates, while dissemination involves digestion of microbial organisms. Through these processes, arthropods put inorganic nutrients (including nitrates) back into the soil, which are readily taken up by plants. The plants are beneficial to microbe biomass, which supply the arthropods with

a food source (Ohtonen et al., 1997). Perhaps measuring nitrate levels in plants would more accurately represent the levels within the grove's regions.

Another factor affecting the density of macroinvertebrates is the productivity of leaf litter (McBrayer et al., 1977). While pervious studies reported that the number of macroinvertebrates present determined litter productivity (Edwards et al., 1970), McBrayer et al. shows that litter production determines and directly correlates with macrofauna densities.

Unlike nitrate levels, percent moisture varied with elevation. In addition, elevation showed similar affects on moisture levels and macrofauna abundance, indicating that soil moisture may influence macrofauna densities. Although I did not investigate a correlation between these two variables, studies have shown that macrofauna abundance is directly correlated to percent soil moisture. Evidence shows that many soil inhabitants descended from aquatic ancestors (Schaller, 1968), and thus are vulnerable to desiccation. While macrofauna eat what the ground provides, i.e. leaves, fungi, and roots, they favor food conditioned, or softened, by water (Schaller, 1968).

Further recommended studies to investigate factors governing macrofauna distribution and abundance in the maple grove include testing nitrates in surrounding plants, as previously discussed, along with correlating the abundance of plants with that of macrofauna. In addition, since variation of nitrate levels within the regions could have affected my results, one could test each of the twenty sites for a correlation between macrofauna abundance and nitrate levels. Other correlation tests could include leaf litter production versus macrofauna density and organic content of the soil versus macrofauna density.

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SEXUAL DIMORPHISM OF HEAD SIZE IN EASTERN FENCE LIZARDS

Michael E. Kenawell

ABSTRACT

I examined sexual dimorphism in Eastern fence lizards (*Sceloporus undulatus*). I tested the hypothesis that males had larger heads than their female conspecifics, relative to individual body size. I measured head width, head length, and snout-vent length for separate samples of male and female lizards. I found that both head width and head length were significantly larger in males than in females when compared to snout-vent length. The cause of this relationship requires further investigation into male and female mating and feeding behaviors.

INTRODUCTION

Sceloporus. undulatus is a widespread North American lizard species in which females usually attain a larger average and maximum size than males. Cooper and Vitt (1989) found that mature males of *S. undulatus* have larger heads than females of similar snout-vent length. I examined sexual dimorphism in body size and head size of fence lizards. I hypothesized that males would have overall larger heads than females when comparing a head-to-body ratio.

METHODS

I obtained 83 adult male and 21 female *S. undulatus* from Dr. John Matter, Juniata College who had retained the specimens from a previous study. No juvenile lizards were used in this research. The lizard's gonads had been removed and examined for seasonal changes in reproductive tissue (Matter, 1987). Using these lizard specimens, I recorded the following morphological measurements: head length (anterior edge of the auditory opening to the tip of the snout), head width (at widest point), and snout-vent length (SVL) to 0.0001 mm using a dial caliper (Vitt and Cooper, 1985).

I compared head/SVL ratios of males to females using a Two Sample T-test (Ambrose and Ambrose, 1995). I used an alpha level of 0.05 and I considered differences to be significant if $p < 0.05$.

RESULTS

Male lizards had significantly wider heads than females when comparing head width with SVL ($t = 2.94$, $df = 102$, $p = 0.0020$). Males had significantly longer heads than females when comparing head length with SVL ($t = 4.38$, $df = 102$, $p = 0.0000$. Females differed significantly from males in snout-vent length ($t = -6.28$, $df = 102$, $p = 0.0000$), head width ($t = -4.54$, $df = 102$, $p = 0.0000$), and head length ($t = -3.73$, $df = 102$, $p = 0.0003$).

DISCUSSION

Similar to many other lizard species, sexually mature males of *S. undulatus* have larger heads than females of similar snout-vent length (Cooper and Vitt, 1989). The reasons for these dimorphic characteristics are still debatable. Scientists have suggested various reasons for why sexual dimorphism occurs in lizards. One hypothesis is that sexual selection acts upon certain individuals to give them an advantage over others of the same sex in obtaining successful matings (Cooper and Vitt, 1989; Hews, 1990; Stamps, 1983). This viewpoint comes from an evolutionary perspective, which may help explain many sexual differences in various species. An alternative hypothesis to sexual selection is that sexual dimorphism may occur to reduce competition for food between the sexes of the same species (Cooper and Vitt, 1989; Stamps, 1983). This hypothesis is dependent on the extent to which males and females forage in the same areas.

Cooper and Vitt (1989) found that female *S. undulatus* body size increased at a greater rate than head size once they had attained sexual maturity. They believe this allows for increased growth of reproductive morphological characters that allow for greater reproductive success. Vitt and Cooper (1985) found the same hypothesis to be applicable to female broad-headed skinks (*Eumeces laticeps*). Female lizards of various species have shown an increase in clutch size with an increase in SVL (Cooper and Vitt, 1989).

Vitt and Cooper (1985) found significant differences between males and females in mean and maximum prey size and morphological characteristics related to feeding in *Eumeces laticeps*. An argument could be made that the same selection has occurred in *S. undulatus* and allows the lizards to partition their resources.

Another hypothesis that could help explain the sexual dimorphism in *S. undulatus* is that males have larger heads to compete for the right to mate with females. Stamps (1983) believes that intrasexual selection among males is more intense in territorial species than in non-territorial species. *S. undulatus* is known to be a territorial species where sexual dimorphism may increase a males chance of successfully defeating other males for the chance to reproduce.

In conclusion, sexual selection is frequently relied upon to explain sexual dimorphism in characteristics such as head and body size in lizards (Cooper and Vitt, 1989). Resource partitioning and intrasexual competition between males may be a result of sexual selection on *S. undulatus*. I do caution the attribution of any hypothesis unless further research implicates that morphological characters are determinants of either reproductive success or resource partitioning.

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THE EFFECTS OF CATTLE GRAZING AND STREAM BANK FENCING ON MACROINVERTEBRATE POPULATIONS IN HUNTINGDON COUNTY, PA

Mark Berkheimer

ABSTRACT

My research hypothesis was that the diversity of macroinvertebrate populations in streams that have stream-bank fencing is higher than the diversity of streams that do not have fencing. I found that this difference, measured by a Shannon Wiener Diversity Index, was slightly significant. I also found that overall family richness and the number of EPT taxa was higher in fenced streams. Fenced streams also supported a greater variety of pollution intolerant organisms, as measured by Beck's Biotic Index. All of these results show much healthier and diverse populations of macroinvertebrates living in fenced streams.

INTRODUCTION

Riparian livestock grazing can have numerous degrading effects on streams, as well as the organisms that live in the stream or on the banks (Lalo & Lutz, 1994). This degradation of the stream and the stream side vegetation leads to a greater variability in the amount of discharge, the temperature, and sediment loads that are transported by the stream (Wohl & Carline, 1996). Loss of stream side vegetation also leads to increased nutrient runoff and decreased bank stability (DEP, 1995). There are biological hazards to the farmer's herd, as well as environmental degradation. Keeping the herd out of the streams can greatly reduce the amount of time that they spend in contact with microorganisms, pests, and parasites. Degraded conditions favor pollution tolerant macroinvertebrates, many of which are known to be pests or carriers of disease. Also, bacterial diseases are associated with water (Drake). To protect streams that flow through agricultural regions, it has been recommended that farmers put a barrier between their livestock and the streams that flow through their fields. Land-use legislation, tax incentives for property owners, and other economic incentives have all been used recently to encourage stream-bank fencing and the protection of the riparian habitat. In 1988, the Pennsylvania Game Commission started its voluntary stream-bank fencing program. The fencing used to build this barrier is supplied to the farmers and installed at either minimal or no cost. However, the maintenance of these fences is solely the farmer's responsibility. The fence is single wire (double if there are calves in the field), high tensile, solar-powered, electric fencing (Hafner & Brittingham, 1993). Until now, relatively few studies have been done to assess the success of these fences in protecting the organisms in the stream. I tested the hypothesis that fencing placed along streams leads to a more diverse population of macroinvertebrates.

METHODS AND MATERIALS

I selected three sites that have electric fences along the stream, and three sites that do not. All six sites were similar in their physical compositions. To find similar streams I looked at width, depth, velocity, substrate, riparian vegetation, and structure. All of the streams were free stone streams. My three sites that did not have fencing were located along PA State Route 26, around the villages of Marklesburg and Entriken in Huntingdon County, Pennsylvania. These include the lands of Gary Gutshall (Unfenced Sample Site #1), Fred Foust (Unfenced Sample Site #2), and Roy Scott (owner of Scott's Sporting Goods who owns a piece of land across from his business that he rents out as grazing land) (Unfenced Sample Site #3). The streams at these sites all eventually drained into Raystown Lake. The three fenced sites were all located in the Petersburg and Alexandria areas of Huntingdon County, Pennsylvania. They were farms operated by Larry Claar (Fenced Sample Site #1), John LeCrone (Fenced Sample Site #2), and Bill Stout (Fenced Sample #3). These empty into Shaver's Creek.

I first established a location at which to take my sample. My samples were taken in riffle regions of the streams. Riffles were chosen because they are easier to define than pools and margins, more uniform than other stream microhabitats, easier to compare among different streams, and have fast moving shallow water that makes sampling easier (Karr &Chu). For the unfenced sites, my locations were selected based on ease of access. I randomly selected one of the possible riffle areas to be my site. For the fenced areas, I randomly selected one of the riffles located downstream from any crossing area where the cattle had limited access to the stream. I sampled using a D-frame net. At each location I stood upstream from the net and kicked my feet around for thirty seconds. I repeated this process two other times, each time one meter further upstream. I emptied my net into a white sorting tray and removed any rocks or other large debris that would be difficult to transport to the lab. Each discarded piece of debris was check for any macroinvertebrates. The contents of the tray were then transferred to a zip-lock bag, which was filled with 70% ethyl alcohol to preserve the sample until lab work was done. Once back in the lab, I separated all of the macroinvertebrates from the sediment and debris of the sample. I preserved them once again in 70% ethyl alcohol. I identified them down to the family level (Merritt & Cummins) and the numbers of each were noted.

I calculated a Shannon's Diversity Index (Kesh & Jackson) for each of the sites using the family level identification data. I compared the data to the normal distribution and made sure that the two populations (unfenced and fenced) had homogenous variances. I used Minitab to do a two-sample t-test to see if there was a statistically significant difference between the diversities of streams that do not have fences and those that do. I used an alpha value equal to .05, and considered a p-value < .10 be slightly significant, and a p-value < .05 to be significant. I also calculated other metrics that have been shown to vary based on different ranges of human influence or degradation. These included the number of EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa, overall family richness, the ratio of scrapers to filterers, Beck's Biotic Index, the ration of EPT individuals to chironomidae individuals, the percent of the total population that is of one dominant taxa, the percent of the population that is not of the family diptera, and the percent of the population that is shredders. I calculated Beck's Biotic Index by assigning a I, II, or III to each family of invertebrates. The number of I families found at a site were counted. This number was then multiplied by two, and added to the number of II families found at the site. Any of these metrics that were of count data needed to be converted to some kind of continuous data so that statistics could be applied to them. Since I placed the net at three different locations for each kick sample, the count data for each site I could be divide by three, to get a continuous average per pseudoreplicate that could be analyzed statistically. I repeated all of the statistical steps I used for the Shannon Wiener Diversity Index for each of these metrics.

RESULTS

Table 1 indicates what families of macroinvertebrates were collected, as well as how many. The total number of organisms found varied greatly among all stream sites. However, there was much more variation in the samples from the unfenced streams. More useful differences were shown when the list was broken into family groups. Although families of gastropoda were present at all six of the sites, the diversity of gastropod families and actual numbers of each collected were much higher at the fenced sites. Annelid families on the other hand were more populous at the unfenced sites. The presence of crustaceans at the sites was fairly variable as well. One noticeable difference was the numbers of EPT (Ephemeroptera, Plecoptera, and Trichoptera) found at each site. There were much higher numbers collected at each of the fenced sites. Also, many families that were present at the fenced sites were not found at the unfenced sites. Other families such as those of Odonata, Coleoptera, and Megaloptera followed suit with the EPT families in only being present, or being present at much higher numbers in the fenced sites. In the unfenced sites, the Diptera families, especially Chironomidae and Simuliidae made up a much higher percentage of the collected invertebrates.

My original hypothesis was that the diversities of macroinvertebrate populations, measured by Shannon's Index of Diversity, of streams that have the stream bank fencing would be higher than that of streams that do not. There was a slightly significant statistical difference between the populations of macroinvertebrates in fenced streams and those of unfenced streams (2-sample t-test, t=-1.67, p=. 085, df=4) (Table 2). (Karr & Chu, Kesh & Jackson). The other metrics, their values, and the statistical significance of their differences are also listed in Table #2. As I mentioned before, some of these metrics

were based on count data, and needed to be converted to continuous data (divided by three) before they could be subject to statistical analysis.

Table 1. Number of individuals collected in macroinvertebrate taxa in six streams in Huntingdon County PA, March 2000.

	Unfenced	**Unfenced**	**Unfenced**	**Fenced**	**Fenced**	**Fenced**
Mollusca						
Gastropa						
Ancyclidae	-	-	3	31	1	8
Lymnaeidae	1	-	-	1	-	1
Physidae	-	-	-	6	10	1
Planorbidae	-	1	-	-	23	-
Sphaeridae	-	-	-	20	16	4
Annelida						
Hirudinea						
Glossiphoniidae	2	22	-	2	10	-
Oligochaeta						
Tubificidae	67	45	1	2	1	6
Arthropoda						
Crustacea						
Decapoda						
Astacidae	-	-	3	10	1	4
Isopoda						
Asellidae	-	-	77	-	-	-
Amphipoda						
Gammaridae	-	2	4	-	-	-
Insecta						
Ephemeroptera						
Ephemerellidae	4	6	14	15	82	71
Heptageniidae	-	-	-	19	12	44
Siphlonuridae	5	-	-	-	15	18
Odonata						
Aeshnidae	-	-	-	-	-	14
Calopterygidae	-	-	-	1	-	-
Coenagrionidae	-	-	-	1	-	-
Gomphidae	-	-	-	19	1	2
Plecoptera						
Perlidae	-	--	-	-	1	3
Trichoptera						
Hydropsychidae	-	-	104	176	11	104
Limnephilidae	-	-	-	-	1	3
Philopotamidae	-	-	-	27	-	125
Coleoptera						
Dryopidae	-	-	-	1	-	-
Psephenidae	-	-	6	28	-	37
Elmidae	-	-	39	74	35	258
Haliplidae	-	-	1	-	-	-
Hydrophilidae	-	-	-	3	-	-
Megaloptera						
Sialidae	-	-	-	1	-	1
Diptera						
Tabanidae	1	2	-	-	-	2
Tipulidae	-	1	10	15	31	84
Simuliidae	61	120	105	321	319	252
Chironomidae	910	120	97	458	181	211
Hymenoptera						
Myrmardiae	1	-	-	-	-	-
Total Organisms:	**1052**	**319**	**464**	**1231**	**751**	**1253**

Table 2. Different metrics calculated from macroinvertebrate data (Table 1) as well as their test statistics, p-values, and degrees of freedom from six streams Huntingdon, PA, March 2000.

	Shannon Div.	#EPT taxa/3	Fam. Richness/3	Scraper/Filt.Coll	Beck's/3
Unfenced 1	0.544	0.667	3	0.005	2.333
Unfenced 2	1.371	0.333	3	0.029	1.667
Unfenced 3	1.886	0.667	4.333	0.203	4.667
Fenced 1	1.862	1.333	7.333	0.175	8.667
Fenced 2	1.789	2	6	0.383	6.667
Fenced 3	2.22	2.333	7.333	0.608	8.333
t-value	-1.67	-4.24	-5.48	-2.22	-4.55
p-value	0.085	0.0066	0.0027	0.045	0.0052
df	4	4	4	4	4

Besides a Shannon Diversity Index, I also used the number of EPT (Ephemeroptera, Plecoptera, and Trichoptera) families to compare the fenced and unfenced sites. As shown by Table 2, the number of EPT families found at each location that I placed my net while collecting is greater at sites that have stream-bank fencing. This difference is highly statistically significant (t-value=-4.24, p-value=.0066, df=4). The Family Richness at the fenced sites was also significantly greater than the richness at the unfenced sites (Table 2). This difference was also highly statistically significant (t-value=-5.48, p-value=.0027, df=4). I also calculated the ratio of scraper-feeding individuals to filtering collector organisms. The ratios for the fenced streams were significantly higher (t-value=-2.22, p-value=.045, df=4) than those for the unfenced. I also found a highly statistically significant difference (t-value=-4.55, p-value=.0052, df=4) in the Beck's Biotic Index between the populations of invertebrates at fenced and unfenced sites. The sites that had stream-bank fencing scored higher Beck's scores.

I did calculate some other metrics that did not, for many different reasons I will go into in my discussion, show any statistically significant differences between the macroinvertebrate populations in fenced and unfenced streams. These are shown along with their t-values, p-values, and degrees of freedom in Table 3.

Table 3. Metrics calculated that did not show statistically significant differences between macroinvertebrate populations in fenced and unfenced streams in Huntingdon, PA, March 2000.

	EPT/Chiron	% Dom. Taxa	% Non-Diptera	% Shredders
Unfenced 1	0.0099	0.865	0.076	0
Unfenced 2	0.05	0.376	0.238	0.009
Unfenced 3	1.2165	0.226	0.543	0.196
Fenced 1	0.5175	0.372	0.355	0.020
Fenced 2	0.674	0.425	0.293	0.044
Fenced 3	1.7441	0.206	0.562	0.073
t-value	-1	0.76	-0.74	0.35
p-value	0.19	0.25	0.25	0.63
df	4	4	4	4

DISCUSSION

The degradation that grazing livestock cause to a stream goes far beyond the obvious physical destruction of the stream and the riparian area (Lalo & Lutz). My results show that the populations of macroinvertebrates are more diverse in streams that have the stream-bank fencing keeping livestock from degrading large portions of the stream's reach. The absence of a fence and the presence of livestock can lead to a great decrease in the overall health of a stream, and that the application of fencing to a stream can improve the overall biological health of the stream. There are some invertebrates, such as many members of the order Diptera, which can survive despite degraded conditions (Kesh & Jackson). However, most macroinvertebrates are very intolerant to pollution or degradation. Any changes in the quality of the stream will quickly lead to the loss of these taxa (Kesh & Jackson).

When I was selecting my sample sites, I attempted to keep all of the physical attributes of the streams the same. However, the amount of sediment in the stream was hard to keep constant. This was due to the increased stream-bank degradation that was occurring in the streams that lacked the fencing. Any degradation of riparian vegetation can lead to large variability in amounts of stream discharge and sediment load (Wohl & Carline, 1996). While the substrate captured along with the macroinvertebrates was mostly rock or organic materials in the fenced streams, it was for the most part sediment in the unfenced. While I am sure that this had large effects on the macroinvertebrate populations, I allowed this variation because it is a function of the cows' presence. Any change this may have caused could directly be connected to the lack of a fence separating the cows from the stream.

I felt as though the connection between the lack of fences and decreased macroinvertebrate diversity was going to be much stronger than only "slightly significant (p-value < .10)." Most of the complications were caused by the fact that one of my unfenced sites, Unfenced Site #3, had a diversity index higher than that of two of my fenced streams. After talking with the landowners of the three unfenced sites I developed ideas as to why. First of all, there is a certain amount of variation in natural systems. I was not going to find exactly the same things living at different places. Macroinvertebrates have been shown to vary their existence based on a continuum of human influence and degradation (Karr & Chu, 1999). For this reason, it would have nice to have had a few pristine, non-agricultural reference sites with which to compare my data from the fenced and unfenced sites (Rinne, 1988). However, this was not possible due to time constraints and the lack of rarity of truly pristine conditions. The two unfenced sites that were located in actual farms had an extremely long history of cows being in the same place, degrading the same portion of the stream. Unfenced site #3 was a piece of land that was rented out by Roy Scott as grazing land. Although he mentioned that the cows had been there for a long time, the degradation of the riparian vegetation, despite the fact that it was extensive, was not quite as serious as it was at the farms. Also, it is doubtful that he had rented out that land as long as the cows had existed on the farms. Although life spans for macroinvertebrates are very short, continued impact over long periods of time is more serious than heavy degradation over a short time. Another way in which unfenced site #3 could have given a misleading diversity index is by the nature of the Shannon Diversity Index itself. First of all the index is based on counts of individuals. Individual counts can often times, especially in degraded conditions, be extremely variable. This can easily be seen by the total organism counts of Table 1. The Shannon Diversity Index also incorporates evenness into its calculation. Unfenced site #3 might have had a smaller number of total organisms, but this total number was divided among relatively few families. Four families, each comprising of around 100 individuals made up most of the 454 total organisms. This translated to a very high diversity index.

The best way that I could have made my results more concrete and significant would have been more replicates. When I broke it down to net locations during kick net samples, I had nine replicates. However, these were only pseudoreplicates. In actuality, I had only three true replicates. A small number of replicates will not eliminate a lot of the variation that can occur in natural systems. An abnormally high or low value will have much more of effect on a two-sample t-test if the number of replicates is small. Also, many statistical tests have mechanisms built into them to make it very hard to reject the null hypothesis if the degrees of freedom value, which is calculated from the number of replicates, is low.

There were certain things that I could tell from looking at counts of individuals. However, do to the extreme variability in dealing with individual counts, I found it was more useful especially with this small number of replicates, to look at things in terms of families. I could tell that the numbers of individuals in pollution intolerant taxa were much higher in the fenced streams. I could also tell that the proportion of Diptera family members was much higher in the unfenced streams. These measures of stream health, based on individual counts, ended up being extremely hard to prove statistically (Table 3). The community instability that results from environmental degradation is extremely obvious in my results from the unfenced streams. The metrics that I calculated based on family structure of the sites ended up giving me statistically significant results (Table 2). They show that the number of EPT taxa, overall family richness, and the total number of pollution tolerant families definitely do increase with decreased environmental impact and increased water quality.

In addition to what my results have shown, stream-bank fencing benefits everyone through many different ways. Increased sediment loads and decreased macroinvertebrate population health and diversity have implications not only at the site on the degradation, but also far down stream. Both of these factors have been shown to influence the populations of salmonid fish species. This influence can be attributable to the sediment choking out the fish or killing off their macroinvertebrate food source, as well as the

increased environmental variation that occurs without the stream side vegetation. This decrease in the populations of fish species has both recreational and economic effects. One study mentioned by Platts & Wagstaff, 1984 found 88% nongame fish in a stream during a period of heavy grazing. Soon after the removal of the grazing animals the fish population had shifted to 97% trout. Stream-side resident bird populations are also affected by the absence of stream-bank fencing. This is for the most part a function of the presence of the cows and the destruction of the bird's required habitats (Hafner & Brittingham, 1993).

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CHANGES OF PLANKTON COMMUNITY WITH DEPTH IN RAYSTOWN LAKE

Shannon V. Nayyar

ABSTRACT

I compared plankton density, diversity, richness and evenness among at three depth intervals in Juniata Bay, Raystown Lake, PA. I also recorded turbidity, temperature, dissolved oxygen, and light penetration at each interval to correlate with plankton community data. Species diversity was significantly different among the depths. Changes in plankton population may be due to temperature, dissolved oxygen and light differences throughout the water column that relate to the time of year the samples were taken and the turnover conditions of the lake.

Keywords: Oxygen, Raystown Lake, plankton, water quality.

INTRODUCTION

Plankton compose the base of the food chain of a lake and thus provide food support to top predators such as fish, birds, and humans. The greater the amount of zooplankton species (richness), the more likely the lake is to have more species of fish, many of which are particularly important to sports fishermen (Waite 1996). To understand how plankton affect the top of the food chain, we must first understand the vertical distribution of plankton communities. This distribution of plankton is effected by the biannual lake turnover. Top predators often depend upon plankton blooms as a food source, such as those that occur with diatoms during spring turnover. The timing of the bloom can influence the survival of larval fish (Waite 1996).

I examined phytoplankton communities at three depth intervals. I tested the hypothesis that plankton communities did not vary among depth levels in the early spring. I also examined abiotic factors that might influence plankton communities.

METHODS AND MATERIALS

I sampled plankton from Juniata Bay, a small inlet of Raystown Lake, near the main channel of the lake using a Birge Closing Net at three depths of 4 meters each: 1) 0-4m, 2) 5-9m, and 3) 10-14m. I identified and counted plankton by using a 1.05 microliter counting cell and microscope. I selected ten randomly generated fields of microscope view to estimate plankton densities. I calculated plankton density, richness and Simpson's Diversity (Brower, et. al. 1998) for each depth interval. I took measurements on temperature, dissolved oxygen, and light penetration throughout the water column using a YSI oxygen meter and a photometer.

RESULTS

Plankton diversity differed significantly among depths (F=439.58, df=29, *P*< 0.000) with depth 1 having lower diversity than depths 2 and3. Only three species were found in all three depths: *Asterionella, Fragilaria*, and *Closterium* (Table 1).

Table 1. Plankton species found in three depths of Raystown Lake,PA, in March, 2000

0-4 m	5-8 m	9-12 m
Asterionella	*Asterionella*	*Asterionella*
Fragilaria	*Fragilaria*	*Fragilaria*
Closterium	*Closterium*	*Closterium*
Phormidium	*Spyrogyra*	*Melosira*
Spyrogyra	*Nitzschia*	*Oedogonium*
Oscillatoria	*Diatoma*	*Ulothrix*
Melosira	*Tabelleria*	*Volvox*
Nitzschia	*Ankistrodesmus*	*Ploesoma*
Chaetophora	*Daphnia*	*Acanthocystis*
Protococcus	*Oedogonium*	*Microspora*
	Cladoph	*Stauroneis*
	Keratella	*Synedra*
	Naupalis	*Trichocera*
	Cyclops	*Pediastrum*
	Zygnema	

Plankton richness was also significantly lower at depth 1 but did not differ between depths 2 and 3 (F= 8.36, df= 29, *P*=0.001). Species evenness also differed significantly among depths (F= 70.32, df= 29, P=0.000). Temperature (Fig. 1), dissolved oxygen (Fig. 2), and light penetration (See Fig. 3) decreased as depth increased. The depth at which all parameters drop off to less than 5% was at 14 meters.

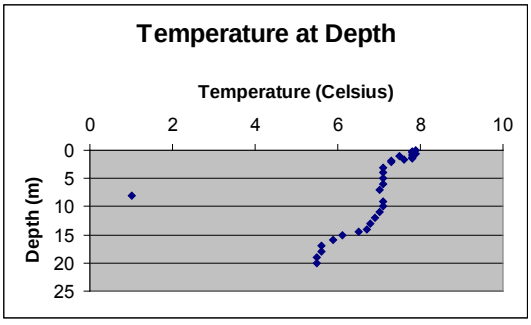


Figure 1: Temperature profile of Juniata Bay, April 2000.

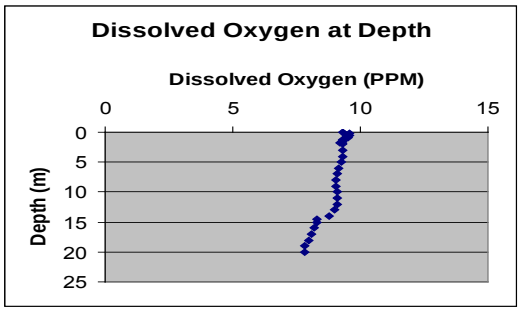


Figure 2: Dissolved oxygen profile in Juniata Bay, April, 2000.

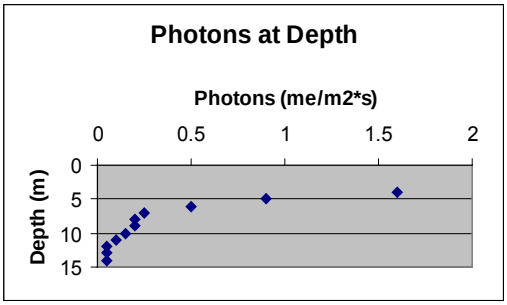


Figure 3. Light penetration through the water column.

DISCUSSION

The low density of plankton at the lowest depths is probably caused by poor light penetration (Sprules & Munawar 1984). A limited amount of light, for example, might limit a phytoplankton's range in the water column. Light scatters in water, thus the amount penetrating the bottom of the lake is less that 5% the amount of light at the surface. Temperature also decreases with depth as well because deeper water is less likely to engage in the energy transfer with the sun's energy at the surface. A completely mixed lake would have more uniform temperature throughout the water column. Therefore, the temperature curve may indicate the beginning of a mixing period.

Correlating the environmental data with the plankton data supports the conclusion that the lake is mixing. The warm weather prior to collection on March 29, 2000 may have begun the mixing. The phytoplankton are increasing in abundance, but only where light is available. However, the lake is in the early stages of mixing as indicated by the presence of winter-only diatoms. The genus' *Asterionella*, *Fragilaria*, and *Tabellaria* are present in abundance in the spring bloom because they grow faster than competing algae. One of the reasons these algae can grow faster is its ability to store phosphorus, a growth-limiting nutrient. However they are also "holoplankton", which are always found in the plankton of lakes (Sprules & Munawar 1984). A further look at other forms of plankton will decipher which stage the Juniata Bay was in at time of sampling. The diatom *Melosira* benefits from low levels of competition and is thus abundant in the winter. It also takes advantage of the high nutrients in the spring bloom. *Melosira* is most abundant from October to May (Horne and Goldman 1994). The phytoplankton indicate that the lake was in the first stages of mixing at collection. *Asterionella* numbers increase 500 to 2000 times each spring, whereas *Melosira* can only increase to 200. This is the explanation of the abundance of *Asterionella* in the plankton sample (Horne and Goldman 1994).

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THE EFFECT OF METHYLATED MERCURY ON THE DIVING FREQUENCY OF THE COMMON LOON

Brian Olsen, Dave Evers, and Christopher DeSorbo

ABSTRACT

Rising levels of atmospherically deposited mercury and its incorporation into aquatic food webs have long been a topic of concern for threatened populations of the common loon, *Gavia immer*, in the northeast. Although little is known about the effect of mercury on adult loon behavior, it has been shown that mercury inhibits heme production, and may affect the oxygen carrying capacity of loon blood. We examined the relationship between diving frequency and mercury concentration in common loons. We found a significant difference among the frequency of foraging dives in loons with different mercury burdens ($H = 8.75$, $df = 3$, $p = 0.033$) and a significant correlation between dive frequency and mercury level ($r = 0.136$, $N = 249$, $p = 0.032$). Additionally, the effect increased at higher concentrations ($H = 7.48$ $df = 1$, $p = 0.006$). This result prompts concern over contaminated loons' ability to forage for themselves and their offspring, especially in populations that are already stressed due to other anthropogenic disturbances.

INTRODUCTION

In recent decades the level of atmospherically deposited mercury in aquatic systems has been steadily rising (Swain et al. 1992). Since the largest source of mercury in aquatic systems is due to atmospheric deposition (Swain et al. 1992, Carpi 1997), the effects in the northeast have been greater than elsewhere, due to prevailing weather systems (Evers et al. 1998). The mobilization of mercury in biological systems is also noted to be far above what occurs naturally (U.S. EPA 1997, Vitousek et al. 1997). Because of this pattern, methylated mercury concentrations in common loons, *Gavia immer*, generally increase from west to northeast (Evers et al. 1998). Although the effects of this escalating contamination on reproductive productivity have already been noted in various aquatic birds (Barr 1986, Heinz 1976, 1979, Scheuhammer and Blancher 1994, Tejning 1967), little has been recorded in loons. Nocera and Taylor (1998) found that contaminated chicks tend to brood and preen less, and Evers (unpublished DEP Report, 1998) noted that males with high mercury loads incubate eggs less frequently. Little work has been done, however, to link lower levels of mercury with adult loon behavior. This deficiency is an important gap in our understanding of the anthropogenic effects on declining loon populations (Sutcliffe 1978, Blair 1992). It has been documented, however, that methylated mercury inhibits the production of heme (Marks, 1985; Matts, et al, 1991). We hypothesized that inhibited heme production would limit the oxygen carrying capacity of loon blood, thereby decreasing diving duration. We assumed that as diving duration decreased, loons would be required to dive more frequently per foraging interval to secure the same caloric needs. We tested the hypothesis that there was no change in the diving frequency of loons at different mercury contamination concentrations.

METHODS AND MATERIALS

Field sites

We collected data from a total of nine loon territories on six lakes in Franklin and Somerset Counties, Maine from May until August, 1999. The lakes are located in the upper drainage basins of the Androscoggin and Kennebec rivers. Both Rangely and Flagstaff lakes are dam controlled, but only Flagstaff's water level fluctuates widely. The majority of all shorelines are wooded with mixed evergreen and deciduous forest.

Approach

Loon territories were divided into four risk categories according to levels of blood mercury: extra high (> 4.0 ppm), high (3.0-4.0ppm), moderate (1.0-3.0 ppm), and low (0-1.0 ppm). We gathered diving time observations in one hour time blocks for up to 4 hours/day using one or two 15-45X spotting scopes and 10X binoculars. Observers monitored behavior continually through a spotting scope and relayed behaviors to a recorder, who noted times from a digital stopwatch and recorded observations. We gathered data from early May until late August in order to incorporate data from pre-nesting, nesting, and post-nesting intervals. Observations time were not stratified throughout the day in accordance with Evers (1994), Gostomski and Evers (1998), Mager (1999), and Paruk (1999), who found minimal or no significant relationships between time of day and behavior. During observations, we concealed ourselves as much as possible from a distance (up to 300m) to avoid any possible change in behavior due to our presence. Bradley (1985) found that this bias can influence data significantly. We collected 6 cc of blood from each loon through the methods described by Biodiversity Research Institute (Unpublished, 1999) and determined mercury concentration through cold vapor atomic absorption (CVAA).

Statistical Analysis

We calculated diving frequency as the number of dives per second foraging. We determined foraging to be a behavior state as defined by Altmann (1974), Tacha et al. (1985), and Nocera and Taylor (1998) in their time activity budget protocols. We calculated differences among treatments with the Kruskal Wallace test (Sokal and Rohlf, 1995) and Mann Whitney U (Sokal and Rohlf, 1995), and also used Pearson's Product Moment to investigate correlations between dive frequency and mercury risk category (Sokal and Rohlf, 1995). We used an alpha level of 0.05 and considered differences to be significant at $p < 0.05$.

RESULTS

Non-parametric testing determined that there was a significant difference among diving frequencies of common loons which have different levels of mercury contamination ($H = 8.75$, $df = 3$, $p = 0.033$) (Fig. 1).

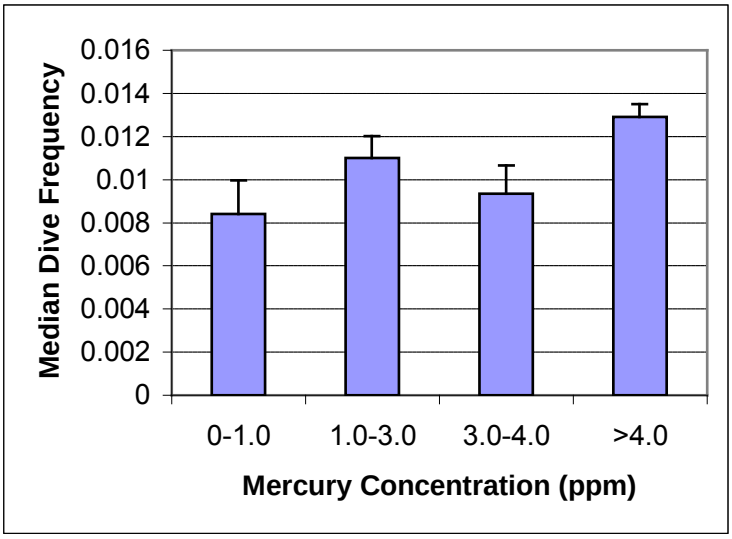


Fig 1. Median frequency of Common loon dives (+SE) among four categories of Hg contamination in loon blood during the summer of 1999 in Maine.

The frequency of diving was positively correlated with mercury load ($r = 0.136$, $N = 249$, $p = 0.032$) (Fig. 2).

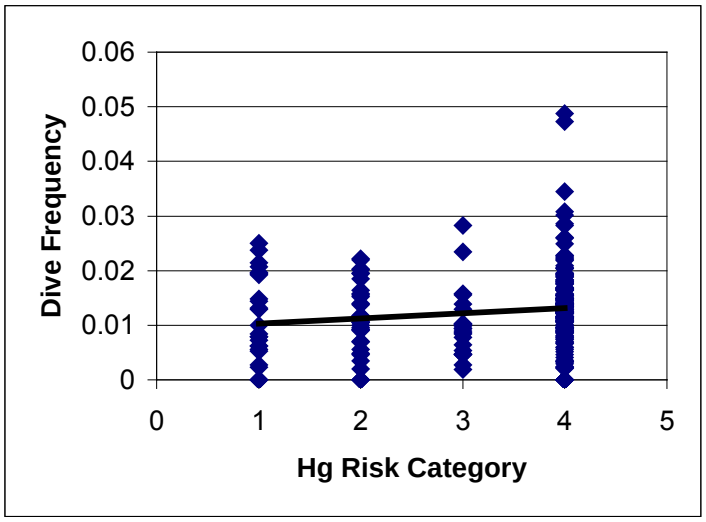


Fig. 2. Frequency of common loon dives as a function of mercury contamination in the blood. Loon territories were divided up into 0-1.0 ppm , 1.0-3.0 ppm , 3.0-4.0ppm , and >4.0 ppm risk categories respectively.

This difference increases in significance as mercury loads reach the high risk category (>4.0ppm). When we pooled our first three risk categories to reduce the possible effect of low sample size, the significance of the difference increased (U = 151.0, N= 85, 164, p = 0.0063) (Fig. 3).

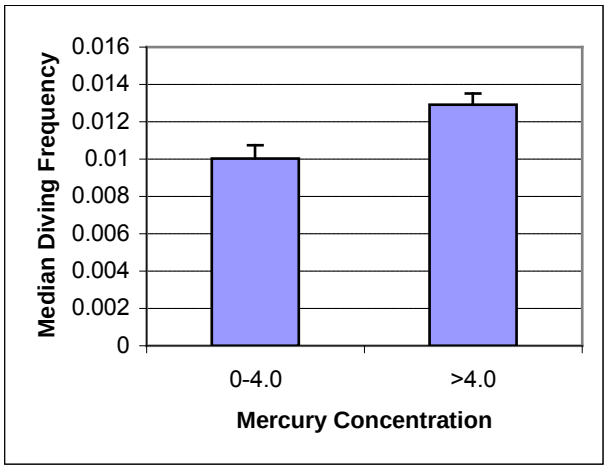


Fig 3. Median frequency of Common loon dives (+SE) of two categories of Hg contamination in loon blood during the summer of 1999 in Maine.

There was a highly significant positive difference between the diving frequencies of loons with blood concentration of 0-4.0 ppm and those with >4.0ppm.

DISCUSSION

Our findings support the supposition that there is a positive correlation between mercury contamination in loon blood and diving frequency. We hypothesize that mercury, a known heme inhibitor (Marks, 1985; Matts, et al, 1991), lowers the blood carrying capacity of the blood, thereby making it harder for loons to stay underwater as long. Shorter dives should lead to more frequent dives unless the loss in duration can somehow be compensated by foraging efficiency. In nearly exclusive piscivores such as loons, a shorter dive is presumably a less efficient dive. Thus, to meet daily caloric needs, a loon would have to dive more frequently. Although this study does not prove that mercury and dive frequency are linked, the correlation should raise sufficient concern to prompt further investigation. More frequent diving could conceivably have wide ranging effects on loon populations. Birds might have to spend more energy foraging, both because of a need for longer foraging duration, and more dives. Their ability to feed both themselves and

their young might also be impacted by this effect. For many loon populations which are already under stress from shoreline development, lead poisoning, and other water quality issues, this added effect further inhibits the population's ability to rebound from disturbances and to thrive in currently established habitats.

Our conclusions are tentative, however, because of a low sample size. The moderate and high risk categories consist of only one territorial pair over the entire summer. The low category only consists of three pairs, and the extra high category consists of four territorial pairs. The high risk category's deviation from the overall pattern of increase may be because of this low sample size. However, since such a low sample size indicated a significant correlation, it is possible that further study with more sufficient sample sizes would discover a more significant relationship. It should be noted that although our correlation was not a strong one, it was a significant one. Although a number of other factors such as prey availability, water depth, and chick age may correlate more strongly with diving frequency, mercury concentration correlates significantly. Limitations of the parent data base restricted us to using diving frequency, but comparing exact diving times would yield a more direct result without further assumptions. Further study might also address the effect of increased diving frequency on foraging efficiency, caloric intake, chick feeding, and foraging duration as well as examining blood-porphyrin levels to connect the observed pattern directly to heme inhibition.

ACKNOWLEDGMENTS

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Population Ecology and Home Range Study of the Wood Turtle (*Clemmys insculpta*) at the Raystown Field Station

Todd L. Quinter and Roy D. Nagle

ABSTRACT

Wood turtles (*Clemmyss insculpta*) are a medium-sized emydid turtle that utilizes a variety of both aquatic and terrestrial habitats. We used mark-recapture to determine population characteristics, and radio telemetry to determine seasonal movements of wood turtles from January 1998 to March 2000 at the Raystown Field Station. We tested the hypothesis that male turtles would have greater home ranges than female turtles. A total of 31 individuals, 11 males and 9 females and 11 juveniles, were captured by searching both aquatic and terrestrial habitats and by using baited hoop traps. Individuals were measured, weighed, and individually marked. We also attached radio transmitters to 3 adult males and 4 adult females. Individuals were located at approximately weekly intervals during spring and fall, bimonthly during the summer, and monthly during the winter. All turtles overwintered in the lake, whereas they utilized terrestrial habitats during the majority of the other seasons. We found that male turtles had significantly larger home ranges than female turtles.

INTRODUCTION

Wood turtles (*Clemmys insculpta*) are a medium-sized emydid turtle that utilizes a variety of both aquatic and terrestrial habitats. Wood turtles are typically found in disjunct and fragmented populations (Harding *et al.*, 1998). Major declines in the wood turtle populations have been attributed to human activities, including collection for the pet trade (Harding *et al.* 1998) and increased disturbance of wood turtle habitat for recreational activities (Garber and Burger, 1995). Other contributing factors to the decline in wood turtle populations include habitat loss, fragmentation, and degradation (including water pollution and siltation), low recruitment, and road mortality (Harding *et al.*, 1998).

Garber reported that there was a strong correlation between human recreation and wood turtle population decline (1995). In order to preserve and protect a species, documenting critical habitat and seasonal use patterns are essential (Kaufmann). Home ranges have been defined as the area over which an animal normally travels in pursuit of its routine activities (Jewell, 1966 as cited in Kaufmann, 1995).

Thirty-one total individuals (11 male, 9 female, and 11 juvenile) have been captured. We transmittered and tracked the seasonal movements of 7 individuals (3 male, 4 female) from January 1998 to March of 2000. Using these location records, we have defined seven home ranges. The size of home ranges and use within is not well documented and remains largely undefined for most chelonian species (Kaufmann, 1995). Kaufmann's population is primarily located within a lowland floodplain setting, while our study location includes various habitat types as well as extensive geographic changes in elevation. The null hypothesis being tested is that male and female wood turtles have similar sized home ranges.

STUDY AREA

Our study was located at the Juniata Colleges Raystown Field Station in Huntingdon County, Entriken, Pennsylvania. The site includes primary succession reclaimed rye fields, as well as established 80 yr. Oak Hickory forests within its 365-acre boundaries. The ridges run primarily northeast to southwest and have dominant slopes facing the southeast and the northwest. The southeastern slopes are characteristically

more sunlit. Ridge-top species include primarily Oaks (Quercus spp.), while low-line flood-plane areas are composed of Hemlocks (*Tsuga* sp.), Sugar Maples (*Acer saccharum*) and Locust. Concentrations of wild berry bushes (*Rubus* sp.) have been observed in both floodplains, yet they are more prevalent in Township Creek. Each bay location, Juniata and Township are lined with steep hills on both sides, while the upstream floodplain remains quite level. Both bays are also accessible to the main channel of the lake and are fed by separate small streams. Recreational disturbance, such as fishermen traffic, was more prominent in Township Bay, while Juniata Bay is posted from public traffic.

METHODS AND MATERIALS

All individuals had their marginal scutes notched during their first capture for identification purposes. Each animal was also aged upon first capture. This becomes prevalent in determining life history information. Each animal was weighed (g) and measurements were taken of the animal's height (mm), carapace length (mm), plastron length (mm), and temperature (C). The majority of captures, 167 of the 250 total captures, were achieved with the use of radio telemetry, while 83 were by hand, net, or hoop traps. Three adult males and four adult females were fitted with transmitters. The cylindrical transmitters measured 1.5 x 4 cm, had 25 cm antennas, and weighed 27.5 g each. Each transmitter had flat brass extensions that allowed them to be secured with two nylon cable ties through small holes drilled into marginal scutes. Transmitters were placed anteriorly on females and posteriorly on males, as to not obstruct with mating. We located individuals weekly from April through October and monthly during November through March.

Two hundred and fifty capture locations of thirty-one individuals were recorded on a 20 ft topographic contour map. I transferred home ranges of the 7 transmittered individuals to the Geographic Information System (GIS) program ArcView 3.2. This was due to those 7 individuals comprising of 215 of the total 250 captures. This method has been used with a high amount of confidence that location sites have been accurately transferred as a result of the unique contours and geographic landmarks of the research site.

Overlaying the location sites upon multiple GIS base layers allowed us to determine the home ranges of each individual. The base layer themes included Raystown Lake, contours, black and white arial photography, streams and local roadways. Each capture location was then determined by comparing the original field contour to the available themes. Once all locations were inserted within GIS, they were attributed with date of capture, ID, paint number, sex, reproductive condition, capture method and location of capture. All captures were then summarized by their ID and were separated into themes of their own. This allowed us to display one individual at a time and determine its home range by designating a minimum convex polygon surrounding the capture locations.

We calculated the home range sizes for each sex of turtle using convex polygon (MCP) method. Home range sizes were then compared by using a Mann-Whitney U test. Location and size of the individuals, as well as male and female home ranges were analyzed and compared. Location of gravid females in respect to habitat type, geographic and vegetative, was investigated as well. The Lincoln Index was calculated to determine population size in respect to sample size of the population. Our data was tested for homogeneity of variance.

RESULTS

Home range capture locations were recorded over a two-year period, from January 1998 to March 2000. We used mark-recapture to determine population characteristics and radio telemetry to determine seasonal movements of wood turtles. Captures were reported every month of the year. Turtles fitted with transmitters were located approximately during weekly intervals during the spring and fall, bimonthly during the summer, and monthly during the winter. All wood turtles overwintered aquatically.

Locations of turtle captures varied from aquatic to terrestrial, depending upon the season. There were aquatic captures during every month of the year, while land captures only occurred from April through October (Figure 1). All seven transmittered wood turtles overwintered in the same bay during both

years of our study. Likewise, all turtles exhibited primarily terrestrial, and stream traveling throughout all other seasons of the year.

Home ranges of the individuals (Table 1) ranged from 1.15 ± 1.22 ha to 16.86 ± 4.24 ha, and 5.24 ± 5.25 ha. Males had larger home ranges (8.41 ± 7.34 ha) than females (2.86 ± 1.22 ha), and the difference was marginally significant (W=11.0, df=6, *P*=0.056). The maximum straight-line distance (Table 1) traveled was 1,002 m, while the minimum was 502 m. The minimum elevation was the same for all individuals, around 800 ft, while the maximum elevation of any turtle studied was 940 ft.

DISCUSSION

Kaufmann (1995) reported that within his Centre County, PA study, male wood turtles exhibited an average home range of 4.99 ha ± 1.48, while female home range averaged 3.30 ha ± 0.52. The longest straight-line distance for males was reported as 481 m ± 75.3, while females had a slightly smaller straight-line distance of 435 m ± 73.7. Home ranges of most wood turtles in our study were similar to those found by Kaufmann. We had expected that home ranges of wood turtles at our site, which are characterized by steep ridges and major changes in elevation, might be different than those studied in Kaufmann's lowland floodplain community.

The home range expanse of one male, R, included both bays as well as terrestrial movement over a ridgetop and two floodplains. The travels of many individuals, including R, were to summer locations that had continuous supplies of wild berries. The six remaining wood turtles exhibited linear home ranges that strictly follow the separate valleys.

One prominent location of captures was in Township Creek floodplain, at an old house foundation. At this location, there is a high concentration of berry bushes. It has been observed on many captures that individuals had berry stains on their mouths. Slight differences in overwintering locations were contributed to the low level of the bay the first year observed. This caused the overwintering turtles to travel much further out within the bay as they did the second year.

In total, we captured and marked eleven juveniles, eleven males and nine females. That juveniles comprise 35.5% of our sample suggests a population with substantial recruitment. Based on the Lincoln Index, we determined the size of the population to be 31 ± 3.2 individuals (identical to the number marked). Our results thus indicate that the population is small, therefore major disturbances to critical habitats could potentially drive the population to extinction.

Knowing the expanse and variety of habitat types used within a turtle's home range will greatly help us to determine appropriate measures for conservation efforts and preservation (Kaufmann, 1922). Areas of seasonal movements, as well as critical habitat locations (i.e. overwintering sites and nesting locations) should be preserved to ensure population stability. Future development and activities at the Raystown Field Station should recognize the habitat requirements of wood turtles, and that the unique suite of life history characteristics exhibited by wood turtles makes them vulnerable to rapid population declines.

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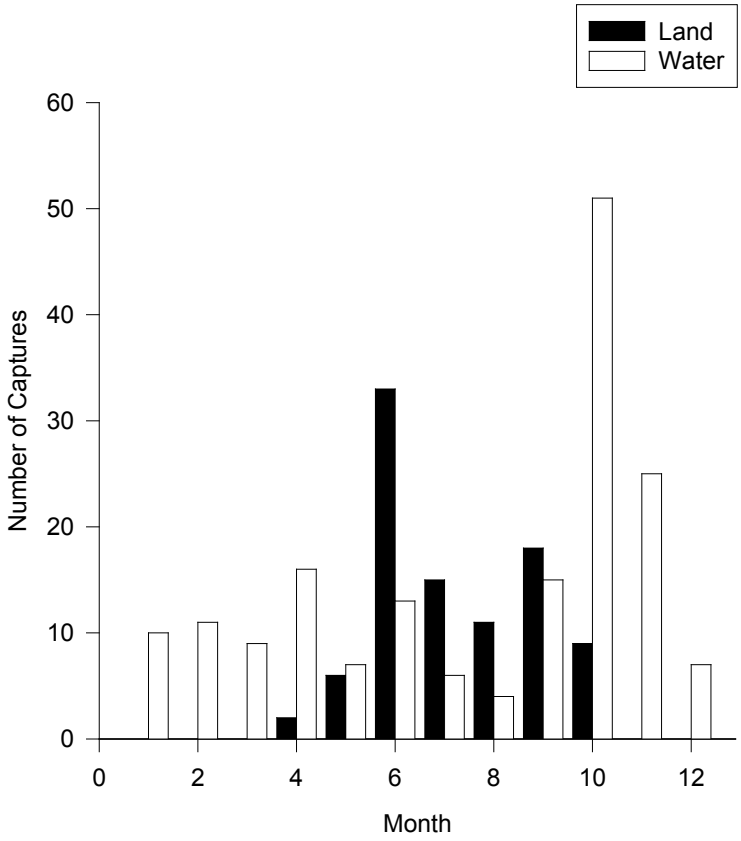


Fig. 1. The number of captures of *Clemmys insculpta* as a function of the month of year. Figure represents data from January 1998 to March of 2000.

Table 1. Home Range Sizes and Maximum Straight-Line Distances of Seven Radio-Tracked Wood Turtles.

Males	Paint ID	Area (ha)	Straight Line (m)
ABCH	R	16.86	1002
ABCI	X	3.59	502.23
ABCU	B	4.79	923.86
Average		8.41 ± 7.34	809.36 ± 268.84
Females			
ABDP	O	4.03	955.96
ABCXY	Y	1.15	367.57
ABCN	P	3.01	555.3
ABCY	D	3.24	690.49
Average		2.86 ± 1.22	642.33 ± 247.49

Average M&F		5.24 ± 5.25	713.92 ± 250.38

COMPARITIVE STUDY BETWEEN AMPHIPODS AND THE WATERCRESS SNAIL

GalenWoleslagle

ABSTRACT

Gammarus minus, commonly known as Amphipods, are common in springs and low-order streams of the mid-Appalachians west to the Ozarks. Glazier et al (1992) reported a possible negative relationship between the presence *of G. minus* and *F. nickliniana*, the Watercress snail. I compared abundance of *G. minus* to F. *nickliniana* in 4 spring runs with *F. nickliniana* and 4 spring runs without *F. nickliniana* and found that there was no correlation between the presence of the two organisms. I also found dissolved oxygen levels to be greater in *F. nickliniana* absent spring runs than in *F. nickliniana* present spring runs.

INTRODUCTION

Gammarus minus, commonly known as Amphipods, are common in springs and low-order streams of the mid-Appalachians west to the Ozarks (Holsinger 1976). There have not been many comparative studies of spring macroinvertebrate communities undertaken in North America and no studies have been done on the relationship between the *Fontigens nickliniana* and *G. minus* (Glazier, personal communication). Glazier et al (1992) reported a possible negative relationship between the presence *of G. minus* and *F. nickliniana*, the Watercress snail. *F. nickliniana* is abundant in hardwater springs, usually with dense macrophytic coverage (Glazier and Gooch 1987). The goal of my research was to confirm the negative correlation between *G. minus* and *F. nickliniana* exists in local spring runs and to investigate abiotic parameters that might affect that relationship. I hypothesized that there was a negative correlation between the abundance of *G. minus* and *F. Nickliniana* in local spring runs.

METHODS and MATERIALS

I studied eight spring runs within a 20-mile radius of Huntingdon, PA, which were known habitats for *G. minus*. I categorized each spring run as being either *F. nickliniana* present or *F. nickliniana* absent based upon whether they were known to have *F. nickliniana.*

I randomly selected five points in each spring run and collected six-inch diameter surber or grab samples at each point. From these samples, I counted the number of *G. minus* and *F. nickliniana*. I examined the relationship between *G. minus* and *F. nickliniana* present using a Pearson product normal correlation. I also measured water quality parameters at each of the eight spring runs.

I recorded dissolved oxygen using a model 58 Yellow Springs Inc. oxygen meter, pH with a model 88 Markson digital pH meter, and temperature and conductivity with a model 33 Yellow Springs Inc. conductivity meter. I also recorded the width and depth at three locales along each spring run and noted the vegetation systems and surrounding landscape.

I used a two-sample t-test to compare the dissolved oxygen, pH, and conductivity between *F. nickliniana* present and *F. nickliniana* absent spring runs. I set an alpha level of 0.05 and considered differences to be significant if $p < 0.05$.

RESULTS

I found no correlation between *G. minus* and the presence of *F. nickliniana* (r = -0.011, $p = 0.98$) (Table 1). I found a significant difference in dissolved oxygen levels between *F. nickliniana* present and *F. nickliniana* absent spring runs (t = 3.16, df = 3, $p = 0.051$) (Fig. 1). I found no difference in pH values or conductivity of *F. nickliniana* present and *F. nickliniana* absent spring runs (t = -2.18, -1.86; df = 3, 4; $p =$ 0.12, 0.14; ; respectively) (Figs. 2 and 3).

Table 1. Data collected from four F. nickliniana present and F. nickliniana absent spring *runs.*

Spring Run	Amphipods #/m^2	Snails #/m^2	DO (mg/L)	pH	Conductivity (mho)
Petersburg	16.6	0.0	12.03	6.85	91.2
Emma	6.0	0.0	12.50	7.05	103
Right Fouse	0.0	0.0	9.36	6.91	113
McConnellstown	38.8	0.0	11.90	6.48	250
Hundred	7.8	8.6	9.83	7.33	215
Left Fouse	5.4	4.2	9.07	7.39	338
Camp Kanasataki	28.4	588.4	9.53	7.28	407
Greystone Farm	0.0	730.6	11.90	6.91	180

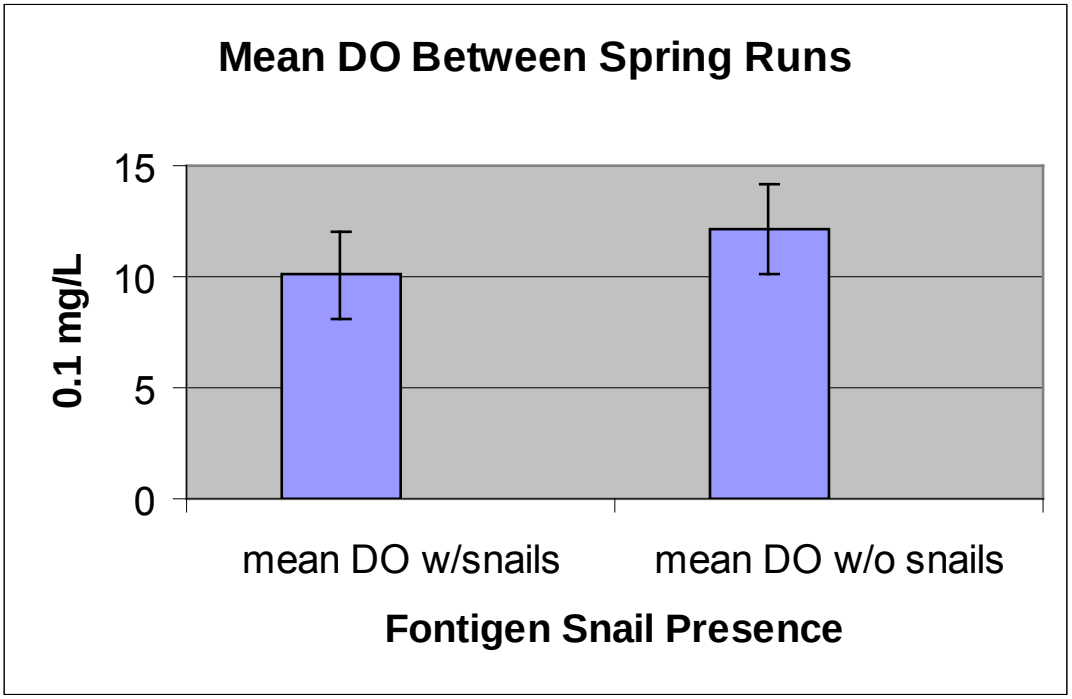


Figure 1. Levels of dissolved oxygen in spring runs with and without snails.

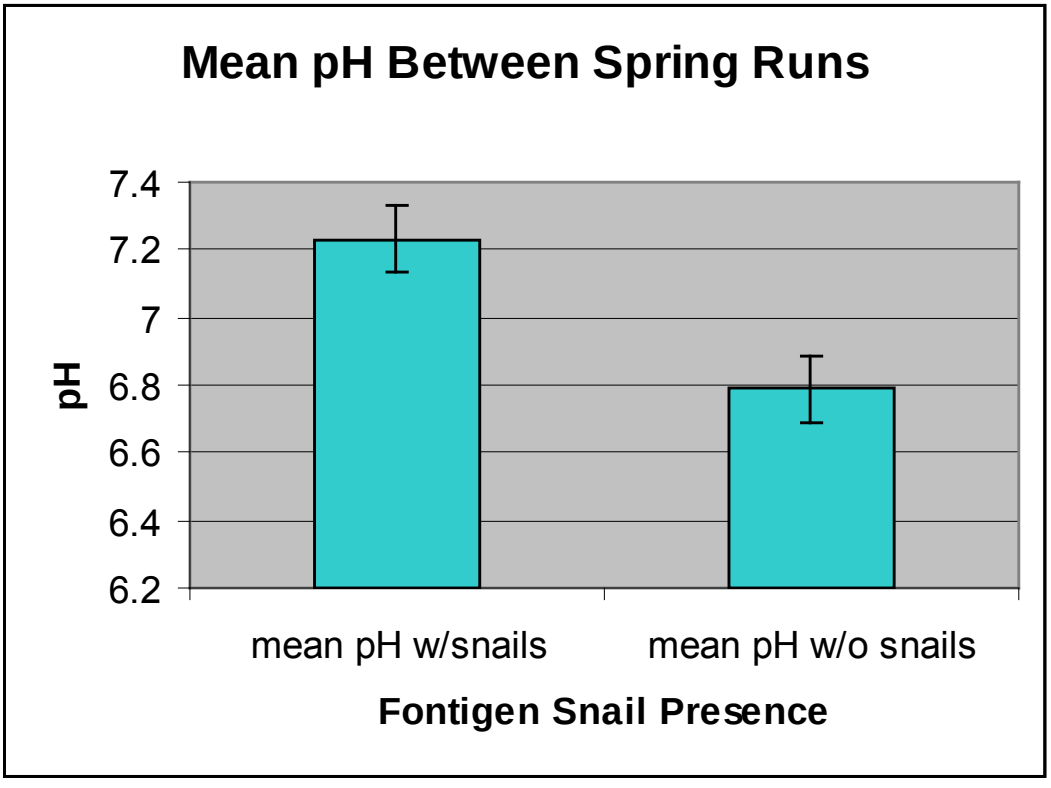


Figure 2. Levels of pH in spring runs with snails and without snails.

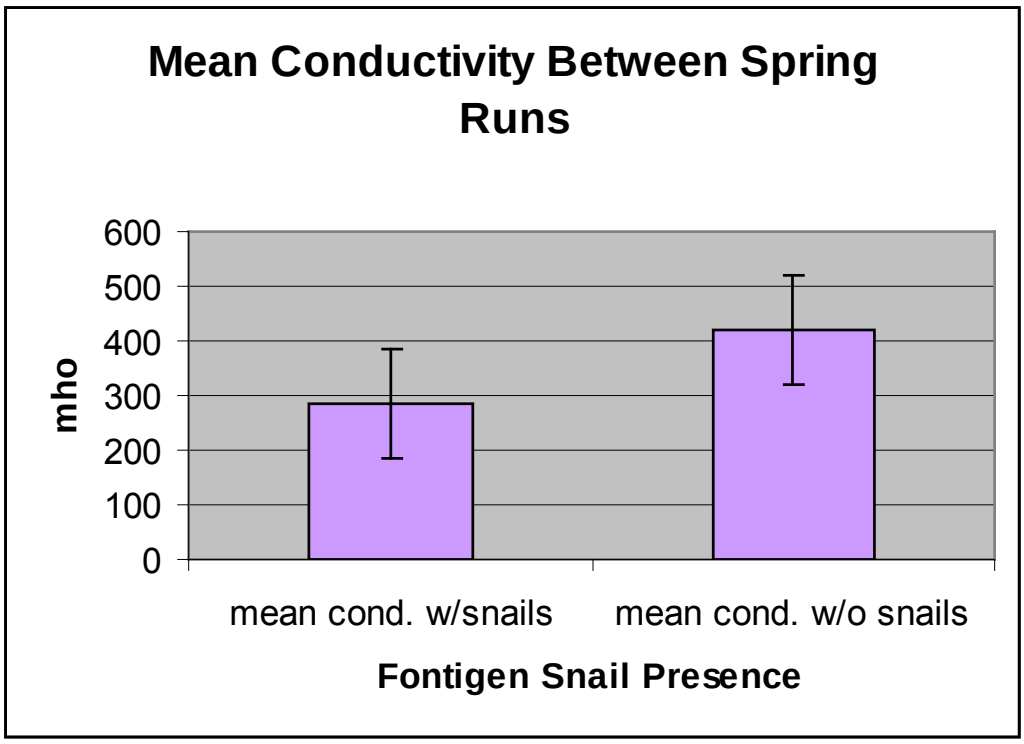


Figure 3. Levels of conductivity in spring runs with and without snails.

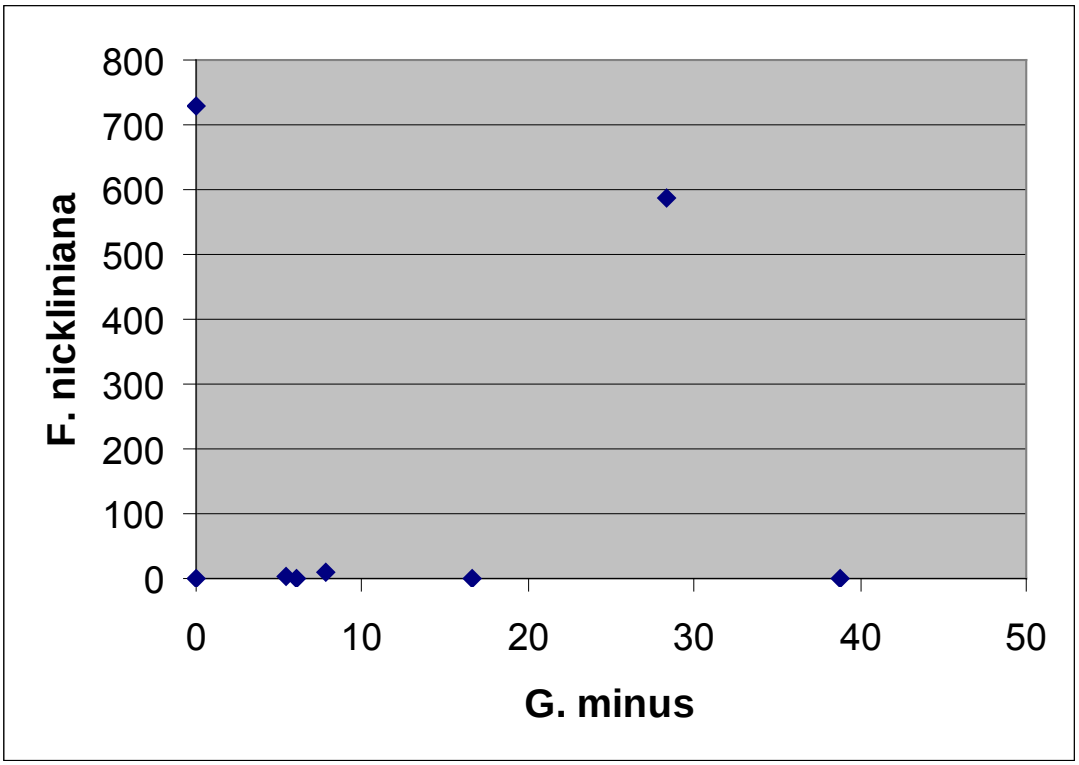


Figure 4. Scatter diagram of G. minus and F. nickliniana comparison.

DISCUSSION

I thought there might be a negative correlation between *G. minus* and *F. nickliniana* because they are both detritovores and, therefore, the competitive exclusion principle (Gouse 1961), states that *G. minus* and *F. nickliniana* would be in competition for food. My results showed that they are coexisting in the same environment. There may be several ways for *G. minus* and *F. nickliniana* to do this. The two species may feed on different types of foods. They may also prefer a different microhabitat in which to feed or they may feed at different times. The other possibility is that the competitive exclusion principle does not apply.

An alternative explanation for my results is that there may have been more *G. minus* present and I didn't detect them. If *G. minus* was present and I didn't detect them, they are most likely in very few numbers. Another reason that *G. minus* may not have been discovered is that there were only five samples taken at each spring run. It may be because the places where the samples were taken in the spring were not good places for *G. minus*. *G. minus* may prefer slower moving water and shelter such as watercress and perhaps the samples were not representative of preferred *G. minus* habitats. The timing of the sampling may have also effected the results. *G. minus* tend to be more active during the night and a daytime sampling regime may have biased the results.

There is definitely a basis for further studies on these organisms and their relation to each other and their resource partitioning. It does seem, however, that *F. nickliniana* prefers spring runs with lower dissolved oxygen levels and *G. minus* prefers spring runs with higher dissolved oxygen levels (Figure 1). Higher dissolved oxygen levels are associated with faster flowing water and this may favor a mobile *G. minus* rather than *F. nickliniana*, which attaches itself to substrate. This was also supported in places like Camp Kanasataki and Greystone Farm where there was an extreme abundance of *F. nickliniana* and also watercress for them to hide in and attach.

ACKNOWLEDGMENTS

I would like to thank Chuck Yohn and Dr. Douglas Glazier for their help with equipment and guidance during the project.

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2001

THE EFFECT OF SUBSURFACE GEOLOGY ON THE WATER QUALITY OF SPRINGS AT THE RAYSTOWN FIELD STATION

Holly Wolbert

ABSTRACT

Juniata College's Raystown Field Station resides on Raystown Lake in south central Pennsylvania and is underlain by two geological formations, the Scherr and the Foreknobs. The different compositions of these formations may affect spring water quality, which in turn may alter the water quality of Lake Raystown. I tested the hypothesis that there is a difference in the water quality between the springs of the Scherr and the Foreknobs formations. To accomplish this I analyzed three springs from each formation for temperature ($P \leq 0.05$), pH ($P=0.693$), conductivity ($P=0.616$), alkalinity ($P=0.783$), and turbidity ($p \leq 0.05$) and found no significant difference between the formations. I then tested the hypothesis that there is a difference between spring water quality and lake water quality. I found significant differences in temperature ($P=0.002$), pH ($P=0.000$), conductivity $P=0.000$), and turbidity ($P=0.018$), but not in alkalinity ($P=0.352$). This data is useful in characterizing the water quality at Juniata's Field Station, and allowing for characterization of stream water quality feeding into Raystown Lake. Such information can be useful in determining the health of Raystown Lake.

Keywords: alkalinity, conductivity, pH, sandstone, shale. Raystown, springs

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INTRODUCTION

Raystown Field Station is underlain by the Scherr geologic formation, to the southeast is the Foreknobs formation, and lastly, beneath the Lake, is the Catskill formation (Fig 1). These formations were deposited during the upper Devonian. The Scherr formation is the oldest of the three and is composed of gray siltstone, shale, mudstone, and some sandstone, and can reach a thickness of 1,900 ft. The siltstone and sandstone are primarily olive gray to greenish gray, and the mudstone and shale are predominantly medium gray. The Foreknobs formation is about 1,500 to 1,600 ft thick and consists of conglomerate, sandstone, siltstone, mudstone, and shale. The Catskill is the oldest strata under examination. Three fourths of this formation is composed of shale and mudstone, with sandstone making up the remainder. Eighty to 95 percent of this formation is red in color. (Taylor et. al. 1982)

These differences in geologic composition may result in variations in the water quality between formations. (Mutti Pers. Comm.)Sandstone has a higher porosity than shale because of its larger grain size allowing for faster infiltration. However, it is highly possible for an equal infiltration rate to occur in the shale if water has previously carved a conduit through the rock increasing the infiltration capacity. The weatherable minerals in the subsurface geology and soil composition of carbonates have a tendency to neutralize acidity and produce alkaline waters. However, little to no carbonates have been identified in these three formations. (Taylor et. al.1982)

Geologic composition has the ability to influence temperature, pH, and alkalinity. The duration of water storage within the strata can determine the temperature of the ground water. If water is contained within the strata it will become the temperature of the strata, approximately 10°C, which is maintained year round. Contrary to this, surface water assumes the temperature of the environment and varies throughout the year. (Washburn Pers. Com.) The buffering capacity of geologic strata can influence water quality by increasing the pH. pH is defined as the concentration of H+ ions in water and is determined by –log[H+]. (Harris 1999) It is measured on a scale of 0 (very acidic) to 14 (very basic) with 7 as neutral: pure water at 25°C (Zagorski 1997). The acceptable level of pH in natural waters is between 6.5 and 9.0 (Horne et. al. 1994), although this varies among publications. Alkalinity is similar to pH, as it is measured in the same units, however is the capacity of natural water to react with H+ to reach pH 4.5. This is the second equivalent point in the titration of carbonate (CO_3^{-2}) with H+ and assists in determining the buffering capacity of the geologic strata.

Conductivity and turbidity are influenced by the productivity of the aquatic system. Conductivity is a measure of the total ions present in a body of water, which allow water to conduct an electrical current. (TPS internet) Conductible ions are more prevalent in stagnant bodies of water as compared to springs as it is dependent on the productivity of the water source. Turbidity is a measure of the dissolved substances suspended in the water, which determine the ability of light to penetrate further indicating the productivity of the aquatic system (Henley et. al. 2000).

As all of these factors are dependent on retention time in the strata, it has been suggested that stream analyses be conducted at base flow to ensure that the results are impacted by subsurface geology rather than surface runoff. (Thomas et. al. 1999)

I compared the Scherr and Foreknobs formations located at Raystown Field Station to determine if there was a difference in the chemical water quality (temp, pH, conductivity, alkalinity, and turbidity) emitted. I also compared this data to Raystown Lake, underlain by the Catskill formation to determine if there is a difference between lake water quality and spring water quality.

FIELD SITE

I conducted my study in Huntingdon County, Pennsylvania on the shores of Lake Raystown. The Scherr is located under the Field Station, the Foreknobs is found to the southeast on Army Corps of Engineers property leading to Nancy's Camp, and the majority of Raystown Lake is underlain by the Catskill formation (Fig 1). The Berks-Weikert soil association overlies these formations (Hockman-Wert 2001). This area currently has deciduous

to mixed forests (Hockman-Wert 2001) with a significant riparian zone and was previously utilized for agricultural purposes until 1972 when Raystown Dam was constructed (Grove Pers. Comm.). I analyzed 3 streams in each geologic formation as well as lake water at the inlet of Juniata Bay (J-Bay). I conducted this study from mid February to mid March 2001.

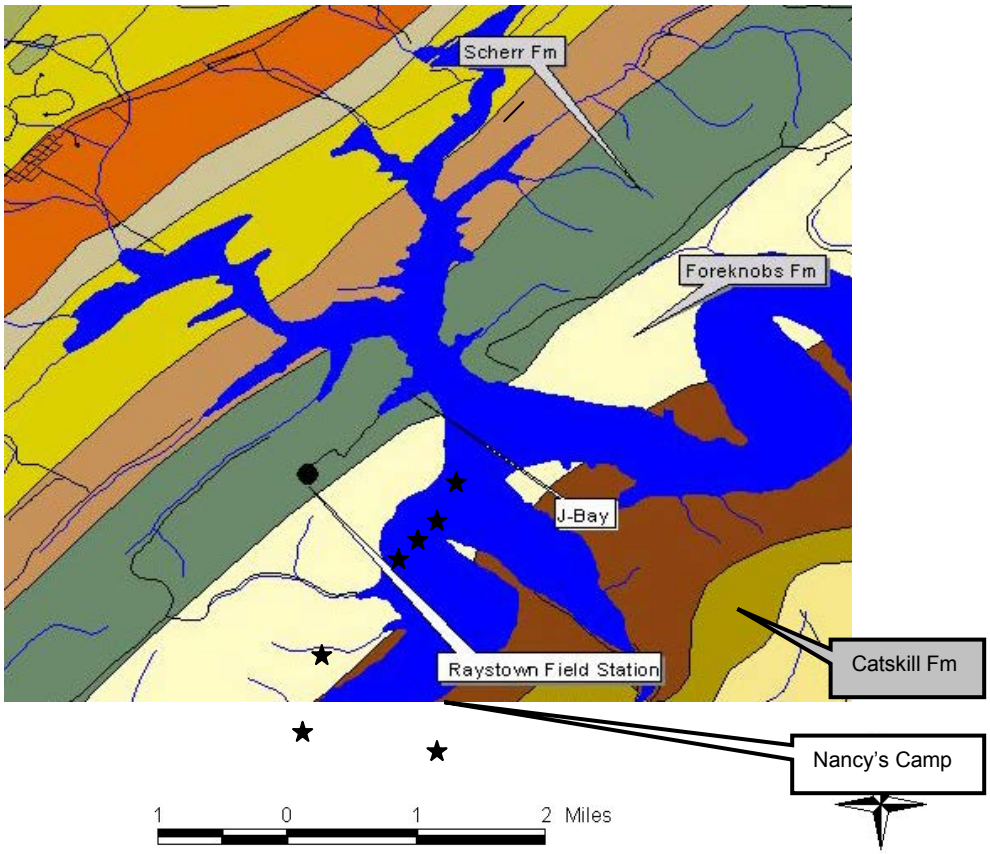


Figure 1. Study sites on Raystown Lake in Central Pennsylvania - 3 sites were located in each of the Scherr and the Foreknobs formations, with an addition site at J-Bay.

METHODS

Using a geologic map I located 3 suitable streams in each of the Scherr and Foreknobs formations that would not run dry in the event of decreased rainfall. I visited these 6 springs on 5 different days. I conducted tests for temperature, pH, conductivity, alkalinity, and turbidity. I collected 3 sets of data from each stream for each day in the field, and repeated the chemical sampling with 10 replicates for each test in J-Bay on an additional day. I operated a pH meter to measure temperature and pH, a conductivity meter for conductivity, and a Hack Kit for alkalinity and turbidity.

I used a paired design to compare the 2 formations using the sample days as my pairing variable. Each day I calculated the differences between the spring averages for temperature, pH, conductivity, alkalinity, and turbidity. I analyzed the data for normality with an Anderson-Darling test, and for heterogeneity of variances using a Levene test. I utilized a non-parametric test, 1-sample Wilcoxon, for temperature and a 1-sample t-test for pH, conductivity, and alkalinity. I analyzed turbidity with a Welches t-test. To compare Raystown Lake to the different geologic formations I used a Kruskal-Wallis Test for all analyses. I maintained an alpha level of .05 and considered results below this to be significant.

RESULTS

A total of 100 tests were run for each parameter (springs and lake combined).

Table 1: Averages and Standard Deviations of temperature, pH, alkalinity, turbidity, and conductivity for all locations.

	Temp	pH	Alkalinity	Turbidity	Conductivity
Lake	4.0 ± 0.04	6.9 ± 0.13	3.8 ± .044	3.0 ± 2.36	238.3 ± 4.42
Scherr	5.9 ± 1.49	5.4 ± 0.64	6.0 ± 3.61	12.7 ± 13.30	60.9 ± 14.59
Foreknobs	5.9 ± 1.80	5.2 ± 0.23	5.1 ± 3.02	24.7 ± 51.90	54.9 ± 12.93

I compared the Scherr and Foreknobs formations and found no significant difference in temperature (df=1, $P \leq 0.05$), pH (T=0.41, df=1, $P=0.693$), conductivity (T= -0.52, df=1, $P= 0.616$), alkalinity (T= -0.28, df=1, $P=0.783$), or turbidity (df=1, $p \leq 0.05$). However, when I compared these to J-Bay, a highly significant difference was present for temperature (H=12.30, df=2, $P=0.002$), pH (H=22.01, df=2, $P=0.000$), conductivity (H=21.99, df=2, $P=0.000$), and turbidity (H=8.03, df=2, $P=0.018$). There was no significant difference in the alkalinity levels (H=2.09, df=2, $P=0.352$).

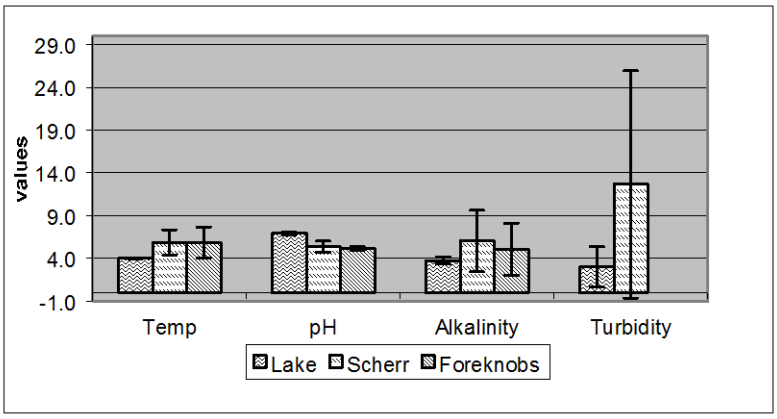


Figure 2 : Average temperature, pH, alkalinity, and turbidity at all three locations. Values for Foreknobs turbidity are: 24.7 ± 51.90.

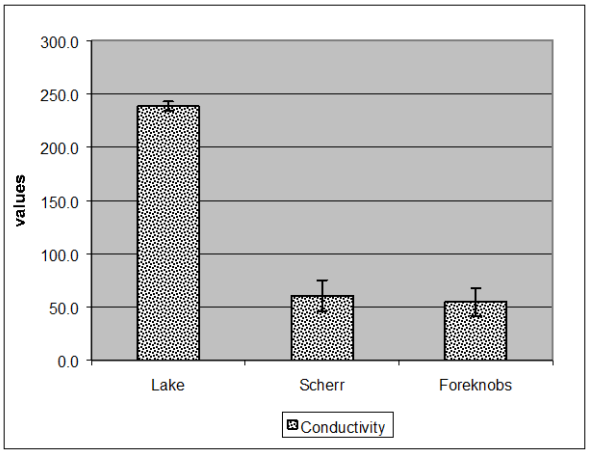


Figure 3: Averages and standard deviations of conductivity at all three locations.

DISCUSSION

The temperatures were most likely higher in the springs than in Raystown Lake due to the impact of winter freeze on lake temperature. In February/March, when I conducted my research, the lake water was still recovering from the winter freeze. Additionally, if the geologic strata had impacted the spring water it would have been maintained at approximately 10°C (Washburn Pers. Comm.), therefore the spring water was predominantly the result of runoff, as it was significantly colder and not impacted by the subsurface geology for any length of time. Repeat testing in the summer would most likely reverse this result as the lake water would be warmer and the subsurface geology would impact the spring water during this low-flow season.

The pH of J-Bay was near neutral and higher than that of the streams. A possible explanation is the greater CO_2 in the lake water due to greater photosynthetic effects. Both of the averages are within the acceptable levels of 6.5 and 9.0 (Horne et. al. 1994).

Conductivity of J-Bay was significantly greater than the springs possibly explained by the increased productivity in Raystown Lake. The descriptions of lakes provided by Horne (1994) indicate that this area of Raystown Lake is mesotrophic. (Degagne Pers. Comm) The ion content at this trophic level is greater than a spring as little productivity is present in the springs based on its size limitation to aquatic life, whereas lakes contain abundant high-order life. These larger specimens increase the impact of defecation and decomposition increasing conductivity. (Horne 1994)

Turbidity was significantly lower in the lake, as it has the ability to allow sediments to settle to the hypolimnion leaving a greater visibility in the epilimnion. Light penetration is typically 2m to 8m in a mesotrophic lake. (Horne 1994) Turbidity testing in the lake was only done within the first meter attributable to low turbidity numbers; additional depths may increase the turbidity. Springs however do not allow for sediment to settle to the spring bottom, but rather the current carries sediment downstream. This results in increased turbidity in spring waters.

Alkalinity was not significantly different between the streams and the lake. In both of these the phenolphthalein alkalinity (carbonate alkalinity) was equal to zero, resulting in the Total Alkalinity equaling the bicarbonate alkalinity. Similar geologic formations are located beneath Raystown and the springs beds with minor amounts of limestone and other carbonates present in each, therefore, geologic composition would have little to no affect on the alkalinity levels. Alkalinity serves to protect the aquatic environment form rapid changes in pH. For optimal protection of aquatic life the buffering capacity should be at least 20 mg/l. (Horne1994) The low alkalinity numbers show that streams are poorly buffered and could be susceptible to fluctuations in pH.

Although my results indicate no difference between the Scherr and Foreknobs formations, a clearer picture is available of what may be going on with Raystown Lake. The streams feeding the lake are relatively similar to the quality of the lake leaving little effect on the water quality. The determination of low alkalinity levels should be studied further to confirm this finding. Further study may also include testing for nitrates, phosphorus, iron and magnesium as well as repeating the experiment during low flow in the summer.

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USE OF ARTIFICIAL STRUCTURE BY CENTRARCHIDAE IN RAYSTOWN LAKE

Andrew Watson, Don Detwiler, and Megan Smith

ABSTRACT

We studied fish usage of artificial structures in Raystown Lake, a reservoir in central Pennsylvania. Because the lake lacks natural structure, a number of organizations concerned about the sport fishery of the lake have placed several types of artificial structures in the lake including black bass spawning structures (BBSS) and porcupine cribs (Cribs). We examined 3 factors which might influence the effectiveness of these structures for fish usage. We tested the hypotheses that there is no: difference in fish usage (1) between BBSS and cribs, (2) of BBSS between a.m. and p.m., and (3) that there is no correlation between fish usage at BBSS and distance from other BBSS. We filmed each structure on two occasions, for ten-minute periods, with an underwater video camera. We sampled 20 1-second interval images for each structure and recorded all fish seen in each image. Neither the abundance of total fish or species richness at BBSS (w = ?, df = 4, p = 0.26, 0.20 respectively) was significantly different from those at cribs. Abundances of Bluegills (*Lepomis macrochirus*), Rock Bass (*Ambloplites rupestris*), Smallmouth Bass (*Micropterus dolomieu)*, and Green Sunfish (*Lepomis cyanellus*) at BBSS were also not significantly different from those at Cribs (p > 0.26). Similarly, we found no significant differences between the morning and afternoon usage of BBSS: total fish abundance (0.90-3.40)(0.60-4.30) fish/structure, richness (0.75-1.60)(0.50-1.90) fish/structure. Differences in individual species abundances were also not significant. Distance to other BBSS did not correlate with total fish abundance or richness: correlation (p=0.459, R^2=0.0%; p=0.468, R^2=0.212, respectively). We conclude from these results that fish do not show a preference for any of the variables we investigated.

Keywords: black bass spawning structure (BBSS), porcupine crib (crib), underwater video camera, bluegill, rock bass, smallmouth bass, green sunfish, fish abundance, species richness, artificial structure, Raystown Lake

INTRODUCTION

Many species of fish that occupy the littoral environment require structure. This structure can be anything that rises vertically from the bottom and provides places to hide from predators. Fish utilize structure for spawning, protection from predators, and secondarily for food. Natural structure can be in the form of flooded trees, boulders, rocky outcroppings, or aquatic vegetation. In many natural lakes there is an abundance of the later two types of structure. Many reservoirs, however, are constructed in a way that provides little structure. Because of this, many artificial structures have been placed in reservoirs to improve their fisheries. These are variously known as artificial habitat, artificial cover, reefs, and habitat improvements. Artificial structures have been created for a wide range of species including Black Bass (*Micropterus* sp.), Crappies (*Pomoxis* sp.), Walleye (*Stizostedion vitreum*), and Lake Trout (*Salvelinus namaycush*) (Bassett 1994, Fitzsimons 1996). While used widely there has been a lack of evaluation on the effectiveness of artificial structures. There is little published work on fish structures in freshwater and none have directly compared effectiveness between reservoirs. Most of the studies on artificial structure have shown that it attracts fish and increases spawning success. It has been much harder to establish whether or not the non-spawning structures actually increase the biomass of fish in a body of water, or simply concentrate fish that would be there anyway (Bortone 1998). A few studies have been conducted to evaluate differences in fish usage between structure types. One study found that Pumpkinseed (*Lepomis gibbosis*), a centrachid similar to Bluegill (*Lepomis macrochirus*), were found in roughly equal numbers at three types of artificial structure (tire reefs, cinder block piles, and brush piles) (Moring and Nicholson, 1994).

We studied two different types of artificial structure: Black Bass Spawning Structures (BBSS), and Porcupine Cribs (Cribs). Both have been utilized by the Pennsylvania Fish and Boat Commission (PFBC) in many lakes in the commonwealth (Mallon 1997). The BBSS consists of a 1.2m x 1.2m x .5m (high) box containing several cinder blocks, and a 3m x 1.2m roof, which overhangs on both sides (figure 1). They are designed to provide spawning areas for the Largemouth Bass (*Micropterus salmoides*) and Smallmouth Bass (*M. dolomieu*), which are collectively called Black Bass. Cribs are constructed of 1.2m x 5cm x 5cm lumber assembled in the shape

of a pyramid with the ends of the upper boards sticking out (figure 2). They are designed for panfish species, specifically smaller Centrarchidae, and Yellow Perch (*Perca flavescens*), as well as Black Bass (Mallon 1997).

The goals of this study were to examine factors that affect fish usage of artificial structure. We tested the following hypotheses 1) There is no difference in fish usage between Cribs and BBSS, 2) there is no difference in fish usage of BBSS between morning and afternoon, and 3) there is no correlation between fish usage of BBSS and distance to the nearest BBSS.

FIELD SITE

Raystown Lake is an 8,300 acre 48 km long, reservoir in Huntingdon County, Pennsylvania. It was created in 1972 by the Army Corp. of Engineers for recreation and flood control, and consists of the inundated valley of the Raystown Branch of the Juniata River. The upper 12 km of the lake has characteristics of an eutrophic lake with secchi disk readings of 1-2m, the middle 15km are mesotrophic in nature (secchi 2-3.5m), and the 21km closest to the dam are oligotrophic and contain sufficient oxygen concentrations for fish life all the way to the bottom (unpblsh. data). When the lake was created, trees which would be in the first 8m of water were removed, leaving a few stumps but a general lack of structure. A few beds of aquatic vegetation have developed, but most areas of the lake are too rocky to support widespread plant growth (pers. obsv.). Artificial structures have been placed throughout the lake, however most of the structures studied were in the lower half of the lake due to better water clarity.

METHODS AND MATERIALS

The structures (14 BBSS and 9 Cribs) we selected were located away from natural structure, in good physical condition, and fully submerged. We collected the data during the fall (non-spawning) period.

We chose to investigate three factors: type of structure, time of day, and distance to nearest structure. To compare BBSS to Cribs we selected 5 BBSS and 5 Cribs most of which were close to other structures. To investigate time of day we selected 5 BBSS to film both morning and afternoon. For comparing distance to fish usage we selected 14 BBSS which varied in distance to other BBSS from 1.25m to greater than 30m. For these structures the nearest BBSS was the closest structure of similar size. As much as possible we selected structures with similar characteristics other than the test factor.

We filmed each structure on two occasions for 10 minutes each visit. For the time of day comparison we filmed each structure twice in the morning (9:00 am-12:00 am) and twice in the afternoon (1:00 pm-loss of light).The structures for the comparisons of Cribs to BBSS and distance were filmed in the afternoon.

We sampled each structure from either a John boat or Boston Whaler held in place with at least three anchors. We used a JW Fishers DV-1 underwater video camera mounted on a 4 meter pole. For both structure types we used a camera angle which revealed about half of the structure. For BBSS we set the camera on the substrate about two feet from the structure. It was angled slightly up from the substrate and at a 45^{o} angle relative to the structure. We used a forty-five degree camera angle approximately two feet away from the deeper side of BBSS with the camera resting on the bottom angled up in order to see under the overhang of the structure. Filming the Cribs required us to suspend the camera at the middle of the structure no less than three feet away.

We sampled 20 1-second interval images for each structure and recorded all fish seen in any portion of the images. We pooled the data from the 20 images for each structure, to get one mean abundance value for each structure. We repeated this pooling process for Bluegill, Rock Bass, Green Sunfish, and Smallmouth Bass. We also calculated species richness for each 1-second image, and repeated the pooling process. In addition we observed all of the recorded video to identify additional species that were not included in the 1-second intervals.

To compare fish abundance between Cribs and BBSS, we performed a Mann-Whitney U test on total fish, species richness, Bluegill, Rock Bass, and Smallmouth Bass. We used a Welches T test for Green Sunfish because the variances were unequal between structure types. All of these tests used an alpha level of .05.

To analyze the data for time of day, we used a Wilcoxon Signed Rank test on the abundance values for total fish, each species, and the species richness.

We graphed the total fish abundance vs. distance, and richness vs. distance. We also used Pearson Product motion sum linear regression test on both of these comparisons.

RESULTS

The species we saw most frequently at the artificial structures were Bluegill, Rock Bass (*Ambloplites rupestris*), Green Sunfish (*Lepomis cyanellus*), and Smallmouth Bass. We also observed Redbreast Sunfish (*Lepomis auritus*), Common Carp (*Cyprinus carpio*), Gizzard Shad (*Dorosoma cepedianum*), Tiger Muskellunge

(*Esox lucius* X *Esox masquinongy*), and Largemouth Bass. In addition we observed two types of hybrid sunfish utilizing the structures: Bluegill X Green Sunfish and Redbreast Sunfish X Green Sunfish.

Our means for richness and abundance of total fish, Bluegill, Green Sunfish, and Smallmouth, were higher for BBSS than Cribs (see Table 1). Abundance of Rock Bass was higher at Cribs than BBSS. Neither the abundance of total fish or species richness at BBSS (w = ?, df = 4, p = 0.26, 0.17 respectively) was significantly different from those at cribs. Abundance of Bluegills, Rock Bass Smallmouth Bass, and Green Sunfish at BBSS were also not significantly different from those at Cribs ($p > 0.26$). None of these comparisons revealed even slight significance.

Our means for the morning were consistently lower than the afternoon means for richness and abundance of all fish, Rock Bass, Green Sunfish, and Smallmouth (see Table 2). Abundance of Bluegill was higher in the morning. Morning vs. afternoon tests showed no significant difference, producing confidence intervals of: total fish abundance (0.90-3.40)(0.60-4.30) fish/structure and richness (0.75-1.60)(0.50-1.90). Similarly, individual species differences between the morning and afternoon were not significant.

Abundance of total fish did not correlate with distance to other BBSS: regression (p=0.459 R2=0.0%), correlation (p=0.459, r=0.216). Likewise, neither regression (p=0.468, R2=0.0%), nor correlation (p=0.468,r=0.212) tests for richness vs. distance revealed significance (see Figure 1 and 2).

DISCUSSION

This study is the first published using an underwater video camera to evaluate fish usage at artificial structures in fresh water. It is also the first published study to determine fish usage of Cribs and BBSS. Other studies generally used divers (Moring and Nicholson 1994) or electroshocking (Bassett 1994), and are not directly comparable to our study.

Most of the 9 species of fish we observed are known to associate with structure. Some other fish we saw just swam through the area and may not be utilizing the structures.

A The Pennsylvania Fish And Boat Commission (PFBC) completed an extensive Fisheries Survey of Raystown Lake in 1994 (Jackson et al, 1994). This survey provides a valuable source of information on how

abundant many fish species are throughout the lake. By comparing our results to this survey we can see which fish are found mainly at the structures and which are also found throughout the lake.

Bluegill will use woody, vegetative and rocky structure (Steiner 2000). We saw more bluegill than any other fish in our study. Bluegill were also the most abundant Centrarchid sampled in Raystown Lake by the Pennsylvania Fish and Boat Commission (PFBC) in 1994 (Jackson et al 1994). Since the PFBC found Bluegill in abundance throughout the lake it does not appear that they are dependant on artificial structures in the lake.

Smallmouth Bass and Largemouth Bass are often found in similar habitats, both utilizing rocky and woody structure. Largemouth are found more often around vegetative structure and soft-bottomed areas, while smallmouth prefer a rocky substrate (Steiner 2000). Largemouth were more common than Smallmouth in the 1994 survey; however, since most of our structures were on rocky substrates it can be expected that a greater proportion of smallmouth will be using them. While locating the structures, we observed many largemouth around the structures. Most of these were larger fish at least 20 cm, and may have been scared by the boat during filming. It is possible that the smaller Largemouth Bass are using vegetative cover or the more eutrophic portions of the lake.

Rock Bass are generally found around rocky structure, but will also utilize woody structure (Steiner 2000). Only 17 rock bass were found in the 1994 survey (Jackson et al, 1994), while we found that the ration of Bluegills to Rock bass at many of the structures was between 2:1 and 1:1. This indicates that Rock Bass are far more numerous near artificial structure than throughout the lake. In addition we observed Rock Bass rarely moving from the structures while we filmed. From these observations we can conclude that Rock bass are very dependant on artificial structures in Raystown Lake.

Tiger muskellunge are known to associate with vegetative and rocky structure. 62 Tiger muskellunge were found by the 1994 survey, making up a significant portion of the fishery (Jackson et al, 1994). The single Tiger Muskellunge we saw swam right through the view and did not seem to linger by the structure, indicating that it may have been just passing through the area. Tiger Muskellunge feed on many of the Species we observed using the structures. Tigers may benefit from the increased food supply near the structures.

Redbreast Sunfish will use vegetative, woody and rocky structure, and prefer flowing water (Steiner 2000). Green Sunfish often utilize vegetative structure and are more common in standing water (Page and Burr 1991). Neither species was collected by the PFBC in the 1994 survey, indicating they have a low population throughout the lake. Green sunfish were found in fairly high numbers at many structures. It appears that Green and Redbreast

Sunfish are much more common around artificial structures than through most of the lake. It is likely that both Redbreast and Green depend on artificial structure more than other habitats in the lake.

We found several hybrids between Redbreast and Green Sunfish. Since Redbreast were seen so infrequently, they may spawn with Green Sunfish if they can not find a mate of the same species. These species spawn in the similar locations (Page and Burr 1991) and the hybrid offspring may be from an accidental drifting of sperm.

Carp and Gizzard Shad usually associate with a muddy bottom (Steiner 2000). Both species were found in high number by the 1994 survey. The Gizzard shad were probably around the structures by chance just because they are so common in the lake. One of the carp we saw was clearly hiding under the structure and not simply swimming through the area. Carp may be using the structures to some degree but do not seem dependent on them.

We found more fish at BBSS than PC, however the numbers were not significantly different. If fish do prefer BBSS, it may be because they provide overhang space and cover a larger total area. Fish may not show a strong preference for one type of structure because they are fairly similar in size, building materials, and amount of cavity space. The lack of clear preference has significant implications for future structure construction. It implies that an easier to build structure of similar design may be just as effective as Cribs and BBSS. One problem with an easier to build structure is how long it will last. Cribs and BBSS can last more than 10 years (Mallon 1997). Other structures must be able to last this long in order to be as effective as Cribs and BBSS.

We saw more fish at structures during the afternoon than in the morning. This difference was reflected in all species with the most pronounced being bluegill. None of the differences were statistically significant. If fish do have a preference for the afternoon, it may be because the water temperature is higher in the afternoon allowing the fish to be more active. If, in reality there is no difference it may be because these periods were relatively similar in terms of light penetration. Most of these fish feed on organisms which are closely associated with the substrate and do not migrate daily. These periods may not have been separated by enough time to make a difference in fish usage. This means that fisherman should expect only slightly more fish to be associating with the structure in the afternoon.

Our results did not show a correlation between fish usage and distance to nearest structure. This indicates that structures can be placed close together and each new structure will attract numerically similar fish populations. A study in National Forest lakes concluded that as structure complexity increased there was a correspondingly smaller increase in fish diversity/usage (Bassett 1994). Our results contradict this. In Raystown Lake structure is

likely the factor limiting the fish populations we studied. A logical conclusion is that as more structure is placed in an area, equal fish populations will colonize each structure as long as other factors which might limit the population are provided. As more structure is added eventually another factor such as food will become limiting and adding more structure will not significantly increase the total population. In the study of national forest lakes the amount of structure may have surpassed this point.

Our sampling method yielded very large variances, this is the major reason none of our comparisons were significant. We would suggest visiting each structure more than two times and using more than 5 structures per factor. We would also suggest a different method of sampling the video possibly a larger time interval than 1 second.

Several of the structures showed fish populations which were much higher than others. These did not break down along any of the factors we tested. This indicates that there may be some factor, other than the three we investigated, which is affecting the fish distribution. Other factors which might influence fish abundance at the structures are predator abundance, food abundance, substrate type, depth, and proximity to natural structure.

We expected to see pumpkinseed sunfish and both species of crappies. Both Black (*Pomoxis negromaculatus*) and White Crappie (*Pomoxis annularis*) were found in greater numbers by the PFBC than Smallmouth Bass, and Pumpkinseed were collected in moderate numbers (Jackson et al 1994). All three of these species prefer soft bottomed areas and may not have been found at the structures because they were on hard rocky substrate. These species may be more common in the more eutrophic portions of the lake but did not seem to be utilizing the structures we studied.

We saw generally very few larger (>30cm) fish in the film. The most likely reason for this is that they were frightened by the boat. We also saw no fish less than about 6cm. Many of the larger rock and smallmouth bass could have easily eaten fish this small. On one occasion we observed a large school of 2cm fish from the surface but could not see them with the camera until they were less than 30 cm from it (unpblsh. data). If smaller fish are using the structures we may not be able to see them.

We made several observations which we did not test statistically. Those structures which were more exposed to weather and waves seemed to have fewer fish than those in more sheltered areas. This may be because there are fewer predators in these areas. It may also be because these areas have a greater build up of organic debris, which serves as a food source for macroinvertebrates which the fish eat. Structures near submergent vegetation

also seemed to hold more fish. This is likely because there is a greater food source of macroinvertebrates on the vegetation. Structures in less than 1m of water did not hold as many fish as those in deeper water. Many avian predators were observed during the study period, structure in shallow water offers these birds a place to perch to catch fish. Another thing we observed was that close to half of the BBSS had lost the overhanging boards on top of the structure, while almost al Cribs were still intact. This is likely because the wave action creates torque on the top and can lift it off. Placing BBSS in slightly deeper water where they are less affected by wave action may help this problem.

By comparing our results to those of the PFBC in 1994 we can hypothesis that Rock Bass, Green Sunfish and Redbreast sunfish are more common at artificial structures than the rest of the lake. These fish may be very dependant on the structures to survive in Raystown Lake.

From our results we can make several recommendations for future construction and placement of structures. 1) a less expensive structure may attract a similar number of fish. 2) fishermen can expect similar results in the morning and afternoon 3) placing two structures in one area will likely attract twice as many fish 4) placing structures at least 2m deep in sheltered areas, near vegetation is likely to attract the most fish, and increase structure life 5) BBSS are more prone to falling apart than Cribs.

We can suggest several areas of future research which will add to our knowledge of these structures. The first and least time consuming is to use a different method of subsampling our video. Filming in the spring will yield a more complete picture of what fish are utilizing the structure. Filming at night is likely to show an entirely different group of fishes using the structures. Experimenting with easier to build and cheaper structures may show that the money invested in these projects can be used more efficiently.

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Figure 1: Porcupine Crib (Crib)



Figure 2: Black Bass Spawning Structures (BBSS)

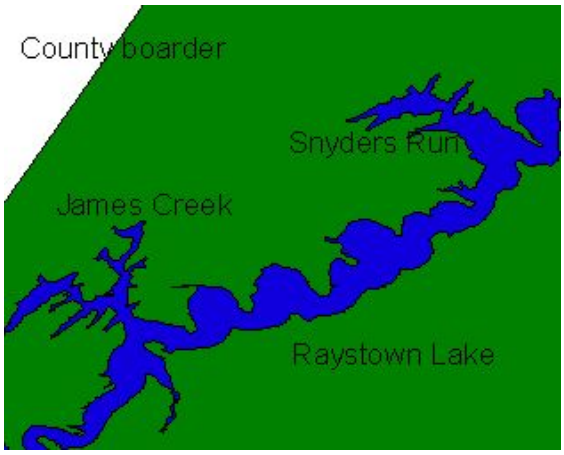


Figure 3: Map of Raystown Lake.

Table 1: PC vs BBSS. Means plus standard error of abundance, and richness, from each structure, calculated from 20-1 second intervals filmed at Raystown Lake, PA Fall 2001.

Response	Mean PC ±SE	Mean BBSS ±SE
Total	1.583 ±1.374	2.210 ±0.623*
Bluegill	0.692 ±0.597	0.800 ±0.542*
Rock Bass	0.658 ±0.610	0.500 ±0.440*
Smallmouth	0.0750 ±0.0524	0.160 ±0.134*
Green	0.133 ±0.207	0.740 ±0.827*
Richness	1.080 ±0.546	1.370 ±0.372*

* df=4, p>.172

Table 2: Means plus standard error of abundance, and richness from each structure, calculated from 20-1 second intervals filmed at Raystown Lake, PA Fall 2001.

Response	Mean AM ±SE	Mean PM ±SE
Total	1.650 ±1.58	1.850 ±1.00
Bluegill	0.990 ±1.025	0.920 ±0.789
Rock Bass	0.340 ±0.706	0.350 ±0.257
Smallmouth	0.090 ±0.125	0.260 ±0.290
Green	0.220 ±0.228	0.320 ±0.342
Richness	0.910 ±0.575	1.180 ±0.362

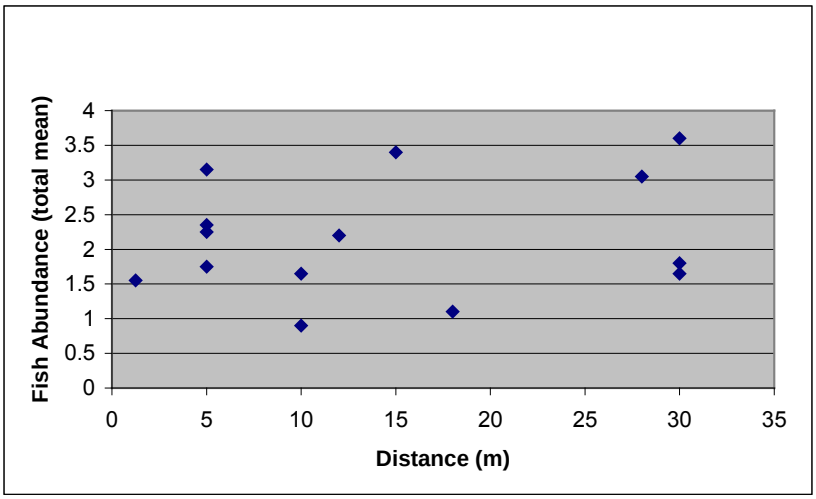


Figure 4: Mean fish abundance for each structure calculated from 20-1 second intervals. Correlation and regression tests were negative (p-values 0.459). Data collected at Raystown Lake, PA in Fall 2001.

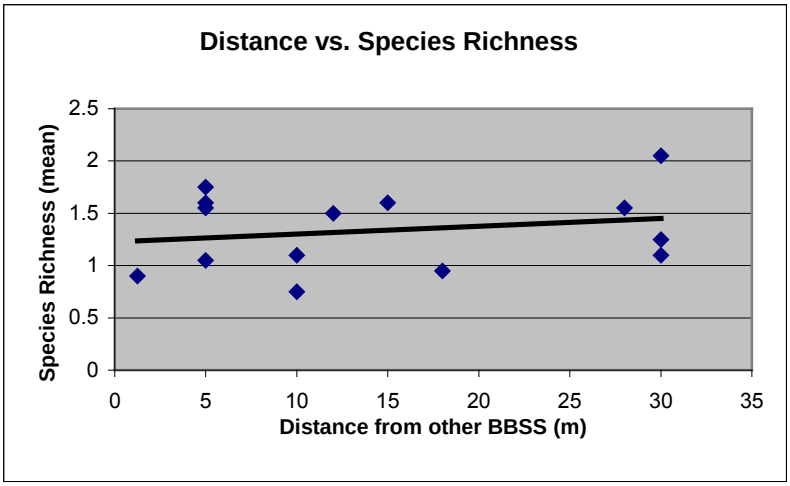


Figure 5: Mean total fish abundance for each structure calculated from 20-1 second intervals. Correlation and regression tests were negative (p-values 0.468). Data collected at Raystown Lake, PA in Fall 2001.

Table 3: Numbers of fish caught in PFBC survey of Raystown Lake spring 1994 (Jackson et al, 1994). Only fish species observed in this study are included.

Fish Species	Number
Bluegill	2506
Rock Bass	17
Green Sunfish	0
Redbreast Sunfish	0
Largemouth Bass	515
Smallmouth Bass	257
Tiger Muskellunge	62
Carp	550
Gizzard Shad	6,977

Effect of Slope Aspect on Field Utilization by White-Tailed Deer (*Odocoileus virginianus*)

Matthew Ulrich

ABSTRACT

Overabundance of white-tailed deer (*Odocoileus virginianus*) has made them a pest species that not only ruins crops but also causes several thousand car accidents a year. Knowledge of deer habitat utilization can assist management efforts. I studied habitat utilization of deer at the Raystown Field Station. I tested the hypothesis that fields with south facing slopes will be more often used then north facing slopes, as measured by using pellet-counts. I established 7 2-meter radius circular plots on each slope and searched the circles for pellets. North slope (0.1 piles per plot) was not significantly different from the south slope (0.07 piles per plot) ($w = 56.5$, $df = 6$, $p > .05$). These preliminary results suggest that deer have no slope aspect preference.

Key words: White-tailed Deer, habitat preference, slope, pellet count

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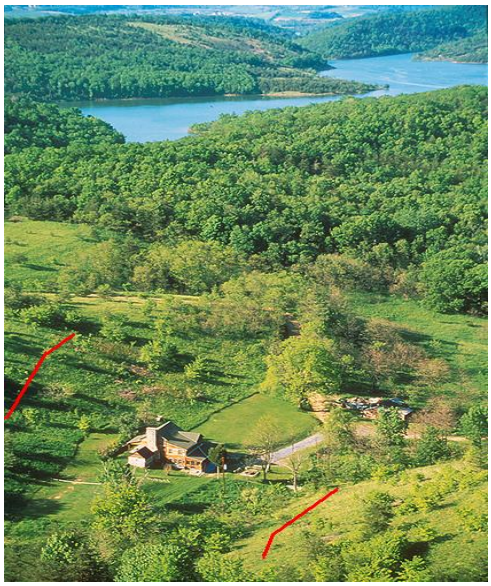
INTRODUCTION

Despite their size and abundance, determining population density and habitat utilization of white-tailed deer (*Odocoileus virginianus*) can be difficult. However, since around 1938, a pellet-count census has been developed (Bennett et al. 1940). This method usually involves establishing a series of plots, typically in a circle or long rectangle, and checking for pellets during certain time intervals and removing them or marking them (Bennett et al. 1940). Through an analysis of amount of pellets per day, pellet counts provide a general population size, and indicate where the deer are located during certain seasons. White-tailed deer spend a large majority of their time where they feed and thereby the larger proportion of their pellets will also be at those locales (Russell 2001). Thus, other influences of the environment, such as weather or even interactions with other local species, and their effects on white-tailed deer, can be studied with a pellet count (Bennett et al. 1940). During the autumn, white-tailed deer feed most in fields, just before the first frequent frosts occur. There is a significant difference between the amount of vegetation between a north-facing field slope and a south-facing slope (Russell 2001). Because of the higher abundance of sunlight and resulting higher growth rate and potential for more food, I hypothesized that deer would utilize south-facing slopes more often than the north-facing slopes, as measured using pellet-counts.

FIELD SITE

I conducted this study on the opposing north and south facing sloped fields on either side of the main house at the Juniata College Raystown Field Station during October and November 2001. The habitat is old field succession made up of the perennial herbaceous plant community type along a small valley (Fig 1). The south-facing slope is very large and extends up and over the top of the hill and length wise well past the house. The north-facing slope is smaller, about a quarter to half the size of the south-facing slope, and surrounded by dense forests. The selected deer trails were about half way up the slopes.

Figure 1. Location of study transects at the Raystown Field Station. Lines show approximately where deer runs are.



METHODS AND MATERIALS

I selected a deer trail that ran horizontally along the slope of both a north and south facing field. I then randomly selected 7 points along that trail and marked the center to establish a 2-meter radius plots. I cleared the plots for deer pellets and then revisited the plots and repeated the count and removal over a 10-day period. I tested the data for equal variances using Bartlett's homogeneity of variance test. I then compared north to south facing slopes using a Mann Whitney U test and considered differences to be significant if $p \leq .05$.

RESULTS

I found no significant difference in mean pellet numbers between north (0.1 piles per plot) and south (0.07 piles per plot) slopes ($w = 56.5$, $df = 6$, $p > 0.05$).

DISCUSSION

There may be several reasons why there was no difference between the north and south slope. Pauley et al. (1993) showed that deer more frequently use forests during the winter season and because my experiment was conducted in late autumn, it is possible the deer were already starting to utilize the forested

habitat. The north sloping field seemed to have a more worn trail then the south-facing slope (pers. obsv.). It is possible that deer may use the north slope for typical travel and only use the south slope for escape paths and minor grazing habits. At the field station there is a rather noticeable difference between the cover from the house on north versus south facing slopes. The south field is somewhat larger and has less cover while the north slope has large trees disrupting the line of sight from the field to the house and is a shorter length field. This difference in amount of cover may effect deer behavior, such as feeding or wintering habits. Thus, it is possible that the north slope was used more frequently, resulting in a balance between amount of time on the south slope as on the north slope. I still hypothesize that there is a possible difference in utilization between north and south facing slopes and further investigation using larger area plots or longer time periods may show this. It has been shown that during the winter months, in forested areas, there is a significant difference in aspect utilization (Pauley et al. 1993). Although my observation area was small enough to avoid large effects of error, some of the common errors associated with most pellet-count data may still apply (Van Etten 1965). Using pellet-counts to determine amount of utilization has not been used very much and the method accuracy is still in dispute.

AKNOWLEDGEMENTS

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IRON, MANGANESE, AND SULFATE CONCENTRATIONS IN TREATED AND UNTREATED WATER SAMPLES OF WELLS AT THE RAYSTOWN FIELDS STATION

Julia Saylor, Nic Patterson

ABSTRACT

High iron, manganese, and sulfate concentrations are characteristic of the Scherr Formation, which underlies the Raystown Field Station in Huntingdon, Pennsylvania. We hypothesized that the concentrations of iron, manganese, and sulfate would be lower in an ozone treated well than in untreated wells. We collected samples over a period of six weeks in fall 2001 from two wells at the Raystown Field Station using a Kemmerer sampler and from a faucet yielding treated water from a third well. Concentrations of iron (2.96 ± 0.68 mg/L) and manganese (0.44 ± 0.33 mg/L) were significantly greater in the untreated wells than in the treated wells (0.3 ± 0.37 mg/L; 0.100 ± 0.0707 mg/L, respectively), ($t=12.89$, $P=<0.001$, $df=9$; $t=5.04$, $P=<0.001$, $df=30$ respectively). However, concentrations of sulfate were significantly greater in the treated well (20.00 ± 2.45 mg/L) than in the untreated well (14.87 ± 5.01 mg/L) ($t=-3.57$, $P=0.004$, $df=11$). The water treatment system at the Raystown Field Station reduces iron and manganese concentrations in the water. Higher sulfate concentration found in the treated sample could be due to the oxidation of sulfide to sulfate by the ozonater in the treatment system or the absence of sulfate reducing bacteria after treatment.

Keywords: Iron, Sulfate, Manganese, aquifer, wells, water chemistry, groundwater, Raystown Field Station

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INTRODUCTION

Groundwater makes up approximately 0.6% of the earth's freshwater, which is relied upon by 250 million people in the U.S. alone (EPA 1999). A groundwater cycle includes recharge areas, aquifers, confining units, and discharge areas and groundwater quality is an important issue given the demand for the resource. Contamination of groundwater can come from natural sources including metals that dissolve from surrounding rocks or soils such as iron and manganese (Moody 1990). Although these two metals are not harmful, high concentrations can cause distasteful water and stains in laundry (Moody 1990).

The Scherr formation underlying the Raystown Field Station, which consists of shale and siltstone, is known to yield high concentrations of manganese and iron (Taylor et. al, 1989). Because of drought conditions in the fall of 2001 at the station, the water table was below normal levels (personal obs 2001). Higher concentrations of iron, manganese, and sulfate may occur during the recharge of the aquifer (Muhlherr et al, 1998).

The goal of our study was to test the effectiveness of the water treatment system at the station during drought conditions when metal concentrations are high. There were four wells at the station, one that provides drinking water. Without treatment, the levels of sulfur and iron cause the water to have a disagreeable odor and taste, as well as staining shower walls (personal comm.). There is little known about the levels of metals and dissolved solids in the groundwater here. We tested the hypothesis that the concentrations of iron, manganese, and sulfate will be the same before and after ozone treatment.

SITE DESCRIPTION

We conducted this study at the Raystown Field Station, Entriken, PA. The bedrock is made up of the Scherr Formation, which is made primarily of siltstone, shale, mudstone, and sandstone (Fig. 1). The depths of the wells in this formation range from 33 feet to 580 feet while shallow wells are abundant in this formation (Taylor et. al, 1982).

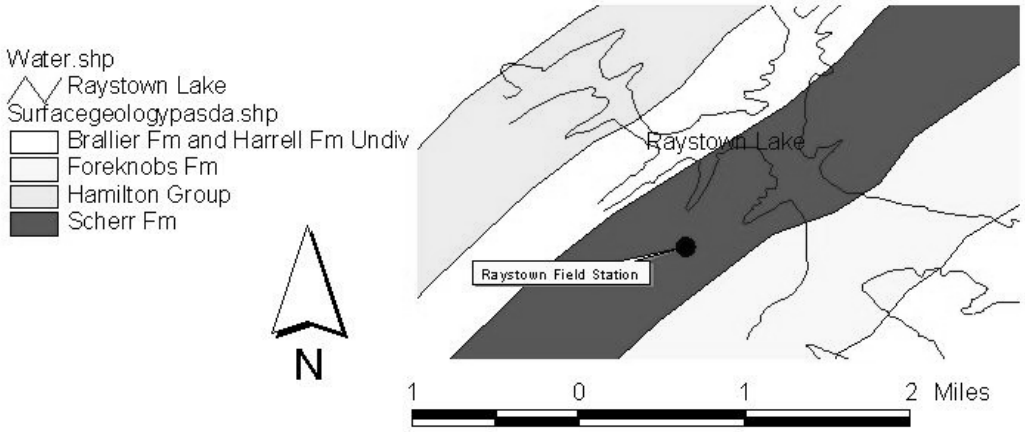


Figure 1: Surface geology underlying Raystown Field Station.

METHODS AND MATERIALS

We sampled two test wells and a drinking water source from the same shale aquifer. The wells were spaced approximately 30 yards in distance (Fig. 2).



Figure2: Location of the wells at the Raystown Field Station. The wells are represented by the dots. The center well supplies the treatment system.

We measured water depth in the well by lowering a weighted string down the well shaft until it hit the surface of the water. We then lowered a Kemmerer bottle 1 meter below the water level to collect five water samples from each well. We also took five samples from the tap inside the station house, as this was the easiest way to obtain the treated water. We collected 5 samples from each well on three separate dates. We recorded pH and temperature of the samples using a HACH pH meter and concentrations of iron with a 1,10 Phenanthroline method, manganese with a Periodate Oxidation method, and sulfate using the Sulfa Ver 4 method and a HACH DREL 2000 spectrophotometer (HACH, 1995).

We tested for normality using a Levene's test (MIITAB 1993) and for homogeneity of variances using an Anderson-Darling test (D'Augostino et. al. 1986). Before completing the two-sample t-test we ran one-way ANOVA's to compare sulfate, manganese and iron levels among sampling dates. We were able to pool our data for each untreated well because there was no difference among sampling dates. We used a two-sample t-test to compare the concentrations of iron, manganese, and sulfate between treated and untreated wells (MINITAB 1993). We used an alpha level of 0.05 and considered differences to be significant if $P \leq 0.05$.

RESULTS

We found no significance difference among sampling days for pH, iron, manganese and sulfate concentrations in the untreated well ($f \geq 0.43$, $P \geq 0.091$, $df = 2,12$). Also, there was no significance difference in pH between the untreated well (6.75 ± 0.15) and the treated well (6.67 ± 0.04). We found manganese levels in the untreated well (0.5 ± 0.3 mg/L) to be significantly higher than the treated well (0.1 ± 0.1 mg/L) ($t = 5.04$, $P \leq 0.001$, $df = 30$). We also found the untreated well water (15 ± 5 mg/L) to have significantly lower levels of sulfate than the treated well water (20 ± 2 mg/L) ($t = -3.57$, $P = 0.004$, $df = 11$). Iron in the untreated well water (2.96 ± 0.68 mg/L) was significantly higher than in the treated well water (0.30 ± 0.37 mg/L) ($t = 2.89$, $P \leq 0.001$, $df = 9$).

DISCUSSION

During our study period, Huntingdon County was under a drought warning based upon below normal water levels (DEP 2001). As the drought progressed, manganese, sulfate and iron concentrations in untreated water samples were not significantly affected. The water levels within the aquifer remained

constant during our study period. Rock strata did not hydrate or dehydrate, thus having no affect on the contaminant concentrations. Raystown Field Station is currently equipped with a water treatment system to lower the concentrations of iron, and manganese in the water. There are two possible theories to account for the higher sulfate concentrations. First, there could be more oxygen present in the well causing the oxidation of sulfate to sulfide. It is possible for that presence of sulfate reducing bacteria (SRB), an anaerobe, in the wells kept the sulfate concentrations low by reducing the sulfate to sulfide. Although SRB are anaerobes they can survive under aerobic conditions and have been shown to consume 0_2 through respiration, a mechanism to avoid exposure to molecular oxygen (Holmer 2001). The water was then oxidized by the treatment system causing the sulfide to become sulfate, giving a higher sulfate reading after treatment (Domenico and Shwartz 1998). Sulfide and oxygen levels should be tested in future studies to determine evidence of SRB and therefore sulfate in its reduced state. Second, the sulfate present in the treated water sample could be the result of residual amounts of sulfate present in the Raystown Field Station plumbing before the treatment system was installed. Future research to test this hypothesis would include testing the plumbing as well as the filter medium in the treatment system for traces of sulfate.

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THE EFFECT OF COLOUR PHASE ON WINTER HABITAT CHARACTERISTICS OF THE EASTERN SCREECH OWL *(OTUS ASIO)*

BRIAN J. OLSEN[1], PAULA J. MOONEY[1], and CHARLES E. YOHN[1, 2]

[1]*Department of Environmental Science and Studies*

Juniata College

1800 Moore St.

Huntingdon, PA 16652

[2] Chuck Yohn, Raystown Field Station Office, Juniata College, Huntingdon, PA 16652, 814-641-3572

ABSTRACT

Previous studies have shown that the rufous phase of the eastern screech owl, *Otus asio*, has a higher metabolic rate than does the gray phase. We speculated that rufous phase owls need a greater caloric intake and choose milder environmental climes for their winter territories. We hypothesized that rufous screech owl territories in Huntingdon County, Pennsylvania would exhibit higher capture rates of small mammals, higher mean and maximum daily temperatures, and lower minimum daily temperatures and temperature ranges. We also hypothesized that the Peromyscus individuals within the rufous phase owl territories would have higher masses than those in the gray phase owl territories. We found significance in the difference between capture rates of small mammals in rufous owl territories (2.92 captures/night) versus gray owl territories (2.12 captures/night) ($T = 1.94$, $N=16$, $P = 0.047$). We found no significance, however, between temperature means in rufous (4.64 ± 0.74°C) versus gray (5.08 ± 1.14°C) territories ($T= -0.62$, $DF= 8$, $P= 0.724$), highs in rufous (5.36 ± 0.40°C) versus gray (5.95 ± 1.92°C) territories ($T=-0.41$, $DF=8$, $P=0.654$), lows in rufous (3.72 ± 0.78°C) versus gray (3.54 ± 0.39°C) territories ($T=-0.61$, $DF=8$, $P=0.718$), and ranges in rufous (5.52 ± 0.57°C) versus gray (5.22 ± 2.00°C) territories ($T= -0.27$, $DF=8$, $P=0.603$). Likewise, we found no significance in Peromyscus masses between rufous (18.78 ± 2.74g) and gray (19.25 ± 2.79g) territories ($T= -0.76$, $DF=88$, $P= 0.774$). Our data suggests that small mammal abundance plays an important role in the selection of territories in rufous and gray phase screech owls.

INTRODUCTION

Eastern screech owls, *Otus asio*, are found in two different color phases, rufous and gray. Until as late as 1853 the two phases were considered separate species, the rufous and mottled owls, and well after that it was hypothesized that one phase was the immature form while the other was the adult. Through careful observation of 3,600 owls, Hasbrouck (1893) determined that the color phases could not be attributed to gender, age, or season. He attributed the presence of one phase over another to local temperature and humidity. Studies by Martin (1950) agreed with Hasbrouck's conclusion that color was independent of gender. As theories of ecology and evolution have matured, many other ideas have been proposed about asexual dichromatism in different avian species. Berry and Davis (1970) cited mate pairing advantages as the reason for skua dichromatism. Johnson and Brush (1972) proposed that dichromatism in sooty-capped bush tanagers was for microhabitat camouflage. Hrubant (1955) hypothesized that the two color phases of screech owls were due to the presence of two or three alleles, where rufous was dominant to gray, with a possible intermediate. Hrubant still didn't explain why owls are completely gray in the northern extremes of the range while in the southern edge of the range they are almost completely rufous (Weidensaul, 1997). Stullken, and Hiestand (1953) showed that coat color can have a dramatic effect on metabolic rate at lower temperatures. They dyed the coats of a group of albino mice black and compared their oxygen consumption to white mice. They found that at lower temperatures (5˚C) the blackened mice consumed 42% more oxygen because of the thermodynamic properties of their coat color. Rufous screech owls have also been shown to consume more oxygen than do their gray counterparts, especially at low temperatures (-5 to -10˚C) (Mosher and Henry 1976). A study by Dexter (unpublished) also found evidence for this same property. He went on to note that rufous phase feathers were less efficient at absorbing solar radiation and therefore had higher metabolic rates to make up the difference in body temperature. According to Stullken, and Hiestand (1953) this effect would be amplified during the winter because of the harsher environmental climes. Accordingly, winter territories would be influenced by small mammal abundance, because these small mammals make up the majority of the winter diet (Dexter unpublished, Weidensaul 1997). Additionally, animals which have adapted to habitats with low food abundance or quality often have lower metabolic rates than do those

animals in habitats with higher food abundance and quality (Dobson 1992, Flannery 1993, Lee and Martin 1990, Philips 1995, Procter-Gray 1990). Because of these observations, we formulated the following hypotheses:

1. The average per night capture rate of small mammals in rufous phase eastern screech owl territories is greater than that of gray phase owl territories.
2. The average mass of Peromyscus individuals in rufous phase eastern screech owl territories is greater than that of gray phase owl territories.
3. The average, minimum, and maximum daily ambient air temperature in rufous phase eastern screech owl territories is greater than that of gray phase owl territories.
4. The daily ambient air temperature ranges in gray phase eastern screech owl territories are greater than that of rufous phase owl territories.

MATERIALS AND METHODS

We attracted owls using broadcasted whinny and tremolo calls with a johnny caller (Adam 1987, Carpenter 1987, Smith, Devine and Walsh 1987), locating eight rufous and eight gray eastern screech owl territories in the ridge and valley region of Pennsylvania (Table 1, Fig. 1). We repeated callbacks up to seven times at one minute intervals until an owl was positively identified with spotlights and 8x42 binoculars. During the course of the study we reconfirmed the color phase of the owl on two subsequent nights. In each territory we established two transect lines, each with eight stations of paired Tomahawk Live Traps. The transects converged at the location of initial owl observation, with each transect running in a direction of observed owl behavior (i.e. visual or vocal confirmation of a spotlighted owl or its mate, or spotlighted bird's exit flight) (Fig. 2). Traps of each pair were separated by approximately ten meters, although specific placement of each trap made allowances to take advantage of microhabitat cover. Trap lines were operated three successive nights in each territory, and captured mammals were marked by fur clipping and massed

before release. To factor out the influence of weather conditions on trapping success, gray and rufous territory trap lines were paired and operated on the same nights (Table 1).

We placed HOBO temperature recorders in 14 of the 16 territories from 18 February, to 15 March. Only one probe was placed between the two gray Spillway territories and one between the two rufous Spillway territories because these territories were adjacent to one another and our temperature recorder supply was limited. Temperature recorders were placed at the intersect of the two trap transect lines approximately one meter above the ground and recorded air temperature every 36 minutes for 26 days.

We tested for normality using a Ryan-Joiner Normality test, and for homogeneity of variance with a Levene's test. We considered differences to be significant if $P \leq 0.05$. We compared capture rates using a one-tailed paired student's T-test. We compared average Peromyscus masses, daily temperature lows and highs, temperature ranges, and average territory temperatures in rufous phase territories to those in gray phase territories using a one-tailed two-sample student's T-test. We only massed rodents of the genus Peromyscus (92% of captures) because of the extremely low capture rate of all others.

RESULTS

We found a significant difference between the capture rates of small mammals in gray (2.12 captures/night) and rufous (2.92 captures/night) phase eastern screech owl territories ($T = 1.94$, $P = 0.047$) (Fig. 3). We found no significant difference, however, between the mean mass of Peromyscus individuals in rufous (18.78 ± 2.74g) and gray (19.25 ± 2.79g) territories ($T= -0.76$, $DF=88$, $P= 0.774$) (Fig.4). Furthermore, we found no significance between temperature means (Fig. 5) in rufous (4.64 ± 0.74°C) versus gray (5.08 ± 1.14°C) territories ($T= -0.62$, $DF= 8$, $P= 0.724$), lows (Fig. 6) in rufous (3.72 ± 0.78°C) versus gray (3.54 ± 0.39°C) territories ($T=-0.61$, $DF=8$, $P=0.718$), highs (Fig. 7) in rufous (5.36 ± 0.40°C) versus gray (5.95 ± 1.92°C) territories ($T=-0.41$, $DF=8$, $P=0.654$), and ranges (Fig. 8) in rufous (5.52 ± 0.57°C) versus gray (5.22 ± 2.00°C) territories ($T= -0.27$, $DF=8$, $P=0.603$). During the study four of the temperature recorders malfunctioned leaving us with ten sampled territories, five rufous and five gray.

DISCUSSION

Rufous screech owls in our study were associated with higher densities of small mammals as measured by relative capture rates. This finding may imply that rufous phase owls, with their higher metabolic rate (Dexter unpublished, Mosher and Henry 1976) demand higher caloric intakes and therefore must occupy territories where this demand can be satisfied. It remains to be seen how rufous owls are able to procure these territories, as they would be equally advantageous to gray phase owls. Whether there is a difference in competitive ability between the color phases is unknown. If rufous phase owls are occupying higher quality territories than gray phase, it is possible that there is some sort of behavioral isolation between the two phases which may have genetic implications. Although there are instances of interphase pairings (Dexter unpublished), it is possible that these habitat demands may limit their occurrence. Mate selectivity in conjunction with habitat demands may act as a factor that limits the increase of genetically dominant red phase owls within the population.

A limitation of our study is that territory sizes were assumed equal between rufous and gray phases. If this were not the case, it allows for the possibility that gray and rufous phase territories have equal amounts of small mammals. Additionally, hunting time was assumed to be equal between the two phases. In actuality this may not be the case, and could have an important effect on caloric intake.

Our study detected no difference in temperature among the territories, and thus it is unlikely that owls are using any of these factors as environmental cues for habitat establishment. The dramatic variations and overlaps in daily and weekly temperatures make it very difficult to detect any possible differences. In all likelihood, these variations are such that the variations themselves would have more of an effect on the owls than any given difference would. It is possible, however, that roost sites would exhibit a difference in temperature. We also did not detect a difference in Peromyscus masses between the two territory types. Because Peromyscus individuals are subject to the same environmental pressures and constraints among all the territories, it would be unlikely that differences in mass would develop among these different populations.

Because many other avian species, including ruffed grouse, jaegers, and many hawks, exhibit this same color dimorphism, these results could have important implications on habitat management and hunting regulations in order to maintain color phase diversity.

ACKNOWLEDGEMENTS

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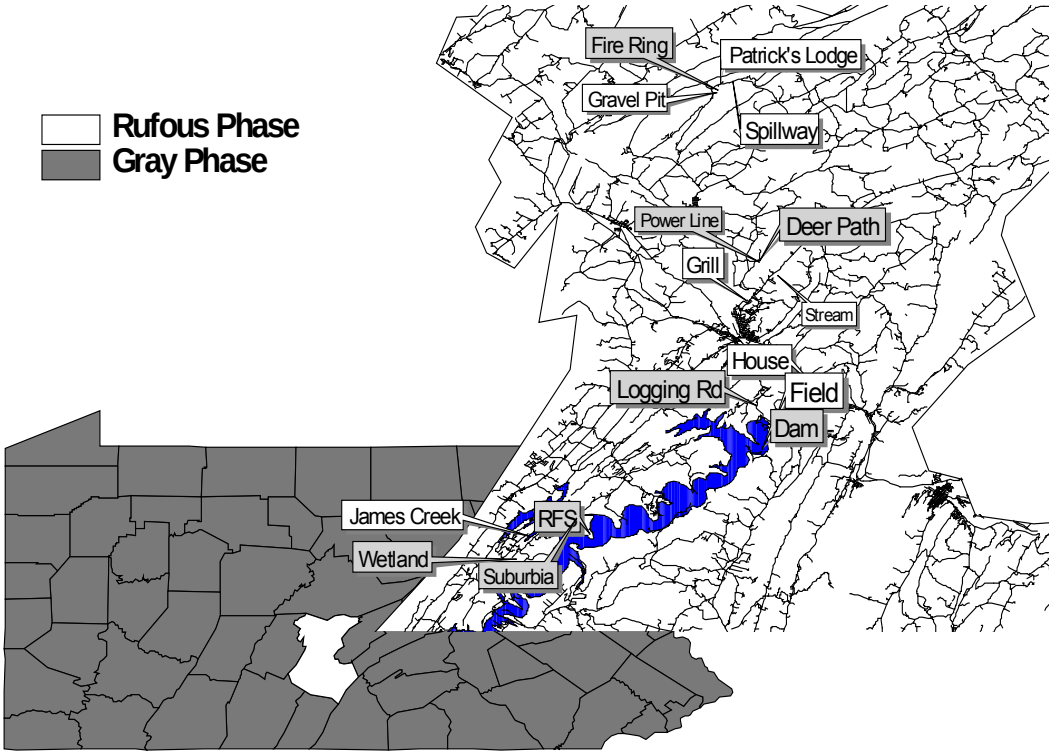
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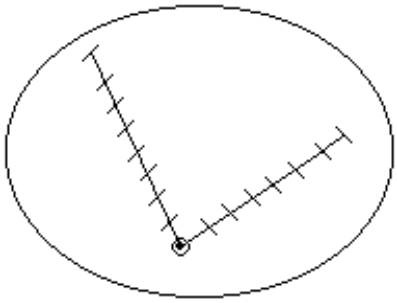
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#	Territory	Rufous	Description
1a	Spillway	Rufous	Primarily evergreen, with scattered deciduous, bordered by small stream and pond, lowland
1b	Fire Ring	Gray	Exclusively mixed deciduous, no significant top soil, instead mostly boulders, elevated hillock
2a	Patrick's Lodge	Rufous	Mixed deciduous and evergreens, alongside very small pond formed by dammed stream
2b	Wetlands	Gray	Primarily deciduous with mixed evergreens, slightly higher peninsula amidst lowland wetlands.
3a	Grill	Rufous	Mixed deciduous and evergreens, stream lowlands
3b	Power Lines	Gray	Exclusive deciduous, immature forest, bordered by power line cut
4a	Stream	Rufous	Mixed deciduous and evergreens, stream lowlands
4b	Deer Path	Gray	Primarily deciduous with scattered evergreens, alongside small clearing
5a	House	Rufous	Primarily deciduous with scattered evergreens, melt-water stream-bed, nearly adjacent to Raystown Branch of the Juniata River
5b	Dam	Gray	Primarily deciduous with scattered evergreens, extremely steep slope on both sides of stream.
6a	Field	Rufous	Primarily deciduous with scattered evergreens, nearly adjacent to Raystown Branch of the Juniata River
6b	Logging Road	Gray	Primarily deciduous with scattered evergreens, slope on both sides of stream.
7a	James Creek	Rufous	An evergreen stand clearly divided from a deciduous stand by a ~20m wide swath of swampy lowlands
7b	RFS	Gray	Mixed deciduous and evergreens, exposed ridgetop
8a	Gravel Pit	Rufous	Primarily evergreen with scattered deciduous, small melt-water stream
8b	Suburbia	Gray	Primarily evergreens with mixed deciduous, steep incline


Rufous Phase
Gray Phase
Fire Ring
Patrick's Lodge
Gravel Pit
Spillway
Power Line
Deer Path
Grill
Stream
House
Logging Rd
Field
Dam
James Creek
RFS
Wetland
Suburbia



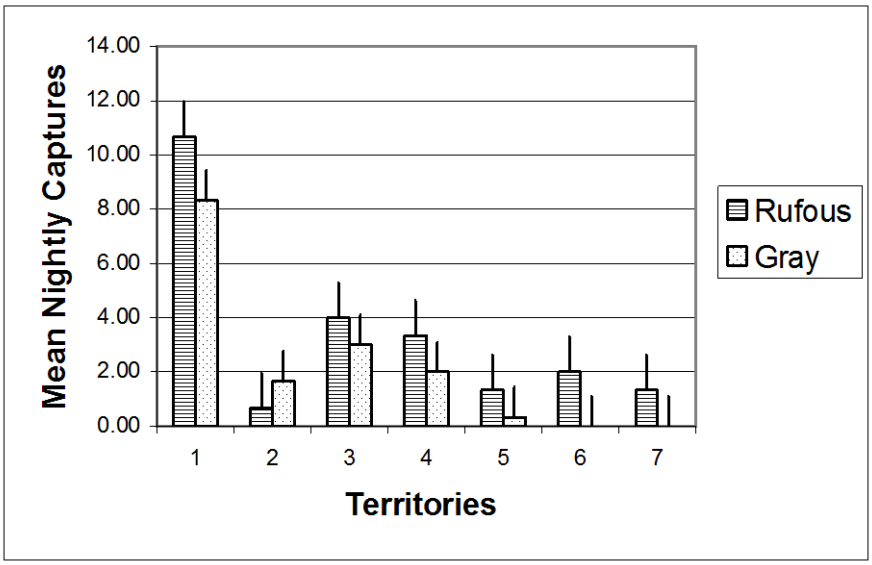
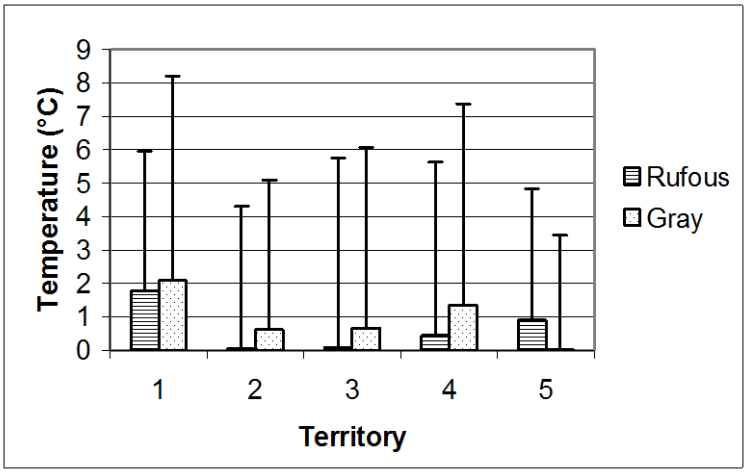
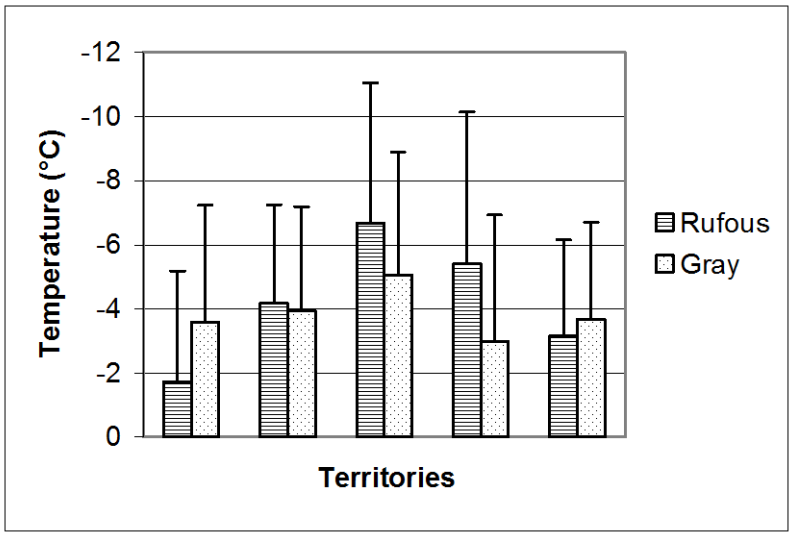
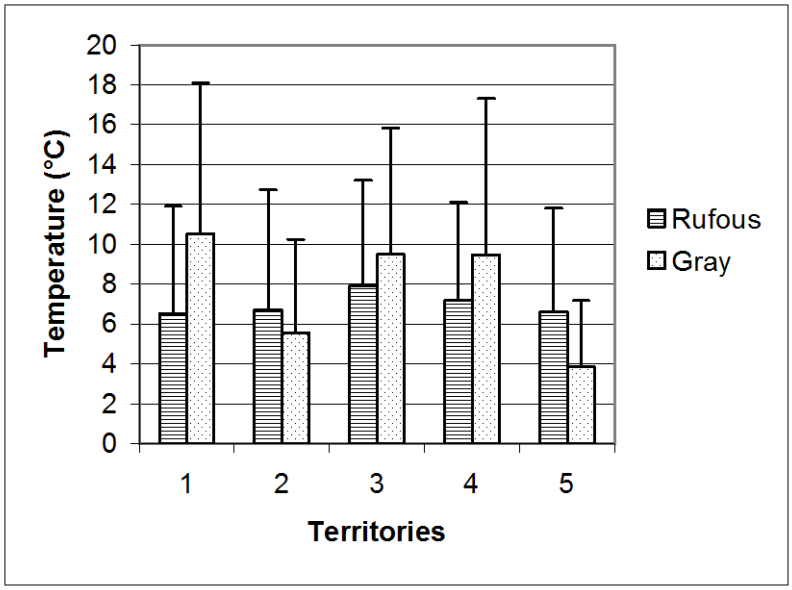

Mean Nightly Captures
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1
2
3
4
5
6
7
Territories
Rufous
Gray



Fig. 4. Mean masses of Peromyscus species captured in rufous and gray screech owl territories (+1SD) (T= -0.76, DF=88, P= 0.774) in Huntingdon County, PA, 2001.


Temperature (°C)
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
Territory
Rufous
Gray


-12
-10
-8
-6
-4
-2
0
Temperature (°C)
Territories
Rufous
Gray


20
18
16
14
12
10
8
6
4
2
0
Temperature (°C)
1
2
3
4
5
Territories
Rufous
Gray

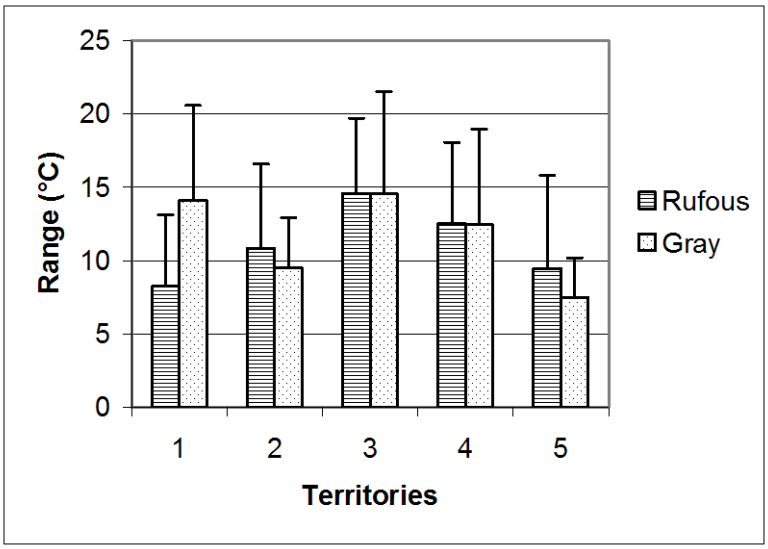

25
20
15
10
5
0
Range (°C)
1
2
3
4
5
Territories
Rufous
Gray

Table 1: general descriptions of the screech owl territories within six locales in Huntingdon County, PA, 2001. A and b are paired territories where traps were operated on identical nights

Figure 1. Location of screech owl territories within Huntingdon County, PA.

Fig 2. two transect layouts in approximate boundaries of a screech owl territory, emanating from the initial point of observation, with two traps placed at this initial point and then every 10 yards in two different directions.

Fig. 3. *Mean nightly capture rates among 8 gray phase and 8 rufous phase screech owl territories (+SE)) in Huntingdon County, PA, 2001. Grouped territories were trapped on the same night.*

Fig. 4. Mean masses of Peromyscus species captured in rufous and gray screech owl territories (+1SD) (T= -0.76, DF=88, P= 0.774) in Huntingdon County, PA, 2001.

Fig. 5. Mean daily ambient air temperatures of 10 screech owl territories, 5 rufous and 5 gray (+1 SD), over 26 days in Huntingdon County, PA, 2001.

Fig. 6. Mean daily ambient air temperature lows of 10 screech owl territories, 5 rufous and 5 gray (+1 SD), over 26 days in Huntingdon County, PA, 2001.

Fig. 7. Mean daily ambient air temperature highs of 10 screech owl territories, 5 rufous and 5 gray (+1 SD), over 26 days in Huntingdon County, PA, 2001.

Fig. 8. Mean daily ambient air temperature ranges of 10 screech owl territories, 5 rufous and 5 gray (+1 SD), over 26 days in Huntingdon County, PA, 2001.

MOSQUITO LARVAE DENSITIES DIFFER AMONG NATURAL WETLANDS, MAN-MADE WETLANDS, AND TIRE PILES

Andrew Miller

ABSTRACT

There are many suitable habitats for mosquitoes to breed in. This research experiment will explore the differenced in how many mosquitoes are produced in natural wetlands, man-made wetlands, and tire piles. There are five replicates for each of the afore mentioned treatments. There is data from about ten visits to each of the replicates. The data was collected by taking samples from water in the replicates and counting the mosquito larvae. Once the data is compiled, it will be statistically analyzed through either a Kruskal Wallace test or an ANOVA.

INTRODUCTION

As we all know, mosquitoes are carriers of many diseases. Therefore, people often wish to exterminate them. The easiest time to do this is when they are in their larval stage. Because of this, I have collected data from three different types of mosquito larvae habitat. The first of these is natural wetlands. I define a natural wetland as one that has not been built. It cannot have water channeled into or away from it. If it does not meet these requirements, it is a man-made wetland, the second type of habitat. The third type is a tire pile. This can be any discarded tire in the environment that holds water and organic material. I propose that natural and man-made wetlands will not produce as many mosquitoes as tire piles do. I tested the hypothesis that there will be no difference among the amount of mosquitoes produced in these three habitats. The purpose of this is to identify the areas that produce the most mosquitoes so that they can be controlled.

FIELD SITE

I used tire piles and wetlands scattered across Huntingdon County, Pennsylvania. I found the tire piles in central to southern portions of the county, while the wetlands are located in nearly all portions.

METHODS AND MATERIALS

I recorded data from five natural wetlands, five man-made wetlands, and four tire piles from May 2001 until mid-August 2001. Approximately once a week, I would go to each wetland and take one sample of water from three different places in the wetland. By using hip-waders, I was able to record data from all the shore area in each wetland. At

each tire pile, I would only take one sample of water. I counted the number of mosquito larvae in each sample. The dipper used holds one cup of water, so I calculated the density of mosquito larvae as mosquitoes per cup.

Since density is continuous data, I can analyze it through either a parametric or non-parametric test. Using a Bartlett's homogeneity of variance test, I can determine if the variances are equal for my samples. I can use an Anderson-Darling Normality test to see how close to normal my data actually is.

EFFECT OF GENDER AND SEASON ON CORE BODY TEMPERATURE IN EASTERN FENCE LIZARDS (*Sceloporus undulatus*)

Jamie M. Irish

ABSTRACT

I compared body core temperature between male and female Sceloporus undulatus among 3different seasons. I found no significant difference in core body temperature between males (33.14 ± 2.91) and females (33.42 ± 2.70), (T=0.65, DF=177, P=0.514) and no difference among 3 seasons (F= 0.36, DF=2, P=0.697). These results suggest that core body temperatures of *Sceloporus undulatus* show no detectable pattern between gender and seasons.

Keywords: Activity seasons, core body temperature, Eastern Fence Lizard, Sceloporus undulatus, Thermoregulation.

INTRODUCTION

Body temperature regulation is necessary in order for the physiological performance of lizards. Body temperature influences the activity seasons, reproductive phenology, survival rates, and growth rates of lizards (Adolph and Porter 1996), and is determined based by behavioral and physiological processes. This process includes various postures for self-heating, skin pigmentation transformations, and positioning of

blood sinuses. Thermoregulation may also correlate with reproductive changes throughout the year (Matter, pers. comm.).

Some authors speculate male fence lizards' core body temperature is significantly higher during the months of May and June than other months (Matter, pers. comm.), because of the energy demands of territorial defense and mating displays. During this season, females may also have higher core body temperatures because copulation and mating occur in mid-June.

At the end of August and into the winter months, the male fence lizard is proliferating spermatocytes and this requires higher core body temperature. On the other hand, female fence lizards are concentrating on surviving and storing fat throughout the winter months so their core body temperature is believed to be significantly lower than the males (Matter, pers. comm.).



Figure 1. Photograph of Eastern Fence Lizard.

MATERIAL AND METHODS

This study was conducted at Juniata College Raystown Field Station, located in Huntingdon. The lizards were captured by Dr. John Matter in 1997-2000 on the mountain slope(s) overlooking Raystown Lake in central Pennsylvania. The methods lizards were caught by were noosing and grab method.

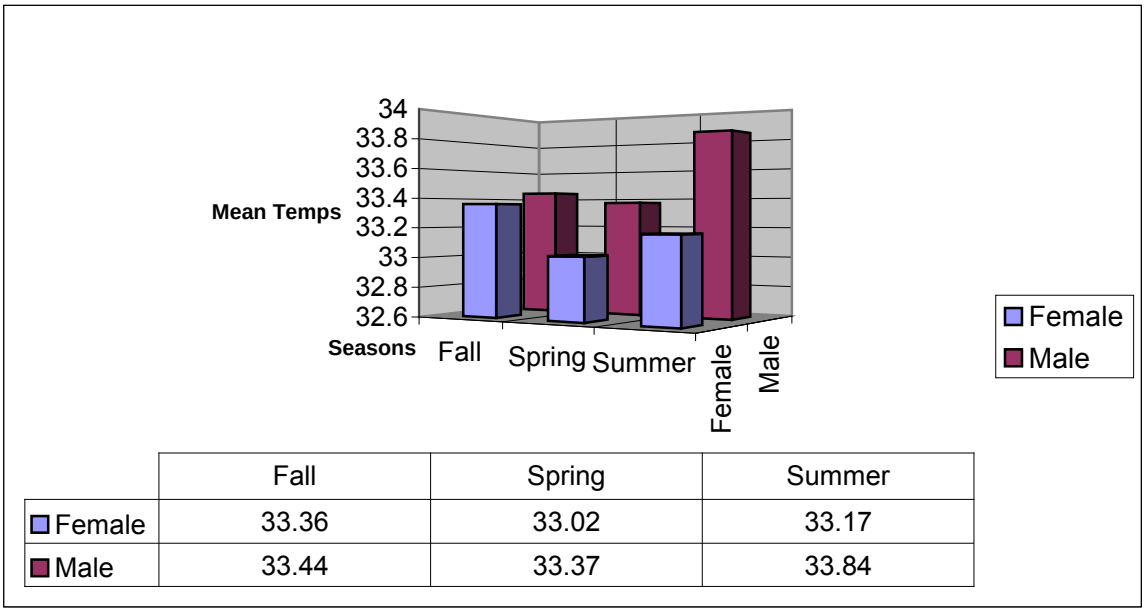
I obtained data on core body temperature and month of capture on 187 S*celoporus undulatus*, (73 male and 114 female) from the seasons spring (May +June), summer (July + August), and fall (Sept + Oct). I checked the data for normality and equal variances, using an Anderson Darling test and Lavene's test, respectively. I compared differences in temperature between the sexes using a two-sample t-test and among the sexes and seasons with a two-way ANOVA.

In order to obtain a sample size of 10 replicates for each cell gender/season combination, I randomly sub sampled the full data set. If fewer than 10 lizards of either sex were captured in a season, I used randomly selected recaptured lizards core body temperatures to complete the sample size. I used an alpha level of 0.05 and I considered differences to be significant if $p<0.05$.

RESULTS

I found no significant difference in core body temperatures between female (33.42 ± 2.70) and male (33.14 ± 2.91) S. *undulatus* (t=0.65, df=177, p=0.514). The temperature means of the lizard's analyzed in this research are found in Table1. Furthermore, I found no difference among season (p=0.697), no interaction between season and gender (p= 0.922), and no interaction (p=0.693).

Table1. Temperature means of Sceloporus undulatus *during the different seasons.*



	Fall	Spring	Summer
Female	33.36	33.02	33.17
Male	33.44	33.37	33.84

DISCUSSION

I had initially hypothesized that the female fence lizards would have significantly higher temperatures than the male fence lizards; instead I found that there was no difference. I hypothesized that the females would have higher body temperatures in the spring because of egg development and the males would have higher temperatures during the fall when they undergo spermatocyte development

There are a few limitations that could have affected my results. First, the methods by which the individual reptiles were captured may result in rapid alterations of their body temperatures (Avery 1982). Some workers have actually rejected records from all lizards that had been grasped around the mid body during capture (Avery 1982). Along with the concern with handling problems there is the issue of the bias in the selection of the animals. This bias includes the possibility of selecting particular individuals while researching. Furthermore, the measured temperature needs to correspond to the temperature, which is operational in the central thermoregulatory control mechanism if there are temperature gradients or differentials within the animal (Avery 1982).

Another limitation is how the data was collected. The females that were collected may have been the most active females with higher temperatures. The same would apply for the males caught. This could have lead to no significant difference. Also, the lizards that were caught could have not been reproductively active. Furthermore, further study with larger sample sizes would shed more light on this research.

ACKNOWLEDGEMENTS

I would like to thank Dr. John Matter for all of his help and support, especially in supplying me with the data from the lizard research and the vast amount of lizard information. I also thank Chuck Yohn for his support and guidance throughout the research.

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COMPOSITION OF AN OAK-HICKORY FOREST IN CENTRAL PENNSYLVANIA FOLLOWING GYPSY MOTH DEFOLIATION

Lee Garner and Beth Hoffman

ABSTRACT

We studied the effect of gypsy moth, *Lymantria dispar*, defoliation on forest composition of a mid- to late-successional oak-hickory (*Quercus-Carya*) forest in Huntingdon County, PA. We hypothesized that there would be significant changes in average basal area, average tree height, species composition, trees per hectare, and tree density between pre-defoliation and post-defoliation forests. We tested this hypothesis by re-conducting a forest composition study done in 1978, prior to defoliation of the forest. We found that average basal area in '01 (2.04 dm^2) was significantly less than in '78 (3.64 dm^2) ($W = 16.0$, $df = 4$, $P = 0.02$). Trees per hectare in '01 (78.10) showed a slightly significant increase from '78 (43.00) ($W = 36.0$, $df = 4$, $P = 0.09$). We found no significant difference between average tree heights among species in '78 (12.23 m) and '01 (12.47 m) ($W = 28.5$, $df = 4$, $P = 0.92$), importance values among the five highest-ranking species between '78 and '01 ($W = 30.0$, $df = 4$, $P = 0.68$), and basal area per hectare among species between '78 (129.40 dm^2) and '01 (162.80 dm^2) ($W = 30.0$, $df = 4$, $P = 0.68$). We conclude that gypsy moth defoliation has had little effect on forest composition at the Raystown Field Station.

Keywords: Forest composition, forest succession, Lymantria dispar, oak-hickory, Quercus montana, Raystown Field Station

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INTRODUCTION

Forest succession is an ongoing process in natural ecosystems, which begins with the recruitment of pioneer tree species on cleared landscapes (Peattie 1950, Walker 1999). This is followed by the replacement of those species with climax tree species, which overtop the pioneer species and choke out their sunlight (Hunter 1983). Later on, when climax members of a forest community die, gaps are created in the canopy, allowing sunlight to reach the forest floor, which promotes the recruitment of seedlings of both climax and secondary pioneer species. Often, secondary species are faster growing and more shade tolerant, which gives them the advantage over the climax seedlings to grow up in the already established climax forest (Nichols 1962, Sutherland 2000). In disturbed forests, this pattern of succession is greatly accelerated (Abrams 1992, Nowacki 1994). If a disturbance causes many climax trees to die at the same time, the forest is opened up for a successional change in overall composition from climax hardwoods to secondary hard- and softwoods (Abrams 1992, Walters 1997). Disturbances can range from acid

deposition to biological pests (Nowacki 1994, Walters 1997). One such disturbance that is currently of great concern in oak-hickory forests is the gypsy moth caterpillar, *Lymantria dispar* (Nowacki 1994).

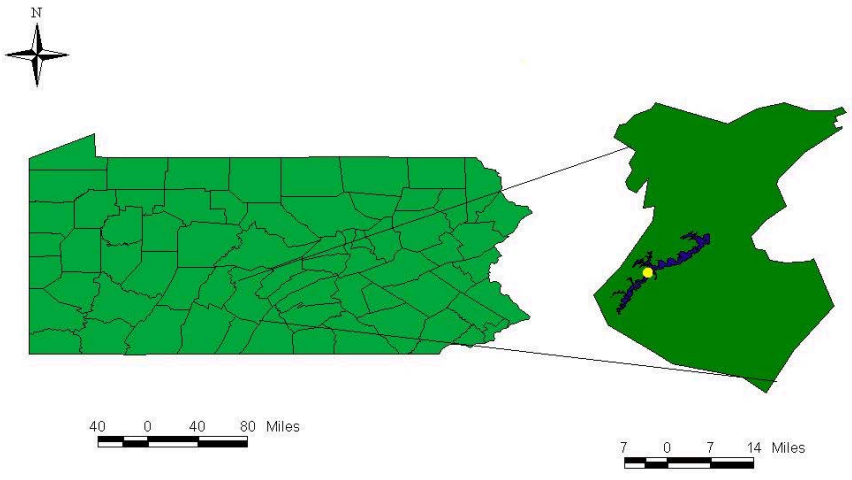
The gypsy moth caterpillar was introduced to the United States in 1868 (Elkinton 1996). Since then it has spread west, reaching central Pennsylvania in the early 1980s (Yohn, pers. comm.). Oak (*Quercus*) foliage is the most favored food of this caterpillar pest, though it will feed on most species of trees (Elkinton 1996, Hunter 1983). The gypsy moth caterpillar defoliates huge expanses of timber foliage as it moves across an area, threatening the health of the mature oak-hickory forests it encounters (Nichols 1962). Several factors contribute to the survival rate of defoliated trees, including how severely the trees were defoliated, how many successive years the trees were defoliated, what time of the growing season the defoliation took place, how many other secondary pathogenic organisms were present during the time of defoliation, geography and geology of the site on which the trees are located, and the amount of precipitation reaching the trees during the time of defoliation (Abrams 1992, Nichols 1962, Statler 1983). Survival of trees also ultimately depends on the susceptibility of the individual species under disturbance (Fajivan 1996). If trees do not survive, accelerated succession will likely take place, especially in areas where caterpillars have killed off large areas of climax tree species (Fajivan 1996).

Gypsy moth defoliation has occurred twice at the Raystown Field Station in central Pennsylvania, in 1982 and in 1999 (Yohn, pers. comm.) A tree survey conducted at the station during 1978, prior to the first infestation (Phillips, unpublished study), found the trees of greatest importance within this section of forest included mostly chestnut oak (*Quercus montana*) and white oak (*Quercus alba*). It is the purpose of our study to determine whether the forest composition at the Raystown Field Station has changed since 1978.

FIELD SITE

Our study area was located on a north-facing ridge at the Raystown Field Station, Huntingdon County, PA, that varied between 45^{o} and 15^{o} slope. Our study encompassed a mid- to late-successional oak-hickory forest (Fig. 1).

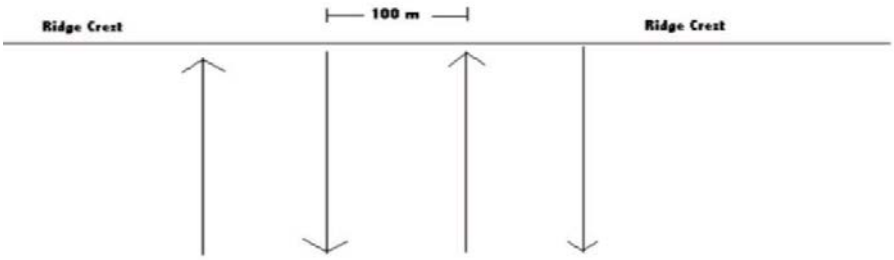
Fig. 1. Location of Raystown Field Station (dot), Huntingdon County, PA.



METHODS AND MATERIALS

We established 11 transects through the forest, spaced 100-m apart and running perpendicular to the crest of the ridge (Fig. 2). We randomly established four survey points within 100-m to the right or left of each transect in a manner similar to Phillips and Hauenstein. At each point we identified the four closest living trees to each of the four cardinal compass points. For each of those four trees, we recorded species, basal area (dm^3) using a dbh (diameter at breast height) tape, tree height (m) using a Sunto clinometer, and distance to survey point (m). We also made qualitative observations of the canopy and forest floor, including estimated canopy height and relative thickness, gaps in the canopy, relative amount of woody debris and snags, and average height and species of saplings at each point.

Fig. 2 – Diagram of forest transects, spaced 100 m apart and running perpendicular to crest of a ridge at the Raystown Field Station, Huntingdon County, PA.



We collected data on four days during early October, 2001. We compared average basal area between '78 and '01 by using a Mann-Whitney U test (Minitab). We used an α level of 0.05 and consider differences to be significant if $P \leq 0.05$. We compared average tree height, importance value, trees per hectare, and basal area per hectare for each species between years in a similar manner.

RESULTS

We found oaks in our plot ranged in basal area from 11.0 dm^2 to 47.0 dm^2. We found all red-type oaks ("oak 4" in Phillips and Hauenstein, unpublished study) to be less than 30.6 dm^2. Chestnut oaks (*Quercus montana*) made up 30% of the species composition of the plot, while red-type oaks (oak 4) made up 16.5%, Virginia pine (*Pinus virginiana*) made up 13%, and white oak (*Quercus alba*), 12%.

Average basal area in '01 (2.04 dm^2) was significantly less than in '78 (3.64 dm^2) ($W = 16.0$, $df = 4$, $P = 0.02$). Trees per hectare in '01 (78.10), however, showed a slightly significant increase from '78 (43.00) ($W = 36.0$, $df = 4$, $P = 0.09$). We found no significant difference between average tree heights among species in '78 (12.23 m) and '01 (12.47 m) ($W = 28.5$, $df = 4$, $P = 0.92$), importance values among the five highest-ranking species between '78 and '01 ($W = 30.0$, $df = 4$, $P = 0.68$), and basal area per hectare among species between '78 (129.40 dm^2) and '01 (162.80 dm^2) ($W = 30.0$, $df = 4$, $P = 0.68$).

Importance values of the five highest-ranking species varied between '78 and '01 with chestnut oak being the highest in both '78 (IV=29.64) and '01 (IV=39.64) and white pine (*Pinus strobus*) being the

lowest in both ‘78 (IV=6.63) and ‘01 (IV=10.04). Red-type oak measured from sixth in importance value in ‘78 (IV=3.64) to second in ‘01 (IV=17.33) (Table 1).

Table 1. Importance values for tree species recorded on a north-facing slope at the Raystown Field Station in Huntingdon County, PA in 1978 and 2001.

Tree Species		**Importance Value '78**	**Importance Value '01**
Chestnut Oak	*Quercus montana*	39.64	29.64
Red-type (Oak 4)	*Quercus rubra*	3.64	17.33
Virginia Pine	*Pinus viginiana*	11.98	12.63
White Oak	*Quercus alba*	21.03	12.31
White Pine	*Pinus strobus*	6.63	10.04
Red Maple	*Acer rubrum*	0	5.94
Sugar Maple	*Acer saccharum*	0.89	3.81
Black-type (Oak 2)	*Quercus velutina*	8.50	3.22
Shagbark Hickory	*Carya ovata*	0.74	1.22
Pignut Hickory	*Carya glabra*	0	1.20
Bear-type (Oak 3)	*Quercus ilicifolia*	3.36	0.72
Scarlet Oak	*Quercus coccinea*	0	0.63
Chokecherry	*Prunus virginiana*	1.34	0.59
Bitternut Hickory	*Carya cordiformis*	0	0.58
Eastern Hemlock	*Tsuga canadensis*	1.49	0

DISCUSSION

Average basal area decreased significantly from ‘78 to ’01, possibly because the older, more mature trees measured in ‘78 have since died from gypsy moth defoliation, and allowed younger trees to grow in their place. Large, dead standing and fallen trees observed at our site support this theory. There was a slightly significant increase in trees per hectare from ‘78 to ’01, supporting the notion of a younger forest replacing an older forest. A young forest is composed of smaller trees that do not require as much resources per individual and are thus able to grow closer together. As a forest matures, dominant trees will require more resources leading to neighbor mortality and thus a decrease in tree density.

We found no significant difference in tree height from ‘78 to ‘01, presumably because when the mature trees died, the younger trees put their effort into rapid vertical growth, trying to reach the canopy quickly so as to not be deprived of sunlight early on (Fajivan 1996). Had we conducted this study several years earlier, a significant difference in height may have been recorded.

The importance values of some individual species changed from the previous study. Phillips and Hauenstein (unpublished study) determined three oak hybrid species as various combinations of red oak (*Quercus rubrum*), black oak (*Quercus velutina*), and bear oak (*Quercus ilicifolia*). Based on their determination process, we categorized our red- and black-type oaks by bark type and general leaf shape (Petrides 1998) and were thus able to divide them into three groups comparable to the three hybrids of ‘78. The decrease in importance value of chestnut oak (*Quercus montana*) and white oak (*Quercus alba*) and the increase of red-type oak (Phillips, unpublished study) as well as the unchanged importance value of Virginia pine (*Pinus virginiana*) suggest a disturbed forest (Table 1). We noticed large clusters of gypsy

moth egg casings on many trees in this forest plot, especially on chestnut oaks, perhaps indicating a preference for this species because of its deeply grooved bark that may offer some protection to the developing young. White oaks also had some casings, though not as many, and red-type oaks had nearly no egg casings. Relative abundance of egg casings per tree species may indicate a preference of gypsy moths for certain tree species and may have caused the decrease in chestnut oak and white oak importance values and the increase in red-type oak importance value. The unchanged importance value of Virginia pine also supports the theory of disturbance. For shade-intolerant Virginia pine to survive in a mature hardwood forest, it must receive ample light from gaps in the canopy. We noticed gaps in the present forest canopy, averaging 1-2 per data collection point, due to fallen dead trees. Although most of the canopy allowed little direct light to pass through, saplings were still present over most of the forest with the exception of the maple (*Acer*)/Virginia pine-covered far-eastern tip of the site where no saplings were found. Chestnut oak, white oak, and red-type oak saplings were present over much of the forest floor in varying heights (mostly 0.5-1.0 m with an occasional stand 2.0-3.0 m) and white pine (*Pinus strobus*) saplings were moderately abundant but no Virginia pine saplings were observed.

We found no significant change in basal area per hectare between ‘78 and ’01. Although there were more trees per hectare represented in ‘01, the average basal area per tree was less. This redistribution of basal area into smaller trees is further evidence of a disturbed forest.

Overall, we feel the decrease in average basal area, yet increase in trees per hectare, as well as importance values and sapling status indicate this forest is recovering from disturbance, yet maintaining its composition as an oak-hickory forest. Although white oaks and chestnut oaks have decreased in importance value, red-type oaks have increased enough to maintain an oak-hickory composition.

ACKNOWLEDGEMENTS

We would like to thank the Raystown Field Station, under supervision of Dr. Chuck Yohn, Dr. Todd Gustafson for background information and for use of his equipment, and Don Detwiler for his help in setting up transects.

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FOREST COMPOSITION OF AN OAK-HICKORY FOREST FOLLOWING GYPSY MOTH DEFOLIATION

Lee Garner and Beth Hoffman

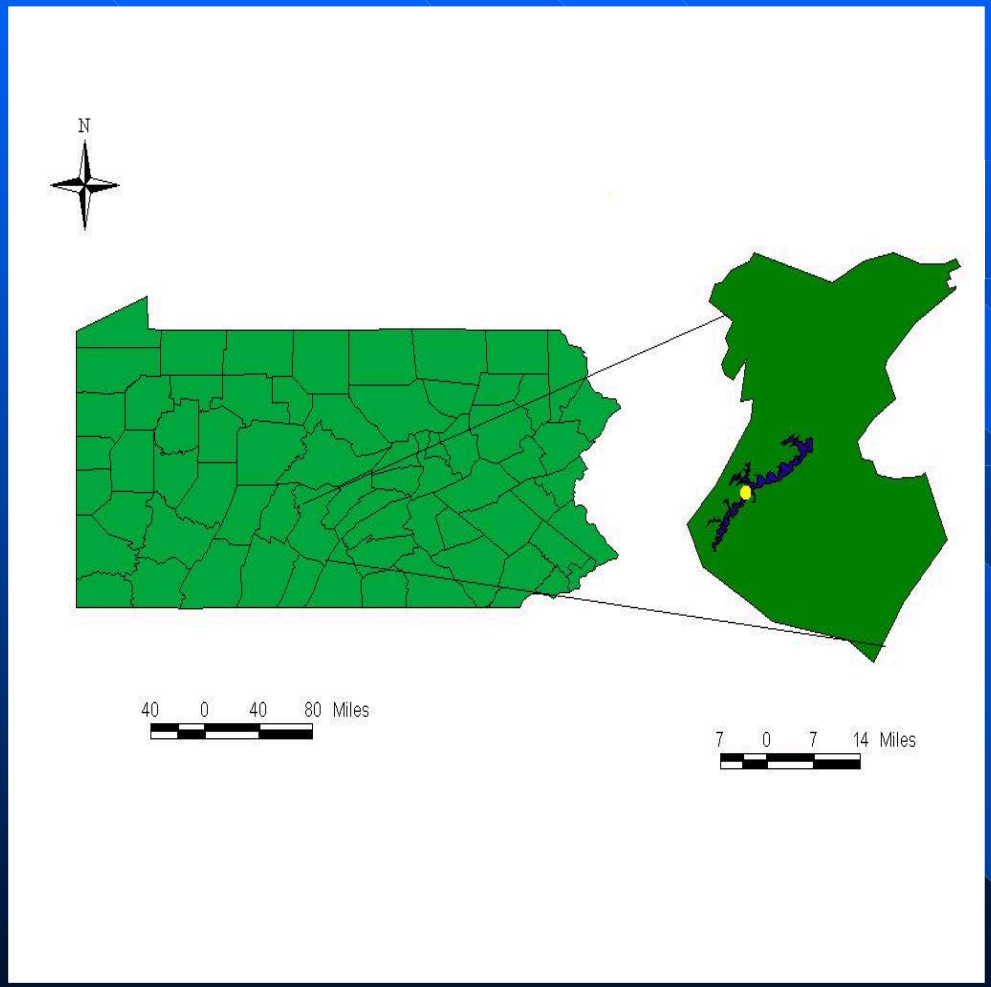
Juniata College
Huntingdon, PA

Introduction

- Forest succession
- Disturbance
- Gypsy moth defoliation
- Survival rates



Introduction



- Raystown Field Station
- Phillips & Hauenstein, 1977-78

Hypothesis

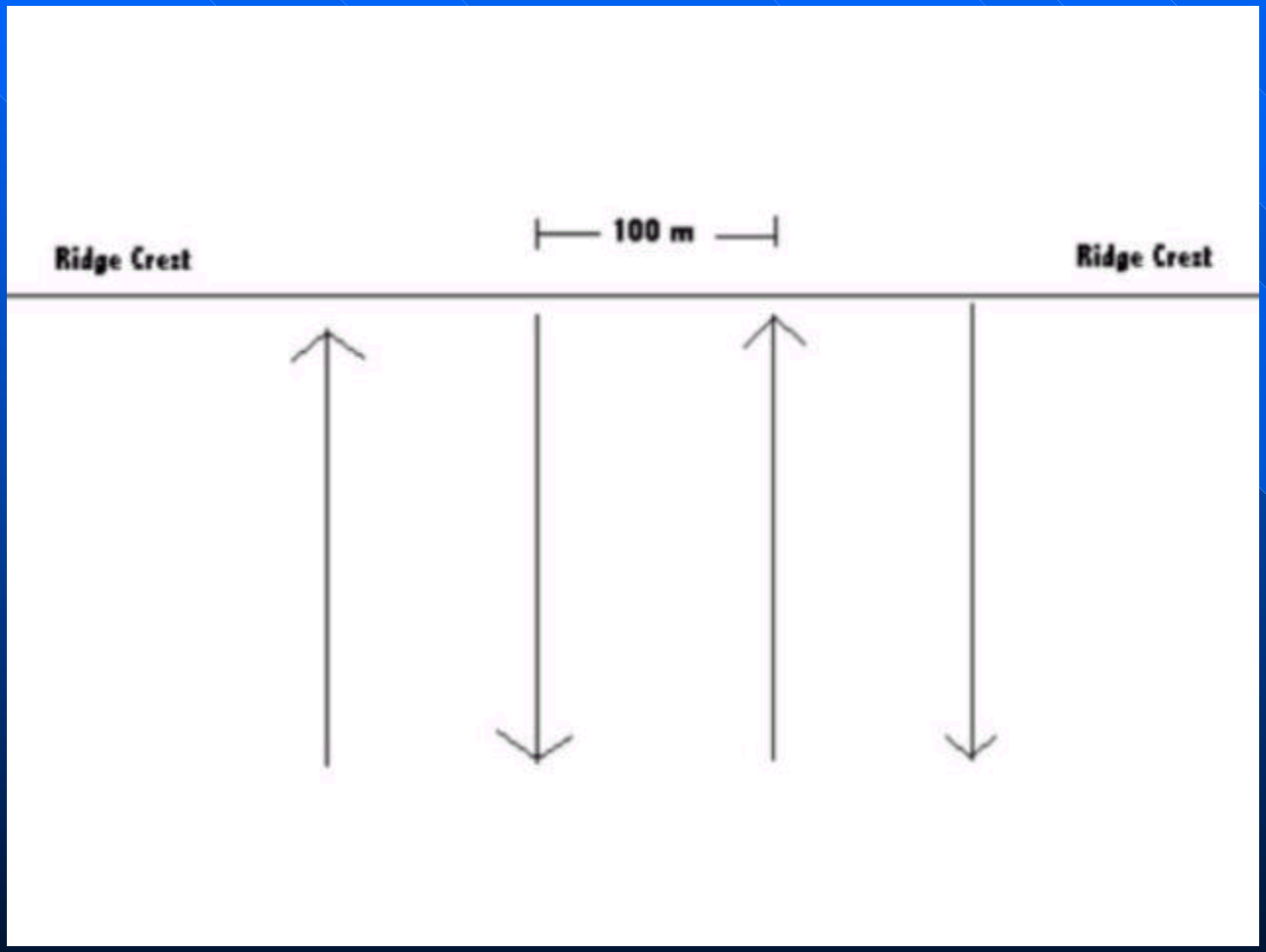
- There would be significant changes in
  - average basal area (BA),
  - average tree height,
  - species composition,
  - trees per hectare, and
  - tree density

  between pre-defoliation and post-defoliation forests.

Research Diagram

1978	2001
11 transects (4 points per transect) (4 trees per point)	11 transects (4 points per transect) (4 trees per point)

Methods



Materials



- Peterson Field Guide
- dbh tape
- Sunto clinometer

Dbh tape



Sunto clinometer



Statistics

- Mann-Whitney U test
- α level of 0.05
- Significant if $P \leq 0.05$

Tested

- Average BA
- Trees per ha
- Average tree height
- BA per ha
- Importance values

Results-ave. BA

1978	2001
3.64 dm^2	2.04 dm^2

(W = 16.0, df = 4, P = 0.02)

Significant decrease

Results-trees/ha

1978	2001
43.00	78.10

(W = 36.0, df = 4, P = 0.09)

Slightly significant increase

Results-ave. tree ht

1978	2001
12.23 m	12.47 m

(W = 28.5, df = 4, P = 0.92)

Not statistically significant

Results-BA/ha

1978	2001
129.40 dm^2	162.80 dm^2

(W = 30.0, df = 4, P = 0.68)

Not statistically significant

Results-IVs

Tree species		Importance Value ‘78	Importance Value ‘01
Chestnut Oak	*Quercus montana*	39.64	29.64
Red-type Oak	*Quercus rubra*	3.64	17.33
Virginia Pine	*Pinus virginiana*	11.98	12.63
White Oak	*Quercus alba*	21.03	12.31
White Pine	*Pinus strobus*	6.63	10.04

(W = 30.0, df = 4, P = 0.68)

Not statistically significant

Discussion

- Ave. BA
- Trees/ha
- Ave. tree ht
- BA/ha

Discussion

- Importance Value
  - Gypsy moth preference?
  - Virginia pine
  - saplings

Conclusion

- Recovering from disturbance
- Slight change in composition
- Remains oak-hickory

Acknowledgements

- Raystown Field Station
- Dr. Todd Gustafson, Professor at Juniata College
- Don Detwiler

Effect of Maple Borer, *Glycobius speciosus*, and Tree Diameter on Sap Sugar Concentration of Sugar Maple

Sarah Frantz and Abbie Gongloff

ABSTRACT

The sugar maple, *Acer saccharum*, is the host of the sugar maple borer, beetle, *Glycobius speciosus*. We examine the effect of the sugar maple borer on sap sugar concentration, annual growth rate, and the relationship between tree diameter and sap sugar concentration of sugar maples at Juniata College Raystown Field Station in Huntingdon, Pennsylvania. We found no significant difference in sap sugar concentration between infected and non-infected trees ($t = 0.43$, $DF = 35$, $p = 0.671$). Likewise, there was no significant relationship between sap sugar content and DBH in infected ($r = -0.079$, $p = 0.755$) and uninfected ($r = 0.193$, $p = 0.486$) trees. Overall, it does not appear that the maple borer affects sap sugar concentrations. These results may aid grove owners in their management decisions.

INTRODUCTION

Sugar maple, *Acer saccharum* is a northern hardowwd species found in the eastern United States and Canada. Sugar maple sap flows during a series of warm days and cool nights in the spring and its solutes are approximately 99% sugar (Koelling, 1996). It is produced when starch stored from the previous summer is converted into sugar and then is dissolved into the sap (Koelling, 1996). This sap is frequently collected and boiled to produce maple syrup. Sugar maples are the only known host of the sugar maple borer, *Glycobius speciosus* (talerico, 1962).

The sugar maple borer is a longhorn beetle, 25 millimeters long, with a two-year life cycle (Allen, 1992). Eggs are deposited in midsummer and the larvae mine within the trees during the summers, and, as a result, the borer disrupts the conductive tissue of the tree (Talerico, 1962). The sugar maple borer is a secondary insect (Newton, 1982) and can only survive in trees of low vigor (Bauce, 1991). It attacks sugar maple trees by boring a four to six foot larval feeding gallery inside the tree (Allen, 1992). As the sugar maple heals the site of attack, a scar is created on the tree. A horizontal scar is created if the larvae do not survive into their second year; a vertical scar occurs if the life cycle is completed (Sendak, 1997).

The purpose of this study was to determine if the sugar maple borer has an effect on the sap sugar concentration and annual growth rate of the sugar maples. We also examined the relationship between Diameter at Breast Height (DBH) of sugar maples and their sap sugar concentration.

<figure one>

Our research was conducted during mid-March 2001, in the sugar maple grove at the Juniata College Raystown Field Station in Entriken, Pennsylvania (Fig. 1). Trees were selected for the study along with both sides of the stream in the area between the field station house and

Juniata Bay. The length and width of the study site was approximately ¼ mile long and 50 feet wide.

METHODS AND MATERIALS

We randomly selected 19 sugar maples infected by the sugar maple borer and 19 not infected, all with the same slope and soil type. We identified infected trees by a scar characterized by a raised vertical or horizontal surface (Fig. 2) left by the borer on the bottom 20 feet of the tree trunk (Talerico, 1962). We used a tree corer to obtain core samples and a DBH measuring tape to measure tree diameter.

<figure two>

We measured the sap sugar concentration on a sunny, warm afternoon using a refractometer, within a two-hour time frame.

To compare the sap sugar concentrations of infected and non-infected trees, we used a 2-sample t-test at an α level of 0.05. We considered differences to be significant $p \leq 0.05$. We used a Pearson Correlation test to examine the relationship between sugar content and diameter.

RESULTS

We found no significant difference in sugar concentrations of infected and uninfected trees ($t = 0.43$, $DF = 35$, $p = 0.671$). Mean and median of infected trees were higher than that of uninfected trees (Table 1).

Table 1: Means (± SD) and medians of sap sugar content of sugar maples infected and uninfected by *G. speciosus*

	Sugar Content (%)	
	Infected	Uninfected
Mean	2.46 ± 0.53	2.39 ± 0.49
Median	2.40	2.30

We could not examine the difference in the growth rates of infected and uninfected trees because growth rings on the core samples were small and did not respond to dyes and thus could not be counted.

There was no significance in the relationship between sap sugar content and DBH in infected ($r = -0.079$, $p = 0.755$) and uninfected ($r = 0.193$, $p = 0.486$) trees (Fig. 3).

<figure three>

Figure 2: Correlation between diameter and sugar content.

DISCUSSION

Because we found no significant difference in sap sugar concentrations of infected and uninfected trees, it appears that the borer may have no effects on sugar content. The infected trees in the study had old scars, indicating old borer attacks. Therefore the trees might have had time to recover and thus do not really represent infected trees.

Concentrations of sap sugar recorded were below the usual average for sugar maples, which is approximately 3.0 (Koellig, 1996). It is possible that the uninfected trees in this study were unhealthy due to some other factor.

Newton and Allen (1982) commented on the difficulty of detecting borer scars. Some damage may have been overlooked, such as fresh attacks, overgrown scars, or situations where the larva died before completing the gallery. As a result, we may have considered some trees to be uninfected when they were actually infected.

We found a non-significant negative trend in the correlation of diameter and sugar content. As diameter increased, sap sugar concentration decreased. The trend was greater in uninfected trees that infected trees (Fig. 3) and it contradicts past studies that have shown a positive correlation with DBH and sugar content (Long, et al, 1998). This could be due to our small sample size.

The original intent of this project was to look at multiple sugar maple groves infected by the borer, but of the three groves we looked at, only one was infected. For further research it would be important to examine multiple infected groves over multiple sugaring seasons. It would also be important to identify and study trees newly infected with the borer.

Our findings may be useful in aiding the management of sugar groves used for maple syrup. Since the borer does not affect the sugar content of sugar maples, grove owners do not need to choose only uninfected trees when tapping.

ACKNOWLEDGEMENTS

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CHARACTERIZATION OF THE MACRO-INVERTEBRATE COMMUNITY OF A TRIBUTARY OF LAKE RAYSTOWN

Colleen Filicky and Andrew Pyle

ABSTRACT

The river continuum concept describes changes in benthic macro invertebrate community structure from the headwaters to mouth of rivers. We examined a small stream in Huntingdon County, Pennsylvania at the Lake Raystown Field Station in March 2001, to see if a continuum in macro invertebrate communities exists on a small spatial scale. We hypothesized that overall species density, richness, and diversity would differ among three sites: a spring area, above a pond, and below a pond. We found a slightly significant difference in overall species density (F = 3.39, DF = 11, *P* = 0.08) among the three sites, the spring site having the highest species density (M = 0.1811 individuals/sq cm), followed by the site above the pond (M = 0.1030 individuals/sq cm) and the site below the pond (M = 0.0809 individuals/sq cm). We found no significant difference in overall species richness (Chi-Square = 2.070, DF = 6, *P* = 0.913) or species diversity (F = 0.28, DF = 11, *P* = 0.764) among the three locales. We also compared abundance of the most common macro-invertebrate groups among the three locales. We found a significant difference in density of a Dipteran (H = 6.84, DF = 2, *P* = 0.033) and in a Plecopteran (H = 8.68, DF = 2, *P* = 0.013). We conclude that overall community structure would not change drastically within a small stream but that specific taxa will. Our study supports the theory that change in community structure of a stream may be explained by the river continuum concept and the effect of a pond on a stream.

Keywords: macro invertebrates, community structure, stream ecology, pond, spring

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INTRODUCTION

The river continuum concept is a holistic view of lotic benthic macro invertebrate communities that exist in streams and rivers. This concept, first developed by Horton and modified later by Strahler, describes changes in benthic macro invertebrate community structure as a river flows downstream (Allan 1995; Resh and Rosenberg 1984).

Rivers and streams are both widely classified by order (Gordon et all 1992). Order 1 and 2 are headwater streams that are permanently flowing and can include 100-250 species of benthic macro

invertebrates. (Allan 1995; Resh and Rosenberg 1984). Common benthic macro invertebrate orders of headwater streams include: Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, and Diptera. The number of species decreases as stream order increases (Resh & Rosenberg 1984).

A factor that may account for changes in a macro invertebrate community structure is obstruction of movement of a stream (Resh and Rosenberg 1984), such as that caused by a dam. A pond can create an altered region downstream, and changes in temperature as well (Resh and Rosenberg 1984).

Does the river continuum concept characterize small streams as it does large rivers? If so, it must be true that in different areas of a stream there are different species that should be present. Also, what effect will a lentic region of a stream have on the community? We hypothesized that among three different sites in one low order stream, obstructed by a pond, that there would be a significant difference in community structure of macro invertebrates.

FIELD SITE

We conducted the study on a 250m stretch of stream at the Juniata College Raystown Field Station, (Fig. 1) located on Lake Raystown in Huntingdon County, Pennsylvania. This low order headwater stream widens as it flows downstream and in the course of the stream is a man-made pond. We selected three sites within the stream: the spring, above the pond, and below the pond (Fig. 2). Our Personal observations of the stream area are that vegetation of the sites varied from thick with weeds to sparse with large trees, when proceeding downstream. Substrate varied from mostly leaf litter to small pebbles and the banks of the stream steepen downstream. Water velocity, discharge, and width all increased downstream.

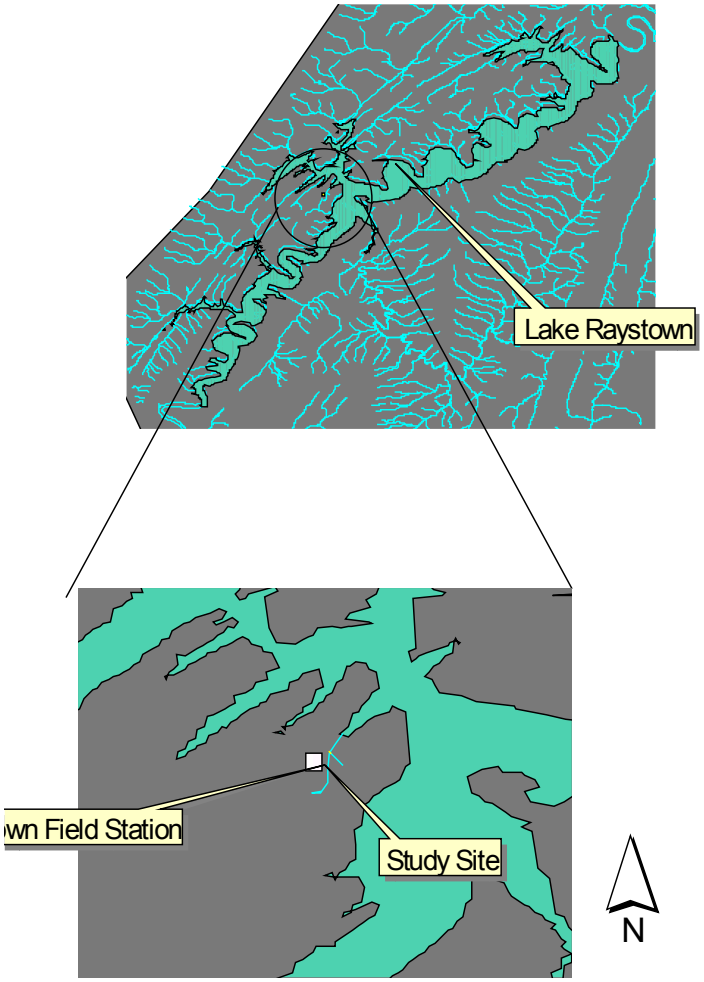


Figure 1. Location of study area Huntingdon County, Pennsylvania.

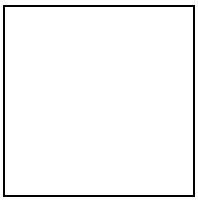


Figure 2. Schematic drawing of our three site locations at the Lake Raystown Field Station in Huntingdon, PA.

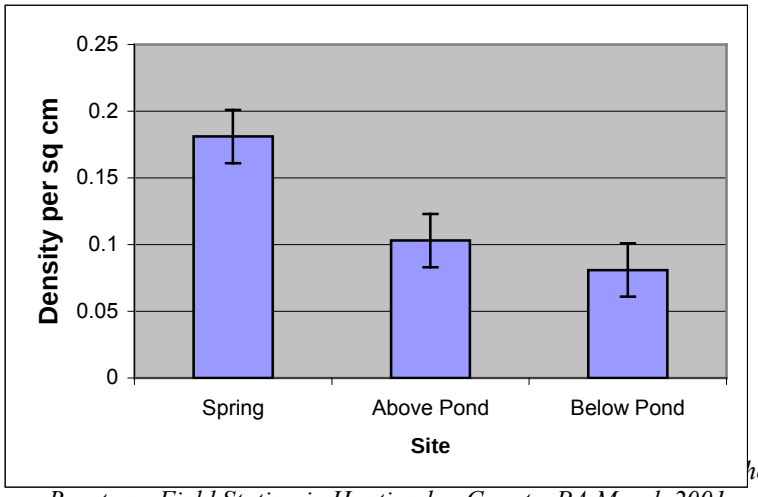
METHODS AND MATERIALS

We sampled on 5 different days in March 2001. We randomly picked four points within each of the three stream sites and recorded four pH and temperature readings, at each sampling site using a Hach pH meter. We sampled macro invertebrates using a 961 sq cm. frame net and a kick technique. We placed the net downstream at each sample site disturbed the area and collected the organisms caught in the net. We sorted through our samples and grouped organisms by order and then separated them into smaller groups labeled A – Z.

We tested our data for equal variances using a Lavene test and for normality with an Anderson-Darling Normality test. We conducted a one-way ANOVA on overall species density. For overall species richness we used a chi-square test. We calculated species diversity using Simpson's index (Brower et all 1998) and then conducted a one-way ANOVA. We compared density of the two most abundant species we using a Kruskal Wallace test. For all of our testing we considered a *P* value less than 0.05 significant and a *P* value between 0.05 and 0.1 slightly significant.

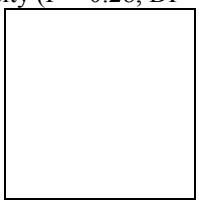
RESULTS

The total number of organisms we collected during our sampling was 1,403 with a total of 26 groups consisting of 6 orders. We found a slightly significant difference in overall species density (F= 3.39, DF = 11, *P* = 0.08) (Fig. 3).



he Lake Raystown Field Station in Huntingdon County, PA March 2001.

We found no significant difference in overall species richness (Chi-Sq = 2.070, DF = 6, *P* = 0.913) (Fig. 4), or diversity (F = 0.28, DF = 11, *P* = 0.764) (Fig. 5).



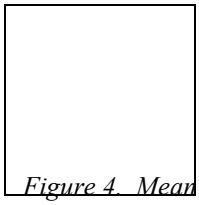


Figure 4. Mean species richness, at three stream sites at the Lake Raystown Field Station in Huntingdon County, PA March 2001.

We did however, find a significant difference in species density for Group D, a type of Diptera (H = 6.84, DF = 2, *P* = 0.033) (Fig. 6) and in species density of Group V, a type of Plecoptera (H = 8.68, DF = 2, *P* = 0.013) (Fig. 7).

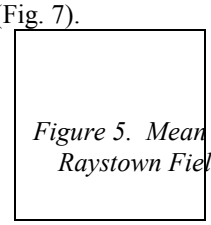


Figure 5. Mean species diversity (D), at three stream sites at the Lake Raystown Field Station in Huntingdon County, PA March 2001.

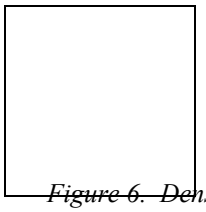


Figure 6. Density per sq cm for Group D, a Dipteran, at three stream sites at the Lake Raystown Field Station in Huntingdon County, PA March 2001.

Figure 7. Density per sq cm for Group V, a Plecopteran, at three stream sites at the Lake Raystown Field Station in Huntingdon, PA March 2001.

DISCUSSION

Our original hypothesis that there would be a significant difference in overall species density, richness, and diversity among the three sites was not strongly supported by our data. This does not mean that this stream did not support the river continuum concept. Species richness and diversity may have not differed significantly due to species replacing each other's niche in different sections of the stream. For example, one type of stonefly may have been present at site 1 but at site 2 another type of stonefly may be present, taking the first stonefly's place in calculations. Our hypothesis was supported by the slightly significant difference in species density. This can be explained by the river continuum concept. Another possibility for this slight significant difference is the pond that was between sites 2 and 3. Mean species density was lowest below the pond. We found that the difference in species diversity of the sites was not significant but the mean was lowest below the pond. The pond could have had an effect on the species because the pond impedes natural movement of the stream, which may have altered lotic regions below the pond, by possibly altering pH and temperature (Resh and Rosenberg 1984). The reason that the pond may

not have altered community structure drastically is that it has been there long enough for macro invertebrates to adapt. However, the pond will always have some effect since water is being changed from a lotic to a lentic system.

Some groups differed significantly in density at each site. Our most abundant group, labeled D and of the order Diptera, had a total of 221 individuals, and differed significantly. Another abundant group of individuals, labeled V and of the order Plecoptera had a total of 213 individuals, also differed significantly. Stoneflies are a good water quality indicator (Kellogg 1994). The highest density of this species was present at the source of our stream. This suggests that water may decrease in quality further downstream. Both group "D" and "V' supports that different kinds of species were present in different areas of the stream.

Our study supported that the stream we conducted our research on was of low order because it was abundant in species and permanently flowing (Allan 1995). It was also supported by the orders present in the stream including, Ephemeroptera, Plecoptera, Trichoptera, and Diptera (Resh and Rosenberg 1984).

A limitation was that this was only the characterization of one small stream. More small streams need to be assessed before this study can be applied to other ecosystems.

AKNOWLEDGEMENTS

We would like to thank Chuck Yohn for his help and advice throughout this project, and also for his use of Raystown Field Station and its facilities, Paula Martin for many useful books and advice on sampling methods, Doug Glazier, for help in identification of one particular species, and the Juniata College Biology Department.

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CHANGE IN COLOR PHASE COMPOSITION OF EASTERN SCREECH-OWL, *OTUS ASIO*, TERRITORIES

Andrea Evans

ABSTRACT

There are two color phases of Eastern Screech-owls, *Otus asio*, rufous and gray. Studies have shown that the rufous phase has a higher metabolic rate than the gray phase. I assessed habitat and color phase continuity by examining residence patterns in sixteen previously studied territories. I tested the hypothesis that there was no change in red and gray color phase composition of screech-owl territories between fall of 2000 and 2001. I used a Johnny Stewart Caller to attract screech-owls to determine color phase. I found no significant difference in color composition of territories between winter of 2000 and 2001(χ^2 =, df = 1, p = 0.420). I also hypothesized that residency of a specific territory does not fluctuate between color phases. I found that 62.5%(5) of the rufous phase territories changed, while 37.5%(3) of the gray phased changed. If one color phase has different territory selection, this could be important for future conservation efforts.

Keywords: color composition, color phase, Eastern Screech-owl, metabolic rate, turnover

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INTRODUCTION

Eastern Screech-owls, *Otus asio*, are common nocturnal predators that are widely distributed through much of Eastern United States (Belthoff and Ritchison 1989). They occur east of the Rocky Mountains, where they are a permanent resident of both rural and urban habitats from south of the Canadian Boreal forest to near the Tropic of Cancer in Mexico (Gehlbach 1995). There are two prominent color phases of the eastern screech-owl, rufous and gray. Hrubant (1955) hypothesized that the two color phases were due to the presence of two or three alleles, where rufous was dominant to gray, with a possible brown intermediate. Studies have shown that rufous phase screech-owls consume more oxygen than the gray phase, especially at low temperatures (-5 to –10° C)(Mosher and Henry 1976). A study by Dexter (1996) also noted that rufous feathers were less efficient at absorbing solar radiation, and speculated that rufous owls had higher metabolic rates to sustain the same body temperature as gray owls. Because rufous phase owls have a higher metabolism, this may effect habitat selection based on prey availability in each territory (Olsen and Mooney 2000). If the prey base does not change, color phase inhabiting that territory should not change. Also, because screech-owls do not migrate, they generally occupy the same areas throughout the year (VanCamp and Henny 1975), and should be found in similar habitats throughout successive years. I therefore hypothesized there will be no change in color phase composition of screech-owl territories between fall of 2000 and 2001. I also hypothesized that residency of a specific territory does not change (turnover). To test this, I revisited Olsen and Mooney's (2000) previously established territories to measure color composition change.

FIELD SITE

I revisited eight rufous and eight gray eastern screech-owl territories found by Olsen and Mooney (2000) in the ridge and valley region of Huntingdon County, Pennsylvania. Site descriptions range from primarily evergreen to primarily deciduous forests (Table 1, Figure 1).

Table 1. Descriptions of 16 screech-owl territories in Huntingdon County, PA, 2000 and 2001.

Territory	Phase 00	Phase 01	Description
Diamond Valley Pond	Red	A	Primarily evergreen, with scattered deciduous, bordered by small stream and pond, lowland
Diamond Valley North	Gray	Gray	Exclusively mixed deciduous , no significant top soil, instead mostly boulders, elevated hillock
Patrick's Lodge	Red	A	Mixed deciduous and evergreens, alongside very small pond formed by dammed stream
Fouse's Crossing	Gray	Red	Primarily deciduous with mixed evergreens, slightly higher peninsula amidst lowland wetlands.
Zinn Springs	Red	A	Mixed deciduous and evergreens, stream lowlands
Supps Gameland S	Gray	A	Exclusive deciduous, immature forest, bordered by power line cut
Muddy Run Headwater	Red	Red	Mixed deciduous and evergreens, stream lowlands
Supps Gameland N	Gray	Gray	Primarily deciduous with scattered evergreens, alongside small clearing
Trail N	Red	U	Primarily deciduous with scattered evergreens, melt-water stream-bed, nearly adjacent to Raystown Branch of the Juniata River
Raystown Dam	Gray	Gray	Primarily deciduous with scattered evergreens, extremely steep slope on both sides of stream.
Trail S	Red	Red	Primarily deciduous with scattered evergreens, adjacent to Raystown Branch of the Juniata River
Logging road	Gray	Gray	Primarily deciduous with scattered evergreens, steep slope on both sides of stream.
James Creek	Red	Gray	An evergreen stand clearly divided from a deciduous stand by a ~20m wide swath of swampy lowlands
Raystown Field Station	Gray	Red	Mixed deciduous and evergreens exposed ridgetop
Diamond Valley South	Red	A	Primarily evergreen with scattered deciduous, small melt-water stream
Fouse's Hill	Gray	Gray	Primarily evergreens with mixed deciduous, steep incline

METHODS AND MATERIALS

I attracted the owls occupying the territories found by Olsen and Mooney (2000) using a Johnny Stewart Caller, which broadcasted the whinny and tremelo calls. I repeated callbacks up to 10 times at 1-minute intervals until owl color phase was positively identified with a spotlight. Each territory was visited until an owl was identified. If no owl was heard or seen on three separate visits then the territory was considered to be abandoned.

I tested for difference in color composition change using a Chi-square test of independence (Ambrose and Ambrose 1995). I used an α level of 0.05 and considered differences to be significant if $p \leq 0.05$. In a like manner, I added turnover and abandoned territories together and compared percentage occupancy.

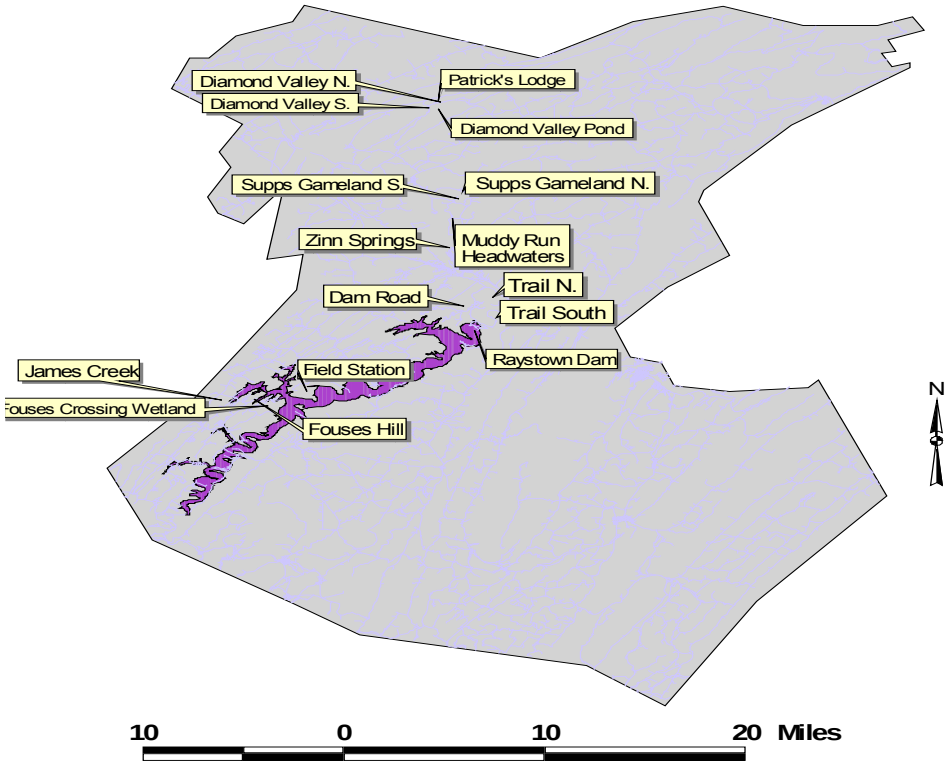


Figure 1. Map of 16 screech-owl territories in Huntingdon County Pennsylvania 2001.

RESULTS

I did not find a significant difference in color composition between winter of 2000 (8 gray, 8 rufous) and 2001(6 gray, 3 rufous), (χ^2 =, df =1, p = 0.4). I recorded one color phase turnover for rufous and 2 turnovers for gray (Table 1), 2 unchanged rufous territories, and 5 unchanged gray territories. One of the rufous territories could not be determined. Abandonment of territories in the rufous owls was more frequent (4) than that of the gray (1). I also found no difference between percentages of combined turnover and abandonment (Table 2). I observed a 62.5% change in the rufous phase, whereas gray phase exhibited a 37.5% change.

Table 2. Turnover in rufous and gray territories in Huntingdon County, Pennsylvania 2000-2001.

	Rufous	**Gray**
Changed	62.5%(5)	37.5%(3)
Unchanged	25.0%(2)	62.5%(5)

DISCUSSION

Reasons for a color phase change in a territory could be due to physical and biological limitations. Because the average lifespan of a screech-owl in the wild is 4 years (Gehlbach 1995), the resident owl could have died and another color phase may have entered its old territory. The reason for the gray phase screech-owls seeming to have lower amount of territory change (37.5% vs. 62.5%) could be a result of better nesting success than the rufous owls. It is known that females with successful broods will reuse an original nest site. Only 24% of females switch to alternative nest after previous success (Gelbach 1995). Switches are usually due to disturbance, death of mate, or divorce related to provisioning. Because availability of prey is another factor that potentially influences home range size in owls (Belthoff et al 1993), the population of mice may have declined accounting for the abandoned territories. The drought in 2001(personal observation) might have affected the productivity of the prey supply thus affecting the color composition in each territory. Olsen and Mooney (2000) determined that the prey base was larger in rufous phase territories than in gray. However, they assumed that both phases had the same territory size. Delineation of territory size of individual owls would help to determine whether or not rufous and gray owls have the same territory size. If this were the case, prey base area would also be similar and more efficient mouse trapping efforts could be managed. Fidelity of color phase composition in territories could be important in relating certain behavior differences between rufous and gray color phases.

ACKNOWLEDGEMENTS

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Dissolved Oxygen Depletion in Raystown Lake PA Among the years 1974-5, 1998 and 2000

Rebecca Degagne, Charles Yohn, Jennifer Smith, and Laurence Mutti

Juniata College Department of Environmental Studies and Juniata College Geology Department
Huntingdon, PA 16652

ABSTRACT

Raystown Lake is a 30-mile long reservoir located in the Huntingdon and Bedford counties of Pennsylvania. Created in 1973, Raystown is an important recreational resource that receives over 1.5 million visitors per year; thus, water quality is a prime concern. Recent studies suggest dissolved oxygen depletion has occurred over past years, indicating a decrease in lake health. We examined average oxygen depletion rates for Raystown Lake's three trophic zones over the summers of 1974-5, 1998, and 2000 to determine if the overall depletion rate increased or if its spatial (longitudinal) pattern changed over the years. We found that the reservoir's overall dissolved oxygen depletion rate significantly increased since the 1970s ($F = 4.51$, $df = 2$, $p = 0.044$) but did not differ significantly between 1998 and 2000 ($F = 3.38$, $df = 2$, $p = 0.082$). Additionally, we determined that in the 1970s the rate of oxygen depletion had a significantly different spatial pattern than it did in 1998 and 2000. More specifically, in the lacustrine zone during the 1970's, the rate of oxygen depletion was significantly greater than in 1998 and 2000 ($F = 9.38$, $df = 2$, $p = 0.006$), but in the transitional ($F = 6.06$, $df = 2$, $p=0.030$) and riverine ($F = 6.38$, $df = 2$, $p=0.035$) zones it was significantly less than in 1998 and 2000.

Keywords: Eutrophication, Dissolved Oxygen Depletion, Raystown Lake, Spatial and Temporal Patterns.

INTRODUCTION

Raystown Lake is a man-made reservoir located in south-central Pennsylvania in Huntingdon and Bedford counties. It was created by the Army Corps of Engineers in 1973 as a flood control project and filled to its current level in 1975. Water quality of Raystown Lake has been an issue of prime concern since that time. Reasons for this include the high intensity use of the lake for fishing and other recreational activities, hydropower, water management, and wildlife enhancement. The watershed of Raystown Lake encompasses 2490 km^2 (960 mi^2), but only a small portion of this area is developed for residential or industrial use. Because the majority of the surrounding land is either forested or utilized for agricultural purposes, the largest threat to the reservoir's water quality is eutrophication, not industrial or cultural contamination. It has been suggested that the rate of eutrophication has increased significantly over past years (Army Corps, unpublished data).

The amount of dissolved oxygen present during the summer-stratified period of a reservoir, its rate of depletion, and its depth profile can all serve as indicators of the water body's health (Herve 2000, Cole 1994, Cole 1990). Oxygen profiles in Raystown Lake demonstrate a negative heterograde curve, which is characterized by an oxygen minimum present in the metalimnion (Cole 1994). (Figure 1). This curve is often found in deep, narrow reservoirs (Cole 1990), with morphology similar to that of Raystown Lake. A previous study of the reservoir suggests that in this specific case, the negative heterograde profile is created by significant decomposition and respiration processes occurring at the metalimnionic level (Simpson

1998, unpublished data). Raystown's vertical depletion pattern is characterized by the decrease of metalimnionic oxygen levels throughout the summer until anoxia is reached (O_2<0.3 mg/L), and the consequent spread of the anoxic zone to the hypolimnion. (Figure1). Several processes detrimental to water quality and an ecosystem's overall health can be activated if significant depletion takes place in the hypolimnion. Two of main concern are: nutrient loading due to positive redox feedback loops, and fish-kills caused by the lack of oxygen needed for normal respiration (Herve 2000, Cole 1990).

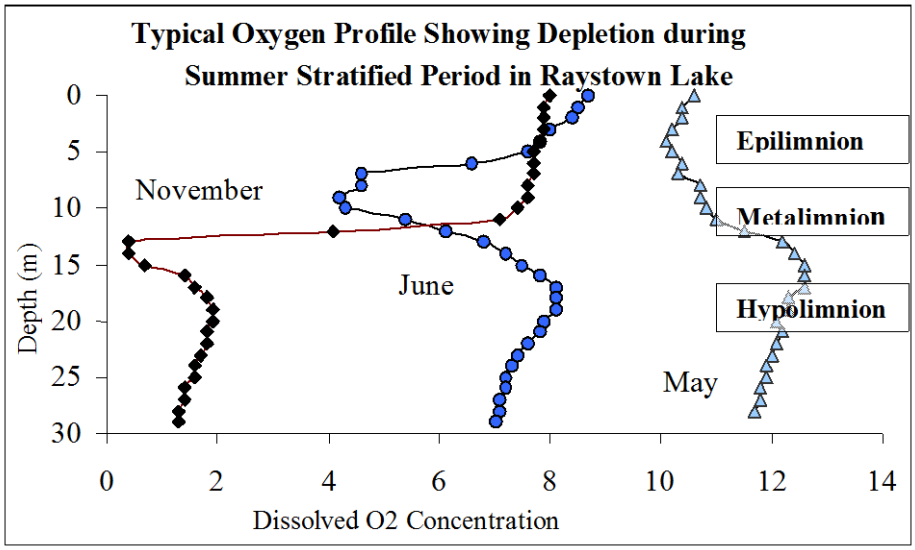


Figure 1. Dissolved oxygen profile showing a typical depletion pattern over the summer-stratified period in Raystown Lake PA.

In this study, we compared dissolved oxygen depletion rates among the time periods 1974-5, 1998, and 2000, in order to determine if oxygen depletion has indeed increased over the past 20 years. We chose rate of depletion (mg/L/Day) as a measure of depletion because it is relatively unaffected by time differences in spring and fall turnover among the years. We also compared oxygen depletion rates for each year among the reservoir's trophic zones to characterize longitudinal, spatial patterns taking place.

METHODS AND MATERIALS

Field Site

We chose 17 sites to sample along the length of the reservoir (Figure 2), including 4 sites sampled during 1974 and 1975 (Williams 1978) and 15 sites sampled during 1998 (Simpson 1998, unpublished data).



Site	Dist. (m)
R1	0.1
I2	2
R21	2.8
R6	6
B1	8.3
R8	9
R20	10.8
R10	13
I2	13.8
I3	14.5
R12	18
I4	20.3
R16	20.5
B4	21.5
I5	21.7
R22	22.2
R23	25.5

Figure 2. The geographic locations of sampling sites on Raystown Lake PA for the 1970s, 1998, and 2000 are shown with their corresponding distances from the dam.

Dissolved Oxygen

Sampling

We recorded dissolved oxygen (mg/L) and temperature (C) profiles at each of the 18 sites with a YSI dissolved oxygen meter (EPA method 306.1). For each depth profile we took readings at 1 meter intervals until we reached either the lake bottom or 29 meters. We began monitoring oxygen and temperature profiles in May and continued sampling at weekly intervals until August. We then continued on a bimonthly schedule until November. When possible (weather and schedule permitting), sampling for the entire reservoir was completed in one day, from approximately 8 AM to 3 PM. If this was not possible, we sampled sites from mile 14 to 24 on one day, and completed the remainder of the sites no more than 2 days later.

Determining Depletion Rate

We calculated the rate of oxygen depletion (mg/L/Day) at each site using the following method. First, for each profile, we determined the extent of depletion (mg) by subtracting the minimum amount of O_2 from the amount of O_2 in the epilimnion. Next, we plotted the extent of depletion versus time, defined as the number of days into the year until maximum extent of depletion was reached. We used the slope of this graph's linear regression line (Sokal and Rholf 1995) as a measure of dissolved oxygen depletion rate. We chose this method to eliminate variation among time periods caused by differences in equipment calibration.

Trophic Zones

We assigned each of our sample sites to one of three trophic zones, based on mean annual Secchi depth (m) (Thornton 1990). (See Table 1). We then calculated mean values of oxygen depletion for each zone for each time period, and used this set of values in statistical analysis.

Table 1. Span of trophic zones in Raystown Lake PA, as defined by Secchi depth, and number of sites per trophic zone sampled during the years 1974&5, 1998, and 2000.

Trophic Zone:	Lacustrine	Transitional	Riverine
Miles From Dam:	0-11	12-18	18-26
Secchi Depth Range:	Above 5m	3-5m	0-3m
# Sites Sampled In:			
1974 &5	4	2	2
1998	5	5	4
2000	6	6	5

Statistical Analysis

We tested all data for normality and pooled the data for 1974 and 1975 after preliminary statistical tests showed no significant difference in depletion rate, either between years or among zones. Next, we compared depletion rates among the three time periods and three trophic zones using a two-way analysis of variance fixed effects model (ANOVA) with an alpha level of 0.05. We also tested for differences among depletion rates within each trophic zone for each time period (1974-5, 1998, and 2000) using a one-way ANOVA. We considered differences to be significant if $p < 0.05$ and used Tukey's test for posteriori pairwise comparisons (Sokal and Rholf 1995).

RESULTS

Overall Oxygen Depletion Rate

We found the following trends throughout the entire reservoir, among the given time periods. (See Figure 5). First of all, the overall rate of depletion in the 1970's was significantly lower than that in 1998 and 2000 ($F = 4.51$, $df = 2$, $p = 0.044$). Secondly, the overall rate of depletion for 1998 and 2000, was significantly different among all three trophic zones ($F = 20.68$, $df = 2$, $p = .000$), with the lacustrine zone having the lowest depletion rate and the riverine zone having the greatest. Furthermore, there was a non-significant trend towards a greater overall depletion rate in 1998 than 2000 ($F = 3.38$, $df = 2$, $p = 0.082$). There was another non-significant trend in the 1974 -5 time period towards a greater overall depletion rate in the lacustrine zone ($F = 4.32$, $df = 2$, $p = 0.081$).

Longitudinal Pattern: A Comparison of Oxygen Depletion Rates among years, within specific Trophic Zones

(See Figure 5). For the lacustrine zone, nearest to the dam, the depletion rate was significantly greater in the 1970s than it was in 1998 and 2000 ($F = 9.38$, $df = 2$, $p = 0.006$). Alternatively, for the transitional zone, the depletion rate was significantly less in the 1970s than in 1998 ($F = 6.06$, $df = 2$, $p=0.030$). Likewise, for the riverine zone, furthest from the dam, the depletion rate was significantly less in the 1970s than in 1998 and 2000 ($F = 6.38$, $df = 2$, $p=0.035$).

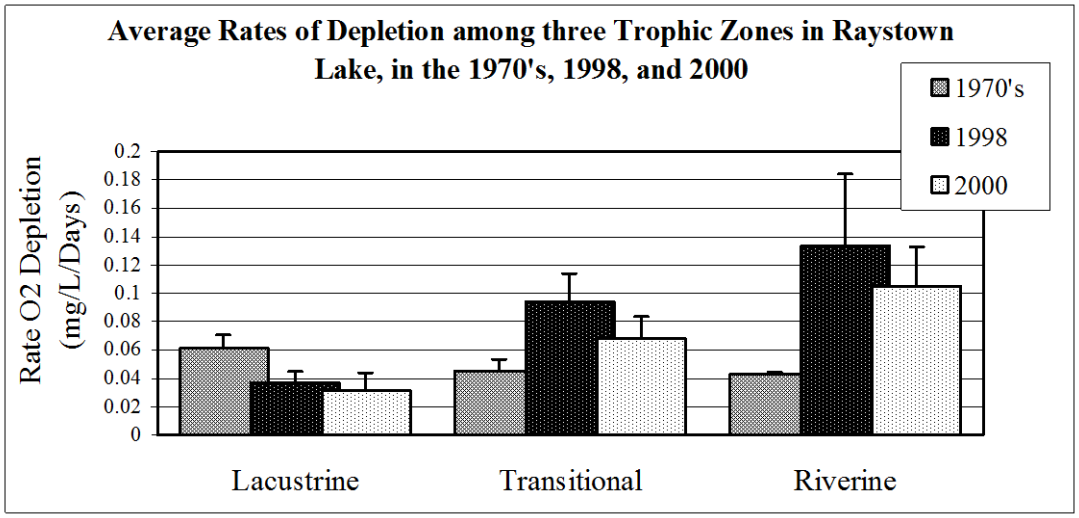


Figure 5. Average rates of oxygen depletion for the lacustrine, transitional, and riverine zones of Raystown Lake PA are shown for the 1970s, 1998, and 2000.

DISCUSSION

Overall Depletion Rate

Our results indicate that significant dissolved oxygen depletion has occurred throughout Lake Raystown since the 1970s. The significantly lower oxygen depletion rate in the 1970s than in 1998 and 2000, suggests that Raystown Lake has become more eutrophic and water quality has decreased over this time span. The statistically insignificant trend towards a decreasing oxygen depletion rate from 1998 to 2000 is most likely due to differences in meteorological conditions, such as wind activity and precipitation between the years (Cole 1990). Studies of other reservoirs suggest that if the rate of oxygen depletion in the metalimnion continues to increase in the future as it has over the past 20 years, a threat of anoxia spreading to the hypolimnion could become eminent (Cole 1990). It should be noted that eutrophication is a natural process that takes place over a lake's life span; however, anthropogenic sources can accelerate its progression and decrease the water body's potential human use and value faster than what is "normal" (Cole 1994). Therefore, we suggest that further monitoring and study of dissolved oxygen depletion in Lake Raystown would be appropriate and beneficial.

Longitudinal Depletion Pattern

The oxygen depletion pattern in 1998 and 2000 is identical to that found in a previous study on Raystown Lake (Simpson 1998, unpublished data) and is typical of reservoirs possessing similar morphological and physical characteristics (Thornton 1990). During the 1970's, however, the oxygen depletion pattern deviates drastically from our expected one. For this time period, the rate of depletion among zones does not significantly differ, although the lacustrine zone shows a trend towards a higher rate of depletion. A probable explanation for this pattern is that the recent impoundment construction resulted in a flush of organic material and debris towards the dam, where their decay produced significant oxygen depletion.

ACKNOWLEDGMENTS

We thank the Juniata College Field Station and the Juniata College Departments of Environmental Science and Geology for use of their facilities and equipment. We also extend our appreciation to all of the people who helped carry out sampling on Raystown Lake and to Chuck Yohn and Larry Mutti for their advice and guidence.

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EFFECTS OF THE CLEAN WATER ACT ON WATER QUALITY: a temporal comparison of water quality on the Susquehanna River Basin.

Diego F. Arteaga and Maria F. Olmedo

ABSTRACT

The establishment of the Clean Water Act in 1972 was a new approach intended to eliminate the discharge of pollutants into the nation's waters by 1985 and achieve water quality levels that are fishable and swimmable by 1983. The goal of this study is to investigate the effect of legislation on water quality in the Susquehanna River Basin. We compared data of five water quality parameters between two periods of time: 1973-1982 to 1983-1993. The water parameters include: total nitrogen, dissolved oxygen, pH, phosphorus and aluminum. We found that pH levels (p= 0.029), dissolved oxygen (p= 0.021) and aluminum levels (p = 0.000) improved between 1972-82 to 1983-93. However Nitrogen in all the stations and phosphorus (p= 0.048) at two of the stations did not show an improvement. Given that nitrogen and phosphorus primary come from farm runoff the Clean Water Act of 1972 seemed not to be effective in dealing with non point sources of pollution.

Keywords: water quality, Susquehanna River Basin, legislation, Clean Water Act.

INTRODUCTION

The 1972 amendments to the Federal Water Pollution Control Act, commonly known as the Clean Water Act, created the nation's landmark environmental legislation (CEQ Report 1993). The fundamental goals of this Act were to eliminate the discharge of pollutants into the nation's waters by 1985 and achieve water quality levels that are fishable and swimmable by 1983 (EPA 2001). State governments and industry responded to regulations that control the discharge of pollutants into waterways, by reducing discharges,

becoming more efficient in water use, reducing the production of wastes and improving the recycling of waste products (CEQ Report 1993).

The Clean Water Act was not as effective as it was previously thought. Its goals were too ambitious, lack of enforcement and control of non point sources of pollution were some of its major flaws (Copeland 1999) and therefore, several amendments have been necessary. Major amendments after 1972 have been The Clean Water Act of 1977, Municipal Wastewater Treatment Construction Grants Amendments of 1981, and Water Quality Act of 1987.

According to the EPA, the quality of the U.S. waters have improved dramatically as a result of the implementation of the pollution control programs established in 1972 by the Clean Water Act (EPA 2001). However, enforcement of the act and its amendments has been a continuous process and a number of problems remain (Copeland 1993). Evaluation of the implementation of these amendments is needed in order to know the effects that legislation has had on water quality.

The Susquehanna River Basin covers half the land area of Pennsylvania and portions of New York and Maryland (27,500 square miles) (SRBC 2001). The Susquehanna River is the largest tributary of the Chesapeake Bay and accounts for almost half (45.7 %) of Pennsylvania's stream miles (SRBC 2001). Population and land use in this area have changed throughout the years. By 1999 it had 4.1 million residents and it consisted of more than 65 percent of forestlands (SRBC 1999).

The Susquehanna River Basin Commission has been the main public entity in charge of water quality in the region. Past research in different areas of the basin have shown an improvement in water quality. Metzgar (1977) stated that the majority of the Lower Susquehanna basin had a good water quality with high levels of dissolved oxygen. McGarrel (1997) stated that the water quality of several streams in the Juniata Watershed has improved dramatically since the late 1970s. Also, a study of nutrient concentrations in the Susquehanna River Basin from 1985 to 1996 indicated downward trends in concentrations of total nitrogen and phosphorous (Lindsey et.al 1998). In addition, a study covering the period 1974 to 1993 of the Susquehanna River Basin, reported that trends in total phosphorus were predominately downward in three of five stations (Edwards 1995). However, other studies have shown other problems. Metzgar stated that the West Branch of the Susquehanna Basin exhibits poor water quality, due especially to an acid mine drainage problem (Metzgar 1977) and in 1999 the Susquehanna River Basin

Commission stated that acid mine drainage continued to be an issue in the area (SRBC 1999). In 1995 Edwards found an upward trend in total nitrogen and phosphorus (Edwards 1995).

The goal of this study is to further investigate the effect of legislation on water quality in The Susquehanna River Basin, by comparing data of five water quality parameters between the periods of 1972 to 1982 and 1983 to 1993. We tested the hypothesis that Nitrogen, Dissolved Oxygen, pH, Phosphorus and Aluminum levels did not differ between 1972-82 and 1983-1993.

STUDY AREA

We selected four stations within the Susquehanna River Basin from the US Geological Survey database (USGS 2001a). These stations have recorded water quality data for the years 1972 to 1993. The stations were: the Juniata River at Saxton, the Juniata River at Newport, Susquehanna River at Harrisburg and Young Woman's Creek near Renovo (Fig. 1).

The stations at Saxton and Newport are located in the Juniata River basin in south-central Pennsylvania. This basin drains about 3,400 square miles. It is characterized by a series of tightly-folded parallel mountains and long narrow valleys. The basin is mostly composed by carbonate rock (Lindsey et.al 1998). Oak, hickory and maple cover most of the basin (JCWP 2000). The Susquehanna River station at Harrisburg is located in the Lower Susquehanna Watershed. The southern part of the basin contains most of the population and some of the most productive agricultural land in the Nation. This area is for the most part underlain by carbonate bedrock. The Young Woman's Creek area is characterized by high, flat-topped uplands dissected by steep- sided stream valleys. Young Woman's Creek is a southwest-flowing tributary of the West Branch of the Susquehanna River. Second and third growth oak-hickory and maple-beech-birch forest types cover the basin. Sandstone, conglomerates and shale compose its bedrock (USGS 2001b).

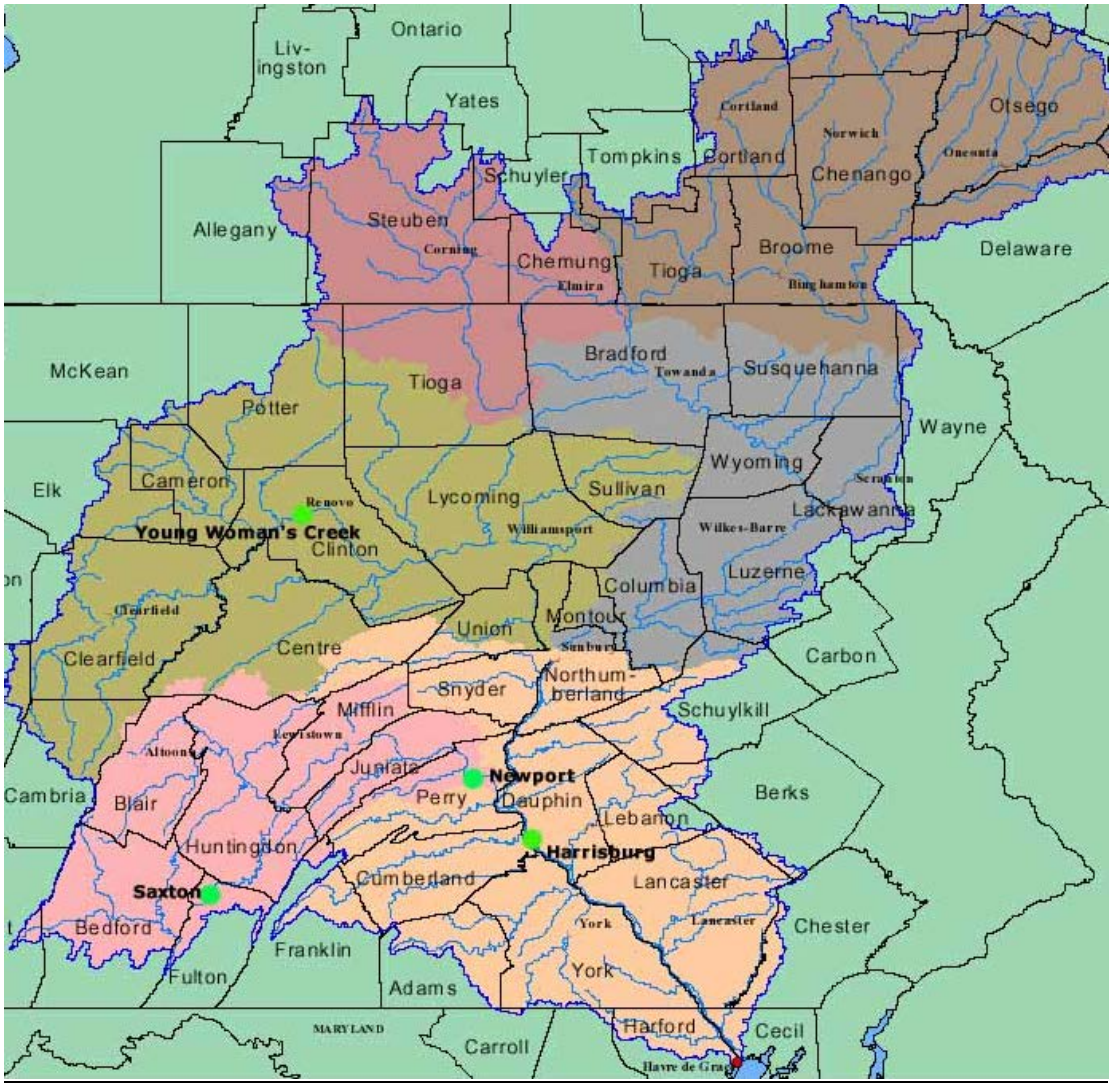


Figure 1. Map showing the stations of Newport, Saxton, Harrisburg and Young Woman's Creek at the Susquehanna River Basin.

METHODS AND MATERIALS

We divided water quality data into two periods of time: 1972-1982 and 1983-1993. We selected five chemical water quality parameters for each station. The parameters were total nitrogen, mg/L as N, dissolved oxygen, m/L, phosphorus mg/L as P, aluminum, ug/L as Al and pH in standard units.

We checked our data for normality using the Anderson-Darling normality test, and ran a test for equal variances in each of the five chemical water quality parameters. We used the Wilcoxon signed rank test to compare total nitrogen. We used a paired design for dissolved oxygen, pH and phosphorus to account for variability among stations. We paired the means of the two periods of time (1972-82 and 1983-93) for each of the four stations and ran a paired t test. We used a two-sample t test for aluminum because

the data for this parameter was available from only in one of our four stations. We used an alpha level of 0.05 and we considered a *P* to be significant $\leq$ 0.05.

RESULTS

We found mean total nitrogen to be significantly greater in 1983-93 (1.07) than in 1972-82 (0.71) (Fig. 2). We found mean dissolved oxygen to be significantly greater in 1983-93 (11.07) than in 1972-82 (11.16) (T= 4.50, DF = 3, *P*= 0.021) (Fig. 3). In a like manner we found mean pH levels to be significantly greater in 1983-93 (7.54) than in 1972-82 (7.29) (T = 3.96, DF 3, *p*= 0.029) (Fig. 4). We found mean phosphorus concentration to be significantly greater in 1972-82 (0.072) than in 1983-93 (0.064) (T= 3.22 , DF= 3, *P*= 0.048) (Fig. 5). Finally, we found mean aluminum concentration to be highly significantly greater in 1972-82 (1123.42) than in 1983-93 (29.64) (T= 3.76, DF = 206, *P* = 0.000) (Fig. 6).

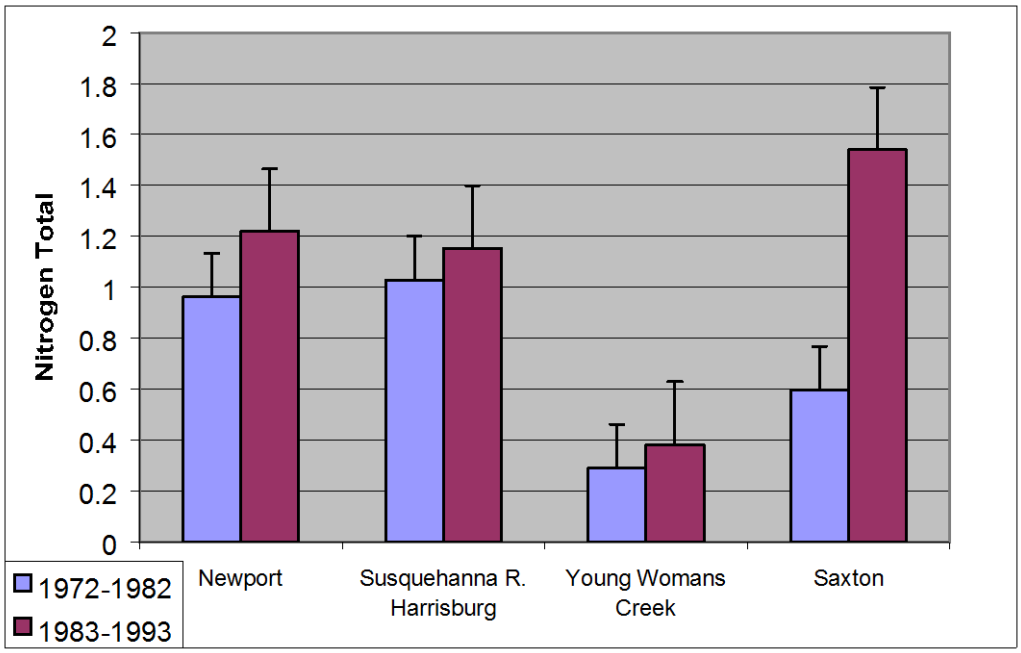


Figure 2. Total nitrogen mean concentrations for the 1972/82 and 1983/93 time periods at each of the stations on the Susquehanna watershed.

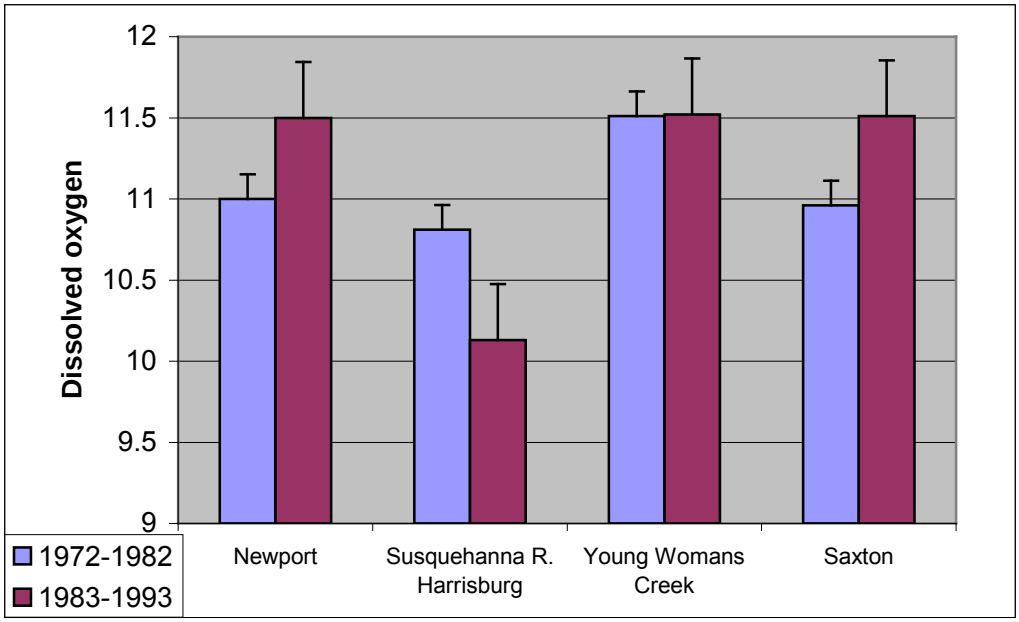


Figure 3. Mean dissolved oxygen concentrations for the time periods 1972/82 and 1983/93 at each of the stations on the Susquehanna watershed.

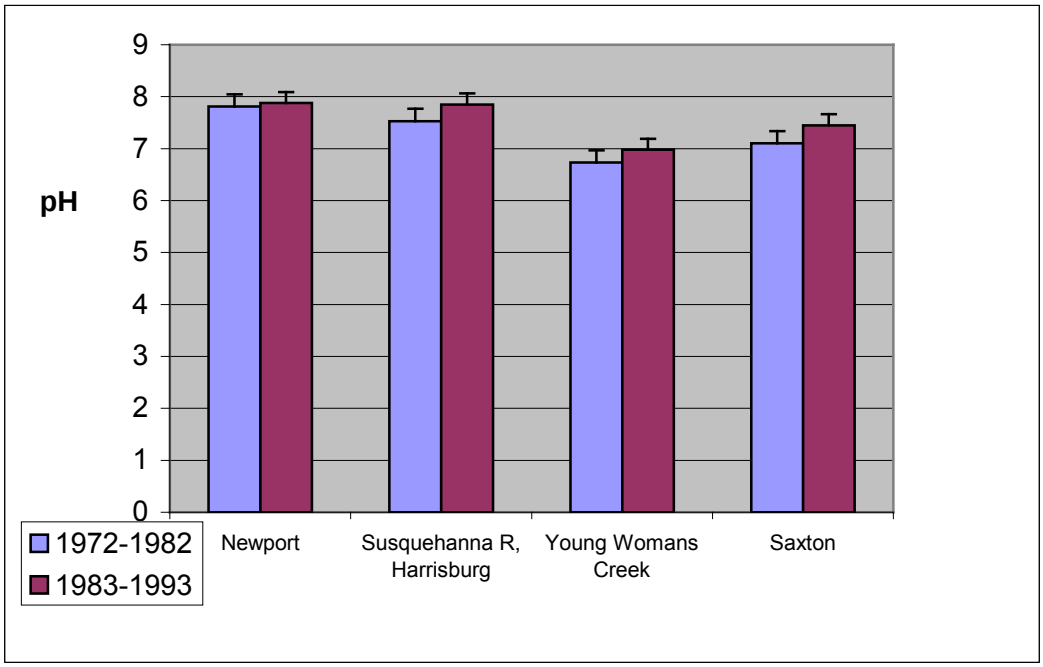


Figure 4. Mean pH for the time periods 1972/82 and 1983/93 at each of the stations on the Susquehanna watershed.

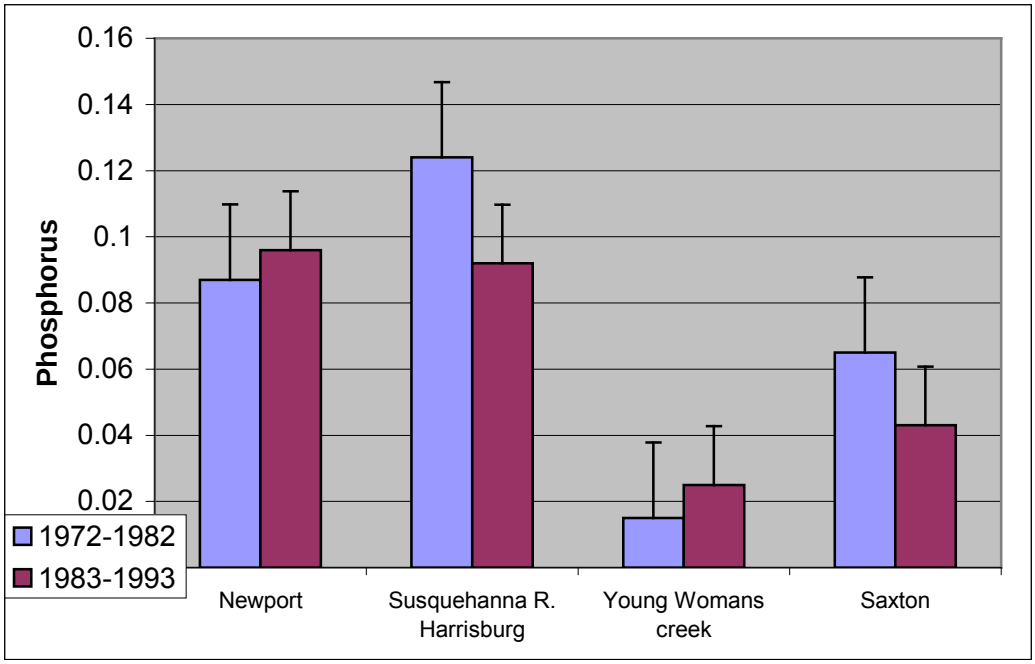


Figure 5. Mean phosphorus concentrations for the time periods 1972/82 and 1983/93 at each of the stations on the Susquehanna watershed.

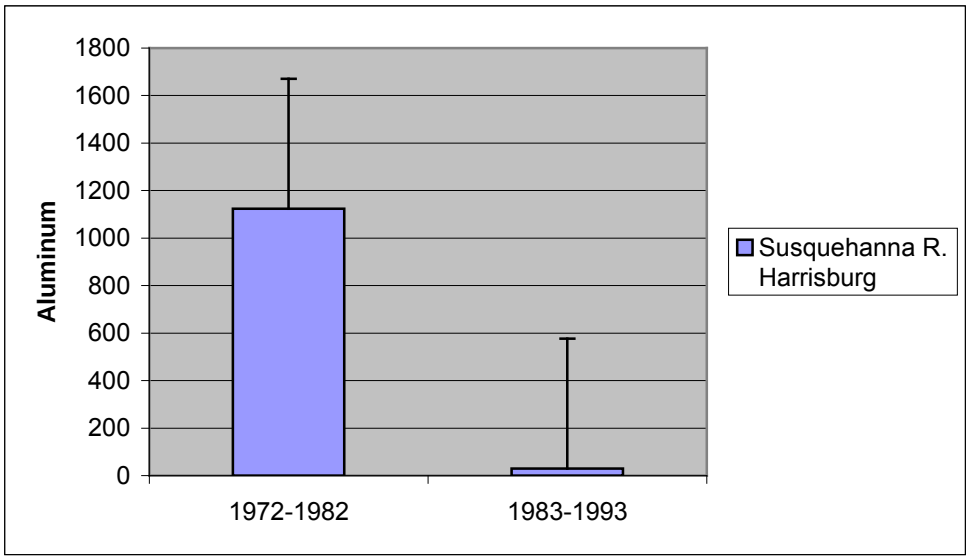


Figure 6. Means concentrations of aluminum for the time periods 1972/82 and 1983/93 at the Harrisburg station.

DISCUSSION

Contrary to our expectation, we found a significant increase of nitrogen in all the stations and an increase in phosphorus concentrations in two (Newport and Young Woman's Creek) of four stations. Our study does not show evidence to support USGS statement that total nitrogen and phosphorus concentrations

in the Susquehanna River decreased in the 1985-96 time period (Lindsey et.al 1998). The causes for the increasing concentrations of nitrogen and phosphorus might be the increasing runoff from farmland, especially manure and discharges from urban and rural developments, such as sewage. Lastly ineffective legislation can be another reason as for why we found increasing concentrations for both of these parameters.

Our dissolved oxygen levels for the 1983/1993 period increased in three stations and decreased in one. However, all DO levels stayed above 5mg/L, the minimum for aquatic life (British Columbia 1998). Our pH levels increased at all stations for the 1983/1993 period and stayed between the 4.5 and 9.5 criteria for aquatic life (British Columbia 1998). We did not find evidence to support previous studies at the West Branch of the Susquehanna River Basin that showed an acid mine drainage problem associated with low pH (Metzgar 1977 and SRBC Report 1999). Legislation might have contributed to maintain dissolved oxygen and pH levels between the aquatic life criteria.

Our aluminum concentrations decreased dramatically in the 1983/93 period. This might be due to a positive effect of legislation. Legislation has targeted industry discharges and industrial effluents such as dye and paper manufacturing which are common sources of aluminum.

A limitation of our study was the lack of data for the aluminum analysis. Our results do not give a general idea of how the aluminum conditions are in the entire Susquehanna watershed. Therefore further research in this specific parameter should include more stations.

ACKNOWLEDGEMENTS

We would like to thank Chuck Yohn for all the help with this project.

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2002

Effect of Soil Type on Susceptibility to the Sugar Maple Borer at the Raystown Field Station

Kimberly Campanaro

ABSTRACT

I examined the relationship between three soil types, Ernst Silt Loam, Blairton Silt Loam, and Berks Shaly Silt Loam to the number of sugar maple trees (*Acer saccharum)* infected with the sugar maple borer (*Glycobius speciou*s) at the Raystown Field Station. Total mean infection rates in Ernst (16.7%) and Blairton (6.5%) was greater than that in Berks (0%) ($F = 2.35$, $df = 8$, $P = 0.117$). I also found that the density of trees within each soil plot had no significant relationship to the frequency of trees infected (R-Sq = 13%). Overall, Berks soil had the lowest relative density of sugar maples. My findings show that there is no correlation between infection rates to tree density, but that infection rate is slightly significantly different among soil types.

Keywords: *Acer saccharum, Glycobius speciosus*, *sugar maple borer, sugar maple, stress*

INTRODUCTION

Sugar maple (*Acer saccharum)* mortality has reached unusually high levels across northern Pennsylvania since the mid-1980's (Horsley et al. 2000). Previous studies have indicated that the decline of sugar maples can be linked to soil acidification. The nutrient factors associated with dieback disease include the interaction of Mg and Mn (Horsley et al 2000). The roles of Mg and Mn nutrition and defoliation stress in plant carbohydrates suggest that root storage carbohydrates may be an integrating factor in sugar maple decline. Other significant factors include insect defoliation, drought, late spring frost, and midwinter freeze-thaw cycles (Horsley et al 2000). Stressed sugar maples are a common occurrence on soils with a low pH.

One specific factor associated with maple decline is the sugar maple borer, *Glycobius speciosus*. The sugar maple borer is a long horned wood-boring beetle that thrives on stressed sugar maple (Forest Service 2002). Although the borer rarely kills sugar maples, small populations can cause substantial damage by laying eggs into cracks or under bark scales. Once hatched, the larva makes a winding mine beneath the bark. Within the first year, the larva makes a deep, horizontal, groove in the sapwood that partially encircles the bole or branch as it spirals upwards. By the second year, a J-shapes tunnel (*Fig. 1*) forms deep within wood where the borer remains until emerging as an adult (Forest Service 2002). Within this J-shaped bore decay is more likely to develop compared to horizontal bore cuts (Sendak et al. 1997). The maple borer destroys portions of the translocation tissue in the trunk and large branches, resulting in crown dieback. This restricts photosynthesis causing sap flow to reduce (Newton and Allen 1982). The sugar maple borer usually invades stressed trees or ones that are located near a supply of dead wood (Greifenhagen 2000).

The goal of my study was to compare the frequency of maple borer infections among three soil types and to examine the relationship between tree density and maple borer infection rate.

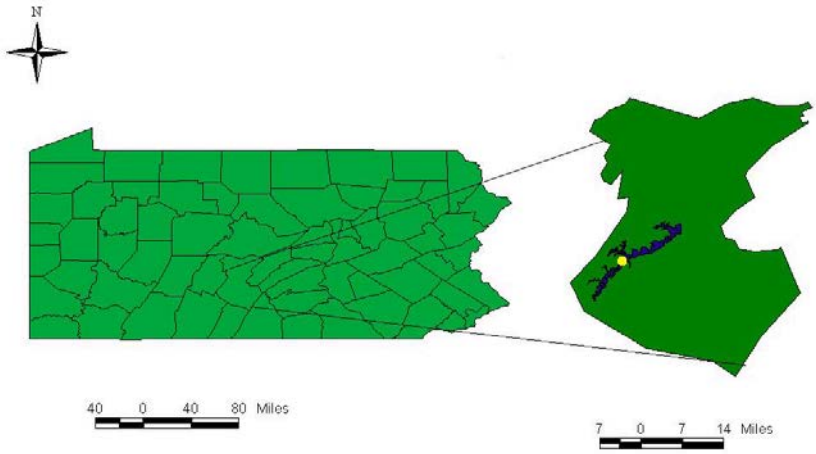


Figure 1: The J-shaped cut in a board sawn from a borer-infested tree.

FIELD SITE

I conducted this study at the Raystown Field Station, Entrikin Quadrangle in South Central Pennsylvania (Fig. 2), in a sugar maple grove located on three soil types; Ernst Silt Loam, Blairton Silt Loam, and Berks Shaly Silt Loam (Fig. 3).

Figure 2: The location of the Raystown Field Station (dot) in relation to Huntingdon County, PA.



These soil plots are located between the Juniata College field station house and Raystown Lake. Ernst Silt Loam is a gently sloping soil with medium runoff and a moderate hazard to erosion in disturbed or cultivated areas. Areas of Ernst Silt Loam have a seasonal high water table. Blairton Silt Loam consists of moderately deep and poorly to moderately well drained soils. These soils formed in weathered shale, siltstone, and fine-grained sandstone. Blairton Silt Loam is moderately low in permeability with available water capacity at low to moderate. Berks Shaly Silt Loam has medium runoff and moderate hazard to erosion (Soil Survey of Huntingdon County 1983).

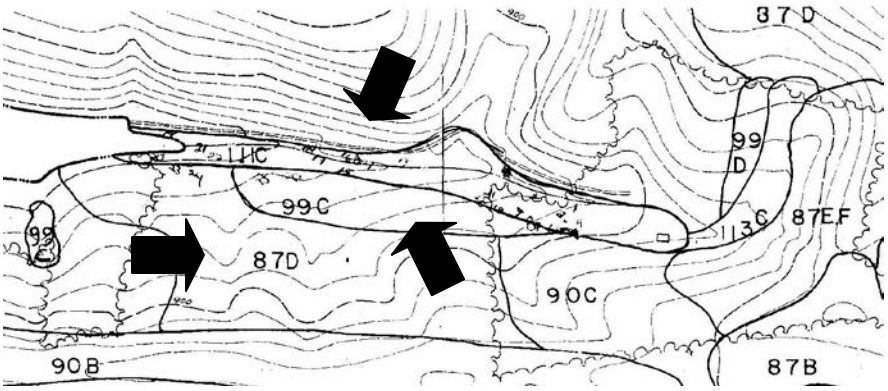


Figure 3: Locations of soil types Ernst Silt Loam (111C), Blairton Silt Loam (99C), and Berks Shaly Silt Loam (87D) at the Raystown Field Station, Entrikin PA.

METHODS AND MATERIALS

I surveyed sugar maple trees at the Raystown Field Station during late October through early November 2002. I randomly selected three, 20m x 20m quadrants, in each soil type Ernst Silt Loam (Ernst), Blairton Silt Loam (Blairton), and Berks Shaly Silt Loam (Berks). For each tree (dbh>7.5 cm) I recorded the dbh in centimeters, using a dbh-measuring tape, and the number of unhealed and healed sugaring tap holes. I also made observations of the canopy, forest floor covering, and amount of dead wood in each quadrant.

I compared infection frequency among the 3 soil types using an One-Way Analysis of Variance (Introductory Biological Statistics) and compared the density of trees to the infection rate with a linear regression (Introductory Biological Statistics). I considered differences to be significant if $P \leq 0.05$.

RESULTS

The mean infection rates in Ernst (16.7%) and Blairton (6.5%) was greater then that in Berks (0%) ($F = 2.35$, $df = 8$, $P = 0.117$) (*Fig. 4*). I also found that the density of trees within each soil plot had no significant relationship to the frequency of trees infected (R-Sq = 13.0%) (*Fig. 5*). Soils Ernst and Blairton had more sugar maple trees compared to the total of all other species combined (*Fig 6*). Berks soil had fewer sugar maples compared to all other tree species combined.

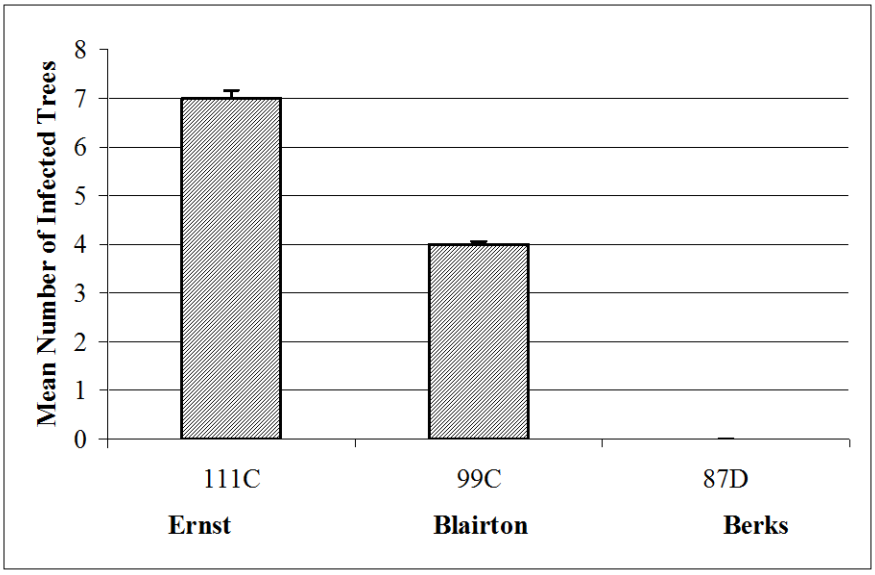


Figure 4: The number of trees infected with the Maple Borer among three soil types during fall 2002 at the Raystown Field Station.

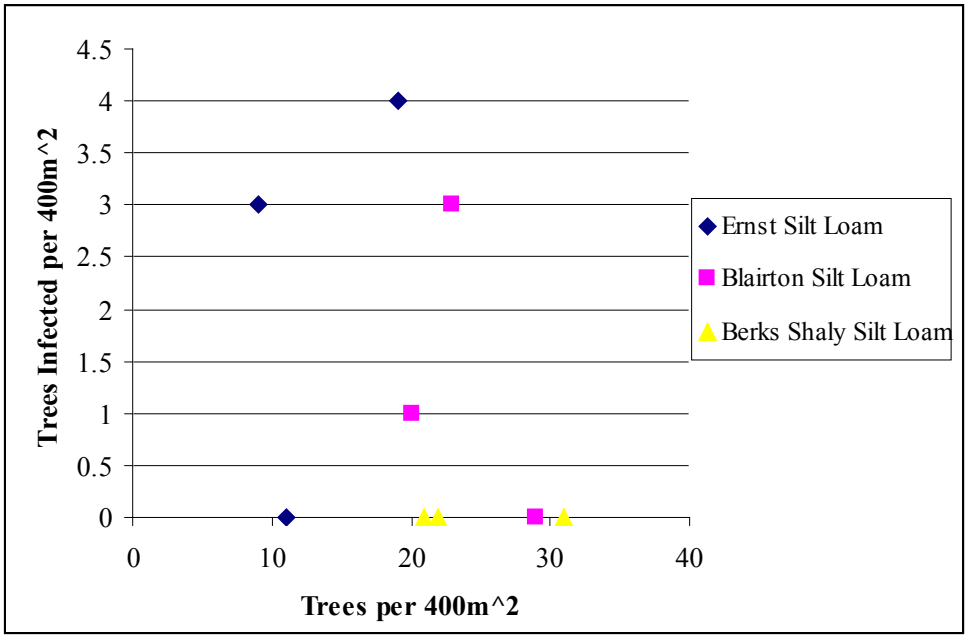


Figure 5: The number of trees infected with Maple Borer compared to the total tree density in three soil types during fall 2002 at the Raystown Field Station.

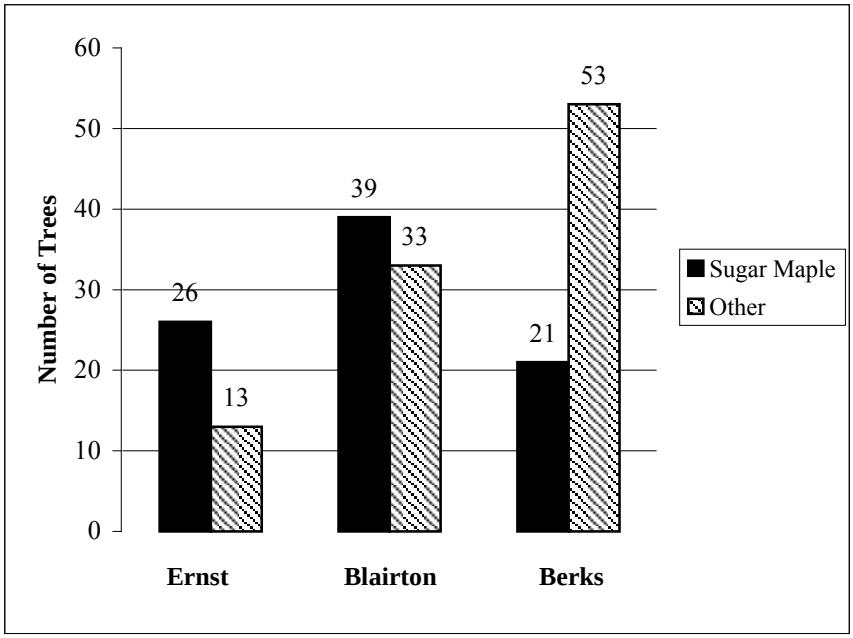


Figure 6: The number of sugar maple and other tree species located within soil types Ernst Silt Loam, Blairton Silt Loam, and Berks Shaly Silt Loam during fall 2002 at the Raystown Field Station.

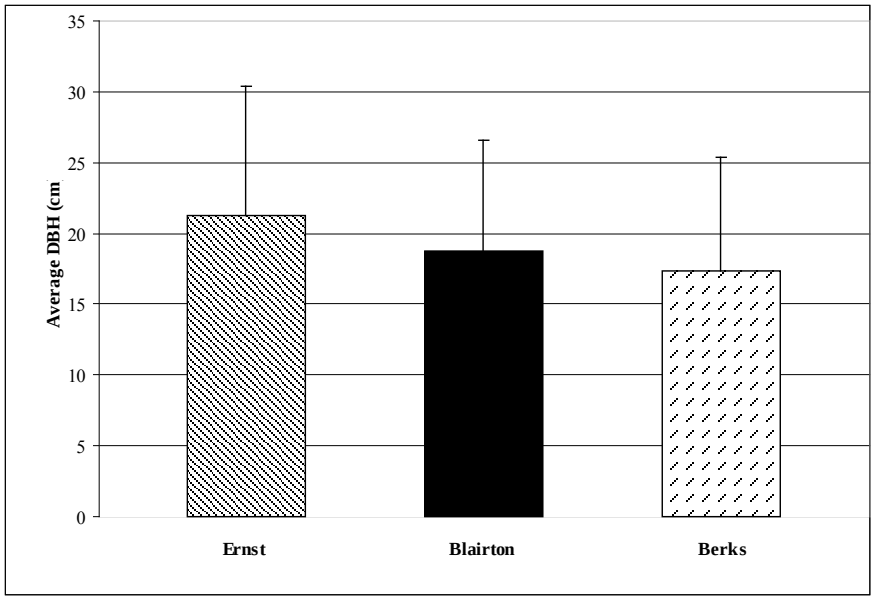


Figure 7: The Average DBH (diameter at breast height) for each tree species located in soils Ernst Silt Loam, Blairton Silt Loam, and Berks Shaly Silt Loam during fall 2002 at the Raystown Field Station.

DISCUSSION

One reason why Ernst and Blairton soils have higher infection rates may be because they are Ultisols (Molesevich, 1977). Ultisols soils are commonly found on unglaciated land and are characterized by having fewer weatherable minerals within the rooting zone and containing low base cations (Ciolkosz et al 1989) than Inceptisols, possibly limiting nutrient supply (Horsley et al. 2000). Long et al. reported that symptoms of maple decline appear to be concentrated on upper slopes of unglaciated sites. Unglaciated soil appears to have inadequate base cation supply where sugar maples may be vulnerable to other stresses (Horsley et al 2000).

Low base cations and low percentages of clay within soil types has also been related to maple decline (Drohan et al. 2002). Mineral availability becomes a problem to trees growing in unglaciated slopes because weatherable minerals are located well below the rooting zone or in the bedrock (Horsley et al. 2000). Glaciated soils, like Berks, have derived from material more recently exposed by glacial erosion, which might be why Berks shows the lowest infection rate. Berks soil falls into the order of Inceptisols, containing weatherable material within the rooting zone making it available to trees (Horsley et al 2000). Sugar maples on Berks soil may show no signs of infection because its soil is composed of minerals that limit stress rates.

When comparing the number of sugar maples to other tree species, Berks has fewer then both Ernst and Blairton. The relatively low number of sugar maples in these plots may contribute to why Berks showed the lowest infection rate. Ideally, Berks soil does not favor sugar maple growth or species quality because of seedling morality and erosion hazard (Huntingdon County Soil Survey, 1983). Therefore, even though the soil limits stress and infection rates it does not support high growth rates for sugar maples. The density of trees within each soil plot had no significant relationship to the frequency of infection, which suggests that it does not contribute to trees stress.

The size of sugar maples could have an effect on their susceptibility to infection. On average, the dbh of sugar maples within Berks soil measured lower compared to Ernst and Blairton. Ernst and Blairton both had higher infection rates than Berks, which suggests that larger sugar maples may have a greater risk of infection then smaller ones (unpublished data).

ACKNOWLEDGEMENTS

I would like to thank Chuck Yohn for his patience and guidance with me throughout this research study and for providing me with all the materials needed. I would also like to thank Cheryn Courtney for helping me in the field to identify trees (even in the rain) and Jennifer Sidleck for helping me get through the stressful times. Thanks to Dr. Gustafson for his information on the subject. Finally, I would like to thank Andy Watson for working through the statistical analysis with me.

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THE EFFECT OF SOIL PORE WATER CHEMISTRY ON THE PRESCENCE OF SUGAR MAPLE BORER *(GLYCOBIUS SPECIOSUS).*

Cheryn L. Courtney

ABSTRACT

Sugar maple (*Acer saccharum*) populations have been on the decline in North America. One symptom this decline is increased infection by the sugar maple borer (*Glycobius speciosus*), which only attacks trees that are under physiological stress. One of the factors related to stress in sugar maples is soil nutrient levels. I compared pH, Al, Ca, and Mg in soil pore water at trees with and without the maple borer infection. The pH of the pore water of infected trees (6.5 ± 0.21) was not significantly different from that of non-infected trees (6.5 ± 0.18) ($t = -0.32$; $df = 8$; $P = 0.39$). The Al concentration of the pore water of infected trees (0.0032 ± 0.00303 mg/l) was not significantly different from that of non infected pore water (0.00060 ± 0.00089 mg/l). Similarly the Ca of the pore water of infected trees (0.93 ± 0.20 mg/l) and non infected trees (1.046 ± 0.1988mg/l) was not significantly different ($t = -0.91$; $df = 8$; $P = 0.194$)and the Mg concentration of the pore water of infected trees (0.200 ± 0.020 mg/l) and non infected (0.194 ± 0.0288 mg/l) was also not significantly different ($t = 0.38$; $df = 8$; $P = 0.356$). I conclude that there is not a relation between the soil pore water nutrients and the presence of the sugar maple borer at the Raystown Field Station.

KEY WORDS

Acer saccharum, Glycobius speciosus, pore water chemistry, sugar maple borer, sugar maple tree, and tree stresses

INTRODUCTION



Figure 1. The natural distribution of the sugar maple in the North East United States

The sugar maple's (*Acer saccharum)* natural range in North America extends over the north east corner of the United States and into Canada (Fig 1). It is most common in the Great lakes states, Ohio, Pennsylvania and New York (Luzadis 1996). Beginning in the early 1980's, sugar maple populations in these areas experienced impaired forest health or decline (Hutchinson et al. 1997). Decline is characterized by gradual deterioration of trees over time due to biotic and abiotic factors (Bauce and Allen 1991). One such biotic factor that can be used to determine stress and decline is the presence of certain sugar maple insects such as the maple borer (*Glycobius speciosus)* (Bauce and Allen 1991).

The sugar maple borer is a wood-boring beetle which only infects the sugar maple. During the 2-year life cycle the larva eats away at sapwood under the bark, leaving a horizontal and vertical scar (USDA 1978) (Fig 2). The sugar maple borer usually only attacks trees that have low vigor (Bauce and Allen 1991) and is therefore found significantly more often in declining than in healthy trees (Bauce and Allen 1991). Infected and non-infected trees may occur in the same forest (Pers obs). A deficiency of soil nutrients is a potential stress contributing to maple declines in Massachusetts, Quebec, northern New York, Vermont and Pennsylvania (Horsley et al 2000). Sharpe (2002) did studies of soils nutrients of sugar maple stands and found that there was



Figure 2. The horizontal and vertical scars caused by the larva of the sugar maple borer.

significantly less Ca, Mg and K in declining stands when compared to healthy ones. He attributed this phenomenon to acidification (Flynn 1995) which is often measured by the amount of exchangeable Al species (Cronan and Grigal 1995).

The goal of this study was to determine if soil nutrients affect the occurrence of the sugar maple borer. I compared pH, Al, Ca, and Mg in soil pore water at trees with and without the maple borer infection to see if there was a correlation between soil pore water chemistry and the presence of the sugar maple borer.

FIELD SITE

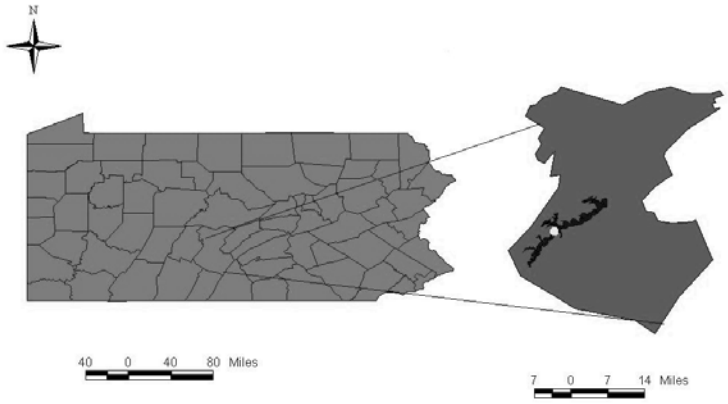


Figure 3. Location of the Raystown Lake Field Station in Huntingdon County, PA

I conducted the study in the sugar maple grove located within the Ernest silt loam soil formation (Molesevich 1977) at Juniata College Raystown Lake Field Station near Entrinken Pennsylvania (USGS Entrinken PA Quadragle) (Fig. 3). The Ernest silt loam soil is located along the lake access road and northwest of the stream and is about 22.5 meters wide and 400 meters long (Fig. 4). I chose the site because of the high incidence of sugar maple borer (Pers Obs). I conducted the study during late October and early November of 2002.

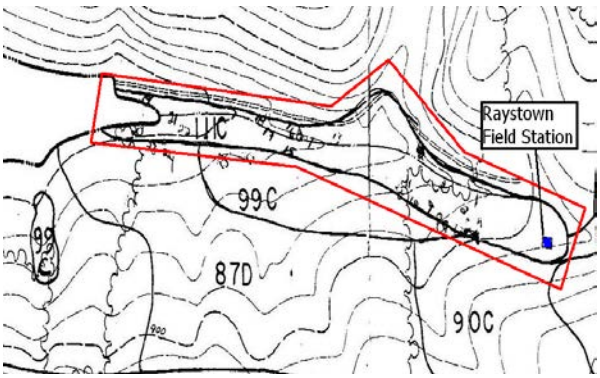


Figure 4. Location of Ernest Silt Loam at the Raystown Field Station in Entrinken PA.

METHODS AND MATERIALS

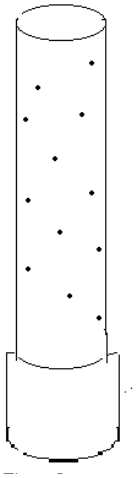


Figure 5. Lysimeter used for collecting pore water

I randomly selected 20 trees of the two different types: 10 trees with no visible sugar maple borer infection and with no infected trees within 5 meters, and 10 trees with sugar maple borer infection and no uninfected trees within 5 meters. The trees that had a visible maple borer scar were considered to be infected, and those with no scar were considered to be non-infected. I collected pore water in lysimeters that were 30 cm in depth by 1.8 cm in diameter with 24 drill holes in them (Fig 5). These lysimeters were placed in the ground, covered with parafilm and left for a week to collect pore water.

I tested the pH of the pore water using a HACH EC10 pH meter while the water was still in the lysimeters (HACH 1996) and then I extracted the water using a pipette. I used the Calmagite Colorimetric Method to asses Calcium and Magnesium concentrations and an Eriochrome Cyanine R Method was used to measure Al (HACH 1994).

I checked the data for normality using an Anderson Darling test (Hampton 1996) and heterogeneity of variances using a Levene's test (Hampton 1996). I compared the pH of the pore water of non-infected trees to that of infected using a two- sample t-test (Hampton 1996). I used an alpha level of 0.05 and considered the difference to be significant if $p \leq 0.05$. I repeated this process for Ca and Mg. I compared the results of the Al levels of infected to non-infected trees using a Mann-Whitney test (Hampton 1996). Again I considered results to be significant if $p \leq 0.05$.

RESULTS

Out of the 20 lysimeters only 10, 5 of each treatment, contained enough pore water to be tested. The pH of the pore water of infected trees (6.5 ± 0.21) was not significantly different from that of non-infected trees (6.5 ± 0.18) (t = -0.32; df = 8; P = 0.39). The content of Al in the infected pore water (3.2 ± 3.03 µg/l) was not significantly different from the non- infected pore water (0.60 ± 0.89 µg/l) (W = 33.0 , df = 8, P = 0.148). The Ca concentration of the infected pore water (0.93 ± 0.2024 mg/l) was not significantly different from the non- infected pore water (1.046 ± 0.1988 mg/l) (t = -0.91; df = 8; P = 0.194). Similarly the Mg concentration of the infected pore water (0.200 ± 0.0200 mg/l) was not significantly different from the non-infected pore water (0.194 ± 0.0288 mg/l) (t = 0.38; df = 8; P = 0.356).

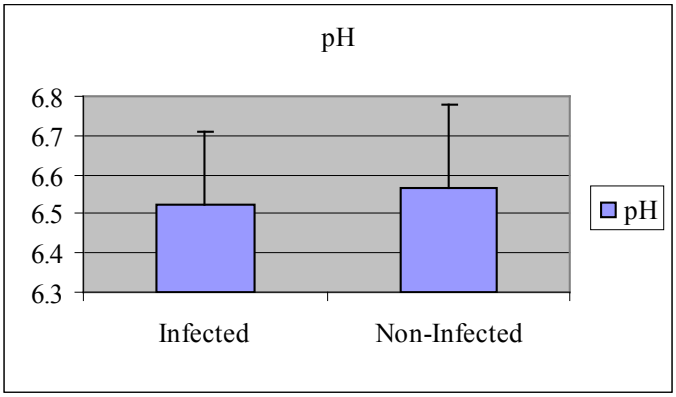


Figure 6. Mean pH of pore water from the maple borer infected and non-infected sugar maples at the Raystown Field Station, fall 2002.

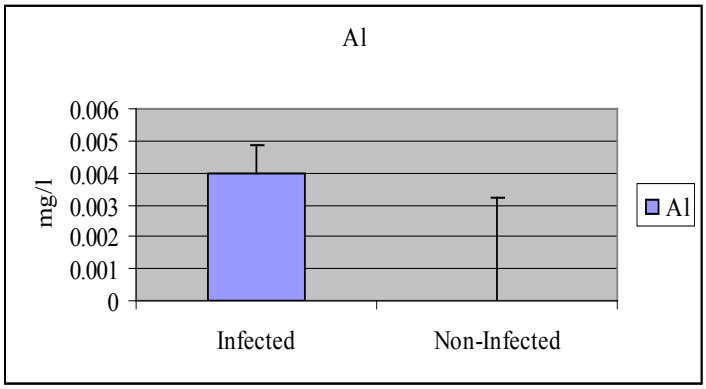


Figure 7. Mean (mg/l) of Al concentration in the pore water for maple borer infected and non-infected sugar maples at the Raystown Field Station, fall 2002.

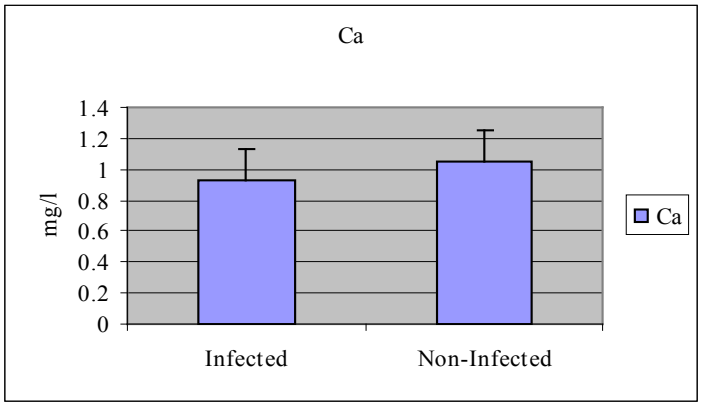


Figure 8. Mean (mg/l) of Ca concentration in the pore water from maple borer infected and non-infected sugar maples at the Raystown Field Station, fall 2002.

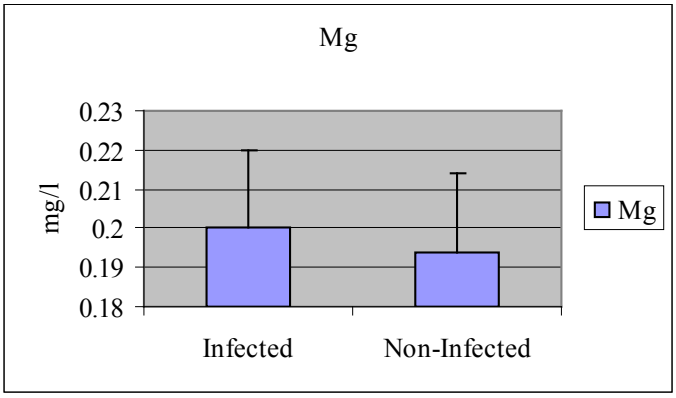


Figure 9. Mean (mg/l) of Mg concentration in the pore water of maple borer infected and non-infected sugar maples at the Raystown Field Station, Fall 2002.

DISCUSION

PH is an indicator of soil acidification. Acidification predisposes the soil to deficiencies of Mg, CA, and K, increasing the chances of toxic acidity in the root system (Ulrich and Matzner 1988). The soil pore water in this study was only slightly acidic (pH = 6.6) and falls within the normal soil pH range for sugar maples (3.7-7.3) and in the most common range for sugar maple soils (5.6-7.3) (Luzadis 1996). My results may not reflect the true soil pH because of heavy rain fall during this study and the typically lower pH of typically lower pH of rain in central PA (Pers Comm). However, if this is the case then the real soil pH would be more basic, further indicating that acidification is not in the soils. Differences in soil pH are not as clearly associated with tree conditions as are foliar nutrient levels (Sharpe et al. 2002).

Acidification is often measured by the mount of exchangeable Al species (Cronan and Grigal 1995). When Al competes with Ca and Mg for absorption sites on the roots the energy transformation, cell balance and division, nutrient accumulation and other Mg and Ca dependant processes can be affected (Cronan and Grigal 1995). My levels of Al in pore water of infected (0.0032 mg/l) and non-infected trees (0.0006 mg/l) are below the Mg dependent Al toxic levels that Cronan and Schofield found for some southern Inceptisols and Ultisols (< 0.0269 mg/l) (Cronan and Grigal 1995). However my results are at the low end of concentrations they found because some German Inceptisols were greater than 6.45mg/L. These wide ranges place the Ernest silt loam, which is an Ultisol, within the range of levels found elsewhere.

Ca is important to maple trees because it stabilizes the prectate in the cell wall, bridges phospholipids and other proteins in the plasmalema that are important for the functioning of membrane bound enzymes for control of phytohormones (Cronan and Grigal 1995). Ca comes into the tree through absorption sites in the roots and has to compete for these sites with Al. If Al binds to the absorption sites the Ca dependant processes become deficient (Cronan and Grigal 1995). Al stress has a 50% chance of occurring at a Ca/Al ratio of 1.0, a 75% chance of occurring at 0.5 and a 95-100% chance of occurring at 0.2 (Cronan and Grigal 1995). The Ca/Al molar ratios for pore water of infected (189) and non-infected (76) trees in the study are above any reported Ca/Al ratios that put a tree at risk for Al stress and toxicity (Cronan and Grigal 1995).

Mg is important to tree health because it is incorporated into the chlorophyll (Cronan and Grigal 1995). It is also found in the cytoplasm and plays a role in cell replication, respiration, and protein

synthesis (Cronan and Grigal 1995). Mg, like Ca, is absorbed through the roots and is in competition with Al. Because Mg and Ca can both be affected by Al, the same scale for Al ratios can be used for Mg as for Ca to determine stress. The Mg/Al ratio's of my infected (67) and non-infected (23) pore water are lower than the Ca/Al ratios reported above but are still large. Although my Mg/Al levels are high they do not appear to be a source of stress because it is low Mg/Al ratios that put a tree under stress (Cronan and Grigal 1995). However these ratios are less studied than Ca/Al.

PH and nutrients such as Al, Ca, and Mg play an important role in the health of the sugar maple. However, these nutrients do not seem to be the cause of the stresses that lead to the occurrence or absence of the sugar maple borer at the Raystown Field Station

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Effects of Road Maintenance on the Health of Eastern Hemlocks (*Tsuga canadensis*)

Natalie Crabbs

ABSTRACT

Eastern Hemlocks (*Tsuga canadensis)*, are found in the eastern United States from Maine to Kentucky, and are so common in Pennsylvania that they are the official state trees. I compared growth rates and crown condition of hemlocks in Rothrock State Forest, PA to examine the effects of road maintenance on the tree health. I hypothesized that Eastern Hemlocks along maintained roads would have a slower growth rate and an inferior crown condition when compared to the trees along a non-maintained site. At two sites, I measured and compared growth rates and crown condition of the hemlocks. Growth rates of hemlocks along maintained roads (0.17cm/yr) were slightly higher than those of non-maintained roads (0.14 cm/yr), but the difference is not statistically significant ($t=-1.25$, $df=22$, $P=0.226$). Crown condition, as measured by pixel counts, along a maintained road (1754) did not differ significantly from a non-maintained road (1475) ($W=140.0$, $df=24$, $p>0.05$). Tree health did not visibly appear to differ between the two treatments and I concluded that both forests seemed to be of decent physical condition and unaffected by the factor of road maintenance.

KEYWORDS

canopy, crown condition, crown transparency, forest health, Rothrock State Forest, tree vigor, *Tsuga canadensis*

INTRODUCTION

Cold and snowy winters in Pennsylvania require the use of sodium chloride to melt ice and aid in the removal of snow. In the United States, over 10 million tons of such rock salt is spread each year over the country's roads (Blasius 2002). Great concern is extending throughout the environmental community over the harm that salt additions and vehicle exhaust are having on groundwater and soil quality as well as the roadside vegetation (Blasius 2002). The health of roadside trees is important for their ecological and aesthetic roles as they are know to catch particulate matter and reduce point source pollution from vehicle emissions and the nearby roads (Cumming 2001). One major concern is that phytotoxic concentrations of NaCl leeching into the soil and spraying in the air are causing damage to all trees close to the road (Hartl 2002). Therefore, it is important on the effects of road maintenance on vegetation. The goal of this study was to find a greater growth rate and better crown condition of *Tsuga canadensis* in the site with no maintenance when compared to the site that is maintained.

FIELD SITES

I conducted this study within Rothrock State Forest, Huntingdon County, Pennsylvania (Fig. 1). I selected a non-maintained section located in Whipple Dam State Park on Laurel Run Road, which is a stone road, not heavily traveled and not maintained in the winter (Fig. 2). I also selected a maintained site is along route 305 between Greenwood Furnace and the Huntingdon County line (Fig. 3). Route 305 is a highly traveled state road that is salted and treated appropriately in the winter months. The two sites are on slight downward slopes from the roadside, facing to the northwest at elevations of 1200-1400 feet above sea level. The two forests are of similar composition (per. obs.). The dominant trees are Eastern Hemlock (*Tsuga canadensis*), Sugar Maple (*Acer saccharum*), Red Maple (*Acer rubrum*), Black Oak (*Quercus velvutina*), Red Oak (*Quercus rubra*), Yellow Birch (*Betula alleghaniensis*), and Sweet Birch (*Betula lenta*). The forests' floors were rocky and moist, scattered with ferns, decomposing trees and tip-ups. The maintained site had many more fallen trees, giving way to a larger fern community and more sunlight diffusing to the ground.

METHODS & MATERIALS

During October and November of 2002, at each study site, I randomly selected 12 hemlock trees between 0 and 30 meters off the road. During these days, there was variable weather; it was sometimes sunny or overcast and rainy. At each tree, I recorded the diameter at breast height (DBH), and took two digital photos of the canopy using a Sony MVC-FD88. I took one photo at the base of the tree looking directly up, while the other photo zoomed in further to get a better view of the canopy. This is to evaluate the transparency of the tree's crowns, as higher black pixel counts indicate thicker crown foliage. If a particular tree is very transparent, this could signify a stressed or unhealthy tree (Metzger 2001). I analyzed each digital photograph for light penetration using the computer program MultiSpec (Biehl & Landgrebe 2002). I compared pixel counts between maintenance and no maintenance roads using the Mann Whitney U test (Gravetter 2000). I used an alpha level of 0.05 and considered differences to be significant if $p \leq 0.05$.

I took core on the side of the tree facing the road. I measured each core and counted the dark rings with the aid of a magnifying microscope. I divided the number of dark rings by the length to obtain the average annual growth. I compared tree growth rates between the two sites by using a 2-sample t-test (Gravetter 2000) and the same significance as above. I evaluated tree health by examining needle thinning, discoloration, and canopy class of each tree using the procedures set in the UNEC Visual Assessment of Crown Condition (United Nations Economic Commission for Europe 2000).

RESULTS

Growth rates of trees along the maintained road (0.17 cm/yr) were somewhat higher than that of the non-maintained road (0.14cm/yr) but the difference was not statistically significant ($t=-1.25$, $df=22$, $P=0.226$) (Fig. 5). Black pixel counts were higher (1754) in the maintained site than in the non-maintained site (1475) yet the difference was not statistically significant ($W=140.0$, $P>0.05$) (Fig. 5). I saw no substantial variation in needle discoloration or needle loss between the sites. Not more than two trees in each site showed any needle discoloration or needle loss over 5%.

DISCUSSION

I found no significant difference between the two sites. The no maintenance road trees appear healthier than the maintenance site trees (per obs.). There were many more fallen trees at the maintenance site, giving way to a larger fern community and more sunlight diffusing to the ground (per obs). I expected more understory growth, but there was not. The tree understory growth of both sites was minimal (per obs.). With the relatively recent tree falls on the maintenance site, and the recent lower annual growth seen in the core bores, I believe that this site is not as healthy as my tests are showing. A 1995 study on

hardwood forest decline in Quebec found average ring widths much greater than my hemlock study. Sugar maples average ring size was 0.994 cm and American beech was 1.000 cm (Payette 1995).

Tsuga canadensis are hardy trees affected by climate change over any other factor, so road salt leeching into the soil or exhaust in the air, may have little or no effect on their health (Gustafson 2002). Increased levels of nitrogen and carbon from exhaust on the more frequently traveled and maintained road may have a positive effect on the trees' health. Further studies in this area will be of great benefit to forest managers and road maintainers as roadside trees are central "in reducing point source pollution" (Cumming 2001), and the need for drivable roads in the winter increases.

ACKNOWLEDGEMENTS

I would like to thank Forester Mark Long for the information on Rothrock State Forest and crown condition judging, and Chuck Yohn for his patience and ideas throughout this project. In addition, I am extremely grateful to Neil Pelkey for sharing his knowledge of MultiSpec with me.

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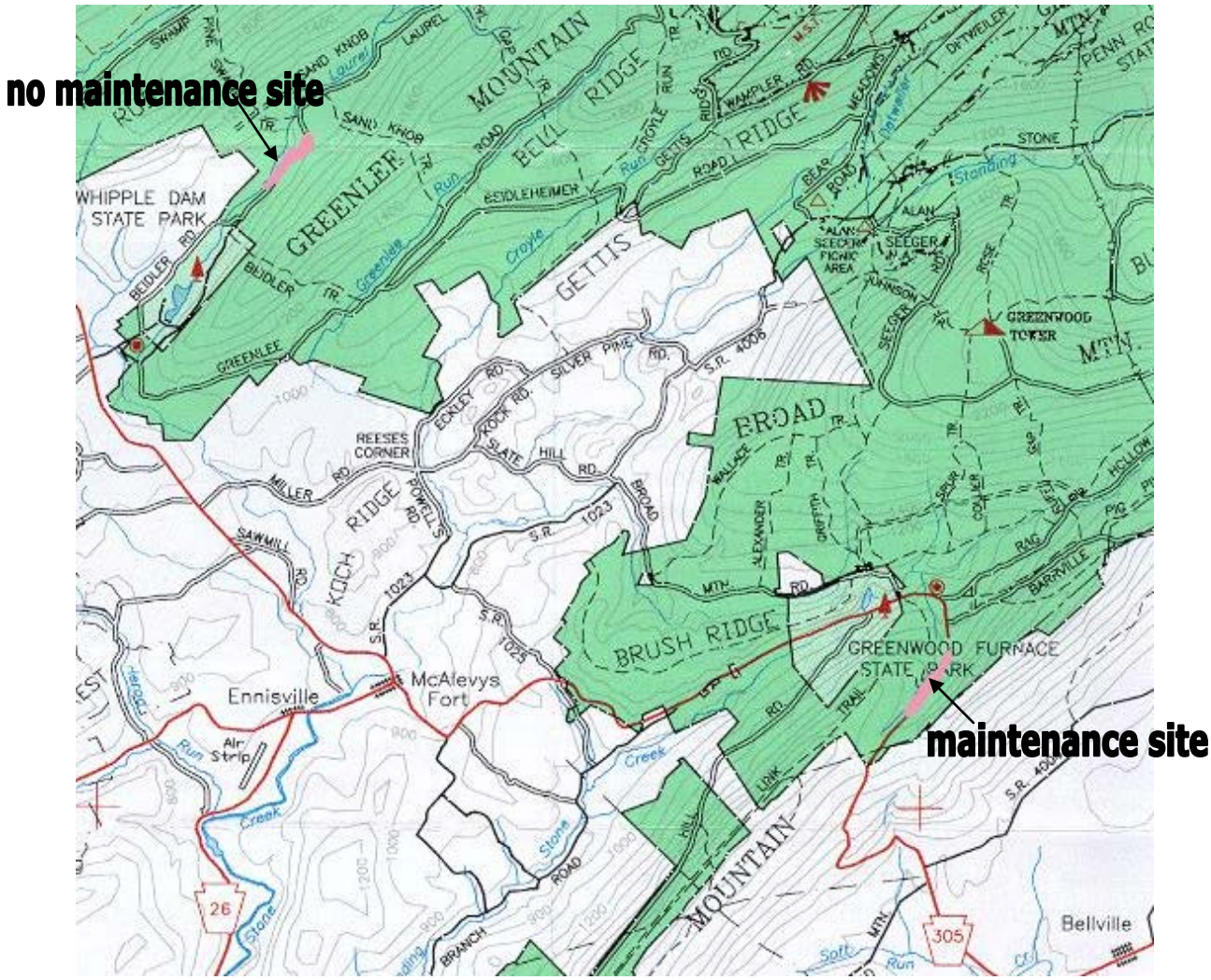


Figure 1. Location of maintained and non-maintained road transects in Rothrock State Forest, Huntingdon and Centre counties, Pennsylvania, 2002.



Figure 2. No maintenance site on Laurel Run Road, in Whipple Dam State Park and Rothrock State Forest, Huntingdon County, PA, 2002.



Figure 3. Maintained Site along route 305 between Greenwood Furnace and Bellville, 30 meters from the road in Rothrock State Forest, Huntingdon, PA, 2002.

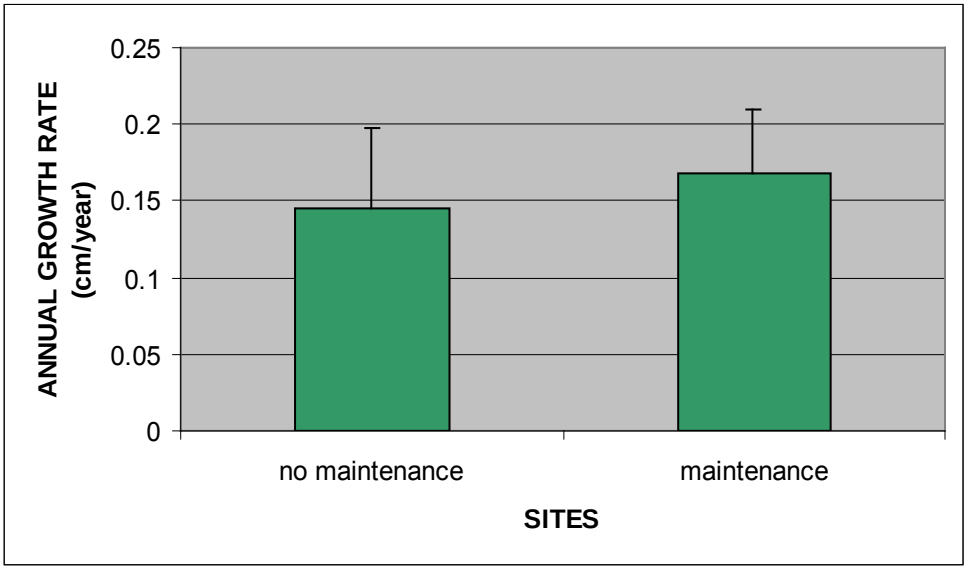


Figure 4. Annual growth rate in centimeters per year from the maintenance and no maintenance sites in Rothrock State Forest, Huntingdon County, Pennsylvania, 2002.



Figure 5. Median number of black pixels from each site in Rothrock State Forest, Huntingdon County, Pennsylvania, 2002.

EFFECT OF WEATHER ON NIGHTLY MOVEMENT OF EASTERN SCREECH-OWL, *OTUS ASIO.*

Andrea Evans, Paula Mooney, Matthew Ulrich

ABSTRACT

Previous studies have shown that behavior of the eastern screech-owl, *Otus asio*, can be affected by cold temperatures. We hypothesized that lower temperatures would cause decreased nightly travel of screech-owls. We captured two rufous phase screech-owls using mist nets and monitored their movements using PD-2 transmitters and handheld two-element yagi antennas. Their locations were recorded at five minute intervals and then triangulated and plotted on topographic maps. We found no correlation between the average distance covered during five minute intervals and the average low or overall mean temperatures ($r = 0.271$, $p = 0.660$; $r = 0.325$, $p = 0.594$) respectively, and no correlation between the average distance covered during 10 minute intervals and the average low or overall mean temperatures ($r = 0.271$,$p = 0.660$; $r = 0.325$, $p = 0.594$) respectively. We also found no correlation between the maximum distance traveled during five minute intervals and the average low or overall mean temperatures ($r = -0.490$, $p = 0.403$; $r = -0.0492$, $p = 0.400$). Our data suggests that the distances traveled were not affected by temperature.

Keywords: Eastern screech-owl, Otus asio, weather, flight distances, radio telemetry.

INTRODUCTION

Eastern screech-owls, *Otus asio*, are non migratory, nocturnal predators found throughout eastern North America (Gehlbach 1995). They may be found in urban or suburban areas, but most commonly inhabit woodlands, especially during the winter, non-breeding months. This increased use of woodlands is due to improved hunting conditions (Sparks et al. 1994). The absence of ground cover from deciduous plants, shrubs, and trees increases the amount of light reaching the ground providing increased opportunities of sight and capture of prey (Sparks et al. 1994). Tall, thick weeds and grasses of open fields may also provide more cover for prey than the forest floor (Dexter 1996). Unlike other owls, screech owls have symmetrical ear openings, which does not allow them to pinpoint sounds as accurately. Because of this it is believed that screech owls must rely more on sight for prey capture (Gehlbach 1995).

Eastern screech owls defend their territories throughout the year. Owls will occasionally overlap home ranges with one owl dominating the use of the overlapped area. This overlap is reduced during the winter months when the amount of prey decreases (Belthoff 1993). During these non-breeding winter months owls must remain active, eating regularly to have enough energy for movement, body temperature regulation and growth (Gehlbach 1995).

Dexter (1996) found that when rufous screech owls were subjected to temperatures less than –10° C they would often shiver violently, while gray owls seemed unaffected by cold even below –15 C (they did not shiver and often preen themselves). During the non-breeding season and cold weather screech owls are thought to remain in the roost sites for extended periods during the night (Sparks et al. 1994). Aside from this no studies have been done to examine the effects of weather on the nightly movement of the screech owl. In this study we examine effects of temperature on distances traveled by screech-owls during a two-hour period after sunset. We hypothesize that owls will be less active on cold nights due to sensitivity to cold. We tested the following hypotheses:

1) The average distance traveled during five and ten minute intervals will decrease as the average low and mean temperature decreases.

2) The maximum distance traveled during a five and ten minute interval will decrease as the average low and mean temperature decreases.

FIELD SITE

Both owl territories studied were in Huntingdon County, Pennsylvania (Figure 1). We used owl territories that were found by Olsen and Mooney in the fall of 2000. The first territory was at the Raystown Field Station, which included an exposed hilltop, exposed areas along Lake Raystown and mixed deciduous and evergreen forest. The second territory was near Patrick Lodge in Diamond Valley, which included mixed deciduous forest and mixed evergreens and several small streams.

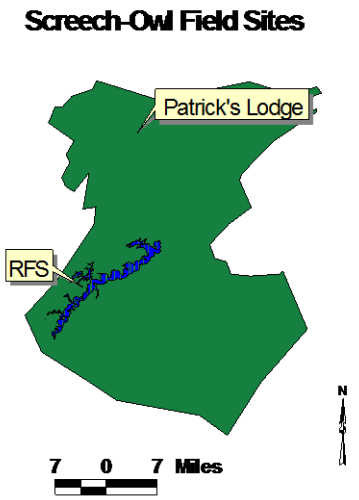


Figure 1. Shows screech-owl territory sites in Huntingdon County, PA.

METHODS AND MATERIALS

We captured two rufous screech-owls by erecting two sets of mist nets approximately 75 yards apart. Each set contained two nets running tangentially to create an L or V, and was placed within territories known to have screech-owls present. The owls were attracted into the nets by playing continuous bounce calls from a Johnny Caller placed nearby. Upon capture, a 3.7g PD-2 transmitter was placed on the owl using a figure- 8 harness made from 1mm plastic string. The two loops of the harness slide over the legs of the bird, with the transmitter resting over the synsacrum (Appendix A).

This design allows for fast non-evasive attachment and minimizes stress and discomfort to the bird. We then tracked the owls on 4 to 5 nights each during the time of December 2001 to February 2002. Locations of the owls were found by triangulating with two receivers (Telonics) and handheld two-element yagi antennas. Points were taken simultaneously from both locations at 5-minute intervals for approximately two hours after sunset. After all of the readings were taken owls were recaptured using the same method as above. To protect the receivers, no points were taken when it was raining and due to the weakness of signal on windy nights, no points were taking if the wind exceeded 15 mph. Points were plotted on topography maps by triangulating the compass readings at each time interval. The area traveled by the owl each night was determined using a digital planimeter (Lasico). Distances traveled between each reading were measured using rulers.

We tested for a correlation between flight distance at five and ten minute intervals versus average low and mean temperatures using Pearson's correlation test (Gravetter 2000). We also tested for a correlation between maximum distance traveled during five minutes and the average low and mean temperatures. We considered correlations to be significant at $p \leq 0.05$.

RESULTS

Tests showed that there was no significant correlation between the average distance over 5 minute intervals and the average low or overall mean temperatures on the specified days ($r = 0.271$, $p = 0.660$; $r = 0.325$, $p = 0.594$) respectively. There was also no significant correlation between the average low or overall mean temperatures and the average distance over 10 minute intervals ($r = 0.271$, $p = 0.660$; $r = 0.325$, $p = 0.594$) respectively. Although an inverse relationship was found, there was no significant correlation between the maximum distance traveled in one night versus either the average low temperature or the mean temperature ($r = -0.490$, $p = 0.403$; $r = -.0492$, $p = 0.400$).

DISCUSSION

We did not detect any effect of temperature on the nightly travel distances of eastern screech-owls. Dexter (1996) found that extremely cold nights (under 10° C) may have resulted in decreased movement and increased time spent in the roost. However, Huntingdon County experienced a mild winter and never reached extreme temperatures during the time of our study. Because eastern screech-owls rely primarily on their keen eye-sight to find prey (Gehlbach 1995) cloud cover and moon phase may affect their movement as well. Increased visibility due to little cloud cover and a full moon may increase the distance traveled while foraging for prey. Decreased cloud cover may have an influence on temperature as well, thereby having an effect on screech-owl travel distances.

A significant change in distance traveled may not have been detected because such changes usually occur seasonally and annually rather than daily (Hayward et al. 1987). In a three-year study on Boreal owls, Hayward et. al (1987) found that home range movements vary seasonally depending on food resources available. However, if a more extensive study was done, examining many screech-owls over multiple years, significant changes in life history traits, such as reproductive success, may be apparent due to yearly climatic changes in the region (Franklin et. al. 2000). Because weather could have an affect on population size over extended periods of time, owls could show stresses of a drought situation through their life history traits, such as reproductive success, etc. A drought could cause a significant decrease in food availability along with possible habitat structures and availability.

ACKNOWLEDGMENTS

We would like to thank Chuck Yohn, Russel Wilson and Andy Watson for their help. We would also like to thank Roy Nagle, the Pennsylvania Game Commission, and the Raystown Field Station for the use of their equipment. We give special thanks to Juniata College Environmental Science and Studies Department for financial support.

APPENDIX A

NEW HARNESS DESIGN FOR ATTACHMENT OF RADIO TRANSMITTERS TO SMALL PASSERINES

John H. Rappole
Conservation and Research Center
National Zoological Park
Smithsonian Institution
Front Royal, Virginia 22630

Alan R. Tipton
Caesar Kleberg Wildlife Research Institute
Texas A&M University
Kingsville, Texas 78363

Abstract.--Proper attachment of radio transmitters to small passerines is critical to success of telemetry studies. Neck loop and wing loop harnesses pose a number of problems. Gluing techniques are better, but are time consuming. A figure-8 harness that slides on over the legs of the bird, with the transmitter resting over the synsacrum, provides a rapid attachment technique that minimizes problems of balance and physical discomfort.

Attachment of radio transmitters is always a serious consideration in field studies. A poorly attached transmitter can cause injury or death of the study subject within a short time; even if the subject does not die, its behavior can be altered to the point where the data collected on it are useless.

We have been using radio transmitters on a small (<50 g) and medium-sized (50-200 g) birds for over a decade, and have employed a variety of attachment methods (Odom et al. 1982; Rappole et al. 1989, 1990; Winker et al. 1990). Initially, we used wing loop or neck loop harnesses, such as described by Nicholls and Warner (1968), Cochran (1980), and Mech (1983:44). We found that these methods caused two kinds of problems. First, they affected behavior of the bird. Observations showed that the bird seldom behaved as if it were not "aware" of the transmitter package, and the packages appeared to affect flight. Second, 10-15% of the birds were able to work a wing, a leg or the bill through a loop of the harness, generally causing complete immobilization.

Until recently, we found that the best attachment method to avoid these problems was that devised by Raim (1978). His method involves the following: 1) removal of feathers from the attachment area, 2)gluing a chiffon patch to the exposed area (using eyelash glue to avoid irritating the skin), 3) tying a cotton patch to the transmitter and 4) gluing the two patches together.

This method works very well, particularly if the transmitter is placed over the synsacrum. Higher placements inhibit wing movement. When the transmitter is correctly placed, flight appears normal and the bird seldom appears to notice the transmitter. Also, there is never a problem with limb inhibition. Nevertheless, the method has drawbacks. First, it is not very suitable for use at the capture site. You almost have to bring the bird back to an enclosed place for processing. Second, it is time consuming. From time of capture to time of release, the process requires about an hour. Third, the method demands considerable handling of the bird, often

weakening the captive. Fourth, it takes some time to perfect the art of holding the bird while applying the patches and allowing the glue to dry. Fifth, the transmitter will fall off in 2-3 wk. This last criticism can be a positive point, of course, depending on the type of study.

Though we have used Raim's (1978) method extensively, we have continued to search for ways to avoid the above-mentioned problems. We believe that the method presented below accomplishes this goal. The design involves a two-loop harness in the shape of a figure-8. The loops are made of catheter tubing, cotton or any other non-irritating ligature material. The ligature should be about 1 mm in diameter. A smaller diameter tubing can cause irritation.

The loops can be attached to the transmitter using epoxy, super glue or any other permanent cement; or they can be tied. We have had transmitters prepared according to our specifications with the tubing already attached as part of the transmitter.

The size of the loop depends on the size of the study species, and is a matter that should be decided with some experimentation. Loop size, as referred to hereafter, is the distance from the base of the transmitter to the end of the stretched loop. As a general rule, a Kentucky Warbler (Oporornis formosus) (12 g) would require a loop of 22 mm, a Wood Thrush (Hylocichla mustelina) (40 g) 29 mm, and a female Great-tailed Grackle (Quiscalus mexicanus) (100 g) 40 mm.

To place the transmitter on the bird, hold the bird firmly in the left hand, slide the right hand loop over the right foot, and pull the loop up as far as possible on the proximal end of the thigh. Now, grasp the bird in the right hand holding the transmitter over the synsacrum. Bend the bird's left leg at the tibiotarsal joint, slide the left loop over the joint, and pull the loop up to the proximal end of the left thigh. When properly placed and with loops of the proper size, the transmitter should ride over the feathers of the synasacrum with 1-2 mm of play (Fig. 1). If the transmitter is too snug, the bird will be unable to hop or walk. If it is too loose, the bird will quickly step out of it.

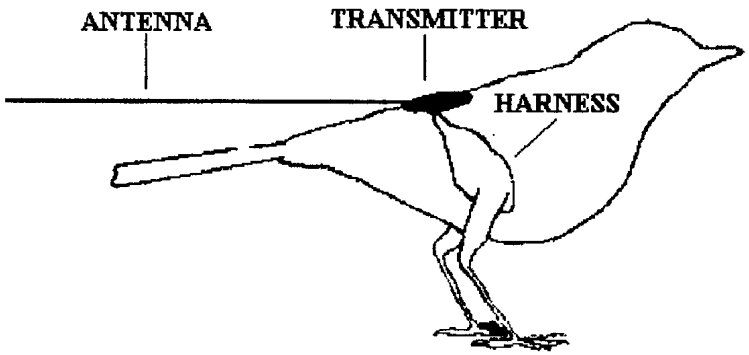


Figure 1. Lateral view of a bird showing placement of the figure-8 harness and transmitter.

We have used the figure-8 design very successfully on several species, from warbler sized to male grackle-sized birds (10-200 g). We believe that it will work well on most avian species that have long, external thighs. We know that the design will not work on species, such as ducks and doves, that do not satisfy these requirements.

Once a person has determined that correct loop length for the study species, and developed some facility in handling the bird, a transmitter with figure-8 harness can be attached in a matter of seconds. The package rides over the synsacrum where disturbance to the bird is minimal.

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THE EFFECTIVENESS OF A VERTICAL FLOW TREATMENT SYSTEM ON ACID MINE DRAINAGE

Jennifer Sidleck

ABSTRACT

I determined the effectiveness of a vertical flow acid mine drainage treatment system on water quality in Joller, Pennsylvania. High school students collected data on pH, dissolved oxygen and iron concentration over a 4-year period from input and output wetlands that are part of the treatment system. The pH of the input wetland (2.99) was significantly lower than that of the output wetland (4.38) (t=-3.51; df=6; P=0.006). Dissolved oxygen was also significantly lower in the input wetland (8.50 mg/L) than the output wetland (9.70 mg/L) (t=-2.16; df=6; P=0.037). The concentration of iron in the input wetland (36.5 ppm) was significantly higher then the output wetland (5.79 ppm) (W=28.0; df=6; P=0.011). My results indicate that the treatment system was treating the acid mine drainage and improving water quality.

KEYWORDS

Acid mine drainage, anaerobic wetland, anoxic drained wetland, iron, limestone, pH, vertical flow wetland

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INTRODUCTION

Acid mine drainage (AMD) is a prevalent environmental problem that originates from active or abandoned mines (Ziemkiewicz 1997). AMD forms when pyrite (FeS_2) or other metal sulfides associated with mineral deposits are subject to oxygen and water (Wieder 1989). This exposure to oxygen and water causes a combination of oxidation and microbial catalyzing reactions, which produce large amounts of dissolved sulfate, iron and other metals (Wieder 1989). AMD is characterized by high acidity and low pH values and when it enters a stream; it consumes alkalinity and introduces metal ions, which can have negative impacts on the biological productivity of the stream (Ziemkiewicz, 1997). Macroinvertebrates may decrease in diversity and change in species composition in areas impacted by AMD (Cherry 2001).

Acid mine drainage affects over 2,500 miles of stream in Pennsylvania (Milavec 2002). In the past, alkaline chemicals were the prevalent treatment for acid mine drainage, but they are expensive, dangerous and can cause excessively alkaline water conditions (Hedin 1994). The Pennsylvania Department of Environmental Protection is now using a variety of passive systems to treat AMD because they are inexpensive and require relatively low amounts of maintenance (Milavec 2002, Ziemkiewicz 1997).

In October of 1998, the Pennsylvania Department of Environmental Protection completed a passive vertical flow treatment system in Joller. This system treats the water from two acid deep mine discharges, and a surface mine site before it enters the Roaring Run watershed (Milavec 2002). Vertical flow treatment systems use a perforated under drain pipe collection system, overlain with three to four feet of limestone, overlain with mushroom compost that ranges in depths from six inches to two feet and with approximately two feet of standing water at the surface (Milavec 2002). These systems operate on the principle that the organic material deoxygenates the water containing oxygen and ferric iron (Milavec 2002). This allows the ferrous form of iron to pass through the limestone without armoring (Milavec 2002). In addition, sulfate reduces within the compost layer, which adds some alkalinity to the water and the limestone adds bicarbonate alkalinity to the acid mine drainage (Milavec 2002, Hedin

1994). These systems also employ a flushing method to put any aluminum or other retained metal into a sedimentation facility (Milavec 2002).

There were numerous problems encountered in this treatment system, which included leaks in the ponds and vertical flow wetlands (Milavec 2002). Leaks prevented water from making it through the entire system (Milavec 2002). The Department of Environmental Protection repaired the leaks in April of 2000 (Milavec 2002).

The goal of this study was to confirm if the treatment system is now working effectively. I tested the hypotheses that pH and dissolved oxygen would increase from the input wetland to the output wetland. I also hypothesized that iron concentration would decrease from the input to the output wetland.

FIELD SITE

The study site is located in Joller, Pennsylvania on route 994 in the Saltillo quadrangle. The vertical flow wetland treatment system (Fig. 1) is on Pennsylvania State Game Land in a clearing from the abandoned mining town.

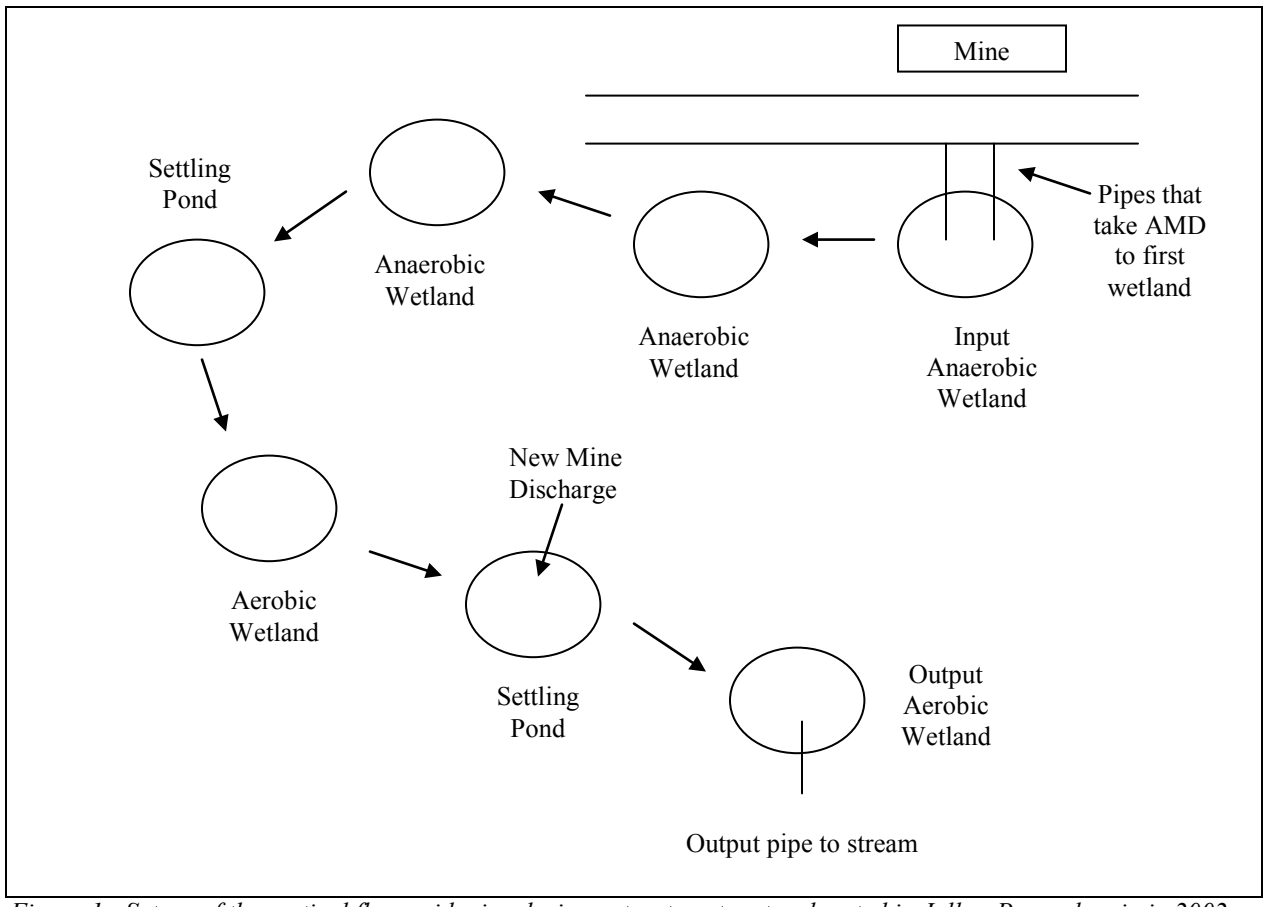


Figure 1: Set-up of the vertical flow acid mine drainage treatment system located in Joller, Pennsylvania in 2002.

METHODS AND MATERIALS

Students from Central High School in Martinsburg, Pennsylvania, collected data on the pH, dissolved oxygen and iron concentration of the system at Joller. Different students collected data 7 times over a 4-year period (1999-2002) using 5 to 15 replicate samples per parameter per visit. The students recorded pH, dissolved oxygen and iron concentration from two locations, the first wetland (input) and the last wetland (output) (Fig. 1). The students used a HACH pH meter, either Winkler titrations or a HACH Dissolved Oxygen meter and a HACH spectrophotometer to measure iron concentration (HACH 1994, 1996).

I first paired the input data to the output data for each parameter by sample date and then compared the dissolved oxygen and pH of the input to the output using a paired t-test (Hampton 1994). I compared the iron concentration of the input wetland to the output wetland using a Wilcoxin Signed Rank Test (Hampton 1994). I considered differences to be significant if $P \leq 0.05$.

RESULTS

The pH of the input (2.99 ± 0.14) was significantly higher than the output (4.38 ± 1.03) ($t = -3.51$; $df = 6$; $P = 0.006$). In addition, the dissolved oxygen was significantly lower in the input (8.50 ± 1.77 mg/L) than the output (9.70 ± 1.72 mg/L) ($t = -2.16$; $df = 6$; $P = 0.037$) and the iron concentration was significantly higher in the input wetland (36.5 ± 36.9 ppm) than the output wetland (5.79 ± 6.9 ppm) ($W = 28.0$; $df = 6$; $P = 0.011$).

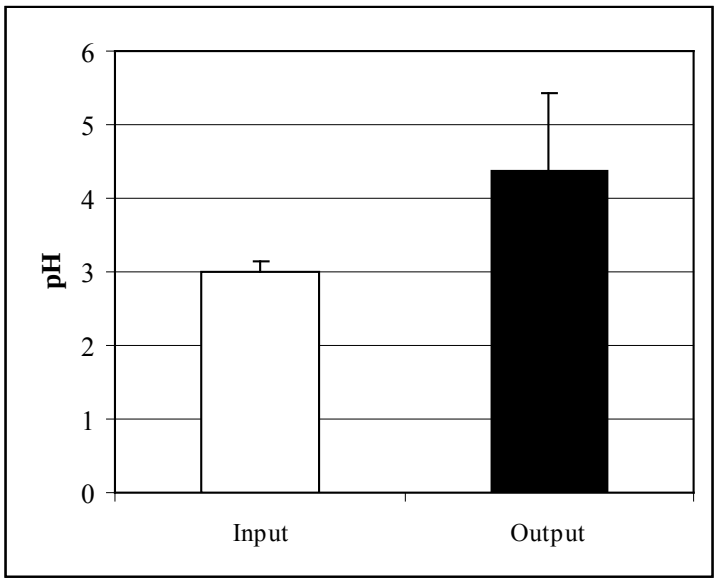


Figure 2: Mean pH for the input and output wetlands at Joller, Pennsylvania, 1999-2002.

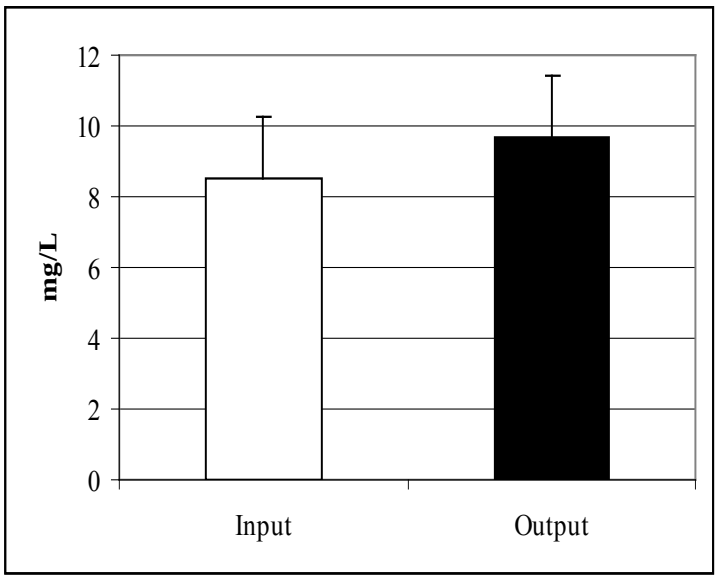


Figure 3: Mean dissolved oxygen for the input and output wetlands at Joller, Pennsylvania, 1999-2002.

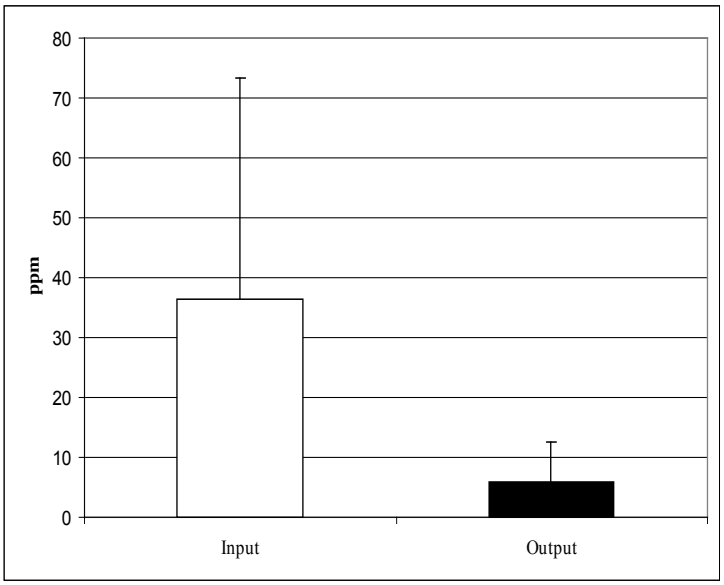


Figure 4: Mean iron concentration for the input and output wetlands at Joller, Pennsylvania, 1999-2002

DISCUSSION

The higher output pH indicates that the wetland treatment system is increasing the alkalinity in the water. This highly significant difference is likely caused by the mushroom compost is reducing sulphate and increasing alkalinity. In the Pennsylvania Code for water quality (1992), the effluent pH for a cold-water high quality fishery varies between 6 and 9. The output pH of 4.38 is lower than Pennsylvania water quality standards. This could be because of the AMD discharge in the second to last wetland, which suggests that additional treatment is needed (pers comm.) According to the Pennsylvania Department of Environmental Protection, the system effluent must be more alkaline than the influent for an AMD treatment system to working effectively (Undated). This was true for the passive treatment system at Joller.

The higher dissolved oxygen in the output wetland indicates that the treatment system is oxygenating the water as it moves through the aerobic wetlands. I expected the dissolved oxygen to be low in the input anaerobic wetland because the mushroom mulch should remove oxygen from the water and prevent more acid mine drainage from forming. I expected the oxygen would increase through the system after it left the anaerobic pools because there are areas along the wetland system that aerate the water. There was a lot of variability in the first half of the dissolved oxygen data (1999-2000). According to Gregg Burns, the first few years that the system was in operation mushroom mulch was overflowing into the lower wetlands (pers comm.). The decomposition of mushroom mulch in the output wetland would decrease the dissolved oxygen. However, this did not appear to significantly affect my results. According to the Pennsylvania Code for water quality, the minimum dissolved oxygen level for a high quality cold-water fishery should be 7.0mg/L (1992). My output value of 9.6mg/L indicates that the vertical flow passive treatment system is effectively aerating the water.

My finding of a lowered iron concentration in the output indicates that the limestone is precipitating the iron and possibly other metal ions in the drainage. However, the Pennsylvania Code lists the daily average for iron concentration as 1.5ppm (1992). This value is less then the mean iron concentration (5.79 ± 6.9ppm) for the output wetland at Joller. In addition, the iron concentration must decrease by 90 percent (Pennsylvania Department of Environmental Protection Undated). However, there was only an 85 percent decrease in the iron concentration. This may be a result of the treatment system not functioning properly in the earlier years or a result of the AMD discharge in the second to last wetland (pers comm., Milavec 2002).

Other studies indicate that anoxic limestone drains work effectively to treat acid mine drainage and treat it in accordance with Pennsylvania Department of Environmental Protection standards (Hedin 1994). One factor that contributes to the effectiveness of the treatment system at Joller is that it employs multiple types of passive treatments. P.F. Ziemkiewicz suggests that coupling these systems allows one system to partly treat the water and then it allows additional treatment from another system (1997). The results of my study indicate that the treatment system is improving the water quality. However, the wetland system may not be improving water quality enough

for Pennsylvania standards. It is important to continue monitoring the wetland system and to study the impacts that the introduction of addition AMD in the second to last wetland is having on the effectiveness of the treatment system.

ACKNOWLEDGEMENTS

I would like to thank the students from Central High School for their help in data collection. In addition, I would like to thank Greg Burns for giving me guidance and advice with this project. I would also like to thank Chuck Yohn for all of his help and support with this research project.

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2003

SEASONAL STRIPED BASS (*MORONE SAXATILIS*) DIET IN RAYSTOWN LAKE

Brad Watkin

ABSTRACT

It has been shown that striped bass, *Morone saxatilis,* in saline environments have seasonal dietary changes (Nelson et al. 2003). The goal of this study was to determine if the landlocked fresh water striped bass in the Raystown Lake of central Pennsylvania also show seasonal diet variation. The diets of captured bass representing the Spring and Fall were compared based on stomach contents. I found significant differences in prey composition ($X^2 = 10.07$, DF = 2, P = 0.007) and median weight (Mann-Whitney U = 2.93, P= 0.047) of stomach contents. This suggests that seasonal diet change does occur in the striped bass of Raystown Lake.

Keywords: striped bass (*Morone saxatilis*), Seasonal diet change, Seasonal feeding, Raystown

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INTRODUCTION

Located in the Ridge and Valley Region of central Pennsylvania, Raystown Lake is the largest lake solely within the state (Fig. 1.). It's deep, clear water offers superb striped bass (*Morone saxatilis*) fishing opportunities and is one of America's top 25 fishing destinations as ranked by Field & Stream magazine (Bestul et al. 2003). Adult striped bass feed predominantly on members of the herring (*Clupeidae*) family, such as gizzard shad (*Dorosoma cepedianum*) and alewife (*Alosa pseudoharengus*) (Schultz et al. 2003). Raystown Lake has a large population of these bait fish (Grace 2003).

Seasonal dietary changes have been documented in ocean dwelling striped bass (Nelson et al. 2003). The goal of my study was to examine the seasonal diet variation in the landlocked striped bass of Raystown Lake.

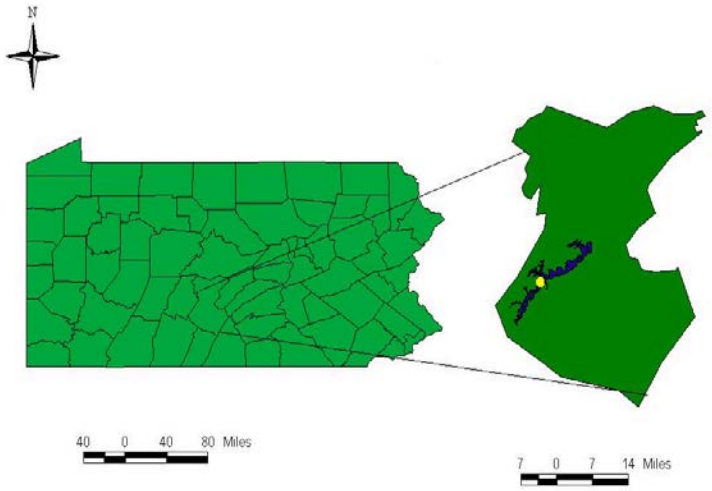


Figure. 1. Location of Raystown Lake in Huntingdon County, Pennsylvania.

METHODS

Striped bass stomachs were obtained from Raystown Striper Club tournaments held at Raystown Lake during the Spring of 2002 and 2003 and Fall of 2003. Captured bass were brought to a check station where the stomachs were removed. I separately bagged and labeled each stomach, preserving them in 70% ethanol and then refrigerated them to avoid post capture digestion. Each stomach was later dissected and its contents identified using a key to fresh water fishes (Eddy 1978). Prey items were grouped by species, blotted dry of excess liquid and then weighed (Nelson et al. 2003).

To compare the number of prey items between Spring and Fall, I used a Chi Square test (Minitab 2000) and to compare median stomach content weight, I used a Mann-Whitney U test (Minitab 2000). I considered differences to be significant if ($P < 0.05$).

RESULTS

I found a significant difference in the number and type of prey items in the stomach contents of striped bass between the Spring and Fall (Table. 1, Fig. 2.), (X^2=10.07, DF = 2, P= 0.007). I also found a significant difference in median stomach content weight of striped bass between the Spring (16.6g ± 18.02) and Fall (8.6g ± 13.45) (Figs. 2 and 3.), (Mann-Whitney U = 2.93, P= 0.047).

# of Stomachs	**Spring** **N= 52**	**Fall** **N= 13**
Alewife *(Alosa pseudoharengus)*	**146**	**17**
Gizzard Shad (*Dorosoma cepedianum*)	**11**	**3**
Cray Fish (*Orconectes virilis)*	**0**	**2**
Rainbow Trout (*Oncorhynchus mykiss)*	**2**	**0**
Empty stomachs	**11**	**4**

Table. 1. Total number of prey items in the stomachs of striped bass (*Morone saxatilis*) in Raystown Lake, Huntingdon County, Pennsylvania. Collected in Spring 2002, 2003 and Fall 2003.

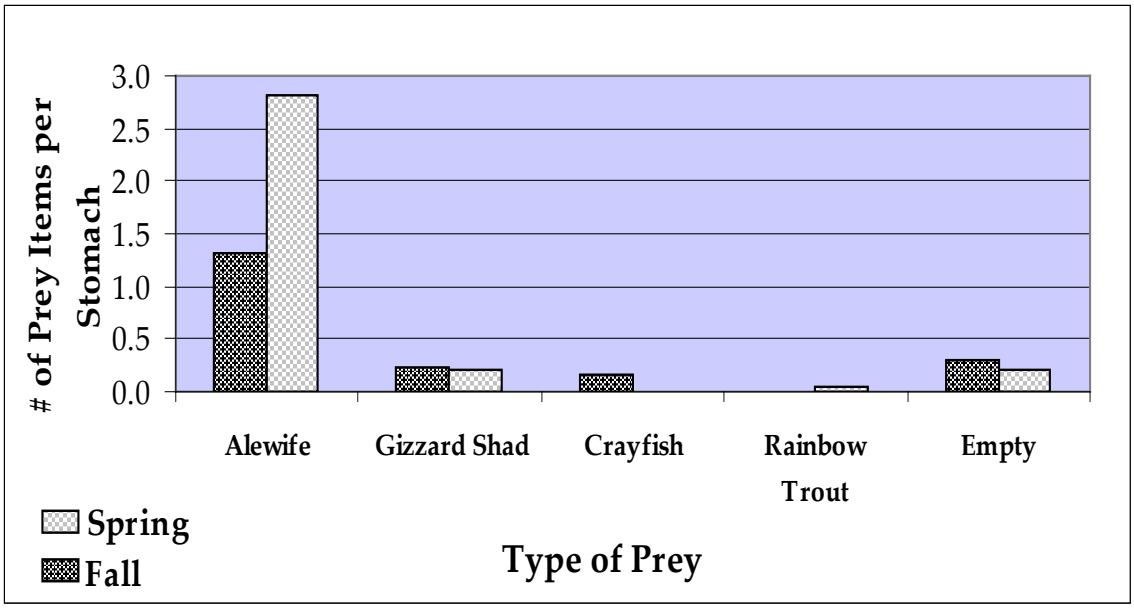


Figure. 2. Mean contents of stomachs for Spring 2002, 2003 and Fall 2003 of striped bass (*Morone saxatilis*) in Raystown Lake, Huntingdon County, Pennsylvania.

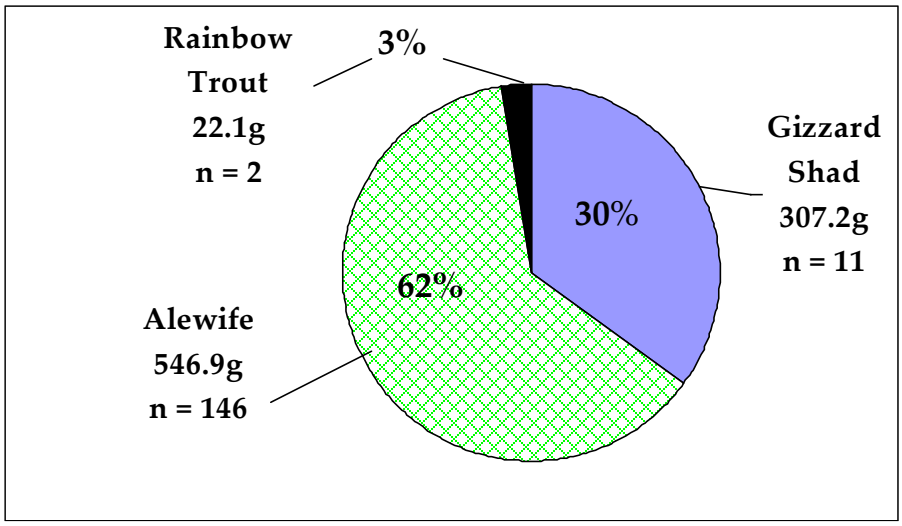


Figure. 3. Spring percent composition by weight of striped bass (*Morone saxatilis*) stomachs in Raystown Lake, Huntingdon County, Pennsylvania. Collected in Spring 2002, 2003 and Fall 2003.

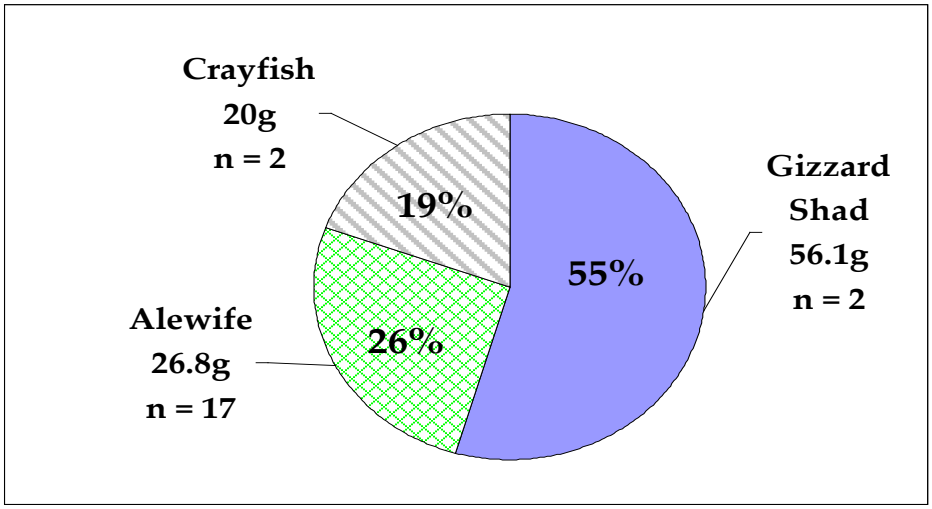


Figure. 4. Fall percent composition by weight of striped bass (*Morone saxatilis*) stomachs in Raystown Lake, Huntingdon County, Pennsylvania. Collected in Spring 2002, 2003 and Fall 2003.

DISCUSSION

My results show a definite diet shift in striped bass between Spring and Fall. Bass in the Spring had fuller stomachs, perhaps due to higher levels of prey availability during that season (Brönmark and

Hansson 1999). Spawning behavior can also account for increased feeding, because spawning occurs in the early Spring. At this time the bass will increase their food intake to make up for the energy loss spawning incurs (Nelson et al. 2003). Another factor that affects the stomach fullness of bass is their digestion rate. The digestion rate of fish is affected by both meal size and water temperature. Because the water is cooler in the early Spring, the rate of digestion would be slower than that of the Fall. This would result in the bass having fuller stomachs during the Spring (Hurst and Conover 2001). A bias in my study is that at the tournaments, only the largest bass caught were turned in by fishermen. Larger striped bass eat larger prey items (Cyterski et al. 2002). Therefore this diet analysis may not pertain to smaller striped bass in Raystown Lake. The knowledge of striped bass seasonal feeding behavior gained from this study will hopefully aid future sport fishery management at Raystown Lake.

ACKNOWLEDGEMENTS

I would like to thank Dr. Charles Yohn, Dr. John Matter, Nick Lambert, the Raystown Striper Club, the Raystown Field Station, and the Juniata College Environmental Science and Studies Department.

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2004

THE EFFECT OF BOAT LAUNCHES ON BENTHIC MACROINVERTEBRATES IN A LENTIC SYSTEM

Lauren E. Forster

ABSTRACT

Benthic macroinvertebrates are often used as an indicator species when analyzing the effects of possible pollution sources (Nelson 2000). To test the impact of boat launch related pollution, I sampled benthic macroinvertebrate populations at six sites on Pennsylvania's Raystown Lake during the fall of 2004. I used the Biological Monitoring Working Party (BMWP) Score (Chapman 1996) to assess the pollution tolerance of macroinvertebrate families. The pollution sensitive families Coenagrionidae ($p = 0.012$) and Libellulidae ($p = 0.000$) were significantly less abundant in harbors with boat launches. The pollution tolerant families Asellidae ($p = 0.000$) and Gammaridae ($p = 0.031$) were significantly more abundant in harbors with boat launches. The differences in diversity and abundance of the other four families between the harbors were not significant. This study supports the hypothesis that boat launches affect certain pollution sensitive families.

Keywords: Boat launch, Hester-Dendy sampler, lentic, macroinvertebrate, pollution.

INTRODUCTION

Benthic macroinvertebrates are important indicator species of aquatic ecosystem health (Nelson 2000), and their abundance and diversity can be used to asses the effects of possible pollution sources (Wilhm et. al., 1978). Although there have been numerous studies examining the effect of human disturbances on macroinvertebrate communities in lotic systems, little work has been conducted in lentic systems. The lentic environment of Raystown Lake, PA serves its primary function as a flood control reservoir and is an important part of the Chesapeake Bay watershed. The lake is also highly utilized for recreation, including fishing, water sports and boating. The 30 mile long, 8,300 acre lake and its boat launches are used by over 1.5 million visitors a year (USACE 2004) which can cause a variety of anthropogenic impacts. For example, water contamination by incompletely combusted fuel is known to occur in areas of increased boat traffic such as launches (Secco et. al. 2004). Because Raystown Lake has been designated as a threatened lake by the state of Pennsylvania (U.S. House of Representatives 1999), it is vital that the health of the lake and consequently the system be monitored closely. The purpose of this study is to examine the effect of boat launches on macroinvertebrate community composition in the lake. My hypothesis is that the presence of boat launches, and the associated boat traffic on Raystown Lake has negatively affected the pollution sensitive macroinvertebrate families.

FIELD SITE

I conducted this study at six harbor sites on Raystown Lake, Huntingdon County Pennsylvania (Figure 1). Three harbors containing boat launches and docking areas were chosen as sampling sites. These three harbors were then compared with three harbors without boat launches. The non-launch harbors were

relatively similar in size, bathymetry and proximity to each of the boat launch harbors. The boat launches are managed by the U.S. Army Corps of Engineers. Harbor 1 is more heavily utilized as a seasonal docking area for boats. The other two are used primarily for launching and the temporary docking of boats.

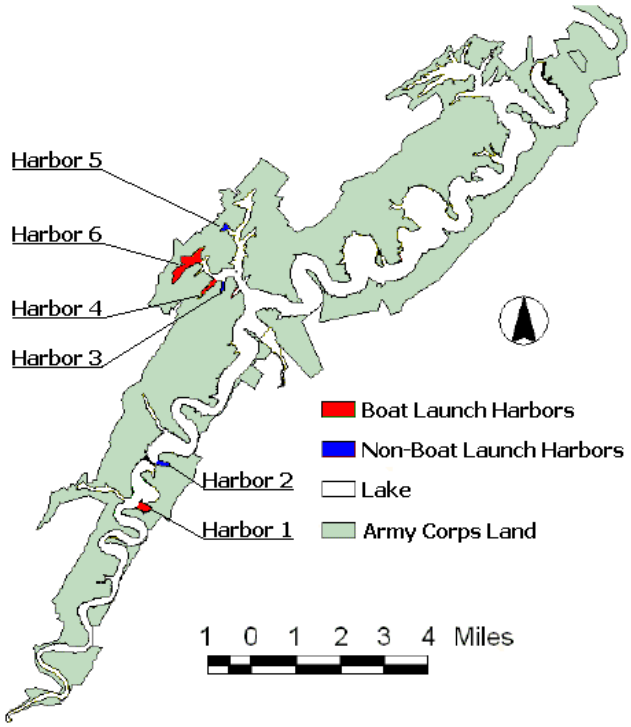


Figure 1. Map of sampling sites on Raystown Lake, Pennsylvania.

METHODS & MATERIALS

I collected benthic macroinvertebrates using Hester-Dendy artificial substrate samplers (Brower et. al. 1998, p 118) at each of 6 harbor sampling sites on Raystown Lake. The samplers each had a total surface area of about 0.12m² and were anchored to bricks (Figure 2) using bailing twine. Three samplers were placed randomly at 1-2.5 m depth in each harbor and were exposed from Sept. 8th to Nov. 3rd, 2004. I retrieved the samplers from the sites after a period of about 44-46 days. Upon retrieval, the samplers were placed in a plastic bag with lake water. I also conducted water quality measurements at each harbor sampling site; including water temperature, pH, and conductivity, and Secchi disk readings (Table 2). I measured the pH using a HACH EC10 meter (HACH 1996). Conductivity and temperature readings were obtained using an Oakton Acorn series meter (Oakton 1998).

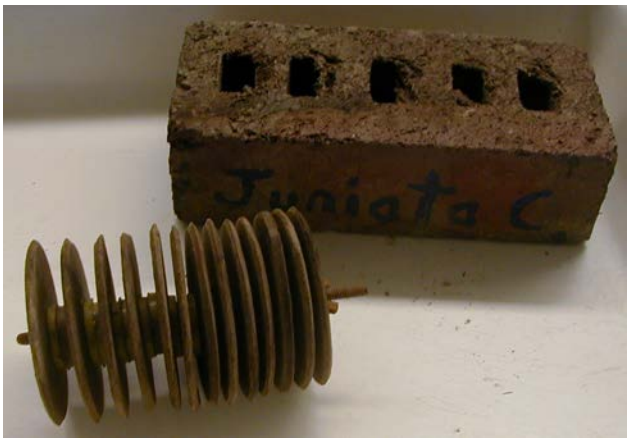


Figure 2. A Hester-Dendy macroinvertebrate sampler with brick anchor.

After collection, the samplers were disassembled and rinsed in a shallow tray to ensure that all the macroinvertebrates were separated and counted. I then preserved the invertebrates in sample bottles containing a 30% ethanol solution. The macroinvertebrate taxa were identified to the family level. I determined family diversity using the Shannon diversity index (Brower et. al. 1998, p 180-185). I then compared the abundance per sampler area of each family between harbors with boat launches and harbors without using a Mann-Whitney U Test (Carver 2004). I set the alpha level of the tests at 0.05 and considered the differences to be significant if $p \leq 0.05$. I used the Biological Monitoring Working Party Scores (Chapman 1996) for each family to assess macroinvertebrate pollution tolerance. The families were scored on a scale of 1 to 10, with 10 being the most sensitive. For the physiochemical data, I used the Welch's t-test to determine if there were any differences between the two harbor types.

RESULTS

Overall, 774 benthic macroinvertebrates from eight families of were collected on the artificial samplers at the six sampling sites. The abundances for the two harbor types are given in Table 1. The families Coenagrionidae ($p = 0.012$) and Libellulidae ($p = 0.000$) were significantly less abundant in harbors with boat launches. The families Asellidae ($p = 0.000$) and Gammaridae ($p = 0.031$) were significantly more abundant in harbors with boat launches. I found no significant difference between any of the other four families of macro invertebrates. Shannon diversity did not differ between boat launch and non-boat launch harbors. Libellulidae were absent from the boat launch harbors, while Asellidae were absent from non-boat launch harbors. Aside from these two families, the other six taxa were all found in both boat launch and non-boat launch harbors. The conductivity in the boat launch harbors was significantly higher ($t = 2.02$) than that of the non-boat launch harbors ($p = 0.034$) (Table 2). There were no significant differences in the pH, temperature or Secchi depths between the two harbor types.

Table 1. Numbers of benthic macroinvertebrates collected from Raystown Lake, 2004.

Order: Family	Common Name	Boat Launch	No Launch	BMWP
Ephemeroptera:Heptageniidae	Mayfly	48	53	10
Odonata:Coenagrionidae	Narrow winged Damselfly	11	33	8
Odonata:Lestidae	Spread winged Damselfly	5	9	8
Odonata:Libellulidae	Skimmer Dragonfly	0	2	8
Diptera:Chironomidae	Midge	289	242	2
Trichoptera:Polycentropodidae	Caddisfly	3	19	7
Isopoda:Asellidae	Sowbug	15	0	3
Amphipoda:Gammaridae	Scud, Sideswimmer	38	7	6

Table 2. Mean physiochemical conditions at each harbor site on Raystown Lake, 2004.

Harbor	Temp (ºC)	pH	Cond. (µS)	Secchi depth (m)

1-BL*	14.1±1.0	6.5±0.5	230±24.3	1.4
2	13.7±0.0	5.7±0.0	205±0.0	1.4
3	13.4±0.5	6.2±0.7	148±10.2	1.4
4-BL*	13.3±0.4	5.9±0.1	200±26.2	1.5
5	14.3±0.4	7.3±0.4	163±3.8	1.3
6-BL*	14.8±0.1	7.0±0.2	156±0.6	1.3

*BL indicates the presence of a boat launch

DISCUSSION

My results generally support the hypothesis that boat launches affect benthic macroinvertebrate populations. The families Asellidae and Gammeridae appear to be more tolerant of boat launches while Coenagrionidae and Libellulidae are less tolerant of launches. The BMWP Scores (Table 1) provide support for this conclusion by ranking Coenagrionidae and Libellulidae as more sensitive families than Asellidae and Gammeridae. Nelson and Roline (2003) found similar abundance patterns in their study, which indicated that some families are more tolerant of pollution, like mine runoff, than others. Pinel-Alloul (1996) found that water conductivity is one of the most significant variables effecting macroinvertebrate communities. The increase in conductivity in harbors with boat launches could be due to anthropogenic sources (Topalian et. al. 1998). The Secchi depth readings were conducted on different days, but indicate murkier conditions than normal which could be attributed to the large flood event that raised the lake level 15ft. during the sampling interval.

Although Shannon diversity did not differ between the harbors, the abundance data indicates that the family richness is comprised of different families depending on whether the harbor has a boat launch or not. These results suggest that the families are competition sensitive, a theory which is supported by the higher abundances of tolerant families in boat launch harbors where there is a lack of sensitive families. The higher abundance of the pollution tolerant families in boat launch harbors may be due, in part, to the availability of resources not utilized by other more sensitive families. Non-boat launch harbors have a higher abundance of pollution sensitive families, which may out compete some of the more tolerant families. Pollution sensitivity and perhaps competition play an important role in determining which families are more abundant in the harbor types.

The abundance of the most pollution sensitive of the families, Heptageniidae, was not significantly different between the two harbor types. I expected that there would be an abundance difference for this family of mayflies, because the BMWP gives it a sensitive score of 2. However, with the removal of an outlier in the abundance data, a significant difference ($p = 0.018$) was observed for Heptageniidae. This outlier could have been caused by a variety of factors, including a substrate the sampler was placed in, which was rockier than any of the other sites (Pinel-Alloul, et. al. 1996).

A large flood event took place in the first few weeks of sampler exposure, during which the level of the lake rose over fifteen feet above normal. This increased the placement depth of the samplers to over sixteen feet for about a week and caused an increase in debris around some sampling sites. This flood event could have caused the loss of the three uncounted samplers and may have had other unknown effects on my results.

Because limited data is available regarding macroinvertebrate abundance in lentic systems, I have compared my results to those of studies conducted in lotic environments. Wilhm et. al. (1978), who used similar sampling methods with 42 samplers, found 36 families. My study found eight families using 15 samplers. In relation to the other study, the number of families I collected is similar relative to the number of samplers used. The results of my study indicate that boat launches do have an affect on macroinvertebrate populations. Because benthic macroinvertebrates are an indicator species of aquatic ecosystem health, these results provide an indication of affects on other parts of the aquatic system. For example, fish populations, which are important for the recreation on Raystown Lake, might be effected by boat launches or the changes in macroinvertebrate communities.

Further investigation is needed to identify what specific biotic and abiotic factors of boat launches influence macroinvertebrate abundance including water chemistry and substrate effects. Alternative sampling methods would also provide more data since artificial substrate samplers attract the colonization of some species and discourage others, which introduces a species bias, favoring those that are equipped for

colonizing artificial plate type samplers (Brower et. al. 1998). Experimentation during peak seasons of boat launch may also provide additional insight.

AKNOWLEDGEMENTS

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COMPARING BODY SIZE TO WEB AREA IN *CYCLOSA CONICA*

Jim Serfass

ABSTRACT

I investigated the relationship between body size and web area in the spider species Araneidae Cyclosa. I hypothesized that there would be a positive relationship between web area and body size. I found no relationship between body size and web area in any of four populations in Huntingdon County, Pennsylvania. Web area was unrelated to body mass, body length, and abdomen length. There were no significant differences in any of the measured variables among the four sample populations. However, the mean mass of spiders with stabilimentum decoration on their webs was larger than that of spiders without decorated stabilimenta ($t = 1.46$, $DF = 42$, $p = 0.076$). Also, the mean web areas for webs with decorated stabilimenta were significantly smaller than other webs ($t = -2.60$, $DF = 30$, $p = 0.007$).

Keywords: body size, Cyclosa conica*, stabilimentum, web*

INTRODUCTION

Prey capture is the ultimate function of a spider web (Foelix 1996). The purpose of my research was to determine if web area is a major factor in this function. I did this by comparing spider size to web area to determine if a relationship exists between the two variables. Without the influence of any other factors, web area should be proportional to prey capture, which would then affect the size of the predator (Foelix, 1996). My hypothesis was that web area would be directly proportional to spider size.

Additionally, I investigated the presence of a stabilimentum in a web as a determining factor in spider size. A stabilimentum is formed by pieces of debris and prey items which are lined vertically through the hub of a web. There are multiple hypotheses as to the purpose of stabilimenta. These include: 1) web advertisement 2) prey attraction 3) camouflage 4) strengthening of the web 5) stabilimenta serve no purpose (Eberhard 1990). Foelix (1996) suggests that different stabilimenta serve different functions in different types of orb webs, the chief function among *Cyclosa* being camouflage. My purpose was to determine if a relationship exists between the presence of a stabilimentum and spider mass. I hypothesized that a larger spider body mass could be the result of more effective prey capture for webs containing a stabilimentum.

FIELD SITE

All field sites were located in Huntingdon County, Pennsylvania. Three sites (RFS1, RFS2, and RFS3), were located at the Raystown Field Station near the village of Entriken while one (PC) was located on the Juniata College Peace Chapel east of Huntingdon. The sites at the Raystown Field Station were all just north of the Grove Farm facility in a deciduous, second growth forest with significant undergrowth. Sites RFS1 and RFS3 were on a south facing slope while RFS 2 was on the top of the hill. The Peace Chapel site was in a similar type of forest and is also on a south-facing slope. All sites had an area of approximately 100 square meters. Overall, the vegetation was similar between the two sites although the Peace Chapel site had fewer small bushes and more young trees.

METHODS AND MATERIALS

I collected samples at the Raystown Field Station on Oct. 8, 2004, Oct 15, 2004, and Oct 28, 2004. The Peace Chapel data was collected on Oct. 21, 2004. The weather was mild on Oct. 8 and Oct. 28, with a temperature of approximately 55^0 F and sunny conditions. On Oct. 15 and Oct. 21, conditions were less favorable, with rain and cooler temperatures.

I surveyed each site for webs, and upon discovering a web, I captured each spider in a small sample bottle. I used a compass to determine the orientation of each web. I took the compass bearing perpendicular to the side of the web on which the spider was resting. I also measured the height of the hub of the web above the ground with a tape measure. I used the same tape measure to find the height and width of each web. Only the radial spirals which are used for prey capture were considered; the outlying connecting and supporting threads were not measured.

Web location was designated by the type of plant growth on which the web was constructed. The four categories were: Large trees, those greater than 6 inches in diameter, medium trees, those less than 6 inches in diameter and greater than 5 meters in height, and small trees, those that had a small diameter and were three to five meters high with few branches. Bushes/young trees were less than three meters high and had mostly small branches near their tops and had few leaves. Webs were inspected for captured prey and stabilimentum decoration. Prey was clearly visible and was either wrapped or unwrapped. I considered a stabilimentum decorated if it had captured prey items lined vertically through the hub or had a thick visible line of thread crossing vertically through the hub.

To calculate web area, I used the average radius of the web and estimated the web as a circle using the formula: $A = \pi r^2$. Lengths were measured using a Leica S4E microscope. Body length was determined by measuring from the farthest tip of the abdomen to the tip of the cephalothorax. Abdomen length was taken from the end of the abdomen to the start of the cephalothorax. Spider mass was determined using a Cahn C-31 Microbalance set to an accuracy of 1 μg for 250 mg. I weighed all specimens within 8 hours of capture.

I compared spider mass to web area using linear regression (Excel, 2003). I considered a relationship significant if $R^2 > 0.70$. I also compared body length to web area and web height to web area in the same way. I compared the sample means for spider mass and web area using a one-sample Z-test (Minitab, 2004). I also conducted a 2-sample t-Test (Minitab, 2004) to compare the masses of spiders with decorated stablimenta vs. undecorated webs as well as web area of webs with decorated stabilimenta to undecorated webs. I used a one-way ANOVA (Minitab, 2004) to compare web area among the four sample groups. I considered the differences to be significant if $p < 0.10$.

RESULTS

The mean body mass of the population was 8.031 +/- 1.830. None of the sample groups fell outside of this range. The mean web area was $114.5 cm^2$ +/- $71.8 cm^2$. All sample means were within this range as well. The most significant relationships were between webs with decorated stabilmenta vs. undecorated webs. The areas of undecorated webs (121.6 cm^2) were 38.4% larger than webs with a decorated stabilimentum (74.9 cm^2) ($t = -2.60$, $DF = 30$, $p = 0.007$). Also, the masses of spiders with webs which had a decorated stabilimentum (8.81 mg.) were 11.1% larger than those without a stabilimentum (7.83 mg.) ($t = 1.46$, $DF = 42$, $p = 0.076$).

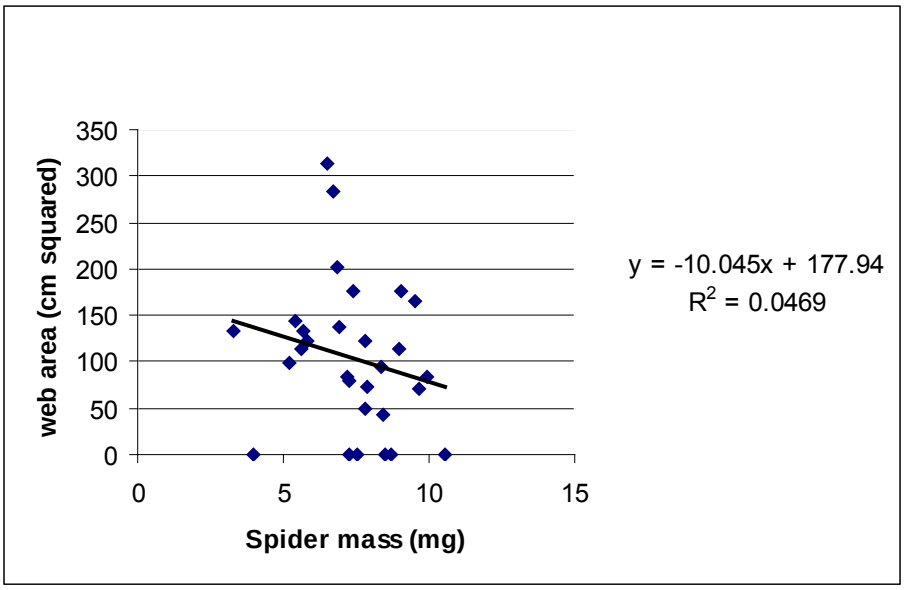


Fig. 1. Spider mass (mg) vs. web area (cm^2)

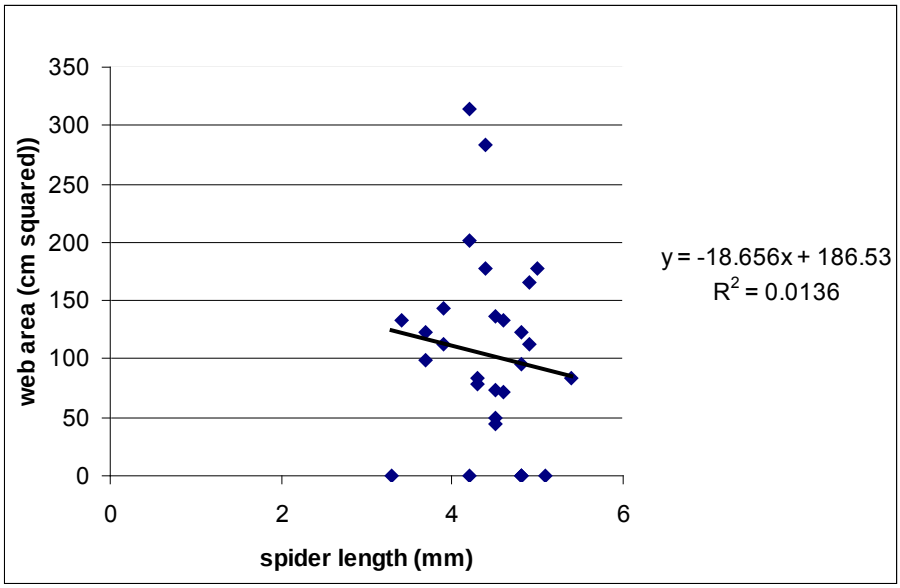


Fig. 2. Body length (mm) vs. web area (cm^2)

DISCUSSION

I found no correlation between spider size (body mass, body length) and web area (Figures 1 and 2). This finding indicates that factors other than web area influence body size in *Cyclosa conica*. These factors may include web location, competition, and the quality of the web itself. Also, spiders often

relocate their webs or change the area based on prey capture (Nakata, 1999). The web on which the spider was captured may not have contained the same characteristics as the spider's previous webs.

Also, the inclusion of incomplete webs in the data set was a factor that affected the linear regression of body size to web area. I collected five webs at the RFS2 site that did not contain sufficient spiral threads for the web area to be calculated Therefore, I counted the areas as zeroes. These zeroes could have affected the correlation slightly, however, even if the zeroes were excluded, the data would not produce a significant R^2 value when comparing web area to any of the variables in body size.

My findings concerning the decorated stabilimenta are supported by Tso, 1998, who found web diameter to be 19% smaller for spiders with decorated stabilimenta and daily insect interception rates 150% higher in those webs. This supports my results that spiders with decorated stabilimenta have a larger mass probably because more effective prey capture would lead to greater food availability.

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Abstract

I examined fish populations directly above and below the dam on Trough Creek, Pennsylvania, to determine the effect of the dam on fish distribution. My hypothesis was that fish diversity would be greater below the dam because of the additional input of fish species from Raystown Lake, which Trough Creek enters several hundred yards down stream. I conducted fish population surveys in the stream in the stretches immediately above and below the dam in October of 2004 using the technique of electro-fishing. Mean Shannon Diversity was significantly greater above the dam (0.827) than below the dam (0.448) ($t = 4.78$, $P = 0.0$, $DF = 12$). Weather conditions, season, and the presence of predatory fish are all possible explanations for the lower downstream diversity.

Introduction

The creation of a dam fragments a stream or river and often has a large impact on fish populations within the river system (Victor 1998). After the establishment of a dam, fish communities become reproductively isolated from each other, migratory fish from lower river sections, and lakes or oceans are prevented from reaching upstream spawning or feeding grounds, and stream habitat may become less suitable for resident fish and more suitable for non-native fish (Holcik 2003). The appearance or disappearance of certain fish species is often directly related to the establishment of a dam (Kukula 2003) as are other changes in fish population dynamics such as relative abundances of species within the system (Paragamian 2002).

Much research has been done on fish population changes after the creation of a dam on large rivers but little research has been done on fish diversity in small streams with dams such as Trough Creek. Studies done on larger rivers generally shows that fish

diversity generally increases from upstream to downstream and that species richness is greater in rivers below dams than above (Gehrke 2002). A study comparing population structures of fish above and below the Tallowa Dam on the Shoalhaven River in Australia showed that the communities differed significantly with species richness being greater downstream of the dam (Gehrke 2002). Ten species of fish are believed to have been extinct above the dam because of obstructed passage in the same study.

My hypothesis is that fish diversity below the dam will be greater than fish diversity above the dam due to the input of migratory, non-native fish from Raystown Lake, a large impoundment of the Raystown Branch of the Juniata River. Raystown Lake is home to many species of fish that could potentially make their way into lower Trough Creek, and add to its diversity. Many species of fish not found in upper Trough Creek are likely to make their way into the lower reaches of the stream from Raystown Lake at some point every year (personal observation). Some fish, such as gizzard shad (Dorosoma cepedianum), alewife (Alosa pseudoharengus), and walleye (Stizostedion vitreum) are known to enter the lower river in large numbers during the spring to spawn (personal observation).

Above the dam Trough Creek is a small stream with resident populations of small baitfish in the darter (Percidae), and shiner and minnow families (Cyprinidae), black bass (Micropterus salmoides and Micropterus dolomeui), and stocked trout. Electro-shocking information collected by Juniata College beginning in 1952 in upper trough creek offers a good picture of what species could potentially exist in the creek above the dam. Nine recorded samplings turned up a total of 21 species, a number that is probably close to

approaching the maximum richness of resident fish species in the stream (Fisher, unpublished data).

Field Site

My study site was in Trough Creek State Park in south-central Pennsylvania 16 miles south of Huntingdon, near the village of Entriken. The dam is located in the lower reach of the park about 70 meters from where Trough Creek enters Raystown Lake (Figure 1). The dam was built in the 1860s to create a swimming area. I sampled two stretches of creek, one immediately below the dam plunge pool and one immediately above the small impoundment created by the dam.

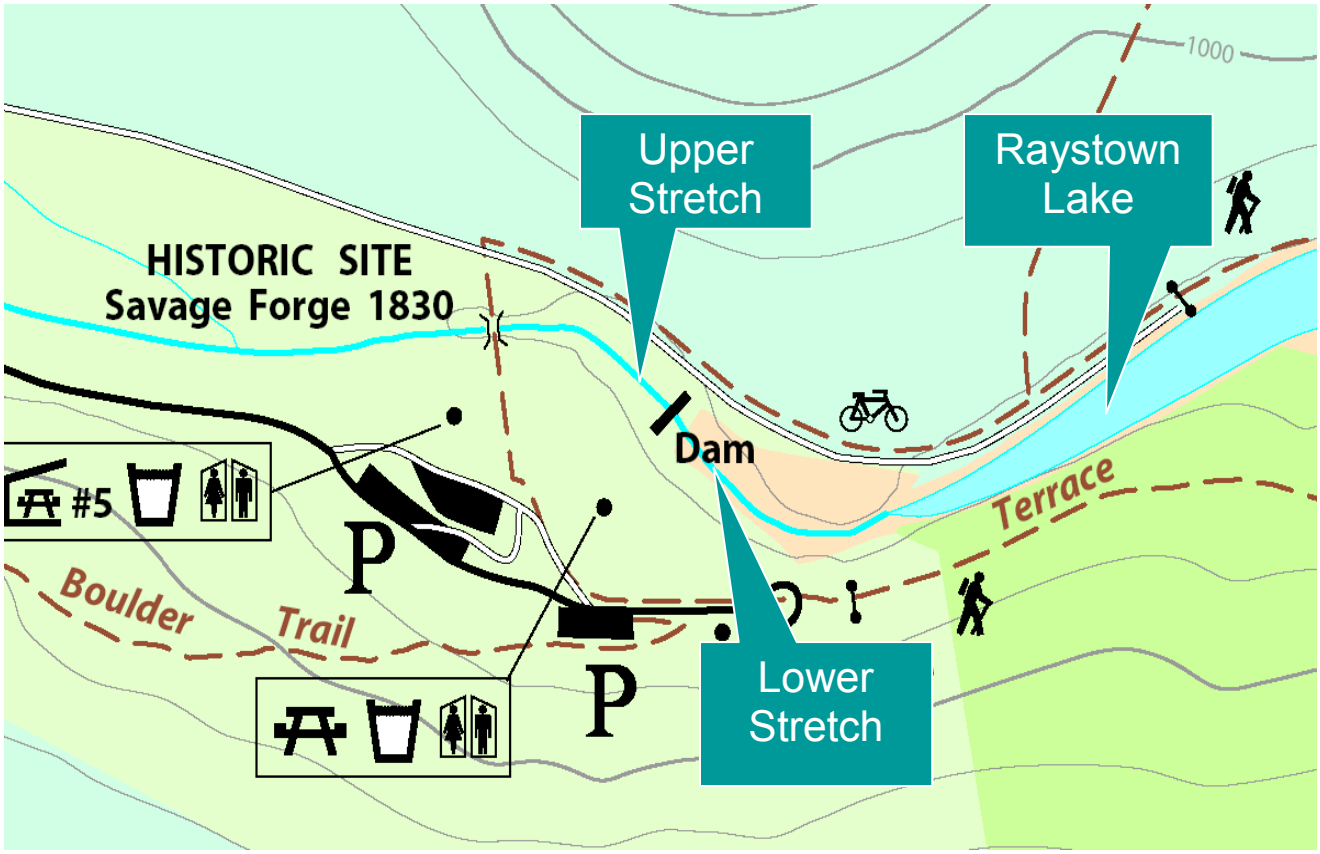


Figure 1: Map of Lower Trough Creek (Study Area)

Methods

The populations of fish in the two stretches of the creek were assessed using an electro-shocking technique. I directed a five member electro-fishing crew in which one member ran the LR-24 Electrofisher, two members flanked the shocker on either side with long handled mesh dip nets, and two members held a 4' by 26' seine net downstream.

When arriving at the site we started our sampling at the lowest ten-meter section of the lower stretch so not to disturb fish in areas that we had not yet sampled. The seine net was stretched across the downstream end of our first sample stretch and held on either end by a crew member to catch any fish that were missed by the dip netters. Once the seine net was in place, the remaining three crew members shocked and netted fish. This process was repeated for each ten-meter stretch. All collected fish in were identified to species and released at the end of the sampling session. The sampling was conducted first on October the 13th and again on October the 27th of 2004.

I calculated fish diversity for each 10-meter stretch on each day using the Shannon-Weaver index (Brower 1998). I used a Welch's t-Test (Minitab 2004) to compare between upstream and downstream stretches as well as within the same stretches. I used an alpha level of 0.05 and considered results to be significant if $p < 0.05$.

Results

One hundred and eleven fish from 18 species were caught and recorded with slightly more than three quarters of them coming from the upper stretch. Most of the fish recorded were small baitfish in the darter, shiner, and minnow families. Several larger predator fish were caught including two large brown trout (Salmo trutta) and three

smallmouth bass in the upper stretch and a rock bass (Ambloplites rupestris) and a brook trout (Salvelinus fontinalis) in the lower stretch. The number of species collected in each stretch and the number of individuals representing each species is given in Table 1.

The stream above the dam had a greater abundance and richness of fish. The cumulative abundances and species richness were 75 and 15 in the upper stretch and 36 and 11 in the lower stretch, respectively. Mean Shannon Diversity was significantly greater above the dam (0.827) than below the dam (0.448) ($t = 4.78$, $DF = 12$, $P < 0.001$,). Mean Shannon Diversity was not differ significantly between sampling days within the upper and lower stretches ($P = 0.06$ and 0.075 respectively).

Table 1. – Numbers of fish collected above and below Trough Creek dam on 10/13/2004 and 10/27/2004

Common Name	Scientific Name	10/13 below dam	10/13 above dam	10/27 below dam	10/27 above dam
shield darter		2	1		
banded darter			2	1	
greenside darter			3	3	8
tesselated darter			1		
rosey face shiner		8	5		6
spotfin shiner		9			
spottail shiner			4		
cutlips minnow			3		2
longnose dace			4	1	8
blacknose dace			6	5	6
northern hog sucker		1	1	3	1
margined madtom			4	1	1
river chub			2		1
rock bass		1			
smallmouth bass			2		1
central stoneroller					1
brown trout					2
brook trout				1	
Total # of species		5	13	7	11
Total # of individuals		21	38	15	37

Discussion

The results of my electro-shocking experiment reject my hypothesis that diversity would be greater in the downstream section. A surprising aspect of the results and a probable reason that my hypothesis was rejected is that the survey of the lower stretch did not turn up any fish that are not historically found in the upstream section of the creek. Either I over-estimated the contribution of fish from Raystown lake fish to the community of lower Trough Creek or my survey was bias to capturing resident stream fish.

One possible explanation for a bias toward catching resident stream fish as opposed to lake run fish is that I did not sample during a wide enough range of conditions, stream sections, times of day, and times of year. Both of my samplings were done on October afternoons when the stream was running very low (personal observation), and the shocking technique limited sampling to shallow riffles and runs. These aspects may have made it less likely to catch fish from Raystown Lake in lower Trough Creek. Many of the lake's fish species (muskellunge (Esox masquinongy), striped bass (Morone saxatilis), rainbow smelt (Osmerus mordax), alewife, and most sunfish (Lepomis)) including species that are known to enter lower Trough Creek in large numbers (walleye and gizzard shad) are spring spawners and are not as likely to be in the creek in October. The fact that the creek was very low on both days also made it less likely that fish from the lake would enter it.

It is also possible that I was bias toward collecting stream fish such as darters, suckers, and other minnows in the runs and riffles that I shocked. Lake species such as walleye, sunfish, black bass, and muskellunge would more likely be found in the deeper

pools. This idea was credited by a juvenile lake trout (a species stocked in Raystown Lake that is not found as a resident in Trough Creek) that I caught while fishing in the pool below the dam in early November.

Although the upper stretch of stream had a greater species richness, the lower stretch had a much higher turnover rate. Of the 11 total species sampled in the lower stretch only one (9 %) was collected on both sampling days. In the upper stretch 9 out of the 15 total species sampled (60 %) were collected on both sampling days. It is likely that the total fish diversity below the dam would be greater than that of the upper stretch in a longer study due to this higher turnover rate and a higher number of potential species.

Another possible explanation for the lower diversity of fish below the dam is the presence of large numbers of predator fish during certain times of the year. I have observed the lower stream in March when it becomes packed full of large adult walleyes on their spawning run. Once their spawning duties are over and they resume feeding, a situation is created in which the number of large predator fish is out of proportion to the number of smaller prey fish and they could easily reduce their populations.

The upper stream also gets a large number of predator fish in the early spring in the form of hatchery trout. It would be far less likely that these small trout have much of an impact on the populations of smaller fish as they are used to being fed pellets and are not skilled predators. Most of these trout are taken from the stream very shortly after they are stocked by an elbow to elbow swarm of anglers on opening day. The predator populations that I observed above the dam were not in any way to large for the baitfish population (5 predator fish out of 75 total fish).

Another possibility for the lack of resident fish populations below the dam is the alteration of stream habitat created by the dam. A study of fish communities in Southern Nigeria found that fish diversity was far lower in the reservoir and downstream stretches of river than in the upstream stretches due to habitat alterations caused by the dam (Victor 1988). Of 58 species caught 90 % occurred upstream while the reservoir and downstream accounted for 48% and 43% respectively. In Trough Creek it is possible that the dam created a situation in which resident stream fish lost access to their shallow, fine gravel upstream spawning habitat.

An additional explanation for the lower fish diversity below the dam is that the area experienced major flooding from several hurricanes in the month prior to my study. During this flood the lake level rose so high that the water covered the dam and the lower river became a part of the lake. This could potentially have had a large effect on dispersing resident or migratory fish populations from the lower creek into the lake.

My study showed that fish diversity below the dam on 10/27 (Shannon Diversity 0.537) was greater than fish diversity below the dam on 10/13(Shannon Diversity 0.359) with the difference being slightly significant (P =0.06). This could potentially demonstrate that the fish community of the lower river is re-establishing itself after the flood.

With so many variables it is difficult to draw any specific conclusions about the fish difference in fish populations above and below the dam other than the upper creek having a significantly more diverse population in October of 2004. It is reasonably safe to assume that I have my data for the fish populations of the stretch of water above the dam is normal due to less potential variability in flows and the presence of historical

electro-shocking data which is consistent with my results. Further research would have to be done in order to determine the normality of my data on the fish populations of the stretch of creek below the dam.

Acknowledgements

I would like to thank Dr. Charles Yohn for his guidance throughout this project. I would like to thank Patrick Cain, Peter Susfal, Clayton Diehl, Benjamin Beas, Jennifer John, Jonathan Marshal, and Britton Tew of my electro-fishing crew for their help with this project. I would also like to thank Terry Wentz of the DCNR for providing me information for this project.

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2005

THE SUSCEPTIBILITY OF WETLANDS TO INVASION BY *PHRAGMITES AUSTRALIS* (COMMON REED) AND *TYPHA ANGUSTIFOLIA* (NARROW-LEAF CATTAIL)

Laura A. Daugherty and Hannah C. Taylor

ABSTRACT

Although there are extensive efforts to restore wetlands through mitigation, these ecosystems remain vulnerable to invasive exotic organisms. We investigated the susceptibility of wetlands to invasion by *Phragmites australis* (common reed) and *Typha angustifolia* (narrow-leaf cattail) in Huntingdon County, PA. We examined 6 factors that may affect the densities of these invasive species, which include wetland age, area of open water, perimeter around open water, proximity of the wetland to development, density of other dominant vegetation species, and wetland elevation. *Typha* densities showed a significant correlation with wetland age and proximity to development ($r = 0.840$, $P = 0.018$; $r = 0.543$, $P = 0.055$) while *Phragmites* densities showed a correlation with wetland area ($r = 0.623$, $P = 0.031$). No other significant correlations were found. We cannot conclude that the manipulation of these factors will help protect wetlands from invasive species.

INTRODUCTION

Wetlands provide an important breeding and resting habitat for a variety of wildlife, fish, and plant species (Cronk 2001). Wetlands also provide habitat for many endangered and threatened species in Pennsylvania, including *Ardea alba* (great egret) and *Rallus elegans* (king rail) (Cronk 2001). The most productive biota residing in wetlands are the plant communities. Unfortunately, wetland plant communities are threatened by the dominating effects of invasive species (Cronk 2001). Invasive plants can spread rapidly into and significantly alter an ecosystem (Cronk 2001, Farnsworth 2003).

In general, wetlands are more vulnerable to invasion than other upland areas. Wetlands are considered "Landscape sinks" that accumulate sediments, nutrients, and other debris from runoff that increase the probability of invasive species entering into the ecosystem (Kercher et al. 2004). Wetlands that lie in lower areas of landscapes, in areas of greater road density, in riparian areas, as well as those wetlands fed by storm water run off from agricultural or urban areas and those in drought like conditions with reduced flows are at a greater risk of invasion (Kercher et al. 2004). Other reasons for the expansion of invasive species may be due to an increasing combination of human development, nutrient enrichment, and salinization (Farnsworth 2003). More opportunities for species invasion occur through flood events and increased nutrients levels that result from increased disturbances (Kercher et al 2004). Also, the presence of herbivores or pathogens, and the degree of the disturbance level may also contribute to an increased invasibility of plant species (Davis et al. 2000).

Invasive species change the habitat structure, biodiversity levels, productivity levels, and food webs in a wetland ecosystem (Kercher et al. 2004). Invasive species often dominate their new ecosystems though greater competitive abilities, reproduction rates, resource consumption rates, and ecological tolerances that allow them to displace native species in the ecosystem (Farnsworth 2003). Over the years, researches have proposed 5 major theories of invisibility. These include: invasive species being free from enemies, having a broader tolerance, using resources more efficiently, evolving hybrid vigor, and utilizing allelopathy (Kercher et al. 2004). Most invasive plants do not utilize one strategy but a combination of multiple strategies which makes it difficult for researchers to determine the exact level of invasiveness of specific plant species.

Two common invasive species in Pennsylvania are *Phragmites australis* (common reed) and *Typha angustifolia* (narrow-leaf cattail). Both species grow in monocultures and are relatively tall compared to other

species in the ecosystem. *Phragmites* and *Typha* have air in their tissues which allow them to obtain more oxygen for their roots and grow to a higher volume and height (Kercher et al. 2004). They tend to have greater biomass, use more resources, and grow rapidly (Zedler et al. 2004). Once established in an area, *Phragmites* has the potential to out compete other species because of its ability to spread rapidly from an initial colonization point to areas of dense, tall stems that shade neighboring smaller plants. *Phragmites* also has decay-resistant dead stems that may interfere with the germination or growth of other neighboring species (Lynch 2002). *Typha* species have also shown more tolerance to increased flooding and higher water tables than native species (Kercher et al. 2004).

Our goal was to determine wetland factors that increase the susceptibility of invasion by *Phragmites* and *Typha* in Central Pennsylvania. We predict that there will be a difference in the density of these 2 invasive species due to one or a combination of wetland factors.

KEYWORDS

Wetlands, Emergent Vegetation, Invasive Species, Pennsylvania, *Phragmites australis, Typha angustifolia*

FIELD SITES

We examined 8 mitigated wetlands in the Ridge and Valley province in Huntingdon County, Pennsylvania (Table 1, Figure 1). We defined wetlands in a manner consistent with the U.S. Army Corp of Engineers and the U.S. Environmental Protection Agency (USACE 2005). We treated the wetlands with multiple open water areas as separate sites.

Table 1: Area of Open Water (ha) and Description of Wetland Sites in Huntingdon County

Name (# of Pools)	*Open Water Area (ha)*	*Description*
Woodcock Community Park (1)	0.01	A pool adjacent to a constructed pond surrounded by a park.
Old Crows (1)	1.59	Mediation/restoration site. Surrounded by fields and close development.
Detwiler Park (2)	0.33	Pools surrounded by well kept grass.
Muddy Run (1)	0.05	Creek that runs into a Pool.
Huntingdon Area Middle School (1)	0.07	Surrounded by small forested area and grass.
Fouses' Crossing (5)	0.26	These pools were part of a Raystown Mediation site with constructed dikes.
Joller Remediation Site (1)	0.47	This pool was part of an Acid Mine Drainage remediation site. The water level was low, and the pH in one pool was high enough to sustain plants and animal life.
Corbin's Island (2)	0.02	These pools were dried up with a low level of stagnant water. These were downhill from agricultural lands.

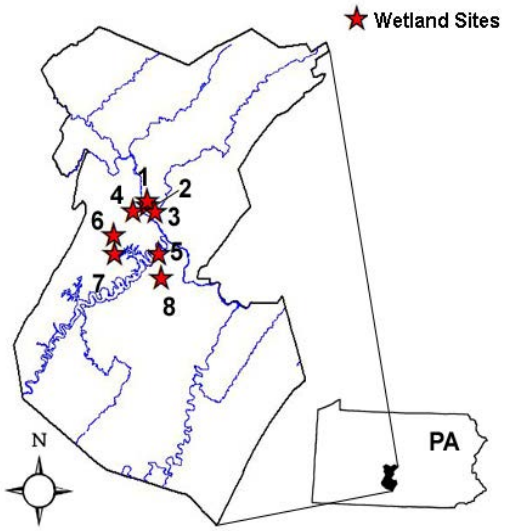


Figure 1: Wetland study sites in Huntingdon County, Pennsylvania. Sites included: 1. Huntingdon Area Middle School, 2. Muddy Run, 3. Detwiler Park, 4. Old Crows, 5. Corbin's Island, 6. Woodcock Community Park, 7. Fouses Crossing, and 8. Joller Remediation Site.

METHODS

We surveyed the 8 wetlands between October 28 and November 11, 2005. We sampled 1 or several open water areas in each wetland, for a total of 14 plant communities in our study.

In each site we quantified the densities of *Phragmites* and *Typha* by establishing a transect along the perimeter of each open pool, 1 meter from the water's edge. Along this transect we selected 10 evenly distributed 1 meter^2 plots and recorded the total number of narrow-leaf cattail, common reed, and other dominant species within the plot. We defined other dominant species as the other emergent vegetation that was noticeably abundant in the wetlands and was similar to our study species.

In addition, we also measured each pool's perimeter with a Rino GPS unit (Garmin 2005). We recorded the proximity of the wetland to development (buildings, roads, etc.) using a Leica Rangemaster 1200 Scan (Leica 2002).

Finally, we determined the Pearson correlation coefficients (MINITAB 2004) between each wetland factor and the densities of *Phragmites* and *Typha*.

RESULTS

The average densities of *Typha* and *Phragmites* ranged from 0.5 to 21.2 plants/m^2 and 0 to 36 plants/m^2, respectively. Three of the 12 comparisons revealed significant correlations between wetlands variables and the densities of the invasive species (see Table 2). The density of *Typha* showed a highly significant correlation to the wetland age ($r = 0.840$, $P = 0.018$). Also, the density of *Typha* also showed a slightly significant correlation to the wetland proximity to development (0.543, $P = 0.055$) and density of *Phragmites* was significantly correlated to the wetland area ($r = 0.623$, $P = 0.031$). No other significant correlations were found for the other wetland variables.

Table 2: Pearson Coeffiecients (r) and P-values for Correlations between Wetland Factors and Densities of *Phragmites* and *Typha* (plants/m^2)

Factor	*Phragmites* Density	*Typha* Density
Age (yr)	-0.190, P = 0.683	0.840, P = 0.018
Elevation (ft)	-0.315, P = 0.346	0.167, P = 0.624
Open water area (m^2)	0.623, P = 0.031	0.173, P = 0.590
Open water perimeter (m)	0.323, P = 0.333	0.439, P = 0.177
Other dominant species density (Plants/m^2)	0.297, P = 0.474	-0.386, P = 0.345
Proximity to development (m)	-0.204, P = 0.503	0.543, P = 0.055

DISCUSSION

We found that *Typha* was more prevalent in older wetlands. This species grows in a monoculture that utilizes most resources and displaces other species. Previous studies on wetlands in the same region have shown that similar clonal species were more prevalent in the older sites as well, and that there were significant differences between the vegetation of younger and older wetlands (Campbell et al. 2002). The same study also found that younger wetlands had species richness levels twice as high as older sites.

Typha was also more prevalent in areas closer in proximity to developments. The disturbance level of the area also increases the susceptibility of wetlands to invasive species. Another study reports that a greater area of disturbance allows more open spaces for seed recruitment and increases genetic and clonal diversity in plant species such as *Typha* (Tsyusko et al. 2005).

Phragmites was slightly more prevalent in wetlands with a greater area. This species is widely known to be one of the most widely distributed plants species around the world (Tewksbury 2002). This species is able to adapt to a wide range of habitat and has high genotypic and phenotypic flexibility which allows it to grow well in wetlands, riversides, road ditches, and other wet areas (Tewksbury 2002).

In conclusion, we found wetland age, area, and proximity to development to be the most significant factors that increases the prevalence of invasive species in wetlands of Central Pennsylvania. The manipulation of these factors may or may not help to decrease the susceptibility of wetland invasion by *Phragmites* and *Typha* species.

ACKNOWLEDGMENTS

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THE EFFECT OF BOAT LAUNCHES ON BENTHIC MACROINVERTEBRATES IN A LENTIC SYSTEM

Lauren E. Forster

ABSTRACT

Benthic macroinvertebrates are often used as an indicator species when analyzing the effects of possible pollution sources (Nelson 2000). I sampled benthic macroinvertebrate populations at six sites on Pennsylvania's Raystown Lake during the summer of 2005 to test the impact of boat launch related pollution. I compared abundance, Shannon Diversity and Shannon Evenness in harbors with boat launches to those without boat launches. There were no significant differences in abundance, diversity and evenness of the ten families between the two harbor types. There were no significant differences found between the harbor types in regards to temperature, pH, conductivity, and Secchi measurements. This study compares the results from a lentic system with those of a healthy lotic system. These results do not support the hypothesis that boat launches affect macroinvertebrate families in Raystown Lake, PA.

Keywords: Boat launch, Hester-Dendy sampler, lentic, macroinvertebrate, pollution.

INTRODUCTION

Benthic macroinvertebrates are important indicator species of aquatic ecosystem health (Nelson 2000), and their abundance and diversity can be used to assess the effects of possible pollution sources (Wilhm et al., 1978). Although there have been numerous studies examining the effect of human disturbances on macroinvertebrate communities in lotic systems, little work has been conducted in lentic systems. The 30 mile long, 8,300 acre Raystown Lake, PA serves its primary function as a flood control reservoir and is an important part of the Chesapeake Bay watershed (USACE 2004). The lake is also highly utilized for recreation by over 1.5 million visitors a year for fishing, water sports and boating (USACE 2004) which can cause a variety of anthropogenic impacts. Impacts include water contamination by incompletely combusted fuel in areas of increased boat traffic such as boat launches (Secco et. al. 2004). Because Raystown Lake has been designated as a threatened lake by the United States Environmental Protection Agency (U.S. 1999), it is important that the potential environmental impacts be examined. The purpose of this study is to examine the effect of boat launches on macroinvertebrate community composition in Raystown Lake to determine if the presence of boat launches has negatively affected macroinvertebrate families.

FIELD SITE

I conducted this study at six harbor sites on Raystown Lake, Huntingdon County Pennsylvania (Figure 1). Three harbors containing boat launches and docking areas were chosen as sampling sites. These three harbors were then compared with three harbors without boat launches. The non-launch harbors were relatively similar in size, bathymetry and proximity to each of the boat launch harbors. The boat launches are managed by the U.S. Army Corps of Engineers. Harbor 1 is more heavily utilized as a

seasonal docking area for boats. The other two are used primarily for launching and the temporary docking of boats.

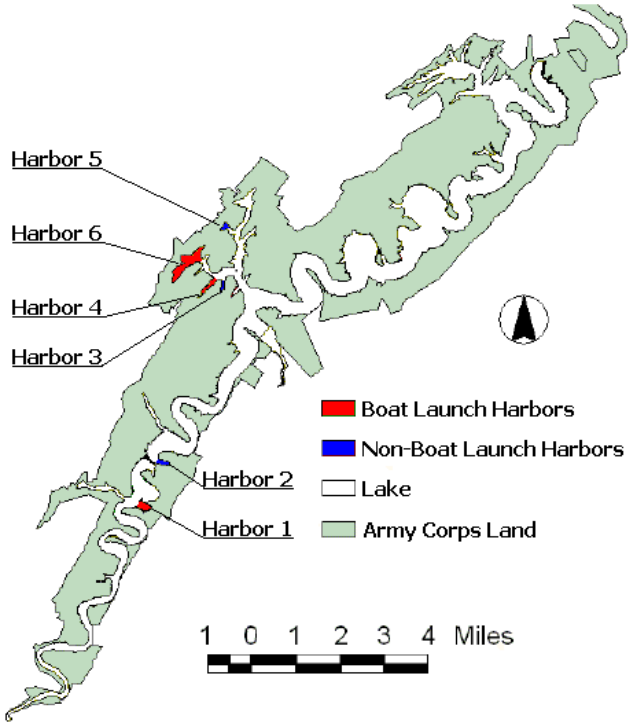


Figure 1. Map of sampling sites on Raystown Lake, Pennsylvania.

METHODS & MATERIALS

I collected benthic macroinvertebrates using Hester-Dendy artificial substrate samplers (Brower et al. 1998) at each of 6 harbor sampling sites. The samplers each had a total surface area of about 0.12m² and were anchored to bricks (Figure 2) using nylon string. Three samplers were placed randomly at 1-2.5 m depth in each harbor and were submerged from May 10th to July 16th, 2005. Upon retrieval, the samplers were placed in a plastic bag with lake water for transport to the lab.

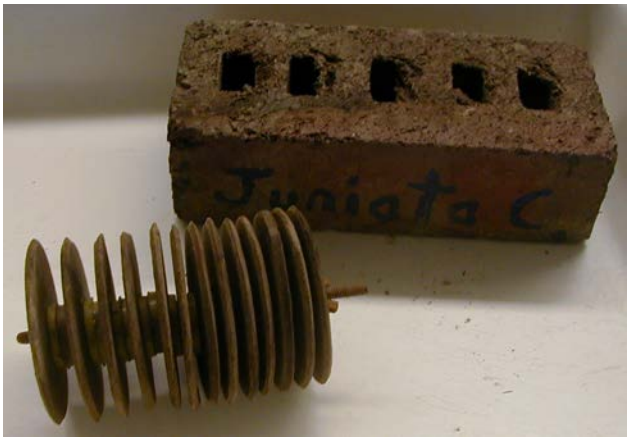


Figure 2. A Hester-Dendy macroinvertebrate sampler with brick anchor.

After collection, the samplers were disassembled and rinsed in a shallow tray to ensure that all the macroinvertebrates were separated and counted. I then preserved the invertebrates in sample bottles containing a 30% ethanol solution. The macroinvertebrate taxa were identified to the family level. I also conducted water quality measurements at each harbor sampling site; including water temperature, pH, conductivity, and Secchi disk readings. The temperature, pH, and conductivity measurements were taken at the location of each Hester-Dendy sampler just before it was retrieved. The Secchi disk readings were taken at about the center of each harbor after retrieving all of the samplers from the harbor. I measured the pH using a HACH EC10 meter (HACH 1996). Conductivity and temperature readings were obtained using an Oakton Acorn series meter (Oakton 1998).

I compared the abundance per sampler area of each family between harbors with boat launches and harbors without, using a Mann-Whitney U Test (Carver 2004). I then determined family diversity using the Shannon diversity index (Brower et al. 1998). I also calculated the Shannon evenness for each harbor and compared the values for harbors with boat launches to those without, again using a Mann-Whitney U Test (Carver 2004). I considered differences to be significant if $p \leq 0.05$. For the physiochemical data, I used a Welch's t-test to test for any differences between the two harbor types.

RESULTS

Overall, 681 benthic macroinvertebrates from ten families were collected on the artificial samplers at the six sampling sites. The abundances for the two harbor types are given in Table 1. The greatest abundances were of the families Heptageniidae and Chironomidae, which were found in both types of harbors. The families Sialidae, Coenagrionidae, Libellulidae, and Asellidae were found to have the lowest abundances of the ten families. The macroinvertebrate abundances in boat launch harbors did not differ significantly from non-launch harbors (Table 1). The abundance values for the families Sialidae and Libellulidae were not great enough to demonstrate significant differences between the two harbor types. Shannon diversity and Shannon evenness values did not differ significantly between boat launch and non-boat launch harbors ($p = 0.383$). There were also no significant differences found between the harbor types in regards to the physiochemical measurements (Table 3).

Table 1. Total abundance of benthic macroinvertebrates collected from harbors in Raystown Lake, 2005.

Order: Family	Common Name	Boat Launch Present	Boat Launch Absent	*p*-value
Ephemeroptera: Heptageniidae	Flatheaded Mayfly	91 ± 8.80	113 ± 17.30	0.500
Ephemeroptera: Leptophlebiidae	Pronggilled Mayfly	31 ± 6.13	31 ± 8.49	0.564
Ephemeroptera: Caenidae	Small Squaregilled Mayfly	4 ± 0.93	59 ± 18.90	0.437
Megaloptera: Sialidae	Alderfly	0 ± 0.00	1 ± 0.35	N/A
Odonata:Zygoptera: Coenagrionidae	Narrow winged Damselfly	1 ± 0.35	1 ± 0.35	0.500
Odonata:Anisoptera: Libellulidae	Skimmer Dragonfly	0 ± 0.00	2 ± 0.17	N/A
Diptera: Chironomidae	Midge	91 ± 7.07	108 ± 14.10	0.396
Trichoptera: Polycentropodidae	Caddisfly	27 ± 4.53	42 ± 6.42	0.124
Isopoda: Asellidae	Sowbug	4 ± 0.93	9 ± 3.18	0.396
Amphipoda: Gammaridae	Scud, Sideswimmer	31 ± 6.18	18 ± 3.30	0.479

Table 2. Shannon diversity and evenness values for six harbors in Raystown Lake, 2005 .

Harbor Name	Boat Launch	Shannon Diversity (H')	Shannon Evenness (J')
James Creek	Present	0.584	0.836
Aitch	Present	0.582	0.748
Resort	Present	0.596	0.766
Shuster	Absent	0.399	0.663
Near Aitch	Absent	0.624	0.738
Near Resort	Absent	0.707	0.783

Table 3. Mean physiochemical conditions in six harbors on Raystown Lake, 2005.

Harbor	Temp (ºC)	pH	Cond. (µS)	Secchi depth (m)
1-BL*	27.5 ± 0.2	9.4 ± 0.1	326 ± 1.41	1.8
2	27.2 ± 0.1	9.1 ± 0.4	305 ± 1.53	1.4
3	28.1 ± 0.1	7.1 ± 0.2	238 ± 1.07	1.4
4-BL*	28.3 ± 0.6	8.6 ± 0.3	239 ± 9.45	1.5
5	30.2 ± 0.2	9.7 ± 0.2	226 ± 21.21	1.3
6-BL*	29.3 ± 0.6	9.3 ± 0.2	246 ± 3.79	1.3
p-value	0.810	0.464	0.989	0.372

*BL indicates the presence of a boat launch

DISCUSSION

The results generally do not support the hypothesis that boat launches affect benthic macroinvertebrate populations. There were no significant differences between the harbors with boat launches and the harbors without for the abundance, diversity, or evenness values. Although family abundance values did not differ between the harbors, there were some families such as, Sialidae, Coenagrionidae, Libellulidae, and Asellidae that only occurred in a few of the harbors. This abundance was not great enough to show a difference between the two harbor types, but it does exemplify the existence of variation among harbors. The lake macroinvertebrate community is highly dominated by mayfly and midge families, while other families may not be abundant enough to show statistical differences either. There may be variations between the six harbors that create different environments for macroinvertebrate life. Such variables include the differing bathymetry between each of the harbors. The substrate that the samplers were randomly placed in could have also caused abundance variations, since some families prefer to live in rockier substrates than others for example (Pinel-Alloul, et. al. 1996). Harbor bathymetry differences may also be a source of variation, as many of the harbors have different depths, sizes, and slopes.

In lotic environments, Wilhm et. al. (1978), who used similar sampling methods, found 36 families with 42 samplers. My study found ten families using 15 samplers. The number of families collected in these two studies is similar relative to the number of samplers used. If the results of this study occurred in a lotic system, they would indicate that there is no difference in the water quality of harbors that have boat launches and harbors that do not. This conclusion is based on the evidence that families which are sensitive to pollution in lotic systems, such as Heptageniidae and Leptophlebiidae according to Chapman (1996), are present in significantly equal abundances in both harbor types. The pollution tolerant families, Chironomidae and Asellidae are also found in equal abundances in both harbor types (Chapman 1996).

Further investigation is needed to identify the effects of the possible variations and control for them. Alternative sampling methods would also provide more data since artificial substrate samplers attract the colonization of some families and discourage others, which introduces a family bias (Brower et. al. 1998). This study differs from the previous study I conducted on the effect of boat launches on macroinvertebrates in Raystown Lake, PA in 2004. The previous study found significant differences in the abundance of four families and water conductivity, which indicated that boat launches affect macroinvertebrate populations. This study found no evidence of boat launches having an effect on macroinvertebrates in Raystown Lake, PA. Further research on this issue would be useful to determine which of the findings are more representative of the conditions occurring in Raystown Lake.

AKNOWLEDGEMENTS

Dr. Charles Yohn and Dr. Paula Martin for their guidance with this project. My research assistants Melissa Wilson and Heather Hassel proved invaluable in completing this project. I would also like to thank the Juniata College Environmental Science and Studies Department and the Raystown Field Station.

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EFFECTS OF RURAL DEVELOPMENT ON THE WATER QUALITY OF TWO SOUTH-CENTRAL PENNSYLVANIA STREAMS

Allison Kielbasa

ABSTRACT

Although much is known about the effects of agriculture and heavy urbanization on stream water quality, little research has been done on the effects of rural development. I examined the effect of rural development on nitrate concentration and load, conductivity, and pH in pristine and developed segments of Shaver and Standing Stone Creek in northeastern Huntingdon County, Pennsylvania. Water quality variables did not differ significantly within 100 m stream segments (lowest $P = 0.11$), but did differ significantly between upstream and downstream sites ($P \leq 0.002$). Rural development did not appear to have a significant effect on stream water quality, and the recorded changes in water quality were likely attributed to other factors (agricultural land use, vegetation types, and surface geology).

Keywords: stream water quality, rural development, nitrate, pH, conductivity

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INTRODUCTION

Heavy urbanization and agriculture are known to have negative effects on freshwater aquatic systems (Groom and Vynne 2006). Land development can cause ecosystem stresses, altering nitrate levels in aquatic systems, as well as pH and conductivity (Chapman and Kimstach 1996, Loeb 1994, Wakida and Lerner 2005).

Nitrates are most often introduced into streams through groundwater, and are often found in aquatic systems near agricultural areas, but have also been linked to non-agricultural sources as well (such as from leaking septic systems, landfills, and home fertilizers). These sources can have a large impact in urban areas with high population density (Wakida and Lerner 2005). In areas of rural development, population densities are lower than in urbanized areas, so the impact of these sources may differ. However, there are homes, recreational grasslands (e.g., golf courses, athletic fields), and commercial zones in rurally developed areas as well, and may be extensive enough to have an effect on stream water quality (Wakida and Lerner 2005).

Increased inputs of organic materials (fertilizers, etc.) can increase the pH of aquatic systems, while atmospheric deposition of acidic compounds from urban areas can decrease the pH (Chapman and Kimstach 1996). These sources may be possible contributors to changes in pH within areas of rural development, but on a smaller scale than that of heavily urbanized or agricultural areas, possibly causing chemical stresses which can alter aquatic niches, and therefore negatively affect aquatic organisms (Loeb 1994).

Higher conductivity values can be attributed to runoff and other dissolved solids in groundwater from both urban areas and agricultural areas, and therefore possibly from areas of rural development as well (Chapman and Kimstach 1996).

Although the effects of agriculture and heavy urbanization on aquatic systems are relatively well studied, there is little known about the effect of rural development. The goal of my research was to determine if rural development had an effect on the nitrate levels, conductivity, and pH of two small streams in the northeast portion of Huntingdon County, Pennsylvania. I considered rural development to be light urbanization (commercial, public, residential, light industrial) in a rural area. Agricultural lands were not included in this description of rural development.

FIELD SITE

I conducted this research on Shaver Creek and Standing Stone Creek, both of which are located in the Northeast portion of Huntingdon County, Pennsylvania and drain into the Juniata River. Two sites (pristine and developed) were chosen from each of the two streams. Pristine stream segments were located near the headwaters in two separate areas of Rothrock State Forest, while developed stream segments were located downstream from the pristine sites, near Huntingdon and Petersburg, Pennsylvania. Both streams had very rocky bottoms, similar water temperature, were similar in size, flow rate, and morphology, and had areas of rural development that were comparable. Headwaters of both streams were underlain with shale and sandstone formations, whereas limestone was present along with shale and sandstone in downstream areas (Figure 1) (PA DCNR 2000). Land use near the replicate stream segments was also similar (Figure 2).

The pristine Shaver Creek segment was located slightly downstream from the Pine Swamp Road crossing, but upstream from the confluence with a smaller intermittent stream. The dominant vegetation of the area surrounding the stream was Eastern hemlocks (*Tsuga canadensis* (L.) Carr.) and tulip trees (*Liriodendron tulipifera* L.), while large rhododendrons (*Rhododendron* L.) were located along the stream bank. The developed Shaver Creek segment was located in a residential area of Petersburg, PA, west of the intersection of Columbia Street and Shaver Street. The left stream bank consisted of riparian vegetation, black walnut (*Juglans nigra* L.) trees and various maple (*Acer sp.*) trees, but homes were located on the other bank. The homes were on lots larger than a quarter of an acre in size and were spread apart. The right stream bank also was lined with a stone wall.

The pristine Standing Stone Creek segment was located in Alan Seeger Natural Area, slightly upstream from the creek's confluence with Detweiler Run. The dominant vegetation in this area was similar to the pristine site along Shaver Creek. However, this site also contained white pine (*Pinus strobus* L.) in the forested area, and the rhododendron was more dense along the stream bank. The developed Standing Stone Creek segment was located in a residential/public area of Huntingdon Borough, PA, near PA 26, behind Detweiler Sports Complex and Cavalry Baptist Church. The area to the left of the stream was forested, containing sycamore (*Platanus occidentalis* L.) and Norway spruce (*Picea abies* (L.) Karst) trees. Silver maples (*Acer saccharinum* L.) and sycamores were sparsely spread along the right bank among riparian vegetation. Located between the right stream bank and PA 26 were sports fields, parking lots, and small public buildings. On the other side of the road from them was a small residential subdivision.

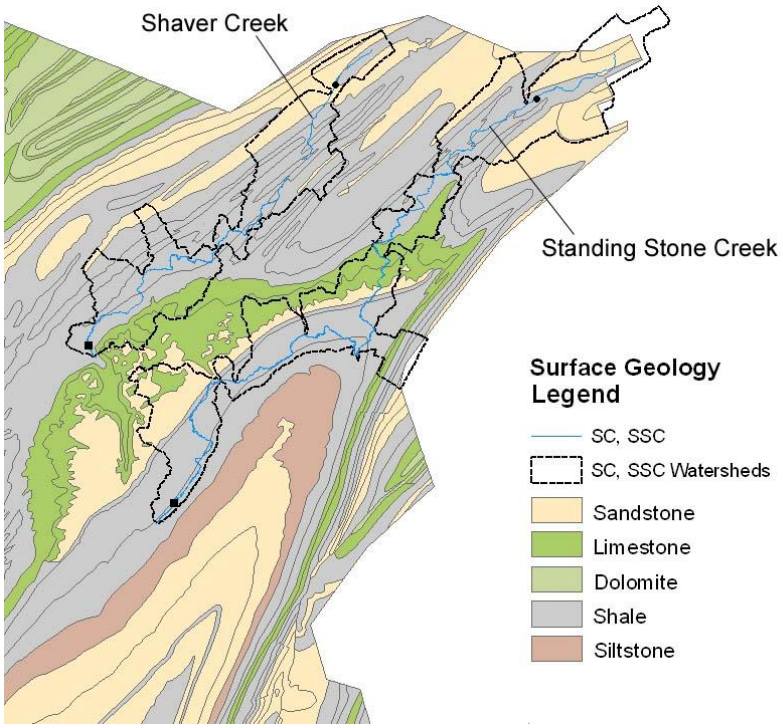


Fig. 1: Surface geology of Northeastern Huntingdon County, Pennsylvania. Outlined areas are the watershed boundaries of Shaver Creek (SC) and Standing Stone Creek (SSC). Dots indicate locations of pristine stream study sites, and squares indicate locations of developed stream study sites.

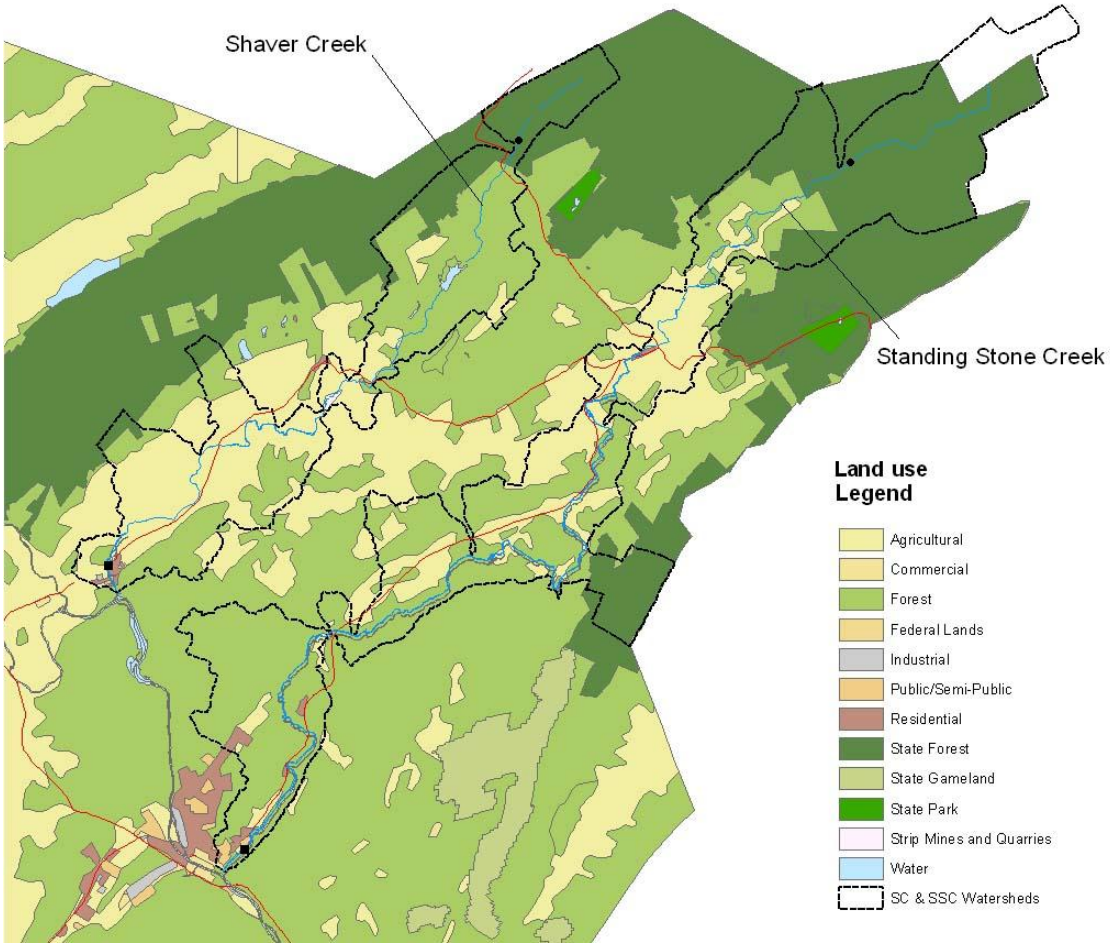


Fig. 2: Land use in Northeastern Huntingdon County, Pennsylvania. Outlined areas are the watershed boundaries of Shaver Creek (SC) and Standing Stone Creek (SSC). Dots indicate locations of pristine stream study sites, and squares indicate locations of developed stream study sites.

METHODS AND MATERIALS

I conducted this study on October 22, 2005. I collected data at one pristine site and one developed site in each of the two streams. At the downstream end of each segment of stream, I took samples while crossing the stream (5 for pH and conductivity, 2 for nitrate), and then did the same 100 yards upstream. I repeated this procedure at each of the four stream segments tested. I measured pH data with a HACH EC 10 pH meter with a sensION electrode (HACH 1999) and conductivity with an Oakton Con 5 Acorn Series conductivity/°C meter (Oakton Instruments 1998). I took plunge samples in 50 mL plastic bottles and put them on ice for transport to the lab for nitrate analysis (EPA 2003). I also measured streamflow at each of the four stream segments (EPA 2004). I analyzed the samples for nitrates, using a HACH DR/2000 spectrophotometer and the mid-range cadmium reduction method (HACH 1992). I multiplied the nitrate concentrations by the streamflow measurement of the corresponding stream segment to obtain nitrate load values (modified from EPA 2004).

I compared the change over the pristine stream segments to the change over the developed stream segments using Welch's T-tests (MINITAB 2004). I then pooled the data and compared the total pristine area water quality to total developed water quality also using Welch's T-tests (MINITAB 2004). In both cases, I considered results to be significant if $P \leq 0.05$.

RESULTS

I recorded no significant differences in any of the four response variables when sampling within any of the four stream segments. Mean pH values varied slightly, ranging from 6.19 to 7.68. Mean conductivity values varied greatly, ranging from 43.95 to 345.90µs/cm. Conductivity showed a non-significant increase in one developed stream stretch (P =0.107). Mean nitrate concentrations varied slightly, ranging from 0.15 to 0.38 mg NO_3-N/L, while mean nitrate load varied greatly, ranging from 0.73 to 22.10 kg NO_3-N/day (Table 1). However, I did find significant changes in all response variables from pristine to developed stream segments (Table 2).

Table 1: Mean (± s.d.) pH, conductivity, nitrate ([NO_3-N]) and nitrate (NO_3-N) load at pristine and developed stream segments of Shaver and Standing Stone Creek, Huntingdon Co., PA. October 22, 2005.

	Pristine		Developed	
	Begin	End	Begin	End
pH	6.19 ± 0.51	6.69 ± 0.28	7.68 ± 0.12	7.63 ± 0.15
Conductivity (µS/cm)	43.95 ± 13.36	44.51 ± 13.26	334.50 ± 89.44	345.90 ± 85.19
[NO_3-N] (mg NO_3-N/L)	0.18 ± 0.05	0.15 ± 0.06	0.38 ± 0.15	0.38 ± 0.15
NO_3-N Load (kg/NO_3-N/day)	0.87 ± 0.35	0.73 ± 0.32	22.10 ± 7.45	22.10 ± 7.45

[A] "Begin" and "end" refer to the beginning and the end of the 100-yd stream segments used in the experiment

Table 2: Mean (± s.d.) pH, conductivity, nitrate ([NO_3-N]) and nitrate (NO_3-N) load at pristine and developed stream segments of Shaver and Standing Stone Creek, Huntingdon Co., PA. October 22, 2005.

	Upstream (pristine)	Downstream (developed)	
pH	6.44 ± 0.47	7.66 ± 0.14	*
Conductivity (µS/cm)	44.23 ± 12.96	340.20 ± 85.21	*
[NO_3-N] (mg NO_3-N/L)	0.16 ± 0.05	0.38 ± 0.14	*
NO_3-N Load (kg/NO_3-N/day)	0.80 ± 0.32	22.10 ± 6.90	*

* Difference between upstream mean and downstream mean is significant ($P \leq 0.002$)

DISCUSSION

Although there were areas of rural development along the two streams, the water quality seemed to be fairly high. The pH values in this study are consistent with those typically seen in natural waters (6.0 – 8.5) (Chapman and Kimstach 1996). The significant difference between upstream and downstream stream segments was possibly attributed to a difference in forest

cover between pristine and developed areas, as Eastern hemlocks were dominant in the pristine areas whereas sycamores and various maples were dominant in the developed areas (personal observation). Tannic acid present in hemlock bark (Zim and Martin, 1956) may have caused the stream water in the pristine areas to have a lower pH than in the developed areas (De Walle, et. al. 1985). In addition, the downstream portions of the watersheds near the developed stream segments had areas of limestone surface geology, whereas sandstone and shale were located upstream (PA DCNR 2000). This limestone could buffer water entering the stream, raising the pH in the developed stream segments (Keener and Sharpe 2005).

Conductivity values in this study are consistent with those typically seen in natural freshwaters, between 10 and 1,000 µs/cm (Chapman and Kimstach 1996). Although I found a significant difference between upstream and downstream conductivity values, the source of these differences could not be pinpointed due to the nature of the experimental design, as well as not being able to measure the ion types present when measuring conductivity (Black 1996). The differences in conductivity values were possibly due to two sources. The surface geology of the watershed near the tested stream segments could have altered the conductivity values, as areas where limestone surface geology is present produce higher conductivity values (150-500 µs/cm) than in areas where silicate surface geology is present (10-50 µs/cm) (Jackson Bottom Wetlands Preserve 2005). The reaction of stream water and storm water runoff with limestone ($CaCO_3$) produces calcium ions in the water (Miller 2004a,), therefore increasing conductivity (Keener and Sharpe 2005). The presence of limestone downstream of the pristine stream segments may have increased the conductivity values measured in both streams near the developed stream segments (PA DCNR 2000). Because this process occurs naturally, I could not link this conductivity source to rural development. Because conductivity measures ion presence, an increase in nitrate ion concentration will inflate conductivity values (Chapman and Kimstach 1996). Because I measured increases in both nitrate concentration and conductivity, I concluded that although development may have an effect on conductivity, rural development in particular was probably not sufficient enough to have been a source of this change.

The nitrate values I measured were all much lower than the EPA's 10mg/L maximum contaminant level for nitrate (Schilling and Zhang 2004) (Table 1). The very low concentrations I measured could have been found because nitrate is carried in groundwater rather than storm water, and because data was taken during a storm event, the normal concentration of nitrate in the tested streams was probably diluted. The difference between upstream and downstream nitrate concentrations was most likely due to the presence of agricultural lands between the pristine and developed stream segments. Nitrate in aquatic systems varies with land use, but agricultural lands are major sources of nitrates due to the use of nitrate-containing fertilizers (Wakida and Lerner 2005, Schilling and Zhang 2004). Fertilizers and animal manure used on agricultural lands contribute large amounts of nitrate to nearby aquatic systems (Schilling and Zhang 2004). Differences in nitrate values between the two watersheds were roughly proportional to the difference in the amount of agricultural land use between the two watersheds. This observation reinforces the suggestion that agricultural land use is the primary source of nitrates for these watersheds. Although there are other non-agricultural sources of nitrate in stream water (including sewage from leaking wastewater mains, landfills, or septic tanks, and runoff containing fertilizers for residential areas or recreational grasslands such as sports fields or golf courses) (Miller 2004b, Wakida and Lerner 2004, Chesapeake Bay Program 2005), high population densities are often necessary to see a significant change in nitrate amounts from them (Wakida and Lerner 2004). Because I did not find a significant difference in nitrate concentration or load over the developed stream segments, I concluded that the population densities in these areas of rural development were probably not high enough for these sources to be contributing large amounts of nitrate into the tested streams.

Although I found a significant difference in water quality between pristine and developed locations, I could not conclude that rural development had a significant effect on the water quality of the two study streams.

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A COMPARISON OF VISITATIONS BY *ODOCOILEUS VIRGINIANUS* TO THREE URINES AT RAYSTOWN FIELD STATION

Matthew Springer

ABSTRACT

The White-tailed deer (*Odocoileus virginianus*) uses olfactory scents to communicate among conspecifics. Hunters use this to their advantage and have created a fifteen million dollar business in the sale of deer attractants. The attractiveness of buck, doe in estrus, and goat urine to deer were compared at Juniata College's Raystown Field Station in Central Pennsylvania during November 2005. Motion sensing cameras monitored artificially created scrapes where the scents were applied and visits were recorded. Deer visitations were at their highest prior to the peak of the rut, 1.5 visits/day, and only 0.44 visits/day after. There were no significant differences in mean visits among the three scents (Buck urine 0.5 visits/day) (Doe in estrus 0.83 visits/day) (Goat urine 0.39 visits/day). I found that it was not the scent used but possibly time of year that affected the frequency of visits.

KEYWORDS

Odocoileus virginianus, White-Tailed Deer, Deer Scrapes, Deer Urine, Deer Lure

INTRODUCTION

Whitetail Deer are a common species found throughout Pennsylvania with an estimated population of 1.6 million animals (PGC 2005). Their breeding season runs from October through December and has a peak in mid November (Hofacker 89). Scrapes are made by both male and females (Sawyer 1982) and are used as message centers (Marchington 1977) leaving olfactory information for other deer (Miller et al. 1987). Hunting coincides with the rut and hunters use this to their advantage and apply urine based scent to attract deer (Dalrymple 136). There are two main types of deer urine manufactured, buck and doe in estrus urine. Hunters spend over fifteen million dollars annually on scent attractants (Stern 1997). The goal of this study was to compare the relative attractiveness of three urine type to deer.

FIELD SITE

I conducted this study at Raystown Field Station in the Ridge and Valley Province, Huntingdon County, approximately two miles north east of Entriken, PA. The dominant vegetation is oak/hickory forest with three most abundant species being Chestnut Oak (*Quercus montana*), Red Type Oak (*Quercus rubra*), and the Virginia Pine (*Pinus viginiana*) (Garner 2002).

METHODS AND MATERIALS

I conducted the study during a four week period in November 2005. Scrape suitable areas were identified as flat ground with open understory and available licking branches (Ozaga 1989). Under a licking branch, I cleared a circular area of about 30 inches in diameter. Care was taken not to step or touch this bare ground. I collected control urine from a female goat; Wildlife Research Center single doe in estrus urine and Code Blue buck urine were purchased. A scent wick was soaked with urine and placed on the licking branch. I randomly chose this scent from the control (Goat Urine) or treatment scent (alternated between Buck Urine and Doe in estrus Urine per 3 day collection). I then placed motion sensing cameras (Stealth Cam MC2-GV Scouting Camera and Stealth Cam STC-WD1 1.3 Digital Scouting Camera) on a tree within a distance of 3 to 5 m. The cameras were placed at a height approximately 2 ft above the ground and positioned to cover the scrape. This was repeated for all scrapes sites.

I used a paired design to present the two scents. I located the paired scrapes around 20 m away each other at an available licking branch. The scrapes were left alone for three days after which the cameras were collected and moved to another site and the alternate deer scent was presented with the goat urine.

The pictures collected were then analyzed to determine the number of deer visiting each scrape. I counted a visit if there was noticeably different deer using the scrape based on sex, fur color, time since last picture, and size of the deer. I compared buck and doe in estrus urine using the paired t test and the total number of visits among the three urines using a Chi Squared. I considered differences to be significant at $p<0.05$.

RESULTS

I recorded a total of thirty-one visitations to scrape sites during the study (Table 1). There was an average of 3.44 deer visits per three day period. The number of visits in the three day period reached a maximum of 12 (once) and the minimum was zero (once). The scent with the greatest number of visitations was the buck urine 15, with the doe in estrus scent following with 9, and the goat urine with only 7 visitations. There was no significance difference in the number of visits among any of the scents. There were twenty-four visits preceding November 11-20 (peak of the rut) 3 during, and only four following (Figure 1).

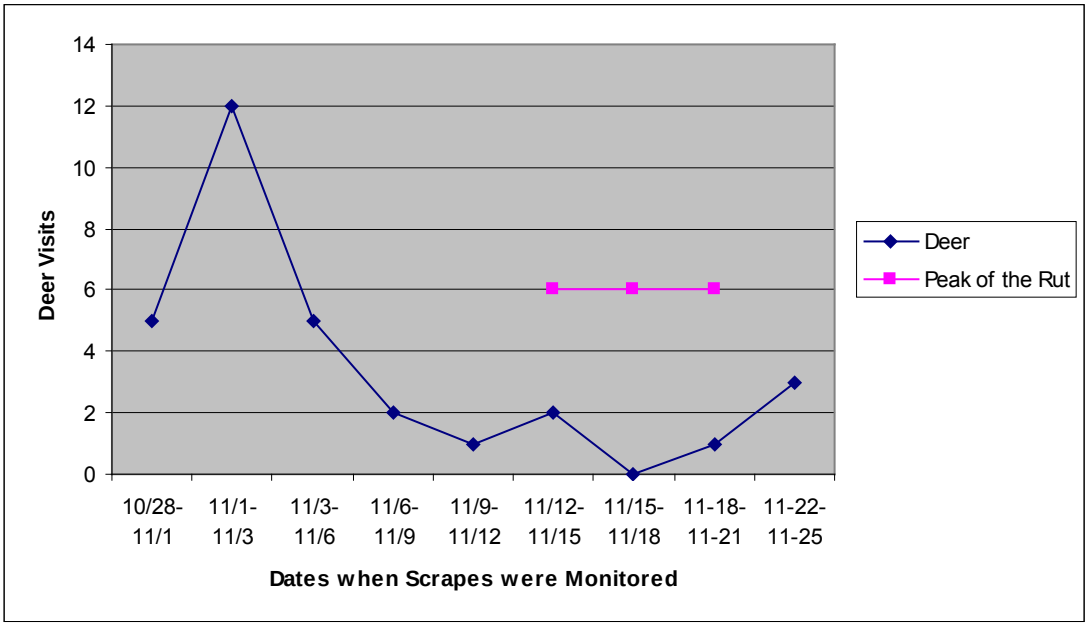


Figure 1 Total number of White-tailed Deer (*Odocoileus virginianus*) visits to monitored scrapes at Raystown Field Station, Pennsylvania during November 2005.

Table 1. White-tail deer (*Odocoileus virginianus*) visits to scrapes at the Raystown Field Station in Central Pennsylvania, during November 2005.

	Goat Urine	Buck Urine	Doe in Estrus
Does	4	11	6
Bucks	3	3	2
Unknown	0	1	1

DISCUSSION

White-tailed Deer (*Odocoileus virginianus*) visited their species urine more frequently than goat urine and showed a non-significant tendency to visit buck urine more than other urine types. This finding is consistent with previous studies (Forester unpublished). Both sexes visited the artificial scrapes, based on pictures, in a manner consistent with natural scrapes. These actions include licking the branch and pawing the ground. This finding is also consistent with previous studies (Woods and Robbins unpublished). Visits to goat urine were few in number and possibly related to curiosity, because there would be limited contact with goats. Visits by deer to novel odors were recorded by Uma Ramakrishnan who noted white-tails visiting sardines (Ramakrishnan pers. Comm.). Decrease in the number of visits over time may be caused by the deer becoming familiar with the urine and no longer being curious of the scent. There was a significant difference in visitation numbers of buck vs. does which may be a result of skewed sex ratio in the population. My finding that maximum visitation occurred prior to the predicted peak of the rut agrees with Ozaga and Verme (1985) but differs from Kile and Marchington (1977) who found that visitations were greatest at peak rut. The discrepancy between these studies requires further investigation.

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Changes in dendroclimatology and growth of edge position trees along an artificial lake.

Carolyn A. Copenheaver[1], Laura E. Hendrick, John W. Houchins, and

Christopher D. Pearce

Department of Forestry, Virginia Tech, Blacksburg, VA 24061

[1] Author for correspondence:

ccopenhe@vt.edu

540-231-4031 (p)

540-231-3330 (f)

Abstract: The objective of this study was to track the change in dendroclimatic response of white oak (*Quercus alba*) that had begun their life in the interior of the forest and following lake construction continued their life along the lake's edge. Understanding how a tree responds to the creation of an edge provides information about how other edges, e.g., roads, forest harvesting, and large-scale natural disturbances, alter tree growth. Twenty white oaks growing along the lake edge were cored and the cores were crossdated, standardized, and developed into a master chronology. Two 32-year segments (pre-lake and post-lake) were removed from the master chronology to compare their dendroclimatic responses. The tree-ring chronology from the pre-lake time period had significant correlations between ring width index (RWI) and temperature in July and significant correlations between RWI and precipitation in October. After the lake construction, the same trees exhibited significant correlations between RWI and temperature in February and precipitation in September and October. Although 39% of trees exhibited growth suppressions and releases associated with lake construction, the overall responsiveness of these trees to climate has not substantially changed over their transition from forest interior to forest edge. Therefore, trees that have changed from interior-to-edge positions remain useful specimens for dendroclimatology studies.

Keywords: Dendrochronology, forest edges, growth release, *Quercus alba*, tree ring

Nomenclature: Gleason and Cronquist 1991

Introduction

Quantifying the influence of forest edge on tree growth elucidates how forest fragmentation and silvicultural practices alter tree physiology and productivity (Bebber et al. 2004, McDonald and Urban 2004). Many edges are created at a single point in time; therefore, trees experience a dramatic transition from interior conditions to edge conditions of greater light exposure, temperature extremes, and lower competition levels (Tremblay and Begin 2005). Examples of common activities that create edge conditions include silvicultural treatments, road construction, residential development, wind damage, and fire.

Trees on newly created edges experience radical changes in their growing environment. Many individuals die because they are unable to tolerate the newly exposed conditions (Tremblay and Begin 2005). Others are able to survive, but will likely be replaced by individuals that are better adapted to the more exposed conditions (Antonic et al. 2001). Some individuals will be favored by the new edge conditions and demonstrate sustainable increased growth (Bebber et al. 2004, McDonald and Urban 2004, Bowering et al. 2006, Py et al. 2006). These higher growth rates are often delayed for several years while the tree directs its energy towards developing a more extensive root system to improve its stability (Urban et al. 1994). Trees that survive have growing conditions with higher variability in hydrology and weather than the more moderated interior of a forest (Xiao et al. 2005).

Most studies of edge trees track how growth rates have altered during the temporal transition from interior to edge; however, another important variable to track is the dendroclimatic responsiveness of the trees. Dendroclimatology studies provide useful

information about which environmental factors limit the radial growth of a tree (Fritts 1976). The method has frequently been employed as a measure of how trees respond across spatial environmental gradients – e.g., moisture, air pollution, topography, competition, etc. (McClenahen and Dochinger 1985, Hofgaard et al. 1999, Meyer and Braker 2001, Copenheaver et al. 2002, Copenheaver et al. 2005). A dendroclimatic study of edge trees would follow the same principle, except the results would reflect a temporal environmental gradient (from a time period when trees were growing in the interior to when the trees were growing along the edge) rather than a spatial environmental gradient. One of the advantages of using a temporal gradient is that the genetics and soils of the trees remain constant, something that is lacking in spatial studies. One disadvantage of a temporal dendroclimatology study is that the age of the trees changes across the study period and it will be necessary to separate changes in dendroclimatic responsiveness resulting from young vs. old trees. Fortunately, dendroclimatology has developed methods for reducing the influence of tree age in the dendroclimatic analysis and therefore this should not be a critical obstruction (Fritts 1976).

The objective of this project was to track the change in growth patterns and dendroclimatic responsiveness of white oak (*Quercus alba*) as the trees changed from interior to edge positions following the creation of an artificial lake. We opted to work with white oak because they were present at the site in dominant and co-dominant canopy positions and had demonstrated significant responsiveness to climate at other sites (Blasing et al. 1988, Orwig and Abrams 1997, Tardif and Conciatori 2006a). We selected to work at Raystown Lake because the lake was constructed by an US Army Corps of Engineers dam that flooded a forested valley and thus created an opportunity for

trees to go from interior forest positions to edge positions within the short time span of the dam construction. Understanding how a tree's responsiveness to climate changes will add new information to an existing body of literature that focuses on how growth rates are altered by edge creation.

Methods

STUDY AREA

Raystown Lake is located in the Appalachian Mountains in south-central Pennsylvania, USA (40.50°N, 78.01°W). The average daily temperatures range from 21° C in July to -2° C in January. Total annual precipitation averages 102 cm. The dominant soil types in this area include: Berks-Weikert, Weikert, Clymer, Albrights, Calvin, Hazelton-Dekalb, and Klinesville (Merkel 1978). The parent materials for these soils are shale, siltstone, and sandstone. These soils are generally acidic and can be fairly stony. Raystown Lake was constructed by the U.S. Army Corps of Engineers in 1973, and the current lake is 45 km in length and approximately 3,240 ha in size. Regional land uses include recreation, management of fish and wildlife habitat, hydroelectric power generation, flood control, and the area also includes Juniata College's Raystown Field Station where the samples from this study were collected. The Raystown Field Station mostly has oak-hickory forest with dominant species including *Quercus alba, Quercus prinus, Quercus coccinea, Quercus velutina, Carya tomentosa, Carya ovata*. Other important species include *Acer rubrum, Acer saccharum*, and *Liriodendron tulipifera* (Braun 1950).

Field and laboratory work

Twenty dominant or co-dominant *Quercus alba* were cored along the edge of Lake Raystown. Each cored tree was measured for diameter at breast height (1.4 m) and total height of the stem. The trees were located along an edge of a peninsula and were selected for coring if at least 40% of the crown was exposed to the edge. Each tree was cored twice at stump height (0.5 m) and the total height and diameter at breast height were measured. Once dried, cores were sanded until cellular structure could be seen under a microscope. All cores were visually cross-dated using narrow rings as pointer years (Schweingruber et al. 1990, Yamaguchi 1991). Tree ring widths were measured to the nearest 0.002 mm using a TA Tree-Ring Measurement System (Velmex, Inc., Bloomfield, NY). Visual cross-dating was verified with the COFECHA program available through the Dendrochrology Program Library. The series intercorrelation for the crossdated cores was 0.683 and the average mean sensitivity was 0.276.

Data analysis

To identify changes in radial growth in the edge trees we used a modified version of the radial-growth averaging technique on the raw ring width chronologies (Nowacki and Abrams 1997). Nowacki and Abrams (1997) proposed more liberal definitions of a moderate release (greater than 25% increase in growth) and a major release (greater than 50% increase in growth) compared to the more conservative definitions (greater than 50% and 100% growth increases) developed for understory trees by Lorimer and Frelich (1989). Given that the criteria developed by Nowacki and Abrams (1997) were

developed for canopy-level oaks in central Pennsylvania (the same species and location as this study) it would appear that using the more liberal criteria for growth releases would be ideal for this study; however, the more liberal criteria were developed for identifying gap-level disturbances and in this study we were interested in identifying the growth patterns following a major disturbance (creation of an artificial lake) therefore, we opted to use the more conservative criteria for releases because we were interested in the large scale disturbance signal rather than the gap dynamics. The radial growth averaging technique was originally designed for identifying growth releases, but it is also an effective method for identifying suppressions (Copenheaver and Abrams 2003) and therefore we looked for both releases and suppression events in our tree-ring data.

For the dendroclimatology analysis, the raw ring widths from each tree chronology were detrended with a spline 30% of the length of the individual chronologies and a master tree ring chronology was developed with the ARSTAN program (also available through the Dendrochronology Program Library). The standard master chronology was autocorrelated (Durbin-Watson D = 0.949, first order autocorrelation = 0.520) and therefore the dendroclimatic analysis was performed with the residual chronology which was not significantly autocorrelated (Durbin-Watson D = 1.838, first order autocorrelation = 0.081). The residual master chronology was correlated with temperature and precipitation data to identify whether a significant dendroclimatic relationship existed at the site. Once a significant correlation was identified with both temperature and precipitation, the correlation coefficients between the tree- ring master chronology and climatic variables were calculated for two time periods to compare dendroclimatic relationships from when the trees were growing within the interior of the

forest (a pre-edge period of 32 years from 1941 to 1972) and after the trees became edge trees with the creation of Lake Raystown (a post-edge period of 32 years from 1974 to 2005). The year when the Raystown Lake dam was constructed (1973) was excluded from the analysis.

Results

The tree ring measurements from 21 trees with 2 cores per tree were used for the analysis. The average ring width for all cores was 1.419 mm and the chronology spanned from 1895 to 2006. Although we calculated release and suppression events for the entire span of the individual chronologies, we were primarily interested in the period after the lake construction when the trees would have changed from interior trees to edge trees. Thirty nine percent of the trees exhibited either releases or suppressions during this period of interest and there were three general patterns (Figure 1). Of the 39%, half of the trees experienced a release in growth that was delayed by 12 to 18 years after the lake construction (Figure 1A). One third of the trees experienced an initial suppression in growth immediately after the lake construction followed by a subsequent release in growth from 16-17 years after the trees became edge trees (Figure 1B). The remaining trees experienced an immediate suppression in growth rate after the lake construction (Figure 1C). Of the trees that did not demonstrate either suppressions or releases following the lake construction, each tree appeared to have factors other than the lake construction that were stronger influences on their growth during this period (Figure 2). Some trees had very rapid growth rates when they were young, and by the time of lake construction, appeared to be less responsive (Figure 2A). Other trees began their life

with relatively slow growth rates then experienced a single release and then remained relatively unresponsive thereafter (Figure 2B). The third common growth pattern was seen in trees that were very responsive (many suppression and release periods) early in their life followed by an erratic growth pattern around the time of lake formation which continues to this time (Figure 2C). There was no apparent relationship between the size of each tree in 2007 and it's growth response to the creation of the lake. Large trees (height and diameter at breast height) were just as likely as small trees to show releases or suppressions following the lake creation (Figure 3).

In the dendroclimatic analysis comparing climatic responsiveness pre- and post-lake construction, white oaks growing before the lake construction had significant correlations between ring width index and temperature during the month of June and after lake construction during the month of February (Figure 4). White oaks before lake construction had significant correlations between ring width index and precipitation in March and October and after lake construction in September and October (Figure 4). From pre- to post-lake construction, the white oaks had a number of non-significant but interesting switches in responsiveness to climate. For precipitation, from January to June the response to climate is opposite from pre- to post-lake with one time period having a positive relationship and the other a negative relationship. This same pattern of opposite (negative vs. positive relationships between the two time periods) is also present in the temperature responses during the months of January, March, April, August, September, October, and November (Figure 4).

Discussion

The creation of an artificial lake drastically alters the environment for trees growing along the new edge of the lake as they undergo the transition from interior trees to edge trees. Based on the results of earlier edge studies which had demonstrated either mortality of edge trees, reductions in growth, or increases in growth (Bebber et al. 2004, McDonald and Urban 2004, Tremblay and Begin 2005, Bowering et al. 2006), we had anticipated similar results from Lake Raystown. Any trees that would have died following the lake construction would have been missed because we only sampled live trees, thus we can not address whether the lake construction contributed to the mortality of trees (Johnson et al. 1994). However, a majority of living trees from this site experienced no detectable growth releases or suppressions as a result of the lake formation (Figure 2). The trees that had experienced releases or suppressions (39%) followed the expected growth patterns seen from other edge sites (Figure 1); however the lack of response to the creation of the lake in a majority of the trees was puzzling. Our first hypothesis was that perhaps the unresponsive trees were very large in size and were already growing at maximum capacity and unable to grow at a faster rate regardless of environmental conditions (Mencuccini et al. 2005). However, our data (Figure 3) had no relationship between size of tree (height and diameter) and growth responsiveness (releases and suppressions) which disproved this hypothesis.

Our second hypothesis was that when Raystown Lake was constructed, perhaps the trees along the edge were not immediately exposed, but instead remained sheltered for many years as trees submerged within the waters of the new lake gradually died. This scenario would have created a more gradual change in environmental conditions. It is known that canopy gap dynamics vary according to whether the gap was formed abruptly

or more gradually (Krasny and Whitmore 1992), therefore a gradual transition from forest interior to forest edge would likely also carry a different signal than an abrupt transition. However, the trees in the future lakebed were cut by the U.S. Army Corps of Engineers when the lake was created which would have resulted in an abrupt transition for edge trees (Charles Yohn, co-director of Raystown Field Station, personal communication).

Our third hypothesis was that the trees had not been growing within the interior of a closed canopy forest prior to the lake construction. This hypothesis holds the greatest promise because the tree ring chronologies show a very dynamic forest with some open-grown trees (Figure 2A), some trees that established in the understory, but were released to the overstory (Figure 2B), and some trees that demonstrated highly variable growth throughout their lifespans (Lorimer 1985). Thus, trees that would have been already growing under relatively open conditions (Figure 2) would not have experienced the expected suppressions and releases associated with a transition to an edge position while trees from denser portions of the forest would have experienced the abrupt transition to edge (Figure 1).

One dendroclimatic change that was interesting was that prior to the lake construction, the white oaks had a significant correlation between ring width index and precipitation in spring, but after the lake construction, this relationship disappeared (Figure 4A). The importance of early spring precipitation on ring width has been identified in white oaks from many different sites (Jacobi and Tainter 1988, Rubino and McCarthy 2000, Bortolot et al. 2001) and according to ring-level analysis is most likely related to the latewood production rather than earlywood production (Tardif and

Conciatori 2006b). Thus, the availability of water during this period is clearly influential for radial growth in white oak. Clearly the presence of a lake close to the trees alters the hydrology and growth of edge species (Xiao et al. 2005)and perhaps this reduced the importance of precipitation's influence on radial growth (Figure 4A). In contrast to the early spring precipitation correlation, the late fall correlations remain unchanged before and after lake construction (Figure 4A).

The relationship between temperature and ring width index had changes in what was statistically significant across the two time periods; however, the general dendroclimatology did not change that much for the periods when significant relationships were present (late winter and early summer). Given that the individual tree chronologies indicate a stand that may not have been totally closed-canopy in structure (Figures 1 and 2), the lack of changes in dendroclimatic response may be a result of the actual environment experienced by the trees not changing that drastically. Our results contrast with a study of *Juniperus virginiana* where edge trees had different dendroclimatic responses from interior trees (Copenheaver et al. 2005). However, this study looked at two different populations of trees and thus included site variation while in this study the site remained constant (with the possible exception of a change in hydrology because of the lake).

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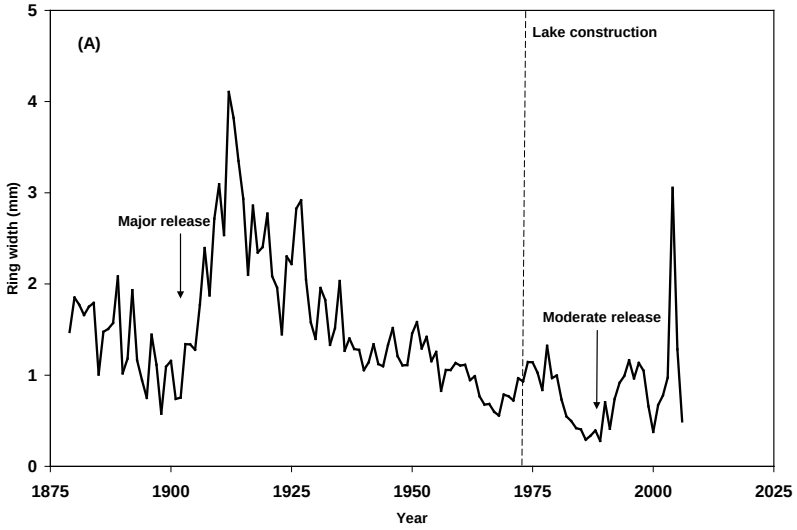
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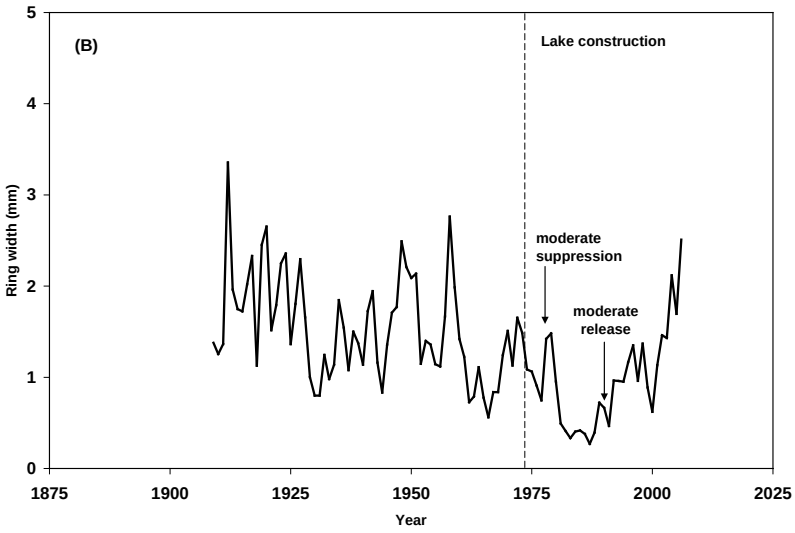
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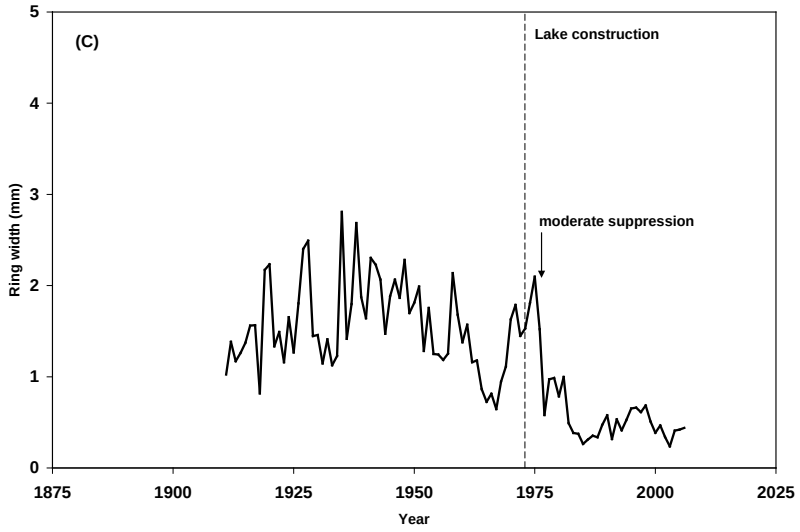

(C)
Lake construction
moderate suppression
Ring width (mm)
Year
0
1
2
3
4
5
1875
1900
1925
1950
1975
2000
2025

Figure 1

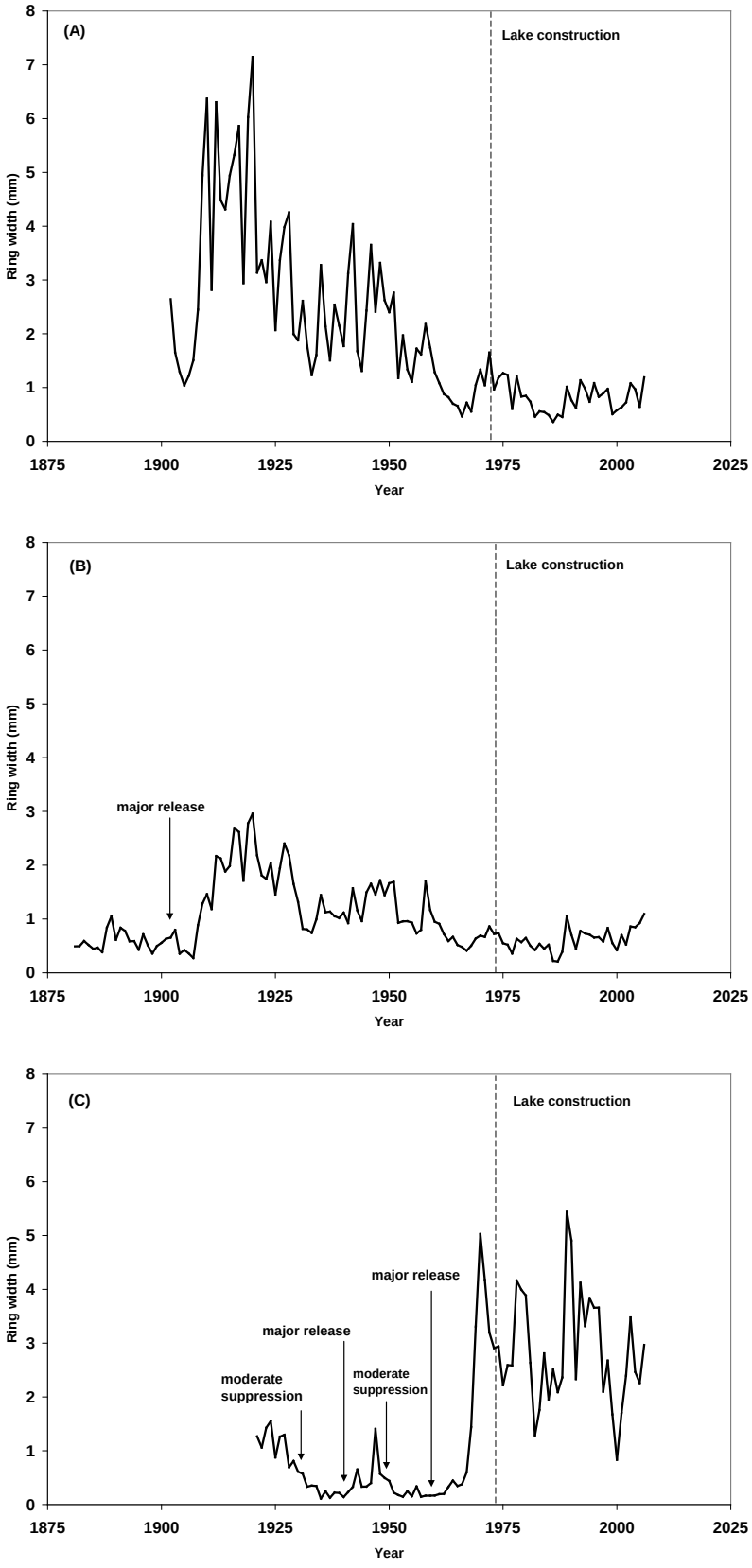

(A)
Lake construction
Ring width (mm)
Year
(B)
Lake construction
major release
Ring width (mm)
Year
(C)
Lake construction
major release
major release
moderate suppression
moderate suppression
Ring width (mm)
Year

Figure 2

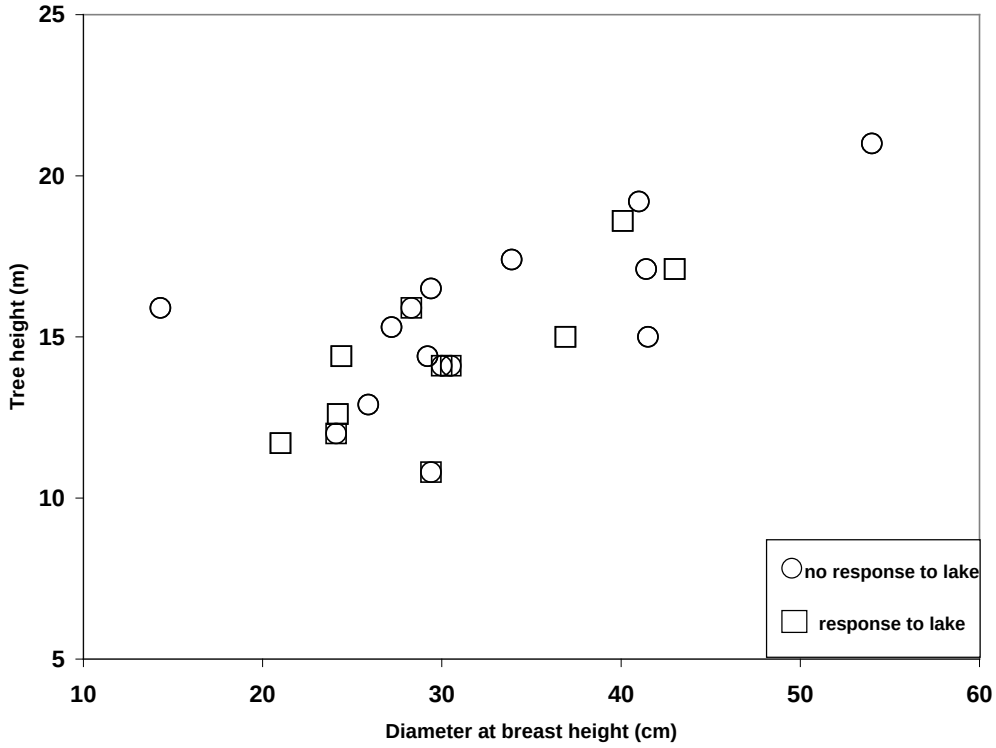
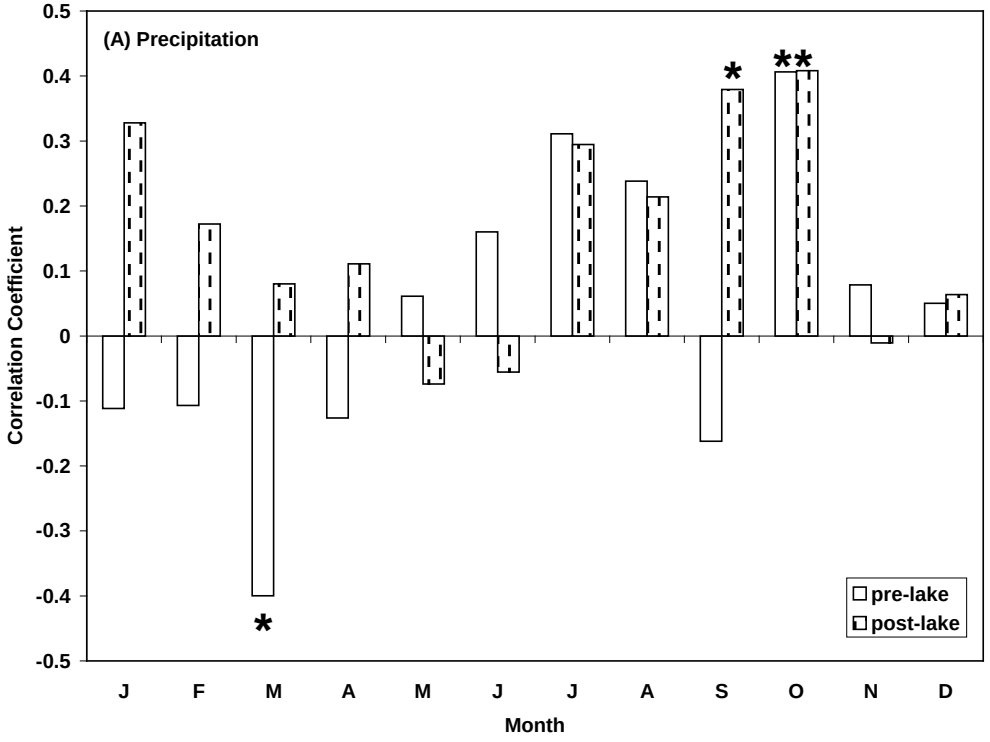

25
20
15
10
5
Tree height (m)
10
20
30
40
50
60
Diameter at breast height (cm)
no response to lake
response to lake

Figure 3


(A) Precipitation
Correlation Coefficient
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
*
*
**
pre-lake
post-lake
J
F
M
A
M
J
J
A
S
O
N
D
Month

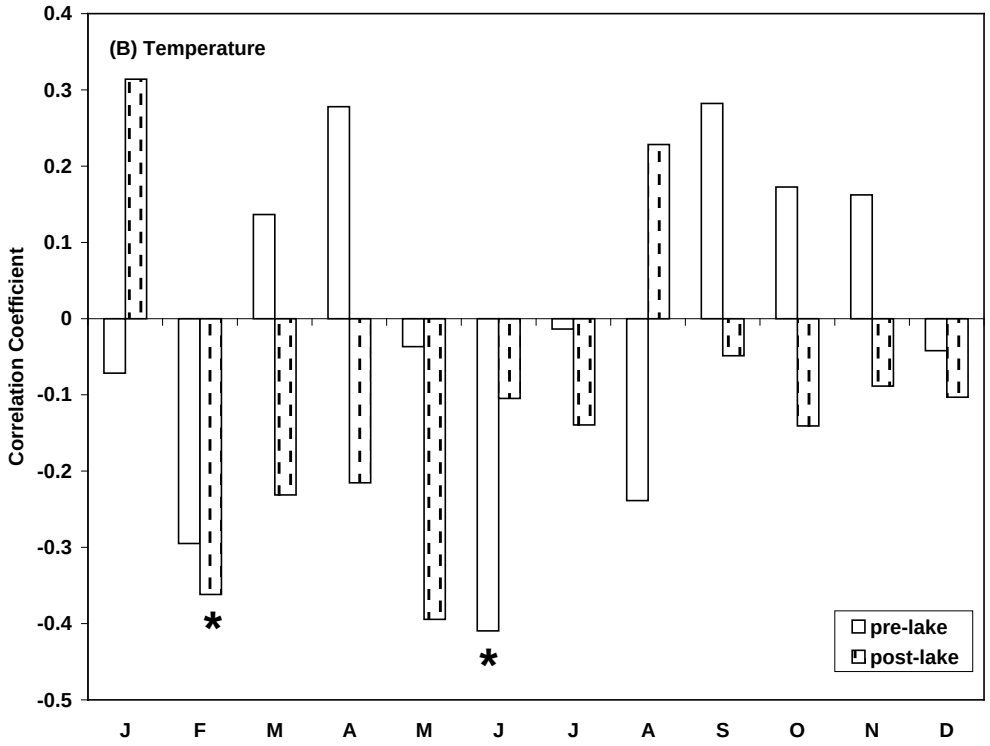

(B) Temperature
Correlation Coefficient
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
*
*
pre-lake
post-lake
J
F
M
A
M
J
J
A
S
O
N
D

Figure 4

Kelly Crosset

9/30/07

Sense of Place Seminar

Land Use of the Raystown Area

Every place has a unique history that explains the present condition in which it finds itself. Like people, the land changes with time, whether it is caused by human influences or by natural processes. The change of the land influences the lives of those living upon it. The area surrounding Raystown Lake is perfect example of how its people and land evolved over the years. It has a rich history of changing industry and ways of life for the people here and has illustrated just how influential the use of the land can be on the population. Today, one most likely would not be able to guess the industrial or agricultural activity that happened decades ago let alone that the lake did not even exist until the later half of the 20th century.

In the late 18th century, the Native Americans that lived in the Great Trough Creek Gorge began to be pushed out of this area by settlers who wanted to use the land for industry. This industry turned out to be smelting and forming iron. In 1827, Paradise Furnace started the trend for this industry by producing 12 tons of cast iron each day[1]. In order to maintain such an industry, there were other resources besides iron ore used to create this product and they included wood and limestone. The resource hit the hardest by its use was the timber. It took 4 acres of wood each day to keep the furnace running. Due to this unsustainable use of trees, the furnaces had to be shut down around mid century. Not only did this industry deplete the tree stock in the area, it created a significant amount development which pushed out the natives that had previously lived there[2].

From this ending of the iron industry transitioned into another beginning for a timber railroad and coal mining. In 1910, from Marklesburg to the Paradise furnace, a railroad was built to transport timber that developed from the second growth of the old iron smelting areas. This eight mile rail came into being from a partnership between Caprio and Grieco, it expanded only seven more miles to include transport for the mining industry that had developed along the Broad Top in Jacobs, PA.[3] Throughout this time period of flourishing industry, the population of this area grew by nearly 100 percent.[4] However, this coal industry also shut down due to exhausted resources and, thus, the railroads where taken apart and sold as scrap metal in order to help fund WWI. Once again the trees were depleted for their timber which caused the land to be vulnerable to floods and fires.[5] During this time period, farming was also a major way in which the settlers used the land. However, the soil in this area was not always the best for farming and the valley and ridge system of topography did not make it easy to plant on as well. [6]

In the early part of the 20th century, major land purchases by the Bureau of Forestry and private citizens, like Dr. Joseph Rothrock, helped transform much of the land into state forest reserves that were divided up and made into public lands like Rothrock State Forest or Trough Creek State Park.[7] I believe part of the reason for buying up the land was because it was not being used by industry for farming anymore due to poor production. The other part of the reason is that the land had been so badly damaged by cutting trees and farming, that there needed to be some sort of recovery plan for these disturbed areas. By creating state land, the region was allowed to recover and grow back. But how will people survive if there is no major industry using the land to provide jobs?

Before the 1960s Raystown Lake did not even exist and in 1968, The Army Corps of Engineers constructed a 28 mile long 8,300 acre lake as a project for flood control in the area.[8]

This lake turns out to be what most of the county survives off of today rather than farming or industry. Recreation from the lake has become the main source of income for this area due to the purchasing of land and redistributing it for public use. Many of the local residents, as well as non-residents, fish and hunt for recreational purposes as well as to feed their families. The lake has provided many jobs to the people living in a once prosperous, industry laden land. It has become a very beautiful tourist attraction for people from all over Pennsylvania and other states. Besides recreation, the Army Corps concentrates on studying wildlife and fish management, generating hydropower from the dam, and low flow enhancement of the lake.[9] Other institutions like the Game Commission and the PA Fish and Boat Commission help the Army Corps regulate the lake which also provides jobs for those who live here. Other businesses have sprouted around the lake such as resorts and campgrounds in order to accommodate the approximate 1.5 million visitors each year.[10] The lake and its surrounding area can also be seen as a learning tool for the state parks and Juniata College to educate others about anything from water quality to forest management.

Over the decades of these past couple centuries, the land of the Raystown area has evolved from industry and farming to being centered around a lake that was made only a few decades ago. While it may seem like a dramatic shift, I do not see much change in this situation for the next 50 years. This is because there is no industry that would move in and develop the land due to the fact of low population and lack of available resources. Also, with Army Corps and the state owning most of the land, public use and activities will always be apart of the land use. The only change I see happening is a little more development of attractions around the lake in order to entice more visitors. One of these attractions will most certainly be the expansion of the field station to attract more students and create a lager learning facility for the pubic to use.

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[2] Class notes taken on 8/3/07
[3] "Trough Creek State Park: History." DCNR website. http://www.dcnr.state.pa.us/stateparks/Parks/troughcreek/troughcreek_history.aspx
[4] "Rothrock State Forest" State Parks website. http://www.stateparks.com/rothrock.html.
[5] "Trough Creek State Park: History." DCNR website. http://www.dcnr.state.pa.us/stateparks/Parks/troughcreek/troughcreek_history.aspx
[6] Class notes taken on 8/3/07
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[9] "Just the Facts." Army Corps of Engineers at Raystown Lake website. http://raystown.nab.usace.army.mil/just_the_facts.htm
[10] "Just the Facts." Army Corps of Engineers at Raystown Lake website. http://raystown.nab.usace.army.mil/just_the_facts.htm

Amanda Fabis
Sense of Place
October 1, 2007

The invaders of Lake Raystown

Taking a pleasant drive into the Appalachian Mountains, I breathe in the fresh air and take in the lush green surroundings. Everything is so peaceful and calm. The visitors behind me remain oblivious to the disheartening landscape overrun with invasive species. It is quite disappointing to learn that a majority of the lush green forests in North America are plagued with introduced species which threaten the survival of natives. Introduced species were often brought abroad by travelers who wished to make their new residence more reminiscent of home. This is true of many species of flowers and birds that dot our skies. Species were also introduced as a result of leisure such as the ring-necked pheasant brought from China for sporting purposes. Still others are introduced to exotic ecosystems unintentionally. This is true of the highly invasive zebra mussel which entered the Great Lakes ecosystem by ways of ballast ship water (88).

So the question is "when do these species present a problem?" Depending on the species, it may or may not be a problem. We must remember that at one time, all of the continents were joined together in one supercontinent, Pangaea (76). In this era, there was no such thing as invasive species since there was no continental separation. Organisms competed fiercely for survival. Whoever was strongest became dominant and lived to the next generation. Eventually the continents separated, competition became less defined and more biodiversity was formed, exclusive of each newly formed continental ecosystem. It is no wonder then, that these ecosystems received a shock when new exotic species were mixed into an already functional and well-operating area. Certain species barely leave an impact and may not even survive in their new habitat. In *A Plague of Bats* it is written, "In fairness, most exotic species, whether

accidently or deliberately moved to new territories, do not survive at all without human help" (82). Others, however, become so much of a problem that native species may risk extinction solely because of their presence. Often this is true of exotic species due to the fact that the invasive species' natural predators are absent from their new environments.

I am embarrassed to admit how naïve and oblivious I was to the area surrounding Raytown Lake. All that I had seen upon my arrival was a beautiful, thriving forest, teeming with life. Little did I know how invaded the area had become. My views can be compared to the thousands of tourists who visit Hawaii and admire the beautiful and colorful forests, not realizing that most of it had been introduced from elsewhere (72). Invasive species in the Lake Raystown region such as garlic mustard, Japanese Knotweed, and Autumn Olive, now threaten the native forest which had just begun to reclaim itself about fifty years ago. So when is it known that there is a problem?

Another plant species too, has made their presence well-known in the area. The infamous Eurasian Water Milfoil seems to be dominating shallow bay areas within the lake. The Milfoil forests are so dense that in many regions, the lake appears more like a wetland. Boat owners too have complained of the aquatic weed clogging up boat motors and making it difficult if not impossible in some areas to paddle.

Problem species can be flora, fauna, or it can come in the form of disease. Newcomers only become an issue once that start to interfere with the native plants and animals. Sometimes, if an introduced species affects the keystone species in a negative way, the entire ecosystem of that particular area is at risk for collapse. The keystone species is one in which controls the balance of the entire environmental system in question. I am not aware of the keystone species in our area if there even is one. However, it is obvious that we have an issue with invasion in our

area, especially after one takes the time to investigate. For instance, when I was out in the field, gathering data on frog populations in the area, I happened to notice the presence of Japanese Knotweed practically everywhere along water. The streambeds were carpeted with this invasive grass. *Polygonum cuspidatum* has made its impact by crowding out native species. It was probably introduced to the United States in the late 1800's (USFWS 1). Originally introduced as a plant used for erosion control or ornamental purposes, the Japanese Knotweed quickly adjusted to its new environment by carpeting exposed areas. I can see the presence of Knotweed in the Lake Raystown area as potentially harmful. According to the U.S. Fish and Wildlife Service, "It can tolerate a variety of adverse conditions, including deep shade, high temperatures, high salinity and drought. Knotweed is commonly found near water sources, such as along streams and rivers, in low-lying areas, waste places and utility rights-of-way and around old home sites. It spreads quickly to form dense thickets that exclude native vegetation and greatly alter natural ecosystems. Japanese knotweed poses a significant threat to riparian areas, where it can survive severe floods and rapidly colonize scoured shores and islands. Once established, populations are extremely persistent" (1-2).

Because it is an extremely hydrophilic plant, Knotweed, along with Eurasian Water Milfoil may be solely responsible for transforming parts of Lake Raystown into a grass marsh. The bay areas are particularly at risk. Because Knotweed can regenerate easily from fragmented stems, roots, and leaves, care must be taken to remove all parts from beneath the soil. Because this is so challenging, Japanese Knotweed is often treated by chemical means. In particular I am interested in learning how the plant has affected local frog populations. According to the U.S. Fish and Wildlife service, the presence of Japanese Knotweed can drastically alter both the flora and fauna of the region (2). It appears to have affected turtle populations in a negative way. The

terrestrial turtles seem to have difficulty crawling over areas overgrown with the invasive grass. I wonder then if frogs have been affected as well. My assumption is that the weed has either had little impact on the frogs or has affected them positively. Because they are small, frog populations might find the Knotweed a shady place to retreat to when the climate is dry. It could also serve as suitable cover for hiding from predators.

Unfortunately explosive invaders are not the only species to worry about. There are also introduced species, commonly referred to as "sleepers" who may not become a problem until the conditions are ideal. Whether or not species such as common mullein become a problem is undefined. The best approach is never to underestimate any particular species if there is any hope of reclaiming the native forest. It was somewhat disheartening to learn that as much as 75% of the flora present at Grove Farm is not native. It was also upsetting to see the invasive aphid wooly adelgid slowly destroying the native Eastern Hemlocks in the area. The Hemlock is the state tree of Pennsylvania and it is sad to know that we may not have many of them left for much longer. The state tree may have to be changed.

The overwhelming presence of invasive species and the damage they inflict cannot be undone. Looking to the future is the only alternative if we are to savor the remaining native species before they are driven to extinction by invaders. Lake Raystown is not immune to the effects of invasive species. Their damaging processes can already be witnessed in the area. The good news is officials such as the U.S. Army Corp of Engineers is working to assist the natives. The Hemlocks are being protected more thoroughly than ever from the wooly adelgids and methods are being devised as to how to kill off the Milfoil in the lake. Humans have caused this problem and now we are the only ones who can stop it from wiping out any more species.

Invasive Japanese Knotweed. United States Fish and Wildlife Service USFWS BayScapes Conservation Landscaping Program. http://www.nps.gov/plants/alien/pubs/midatlantic/pocu.htm October 2004.

Angela Ferrelli
Sense of Place Seminar
Professor Chuck Yohn
September 30, 2007

Go-Betweens

"For wherever and whenever different people have met, there one finds a go-between."

~James H. Merrell

Throughout America's history, as well as other countries, there has been a crucial role played which allowed communication to take place between varying peoples. This role is that of the go-betweens. According to Metcalf there are three different types of go-betweens, the first and most basic being that of the physical go-between. These would be people who have crossed oceans and land masses. Secondly, guides, interpreters, and negotiators qualified as transactional go-betweens. Lastly there were the representational go-betweens. These are people who through mapmaking, writings, etc. defined how Natives viewed Europeans and vice versa (Metcalf 9-10). All these roles are important in understanding how countries developed yet it is not such a well define line between the different types of go-betweens. It would seem that, without physical go-betweens then the other roles would not have developed. Also it may have come to pass that transactional go-betweens may have also acted as representational go-betweens. It would make sense that a guide would be a mapmaker for the area in which he/she has covered or frequently travels. Merrell, unlike Metcalf does not divide the role of go-betweens into smaller sections and this is how go-betweens will be referred, as a whole.

The categories into which the go-betweens are split does not seem to have as great an impact as the jobs that they fulfilled and the many complicated alliances they formed. "Colonial leaders who left most of the records tended to mistrust and despise the intermediary, uncomfortable with his importance and uncertain of his loyalties" (Merrell 32). The fact that colonial leaders did not completely feel comfortable with the go-betweens they were working with did not help matters when they needed

to depend on the go-between for their safety. Though, it would seem that there would be some relationships, between colonists and Native Americas that were stronger than others.

While go-betweens could be natives who can understand foreigners, or the other way around, these people had a grueling task set before them. Not only did they have to be able to translate between peoples, they must also know the customs of both groups. This is because customs and etiquette demand different protocol within different groups of people. The differences and obstacles to cultural understanding were revealed when natives and foreigners traveled together. They had difference approached to nature; the Native Americans believe that there are spirits in everything, while colonists only believe in a narrow view of God. Sometimes food was also a source of cultural separation. There were deeply held preconceptions that each group had and the travel they shared brought these differences to light, it did not bring the Native Americans and colonists closer together. "If colonists and Indians were ever to look past such fundamentally antithetical ideas…if they were to get along at all, someone had to step in in order to downplay differences and play up – or, if need be, make up – areas of common ideology, common interests, and common experiences" (Merrell 27).

The trails in the Pennsylvania area are still relatively similar to what they would have been two hundred years ago when they were being used by the go-betweens. Native Americans from the Delaware and Iroquois tribes used these trails along with colonists, traders, trappers, hunters, and go-betweens. There is still undergrowth and fallen trees across the trail. Birds' nests can be seen and there are methods implemented to indicate where the trail is. The main difference between the trails now and then is the species of trees that can be seen. It used to be that chestnut was dominant species but then disease started attacking these trees and wiped it out. Then oak became dominant, now oak is losing dominance because of gypsy moth. The red maple is now becoming dominant, and this tree is usually a sign of clear cutting when dense amounts of red maples are being seen.

Although it happens that go-betweens were the means for communication and interaction between groups, it is rare that we see them in the paintings and scene re-creation of early interaction between Europeans and Native Americans. "Given their importance, it is astonishing how far these figures remain cloaked in obscurity" (Merrell 29). However, there are some go-betweens that have become famous in name, such as Sacagawea. Without people such as her it would have been almost impossible for Lewis and Clark to obtain what they needed through civil action.

The beginning of the breakdown in the relationship between Native Americans and the British was the Walking Purchase. This 'purchase' was actually an illegal selling on Native American land. William Penn's son started selling land to Europeans before it had been legally bought from the Native Americans. To make the selling of the land legal they made a deal with the local Delaware Indian tribe which stated that the amount of land to be allocated to the colonists would be determined by how far a colonist could walk in a day. The colonist leaders held a contest to find the fasts runner in the area. The top three men were hired to 'walk' as much land as they could. The Indians thought that the white men would walk an Indian trail by the Delaware River but as it turned out they ran on a cleared path. The amount of land covered in the one day was equal to the amount that an Indian covered in a day and a half. This caused Delaware Indians felt cheated and refused to leave the land, but the colonists had the Iroquois force them off the land (Documents).

In terms of go-betweens they are still an integral part of cross-cultural communication today. Though instead of the outdoorsmen that we would have seen when exploration first started in the United States, these go-betweens are mainly found wearing suits or professional attire. The interpreters of today earn an average hourly wage of $16.28 and can find jobs in many different fields such as in the public and private sector of the institutional community, government agencies, and hospitals (Interpreters).

If there had been no go-betweens when exploration first started it seems to reason that there would have been more bloodshed than what actually took place. Colonial and Native American wars would have been more numerous and the Native Americans would have been overwhelmed causing them to become 'an extinct species'. There would have been many breaches of cultural etiquette since there was already a limited cultural understanding.

The paths in the Pennsylvania area are well preserved as to what they would have looked like while go-betweens were traveling in the woods. Defining the go-betweens such as Metcalf does, seems unnecessary as the roles are all interlinked and no matter the definition they were very helpful. In areas such as communication between the colonists and Native Americans the go-betweens were the element that allowed this to occur. However, there were still cultural breaches and the colonists did not always adhere to previously agreed upon arrangements.

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Gregory Kunka

Sense of Place

September 30, 2007

Disturbance Species

One of many topics discussed in the 2007 Sense of Place Seminar is the idea of disturbance species. Disturbance species can be both plant and animal, but most discussed was the plant aspect. The mere presence of these plants in a forest could indicate that there was a disturbance in the region near the time that the plant began to grow. The goal of this paper is to explore the concept of disturbance species a little further and take the concepts of disturbance species and apply them to a fictional large scale disturbance. For this paper, I will imagine that Raystown Lake would be quickly drained, leaving a stream in the deepest parts of the region and many square miles of unforested fertile land.

Of the many disturbance species present in the world, two trees here stand out in dominant numbers. They are the Virginia Pine, *Pinus virginiana,* and the Locust, *Robinia pseudoacacia*. The presence of these two tree species are very indicative of previous disturbances in the area. This concept was first introduced to us by Dr. Chuck Yohn in our recreation area, just off our road by the equipment shed. The area contained a few Virginia Pine and Locust trees. The Virginia Pine all seemed to be very similar in size, which suggests that they are of very similar age. The Locust also seemed to be of similar size to the other locust in the area, also suggesting that they are of similar age. It must be added here that relating tree sizes across species for comparing relative ages should not be done because different species grow at different rates. However tree age can be roughly compared among similar species by

relating size, assuming that similar growing conditions have been met. Another interesting tree that we found in this area is the Black Cherry, *Prunus serotina*. The Black Cherry is a native tree that is a disturbance species in some cases because it thrives in very open lighted areas. Therefore, it was concluded that the land near our recreation area was once largely disturbed. Perhaps 60 years ago the land was a farm field. Much of the area around here was in fact farmers' fields, abandoned when the area was flooded to form the lake.

The abundance of these trees in the Raystown area definitely shows that the amount of disturbance in the area was pretty high about 60 years ago. White pines are a tree species, native to the area that grows relatively quickly. They have a distinctive upwards curving branch pattern that resembles a person's upper limbs outstretched towards the sky. For this reason, the white pine can be spotted on hilltops. When boating by regions of the lake, it is possible to spot white pines. If the white pines were similar in size it may suggest that the trees all grew at the same time, perhaps when a plot of farmland was allowed to grow naturally.

One of the most important of the disturbance species is the Red Maple, *Acer rubrum*. The Red Maple is known for its soft wood and fast growing ability. Often but not always is distinguished from the sugar maple by its red pigmented petiole. The importance of the Red Maple lies in the future of the area. It will soon become the dominant plant in the region. This is because of the speed in which the Red Maple grows. It is able to dominate many areas because, like the sugar maple, it is able to take up much of the available light therefore preventing plants in the understory from growing. The abundance of the Red Maple in this region shows that the forests in the area are not the healthiest and are young enough to be vulnerable to the new growth of the Red Maple.

Other types of disturbance species include the Autumn Olive, *Elaeagnus umbellate*. The Autumn Olive is an invasive species that is able to grow in most any condition. It can be found in established forests like the maple grove near Grove Farm, showing Autumn Olive's ability to grow in a shady area. Likewise, the open well sunned hilltop near the power line trail is home to many of Autumn Olives. The versatility of the Autumn Olive is termed phenotypic plasticity.

The Crown Vetch, *Securigera varia*, is an interesting plant that could be seen as a disturbance species. The Crown Vetch was a project of Penn State Agricultural School. It was initially intended as a roadside stabilizer. It was planted at large scales across PA. It is quick to grow and establish itself and is now considered an invasive species. The Crown Vetch can be found all over PA near roadsides.

The Japanese Stiltgrass, *Microstegium vimineum,* is a plant that shares similar traits to the Crown Vetch. The Japanese Stiltgrass is an invasive that is spreading alongside roads and valleys. Native deer populations do not eat the Stiltgrass, rather they prefer native species. This creates a situation where the natives are being stripped while the Stiltgrass spreads with less competition (Adams). In dense situations, the Stiltgrass creates a thick barrier preventing much sunlight penetration to the soil surface keeping competition to a minimum. The Stiltgrass would be a likely plant found in disturbed areas.

Now, let us imagine that the US Army Corps would decide to abandon Raystown Lake, followed by the release of all water from the Lake. This would result in the return of the native streams at original levels. What milfoil was present in the lake would die and decompose relatively quickly. What would remain from this massive evacuation of water is many square miles of very fertile unforested valleys. What would the landscape look like? What changes

would be seen in a month? What changes would be seen in 6 months? How about 6 years? 60 years?

After a month, much of the organics that were in the lake would be decomposed. A month would not be enough time for many of the disturbance species to move in, but perhaps some grasses and weeds may grow in areas close to the shoreline (Rosalino). Crown Vetch and Japanese Stiltgrass would certainly be found in some locations near the shoreline.

After 6 months, it would be expected that the Stiltgrass and Crown Vetch would be close to establishing itself. I would expect that the Stiltgrass would occupy more than the Crown Vetch because it is not widely eaten by deer. After 6 months, it could be expected to see some Autumn Olive beginning to grow as well as some tree seedlings.

After 6 years, I would expect to see a thick, dense, and immature forest consisting of many Red Maple, White Pine, Virginia Pine, Locust, and perhaps some Aspen saplings. Autumn Olive could be dispersed fairly evenly from bird droppings. Tree species would be pretty scattered, perhaps remaining closer to the shoreline due to not being dispersed far from parent trees. I would expect Black Cherries to be growing well near the stream bank. The abundance of sunlight and the cooler temperature near the stream would be an ideal location for the Black Cherries.

After 60 years, I would expect to see some drastic differences in the species composition of the lake versus the species composition of the land surrounding the lake. The Virginia Pine would have lived most of its dominance out. More established trees such as the Red Maple and Sugar Maple would become more dominant. Black Cherries would be pretty established near the

streams. The Stiltgrass and Crown Vetch may still be growing, but likely they would be kept in check by larger trees.

Disturbance species are indicators of what may have happened historically in areas. But areas are always being disturbed naturally and unnaturally and presences of these species often don't mean large scale disturbances. However, they can help people to quickly suggest forest history.

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Kate McKenney
October 1, 2007
Sense of Place

It is easy to make blanket assumptions about the people that live in rural areas such as Huntingdon, Hesston, and other towns in the Lake Raystown area. Outsiders may think that all of these people are poor, uneducated, and all around your stereotypical hillbilly. However, nobody knows better than the people that live here that not only are these generalizations unfair, but also do not apply to all communities equally. It is difficult to argue against statistics that say that average income and high school graduation rates are lower than many areas of the country, but at the same time, one must understand how the geography of the area affects the basic services residents have access to, and the value systems that they cling to.

Perhaps the biggest question one must ask is why people live in such areas to begin with. Why would anyone choose to stay in an area where poverty is higher, education is lacking, and career opportunities are poor? Why did people settle here to begin with, where mountains made transportation difficult and harsh winters made travel near impossible at times? The first colonists who came to this area were traders, passing through and staying only long enough to exchange goods with the Indians before moving on. However, once the steel industry moved to the colonies from England, this area became a hotbed for iron refining (yielding a product known as pig iron) due to the large quantities of limestone and timber available. Iron ore was brought in from the Mesabi Range in Michigan and Minnesota by barge.

As long as the timber was around to provide material to make charcoal, the iron industry was able to thrive in the Raystown area. However, furnace operators found themselves facing the same problem that the steel industry in England encountered. They were unable to sustain pig iron production because trees were being turned in to charcoal faster than they could mature

into suitable firewood trees. Once the forests had been cleared of trees, the iron industry had to turn to other resources for refinement of iron. In this case, bituminous coal filled the gap left empty by the lack of trees.

After the decline of the pig iron industry in the area, the main industry shifted to coal mining, which took place from the early to mid nineteenth century through the mid twentieth century. These coal miners settled in the Broad Top region, a sandstone rich area, near mountains that contained large reserves of coal. They were largely of Scottish and Irish descent, which is important to take in to consideration when examining the differences we see in mountain communities today. Due to the geology of the Raystown area, the area is rich in bituminous coal (also known as soft coal) which was not only in demand to power steam engines, but was also highly desirable for making coke to be used in the production of steel (Macfarlane, 110). This area thrived as a result of the presence of the coal mines, which brought about the construction of the Huntingdon and Broad Top Mountain Railroad, but when the steel industry fell in to decline, the economic prosperity of Huntingdon and the surrounding area began to decline as well.

The geology of the Raystown area is such that there are alternating bands of limestone valleys, such as the Big Valley, and sandstone ridges, such as the Broad Top region. The valleys were settled by farmers who took advantage of the fertile soil. These farmers were largely of German descent, contributing to the striking difference between these communities. The sandstone ridges allowed for easy access to coal seams, attracting the miners and the railroads. Today we can still see evidence of the coal mining industry in abandoned railroad tracks, empty mines, and the orange deposits that collect in streams and ponds as a result of abandoned mine drainage.

Perhaps a less obvious sign of the decline of the mining industry are the people who were left behind when the mines closed. Some areas of the Broad Top region are so poor that most of the residents rely largely on hunting, fishing, and small gardens for subsistence. This is evident in towns such as Joller, PA, where shallow underground mining exposed seams of coal that interact with the ground water. In this particular town, retention ponds have been constructed in an attempt to control the abandoned mine drainage, but there are approximately 100 similar sites in the Broad Top region, most of which remain unremediated. Joller is no longer inhabited, as the last residents left in 1979, 8 years after strip mining ceased. However, not everyone left after the coal mining industry collapsed. Many of these people live in the same secluded area their entire life. There are people who are born and raised and live their entire life without ever leaving the valley where their family has been living for the past century or two. The same is true for those that live in the Big Valley, one of the largest farming centers in central Pennsylvania. Although we live in a society where mobility is becoming increasingly common and farming increasingly less common, there are a good number of Amish and Mennonite farmers that live and work on the same land that their parents did and have never ventured outside of the valley.

Yet another benefit to the Broad Top region that left with the coal industry was the Huntingdon and Broad Top Mountain Railroad, which was constructed between 1853 and 1855 (Burkey). Although this railroad serviced passengers, it was constructed largely for the transportation of coal. The railroad used by the coal industry used narrow gauge tracks in order to provide more flexibility and maneuverability in the construction of the railroad and the transportation of coal. However, these tracks were not compatible with the standard gauge tracks used by other railroads, and once there was no coal to be transported, there was little use for

these tracks. The Huntingdon and Broad Top Mountain Railroad went bankrupt in 1953, and closed its operations in 1954 (Burkey). Once transportation options within the region became limited and people began to lose jobs as a result of the dying industry, mobility in both the Broad Top region and the Big Valley became limited, isolating communities and individuals. This isolation further contributes to the differences one can observe between these two areas.

Perhaps the easiest way to get an idea of how different two areas can be, despite the fact that they are geographically very close to one another, is to go to the top of Evetts Mountain. One side of the road looks over the westward dipping Tuscarora Sandstone. This land contains some limestone, but is mostly shale and does not make for good farming. The other side of the road looks over a valley with fertile soil that allows for more agricultural activities. There are many smaller farms, along with several CAFOs.

The geology of the Broad Top Mountain region and the Big Valley played a very big role in influencing the development of the communities that exist in these areas today. The magnitude of the difference between the two areas is strikingly obvious when one drives through small, poverty stricken towns such as Hopewell, Defiance, and Robertsdale in the Broad Top Mountain region, where subsistence is a way of life is some cases, and then continues on to the crest of the Big Valley, which contains lush, green fields which sustain healthy crops that support the farmers that grow them. Although these communities are close geographically, they are different in the type of people that occupy them, the occupations that these people hold, and the lifestyle of these people.

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Peter McLean

A Sense of Place

No Correct Answer

If one were to manage an ecosystem, what would they use as a baseline? What is considered native? It is a hard question to answer because there are so many variables to take in to consideration. How long must a species be established in an area before it is considered native? Have established exotic species become integral members of their particular ecosystem? If a species is exotic but not invasive should it still be managed? Should native exotic species be managed too? Is the invasion of exotic species just a natural part of ecological evolution which should not be managed?

The answer to these questions varies from person to person because every individual values the environment for different reasons. A person's values of the environment will determine how they would manage an ecosystem as an individual. Hunters would want to manage an ecosystem in order to preserve the habitat and food of the animals they hunt. Hikers would want to maintain the aesthetic value of the forests and landscapes in which they travel. Bird watchers would want to preserve nesting habitats and plants that feed birds. Lumberjacks would want to manage the trees so that they grow straight and tall with large canopies. Preservationists would want to leave an ecosystem alone and let it run its natural course without human intervention.

The multitude of ways that humans value the land complicates the way in which they manage it, especially when invasive exotic species are considered in the equation. Many invasive exotics were purposely brought over because they had favorable characteristics in respect to the values of their courier. For example, starlings and pigeons were brought to Central

Park by Shakespeare enthusiasts who wanted all the birds mentioned in his plays to live in the park. Pigeons now populate every major city I have been to in America while starlings roam the country in huge flocks of thousands of birds. Another example is autumn olive, which is sold by nurseries because its dense foliage and mass quantity of berries produced attract birds. However, the huge amount of berries produced is eaten by birds which spread them rapidly across large areas of land.

The management of invasive exotics is complicated due to fact that many of them serve a purpose for at least one group of people. While bird watcher may love autumn olive farmers may hate it because it can take over a field in a matter of a single growing season. Another example is feral pigs on the Hawaiian Islands. The destructive eating habits of the swine are a nightmare for Hawaiian conservationists who strive to conserve natural Hawaiian habitat, yet they are valued by the indigenous people whose hunting traditions revolve around the pigs. One management perspective may value an invasive exotic while another is threatened by its presence.

If one were to manage an ecosystem what should they do to reach a balance between all of the different environmental perspectives and human interests? It is not as easy as wiping out all invasive species and returning the ecosystem to its original state; such a feat would require too much money and time, and it may end up doing even more ecological damage. After all, invasive exotics have already established themselves as members of native ecosystems; what roles have they developed as members of their particular ecosystem. It is easy to say that they are destructive and bad for native species, but are there positive aspects of their presence? For example, Lake Raystown has been invaded by Eurasian Milfoil which causes many problems for boaters and fishermen: it clogs boat intake systems, fouls up propellers and alters the way in

which the lake can be fished. Is the answer to this problem as simple as purging the lake of its aquatic invader? What about the minnows and small fish that are protected by the cover the milfoil provides? Does milfoil create better habitat for turtles? Does the increase in temperature and decrease in water movement associated with milfoil benefit the reproduction of aquatic insects?

If one were to manage an ecosystem they must understand the relationship that each plant, animal and fungus has with one another; they are all interconnected by the web of life. Every single organism plays a role within their ecosystem. Whether or not they were the original occupants makes no difference. The answer is not as easy as stating that all invasive exotics are bad because they are not the original occupants of the area. The entire overall health of an ecosystem must be analyzed in order to manage it for future generations. If an invasive exotic is a threat to the health of an ecosystem then it must be managed, but if it is not a threat then I see no reason as to why it should be managed. Even native species must be managed if they also become threats to an ecosystem's stability. No other animal in our area exemplifies this more than the native White Tailed Deer, whose voracious appetite can clear an entire forest floor of young vegetation.

However, the threat that invasive exotics pose to native species should not be understated. According to our class reading about invasive exotics, 49 percent of endangered species in the United States compete with or are preyed upon by invasive species. Those most threatened by invasive exotics are endemic species because they tend to be K-specialists, which have evolved to utilize a specific resource in a specific way. When an invader is able to establish and alter an ecosystem the K-specialist species suffer most because their lifestyle is most fragile and easily knocked off balance. This is an example, among others, that serves to show how

invasive exotics threaten the biodiversity of ecosystems which they invade. If your goal is to preserve biodiversity then invasive exotics are your worst enemy, like the conservationists on the Hawaiian Islands. On the Islands most of the native birds have been wiped out by mongoose and rats and many of the native plants have been replaced by aggressive flowering species brought in to decorate the hotels. Hotel owners are impartial to the destructive nature of invasive exotics as long as their hotels remain colorful and bright. Their main concern is the aesthetic value of the land, not of the natural biodiversity that once thrived there.

If a person were to create a baseline to manage an ecosystem they should choose from the existing species which are not invasive. Invasive species that aggressively multiply and choke out other's growth and survival should be managed, even if they are valued by some facet of human recreation. The ultimate goal should be to preserve an ecosystem for future generations to use and enjoy. That may sound ambiguous but there is a middle ground in which the health of an ecosystem can be maintained and still provide resources for the people that value it. It does not matter if species are native or exotic because what is already done cannot be changed; every organism has the natural right to try and live. After all, if we truly wanted to reverse the expansion of invasive exotics we would eliminate the worst perpetrator of them all: Homo Sapiens.

Colleen Metzger
Sense of Place
1 October 2007

Influence of Invasive Exotics in the Forests of Central Pennsylvania

Over the last 200 years, advancements in travel and technology have effectively removed the barriers to intercontinental species dispersal. Previously, such global species interactions had not occured since the collision of continents that resulted in the formation of Pangaea, the true "supercontinent." This collision initiated intense competition between the North American placental and South American marsupial mammals, which eventually led to the extinction of most of the world's marsupial species. This ancient example demonstrates how the introduction of foreign species can dramatically alter a native ecosystem. Today, exotic species continue to establish in North America for a variety of reasons. Many are introduced for commercial purposes, such as landscaping and bioengineering, while other species simply reach the continent by accident. For instance, of the 235 woody plant species that have naturalized in North America, 85% of those were introduced primarily for the landscape trade (Reichard and Hamilton 1997). Unfortunately, introduced species can sometimes react unexpectedly in their new environment, becoming problematic invasives.

The importation of foreign biota, however, is not a new trend; for thousands of years, flora and fauna have been transported around the globe, whether intentionally for trade or sustenance, or unintentionally as stowaways aboard ships. Cleopatra, for example, ordered the importation of exotic species to Egypt. Columbus himself was responsible for the significant exchange of plants, animals and other goods between the New World and the Old World. In fact, the "Columbus Exchange" resulted in the establishment of cotton, corn, potatoes, vanilla and cocoa in European nations, and coffee, wheat, horses, cows and pigs in the Americas, not to

mention diseases such as smallpox, measles and the bubonic plague. Regardless of the incentive, the release of exotic species into new environments has resulted in the establishment of many of the species we now recognize as commonplace. Of all the species that have been introduced in North America, however, only relatively small proportions have established themselves as invasives, outcompeting native species for resources and altering the biodiversity of the area. Ecologists refer to this occurrence as the "one in 10 rule," which states that of all the species introduced into an area, only 10 percent will establish themselves, and of that established group, only 10 percent will become aggressive invasives. Therefore, it is important to recognize the characteristics of invasive species, as well as of the communities they are invading, to better control and prevent their arrival and dominance in native ecosystems.

Huntingdon County is an excellent area to observe the effects invasive species can have on biodiversity and the overall landscape. Several hundred years ago, when varying Indian tribes inhabited the area, the landscape was mostly wooded, the dominant tree species being American chestnut. After the arrival of the colonists, the area experienced dramatic change: during the 1800s, the area was deforested to make charcoal to fuel the mining industry and to clear lands for agriculture. The landscape was littered with smelting furnaces, railways and small, yet thriving mining towns. However, these industries were not operating sustainably, and as the availability of wood declined, so too did the industries whither away. Subsequently, during the 20th century, the abandoned fields and clear-cut forests began to experience regeneration and succession, significantly influenced by a fleet of invasive species.

In the early 1900s, *Cryphonectria parasitica,* the fungus responsible for the Chestnut blight, entered the United States via an Asian nursery stock. Having never been exposed to such a fungus and thus having no resistance, the American chestnut was particularly susceptible to the

foreign disease. The blight spread rapidly and essentially destroyed chestnut populations throughout their natural range, which extends from Maine to Georgia. By the 1940's, more than three and a half billion Chestnuts had perished (ACCF 2007). Today, the once abundant American chestnut has become a rare species in the hardwood forests of Northeastern United States.

After the virtual elimination of the American chestnut, oak succeeded as the dominant species of the central Pennsylvania hardwood forest. Once oak had colonized the forests, however, another exotic species, the gypsy moth (*Lymantria dispar)*, became severely problematic in the Northeastern United States. The gypsy moth was accidentally introduced from Europe to Massachusetts in the late 1860s, although its native range extends throughout all of Asia and Europe. Originally, the insect was not an immediate pest, however, in the early 1900s, its range began extending across the north Atlantic to the Mid-Atlantic States, destroying millions of trees in its path. Today, the gypsy moth is one of North America's most devastating forest pests (Liebhold 2003). Not only do gypsy moths reduce the biodiversity of the forest ecosystem, but they also greatly reduce the stock of oak hardwood available for harvest, thus negatively affecting the timber industry.

However, as oak species are declining from a combination of overharvesting and gypsy moth predation, the forests are undergoing yet another species turnover. Currently, red maple (*Acer rubrum)* is increasing as an undergrowth species, and serves as a probable successor to replace oak as the dominant forest species. In a recent study conducted by Pennsylvania State University, several students analyzed the proportional species composition of a ten-acre forest near State College, PA. This study demonstrated that white oak (*Quercus alba*) is the dominant overstory species, comprising approximately 76% of the overstory sample. Red maple, however,

was found to be the most common understory species, with approximately 65% relative abundance (Naito). By comparing the relative proportions of understory and overstory species, future forest composition was predicted. The analysis found that red maple will indeed succeed oak; by the next forest generation, oaks will only comprise approximately 2.7% of overstory individuals (Natio), a shockingly small proportion. These results present strong empirical evidence that the oak-hickory forests of central Pennsylvania are in fact converting to red maple-hickory forests. This example demonstrates the wide-reaching effects invasive exotic species can have on native ecosystems by altering forest composition and influencing the process of forest succession.

Another example of how biological invasions are altering the ecology of the area can be seen in the invasion of the hemlock wooly adelgid, a parasite introduced to the Pacific Northwest United States in 1924 from Asia. The hemlock wooly adelgid (*Adelges tsugae*) feeds off the fluids of the Eastern Hemlock *(Tsuga canadensis)*, Pennsylvania's state tree, and the Carolina Hemlock (*Tsuga caroliniana).* Once an infestation had been established, most individual trees will die within four to five years, and thus the insect can rapidly alter species composition of a forest. Although the wooly adelgid arrived in the United States in 1924, it did not reach Pennsylvania forests until 1967. Today, however, 47 counties in the eastern 2/3 of Pennsylvania have recorded infestations (DCNR). The rapid decline of eastern hemlocks is an important concern for forest health, since the presence of hemlocks can improve the forest ecosystem. By inhabiting cool hollows, hemlocks often provide shade for local streams or rivers, which helps to lower water temperature, thus increasing dissolved oxygen content, and creating ideal habitat for trout and other cold-water aquatic species. Several management techniques, including quarantines and insect-killing fungi have been investigated as control mechanisms for the pest,

but have proved ineffective. If the wooly adelgid is not successfully controlled, the Eastern Hemlock will surely suffer the same fate as the American chestnut and White Oak: eradication via invasive species.

Today, many additional exotic species are invading the forests of central Pennsylvania, such as Japanese Honeysuckle, Multiflora Rose, Garlic Mustard, Virginia Creeper, and Japanese Knotweed. Control mechanisms for these species, too, are necessary in order to preserve ecological diversity in the Huntingdon area. The near elimination of the American chestnut by the chestnut blight, the serious decline of the White oak via the gypsy moth, and the dangerous threat posed by the wooly adelgid on the Eastern Hemlock are all excellent examples of the power of invasive species and how they have helped to influence the forest in this area. If invasive species are not properly managed, they will continue to eliminate native species and alter the biodiversity and ecology of Pennsylvania forests.

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Brittany Moyer
9/27/07
Sense of Place

In an Ever-Changing System, What is Natural?

In many ecological landscapes, it is increasingly difficult to define what composes the "natural system." It may seem environmentally responsible to try to return an area to its most natural flora and fauna, but how does one define what is "natural"? Over time, ecosystems evolve at macro and micro levels, often incorporating non-native species into the native system, so that natives and non-natives become indistinguishable. This paper will suggest how a wildlife manager should determine an area's natural system, with specific interest in how invasive and exotic species are judged to belong in an environment. The area of focus is the land surrounding Raystown Lake in central Pennsylvania.

One of the most prominent environmental issues in the coming century will probably be the spread of invasive and/or exotic species throughout the world. When the Pangaea landform came together 250 million years ago, previously isolated species came into contact, causing a mass extinction. In the early 1500s, explorers from the Old World, such as Christopher Columbus, transported goods to and from the New World. This initiated the introduction of numerous exotic species into non-native habitats. Today, globalization is causing a similar process. The natural barriers that have protected ecosystems and fragile habitats are being breached by international transportation and trade. Tiny microorganisms can hitchhike from one continent to another on the shoes of world travelers, just as macroinvertebrates can ride aboard a ship sailing across international waters to a new home. Environments across the globe are being exposed to exotic species, which can have a significant advantage in the new area. The lack of

natural predators to the exotic species can allow it to spread quickly and out-compete native species.

A wildlife manager is faced with a difficult question: at what point do non-native species gain inclusion into an area? Common species we view as native today are actually historically exotic, including the red-tailed fox, the ring-necked pheasant, the nutria, the brown trout, and the horse. Perhaps time is the biggest factor of consideration. If an exotic species has been introduced into a system long ago and currently is established as an important part of the ecosystem, it would probably be destructive to remove it to return the system back to its natural state. Today, the human populace is far more aware of problems associated with spreading exotic species than in the past. While wildlife managers can't go back in time and bar the transport of exotic species, they can prevent further introduction of invasive and exotic species into non-native habitats.

For this reason, a landscape's natural system should be classified as the combination of flora and fauna that most recently provided a stable and healthy ecosystem, regardless if it includes invasive or exotic species. The spread of non-native and potentially destructive species into a given habitat is unstoppable; this process is an occurrence of nature and cannot be completely denied. However, if an area has recently been exposed to an invasive or exotic species that can successfully be removed, such a management technique should be taken.

Ecologists who specialize in invasive species issues are gaining more and more knowledge on how to address this global dilemma. By assessing what traits are associated with successful invasive species and why some particular communities are prone to invasion, they are learning how to begin controlling the spread of invasive species. For instance, many invasive species are fruiting. When birds eat the sweet, colorful fruits, the seed is later dispersed through

the bird's droppings. Other invasive species demonstrate phenotypic plasticity, the ability to grow in a diverse range of environments.

In Raystown country, the list of invasive species is lengthy. Aside the Trough Creek branch of Raystown Lake, several invasive species can be readily spotted. These include invasive grasses, such as garlic mustard (*Alliaria petiolata),* Japanese stilt grass *(Microstegium vimineum),* and crown vetch *(Coronilla varia).* There are also several invasive shubs, including the autumn olive (*Elaeagnus umbellate*) and Japanese barberry *(Berberis thunbergii).*

The story told by trees in this region's forests is also rich. When the colonists came to the Americas, they found large, dense, undisturbed forests. These old-growth forests were composed primarily of American chestnut (*Castanea dentate*) and hickory (*Carya*) trees. The colonists and early settlers, however, cut down a significant portion of the old-growth forests, leaving the forests to move to a hickory and oak (*Quercus)* composition. Now, the forests are moving towards oak and red maple (*Acer rubrum)*. However, in recent history, invasive trees have found their way into Raystown country's forests. One such tree is the tree of heaven (*Ailanthus altissima),* found at Grove Farm.

Historically, this area has been used for farming, timber logging, and iron-ore mining. These different types of resource extraction allowed provided a welcome habitat for "disturbance" species to enter the system. Examples of such disturbance species include the Virginia pine, *Pinus virginina*, and the black locust, *Robinia pseudoacacia*. Neither tree is invasive, but rather opportunistic. They are both able to invade disturbed areas, such as open fields. The presence of Virginia pine and black locust trees suggests that the area has seen some type of disturbance.

The change in species composition of the Raystown area over time illustrates how non-native species can become an important part of the natural system. At Grove Farm, the dominant species are no longer native, and the landscape is highly invaded. With the introduction of so many new species into a disturbed area, the landscape is up for grabs. As rapid change occurs on an ecological timescale, it becomes increasingly difficult to define what naturally "belongs" in an environment.

Just as today's climate change could be perceived as a natural warming cycle of the earth, the spread of invasive and exotic species around the world can also be viewed as a byproduct of human progress and achievement. People may view anthropogenic global events as "natural occurrences" because after all, humans are part of the natural system. Those who profit from a strong global economy will most likely value the interests of international trade over protecting local ecosystems. However, many interests also lie in the health of native species. Simply, an entire ecosystem can be thrown off balance by the introduction of a single new species. Fishermen of Raystown Lake are interested in preserving a balanced ecosystem so that they may continue fishing. And subsistence farmers in less-developed countries depend on native crop species to put food on their table. It is up to our current generation to make use of our knowledge and prevent further spread of invasive and exotic species, for the sake of preserving what is most natural.

Brian Pearson
A Sense of Place

The Dangers of Acid Rain to Forests

The concept of acid rain to anyone in the environmental field is one of significant importance, however many people are not aware of the dangers that acid rain poses to the environment, specifically to our forests. In explaining the dangers of acid rain, we must first define what exactly acid rain is. To begin with distilled water which has not come into contact with Carbon Dioxide has a pH of 7, this is declared as neutral. Any value higher than 7 is considered to be basic, bleach is an extreme example with a pH of approximately 13; if a substance has a pH of below 7 it is said to be acidic, an extreme being battery acid with a pH of approximately 0.8, (Ophardt, 2003).

There are two main cause of acid rain; both of these causes are largely human induced. Worldwide there the two significant industries that are to blame for causing acid rain are the automobile and power industries. In the United States over two thirds of all Sulfur Dioxide and one quarter of all Nitrogen Oxide are released when fossil fuels are consumed. When these gasses are released into the atmosphere they bond with the water vapor in the atmosphere to form Sulfuric and Nitric acid respectfully. This acid rain can and does have a monumental impact

on the forests in the Northeastern U.S. The reason that acid rain is more destructive in the in this area as opposed to states further West because of the winds that blow across the country. The Prevailing Westerlies, as they are called, carry the toxic chemicals that are introduced into the atmosphere from states further west into states such as Pennsylvania. The winds that blow these gases across the Great Plains are relatively unimpeded, that is until they come into contact with the Appalachian Mountains. It is at this point that the toxic gases are able to become incorporated with the water vapor to cause acid rain.

"Over the years, scientists, foresters, and others have noted a slowed growth of some forests. Leaves and needles turn brown and fall off when they should be green and healthy. In extreme cases, individual trees or entire areas of the forest simply die off without an obvious reason," (Acid Rain, 2007). Obviously the dangers that are associated with acid rain are a serious problem, the health of forests are being deteriorated. The forests that are impacted by acid rain are not harmed from absorbing the rain itself. As the acidic rain penetrates the soil it dissolves and washes away many of the minerals that are vital for the tree's survival. Studies that have been done by Cornell University have shown that Sugar Maples growing in acidic soils, caused by acid rain, tend to have less growth than normal. These trees also do not produce the number of seedlings that they would

under average conditions. However when the soil that those same trees was treated to become more basic, the tree growth improved as did the seedling numbers.

Acid rain is not limited in its form, and a more inclusive description would be acid precipitation. Other examples of this precipitation are fog with this low pH. As fog lays into the vallies that are numerous in Pennsylvania instead of nutrients being removed from the soil, because the fog does not come into contact with the soil, nutrients are removed directly from the leaves. In addition to removing minerals and nutrients, acid rain can also deposit metals which are harmful to trees. One example of these metals is aluminum, which interferes with a trees ability to absorb critical nutrients. Some soils naturally contain large amounts of aluminum; however the aluminum is not available to plants because it is an aluminum silicate which plants cannot absorb. The acid rain dissolves these silicates which then allows the roots to absorb the aluminum which clogs the roots to prevent any other nutrient from being absorbed, (Little, 1995).

I personally feel that the issue of acid rain will be of increasing significance even though the forests of today are for the most part able to cope with this man made pollutant. If the major players in the formation of acid rain are vehicles and power plants, assuming our current consumption of these fossil fuels continue, the

forests of tomorrow may be just a myth. We are already beginning to see that acid rain in addition with other factors does have the ability to destroy trees and forests. One then must wonder if this is already destroying forests then how long will it be until all of the forests are unable to cope with the continual burning of fossil fuels.

In addition to harming forests, acid rain does no favors to water supplies in areas that are prone to this low pH rainwater. Once the acid rain has penetrated the soil and removed the nutrients and minerals that are needed by the trees, these minerals and nutrients will continue to remain in the water, eventually coming in contact with a branch of the local watershed. Then the nutrients that were needed by the trees in the forest pose a new threat to the organisms in the water. This acid rain, which has a lower pH than the water that it is being introduced to, will slowly lower the pH of the water supply. Acid rain in the water supply, paired with other pH lowering sources such as Acid Mine Drainage, can have significant affects on previously unharmed areas. When the pH in a water supply is reduced to 4.5 or less, a significant portion of life in that water source will be eliminated. It is amazing to realize that we are slowly, but surely, destroying our forests. Throughout this process of forming acid rain, it is important to keep in mind that fossil fuels are to blame, which means that there is an answer. This answer is

alternative energy, which is the answer to preventing acid rain and all of its devastating consequences.

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2009

Changes in temperature and dissolved oxygen in Raystown Lake during a period of drawdown

Erin Dlabola and Shannon Smith

Juniata College Department of Earth and Environmental Science

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Introduction

Raystown Lake is a 40 year old, 8,000 acre reservoir with important biological and economic impacts on the surrounding area. The dam at Raystown Lake was constructed in 1972 for the purpose of flood control, but there are also recreational, environmental, and economic advantages of the lake. It is the largest man-made lake in Pennsylvania. The deepest part of the 28 mile lake is 200 meters and it is required that water flows downstream at all times (Army Corps of Engineers at Raystown Lake 2009). The lake provides the second largest industry in Huntingdon County with $56 million dollars spent by visitors each year (Beall 2009).

Some recreational areas at Raystown Lake lost 15 to 20 feet of shoreline due to wind and boat generated waves. This could have potentially decreased the profits made by the lake. A drawdown on the lake was implemented from October 2009 to January 2010 in order to recover the shoreline. The water level was decreased 2.5 feet in early October and again in early November, and levels will be recovered beginning in January (Harrington 2009).

There are both positive and negative effects of drawdowns, which can occur naturally during drought or by being human induced. Whether natural or human induced, drawdowns affect the biology and chemistry of the reservoir. Drawdown of water affects aquatic plants by decreasing submerged and floating plant level. Floating plants return to previous levels after the drawdowns end, however submerged plants do not (Thomaz, et al. 2006). Drawdown also affects macroinvertebrate populations by expanding their habitat due to increased light and heat availability (Furey, et al. 2006). Fish populations can also be affected by reservoir drawdown. Their populations and spawning areas may be reduced and eggs can be exposed to air (Benejan, et al. 2008).

The drawdown at Raystown Lake may have an impact on the health of the lake, which may in turn have an economic impact. For these reasons, research was conducted from early September to early November 2009 to collect and analyze data on the chemistry of the lake, and how it was affected by the drawdown. The purpose of this study was to evaluate the impact of drawdown from late summer to early fall by measuring dissolved oxygen levels and temperature.

We expected temperature and nitrates to increase due to the lake becoming shallower. We predicted that dissolved oxygen will also increase, and would be present at higher concentrations at greater depths after the drawdown due to more water movement and shallower water.

Methods

Data was collected at seven previously determined locations at the following mile markers: 0, 6, 9, 13, 18, 20, and 24. They are denoted in this report as MM0, MM6, MM9, MM13, MM18, MM20 and MM24 (Figure 1). At each site, dissolved oxygen levels (mg/L), temperature (^{o}C), nitrate levels (mg/L NO_{3-}), and water clarity were measured.

Using a YSI 550A dissolved oxygen meter, dissolved oxygen, temperature and percent saturation were measured at 1m increments from the surface to 29m, or to the greatest possible depth. Water samples were collected twice at a depth of 3m below the surface and were analyzed in the lab to determine nitrate levels using a HACH water lab. To assess water clarity, a Secchi disk was used. Data was collected on the following dates in 2009: September 8, September 22, October 6, October 13, October 23 and November 3. The water samples for nitrate tests were collected on October 6 and November 3.

On October 13, adverse weather conditions and mechanical problems caused the inability to complete sampling. Data was only collected at MM0, MM6, MM9 and MM13. Poor weather conditions, specifically high winds, and mechanical problems with the boat and sampling equipment were all

possible sources of error in data collection. However, the effects of these sources of error were minimized to the best of our ability.

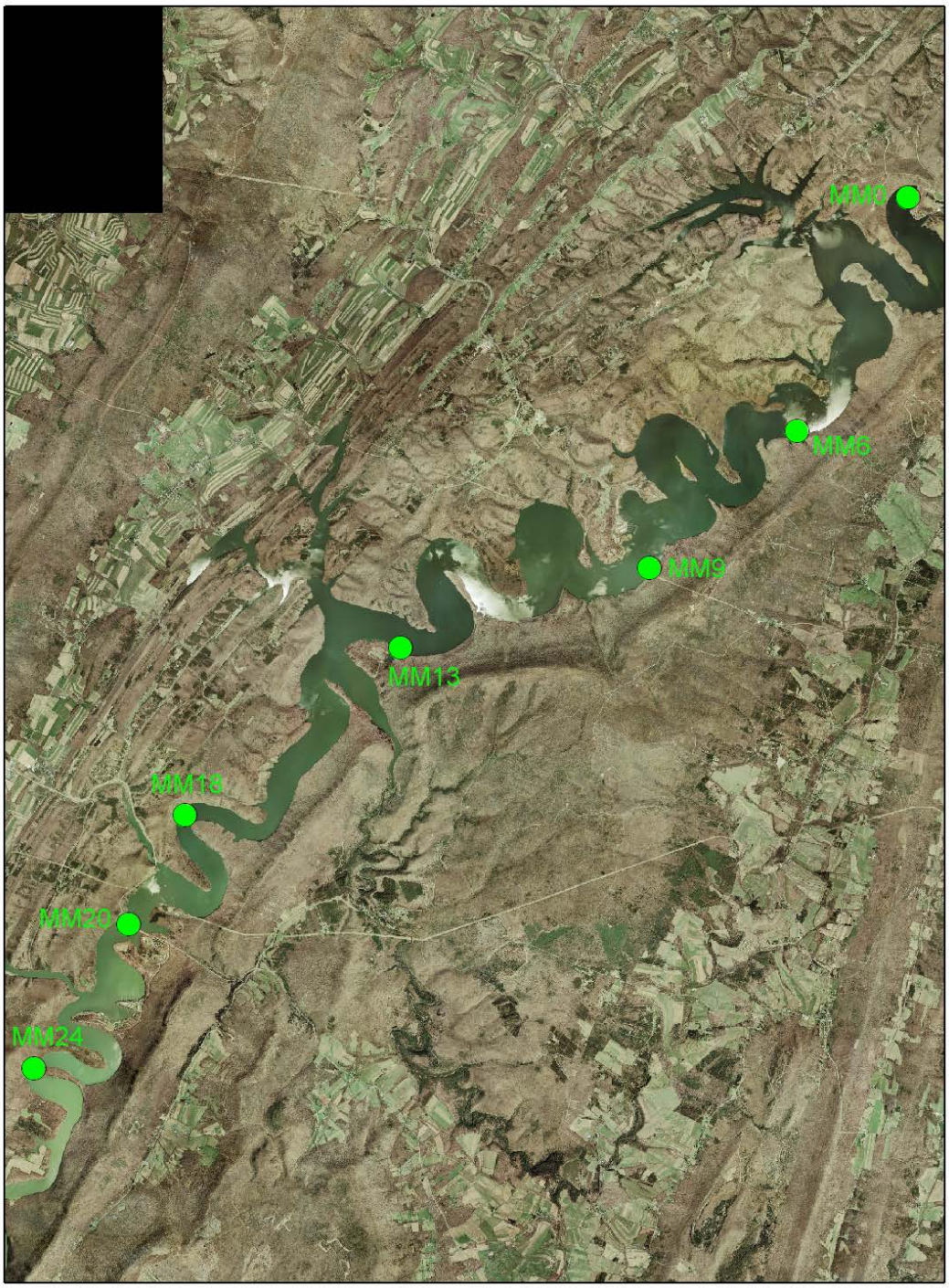


Figure 1 - Aerial photograph of Raystown Lake, PA, showing sampling sites.

Results and Discussion

Temperature

Lakes are stratified in three layers during the summer; this occurs when there is a significant difference in density and the wind is not powerful enough to mix the water. The epilimnion is the top layer, where the water is well mixed and temperatures usually range from 20 to 25 degrees Celsius (Wetzel 2001). The metalimnion is the middle layer with the greatest temperature change; the temperature changes at least 1 degree Celsius per meter. It typically ranges from 15 to 20 degrees Celsius (Wetzel 2001). The hypolimnion is the bottom layer which is uniformly mixed and has cold temperatures, usually 4 to 15 degrees Celsius. In the fall, the epilimnion cools causing the temperature difference to decrease, so the lake becomes de-stratified (Wetzel 2001).

Raystown Lake follows this pattern of stratification, although it is technically a reservoir. This means that it has three lateral zones; the riverine, the transitional and the lacustrine. The riverine zone is narrower than the rest of the reservoir and has well mixed water that tends to be aerobic, and has high dissolved oxygen consumption. The transition zone has a slower velocity than the riverine zone and increased productivity. The lacustrine zone has qualities of a lake, such as having stratification. The sample locations had lacustrine characteristics with typical summer stratification uniformly across the entire lake. The temperatures from the dam to MM24 are very similar (Figure 2).

At the beginning of data collection, the lake was stratified uniformly across its entire length (Figure 2). From September 8 to September 22, the epilimnion remained at the same depth while the hypolimnion seemed to begin at a shallower depth. On October 6, the epilimnion across the whole lake grew deeper considerably at MM6 (Figure 3). The temperatures at the surface of the epilimnion also grew less uniform among sites and they continued to differ increasingly over time.

On October 13, the temperature in the epilimnion from MM0 to MM6 is more consistent at each of those locations than the prior week (Figure 4). It is possible that this was due to windy conditions before the October 6 data collection followed by a calmer week before October 13, which allowed for the water to settle. The abrupt changes in MM6 are most likely due to drifting of the boat due to wind. MM9 appears to have remained stratified; however it was difficult to make conclusions regarding this data due to data being incomplete due to poor weather conditions (Figure 4).

On October 23, the epilimnion was colder and shallower. This could have been due to the water drawdown occurring at the epilimnion. At MM0, the small increase followed by a continued decrease in temperature at 13m in the metalimnion could have been caused by the boat drifting. MM6 appeared to begin to de-stratify at this time because it no longer showed a stratification curve. If there were calm conditions prior to this day and the water settled, this could have caused the increase in the epilimnion depth at MM18 and MM20 (Figure 5). At this point the temperatures in the epilimnion among sites, especially at the surface differed greater than previously. This was likely due to the de-stratification occurring at some sites and the retained stratification at other sites.

On the last date of data collection, November 3, there was still stratification at MM0, MM18 and MM20 (Figure 6). This was possibly due to the movement of water at both ends of the lake: the intake of water at the dam, and the inflow of water from the Juniata River at the other end. The middle of the lake seems to have de-stratified completely, probably because there was less water movement occurring there than at the ends. The cause of the pattern at MM6 was unclear (Figure 6).

Overall, there was a gradual temperature decrease of about 10 degrees Celsius in the epilimnion from September to November due to seasonal changes. It was difficult to determine whether temperature in the hypolimnion changed due to incomplete data collection at all of the locations; however it remained the same at MM0. While the temperatures across the lake at the epilimnion remained similar at the beginning of data collection, as time went on, the temperatures began to differ significantly. The middle of the lake de-stratified, while the region near the dam and the river remained stratified. There was no clear impact determined due to drawdown.

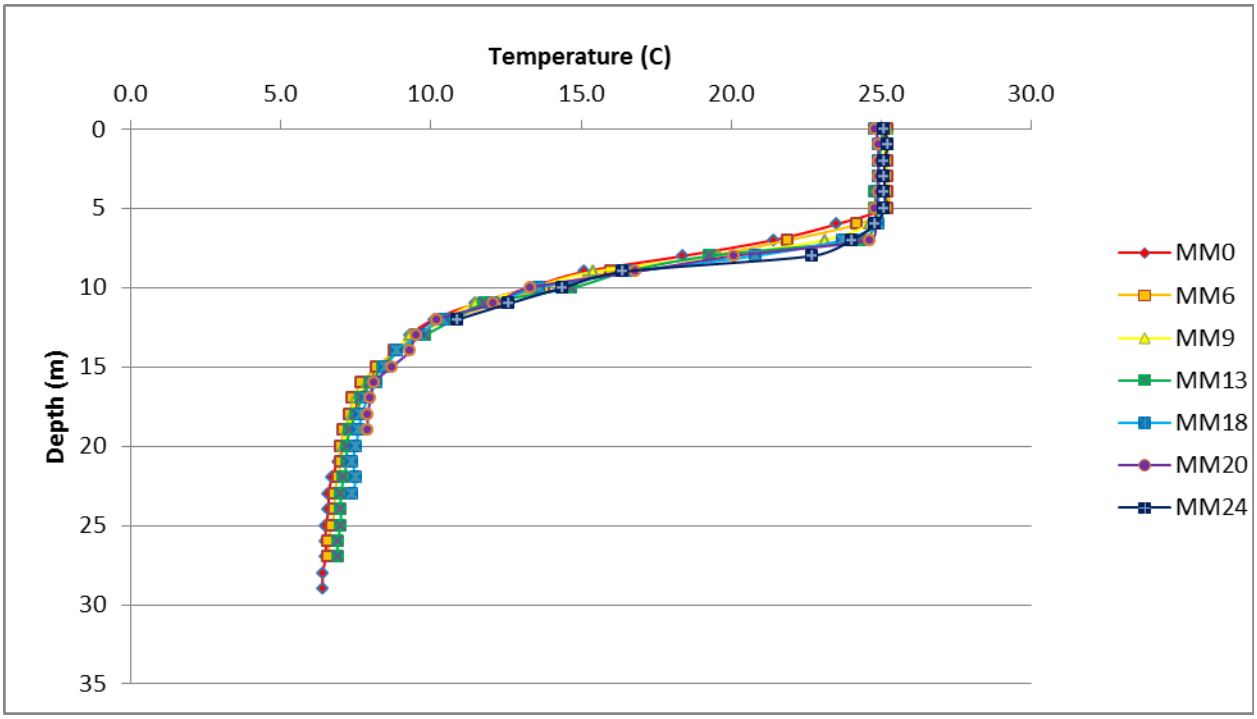


Figure 2 - Temperature (°C) data from September 8, 2009 on Raystown Lake, PA.

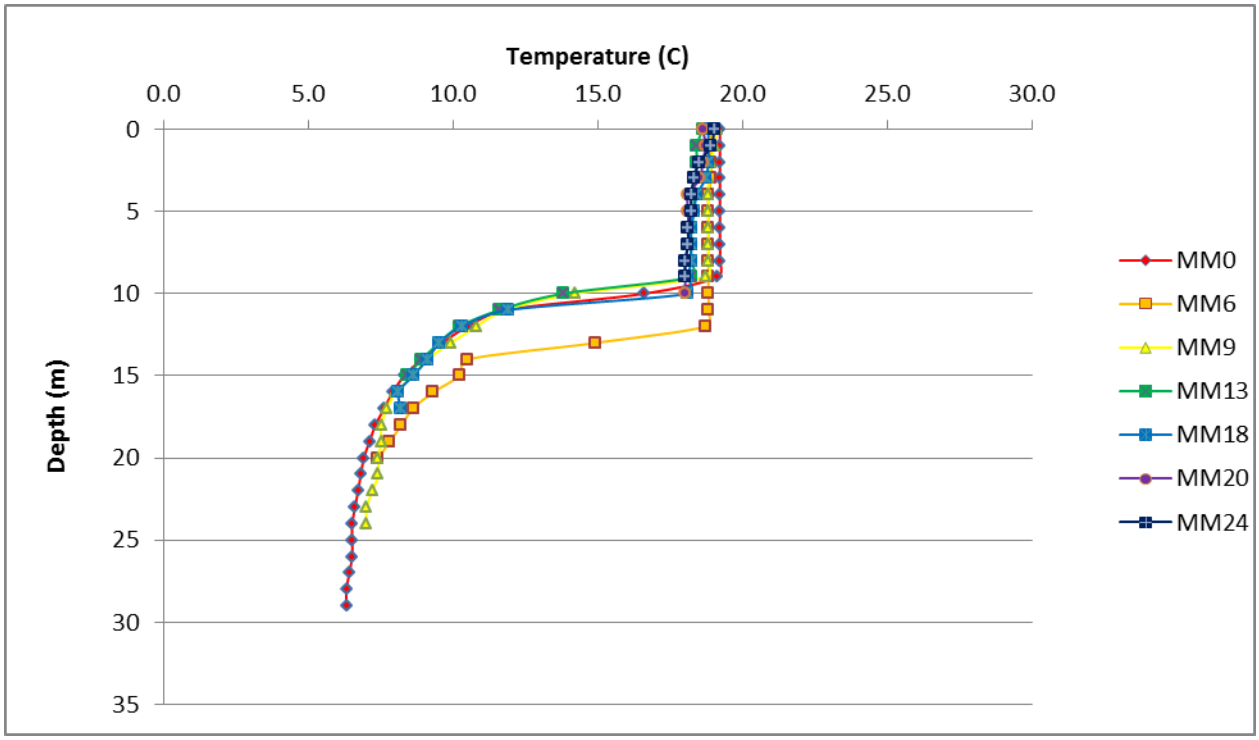


Figure 3 - Temperature (°C) data from October 6, 2009 on Raystown Lake, PA.

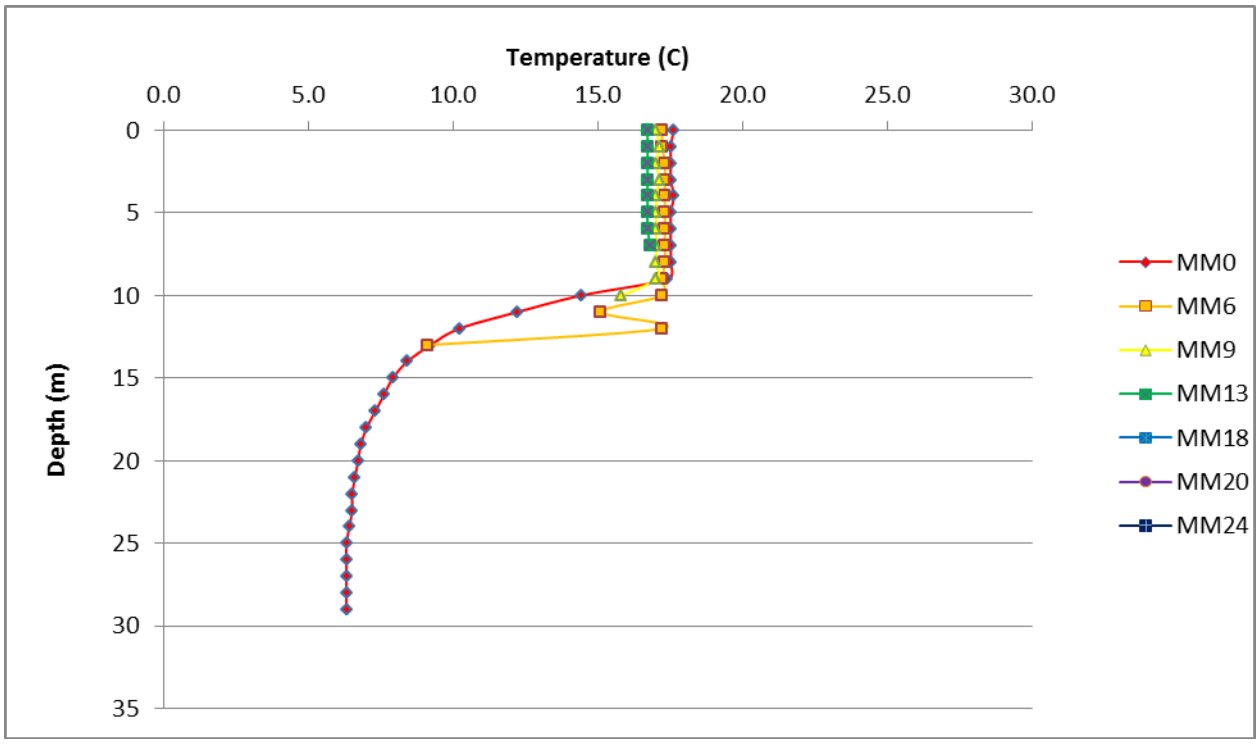


Figure 4 - Temperature (°C) data from October 13, 2009 on Raystown Lake, PA.

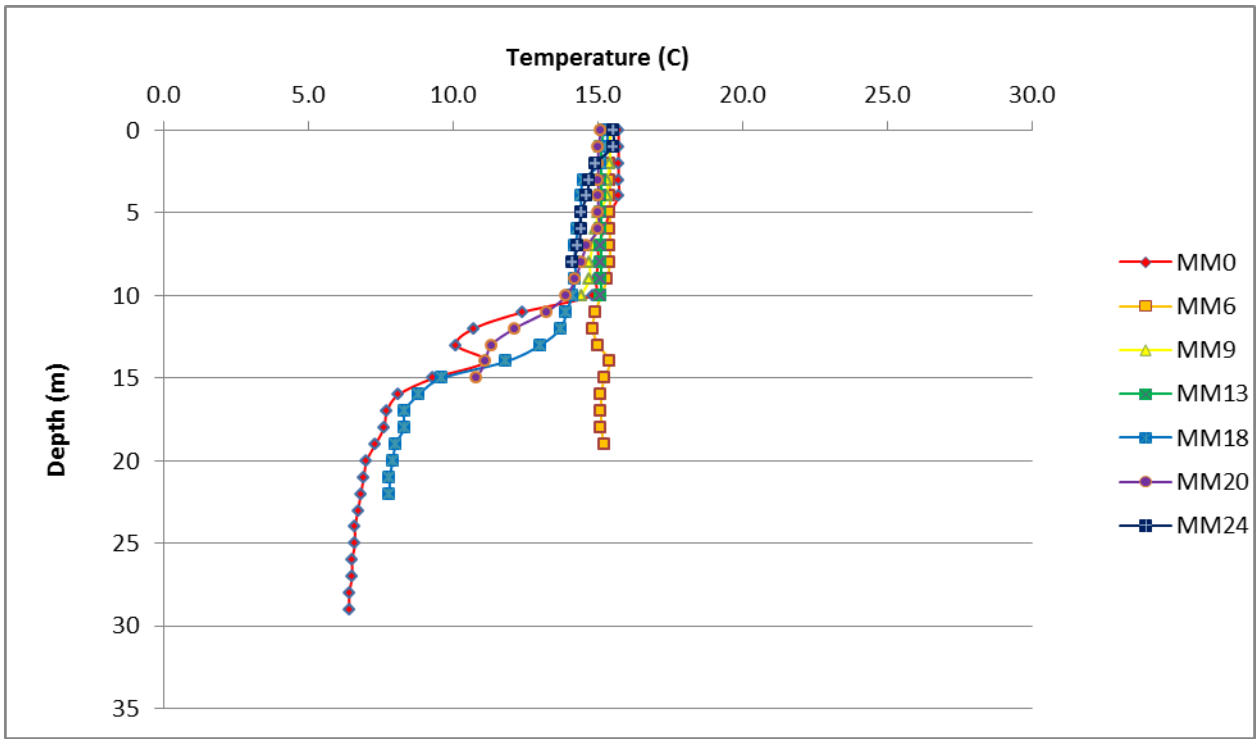


Figure 5 - Temperature (°C) data from October 23, 2009 on Raystown Lake, PA.

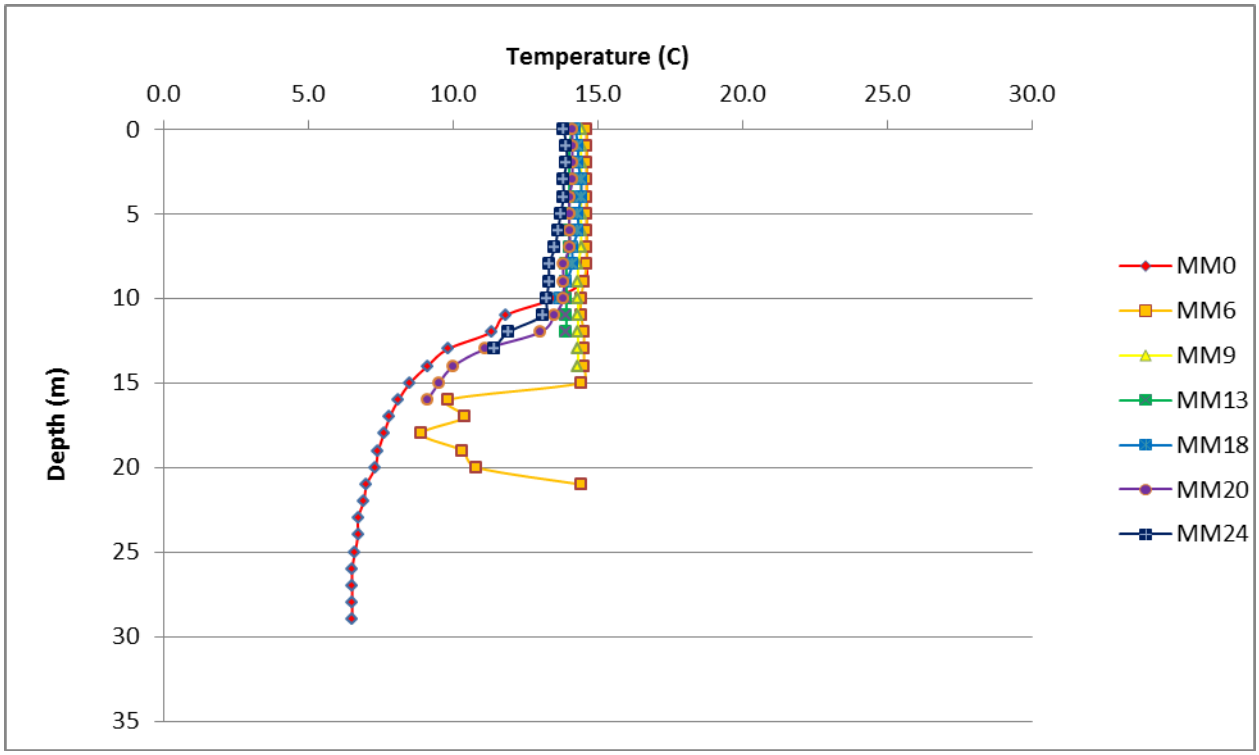


Figure 6. Temperature (^{o}C) data from November 3, 2009 on Raystown Lake, PA.

Dissolved Oxygen

Dissolved oxygen is important to lakes and reservoirs because the amount of dissolved oxygen influences what kind of organisms can live in the water. Dissolved oxygen is a measurement of how much oxygen is available in the water. Oxygen can get into the water through mixing with the air by wind and waves, or as a by-product from the respiration of aquatic plants. During summer stratification the highest levels of dissolved oxygen are usually found in the epilimnion where the most mixing occurs. The hypolimnion, at the bottom of the lake, usually has lower dissolved oxygen levels, and, in some cases, can even become anoxic near the end of stratification, or when nutrient levels are high. When the hypolimnion becomes anoxic that means that there is no oxygen in the water. During initial stratification, in the late spring and early summer, the hypolimnion will be rich with dissolved oxygen; however, the hypolimnion is confined by the metalimnion from making gas exchanges with the atmosphere. Also, no oxygen can be produced by algae in the hypolimnion because it is generally too dark for photosynthesis. Once the original amount of oxygen in the hypolimnion is used up by aerobic organisms during respiration it cannot be replaced, and the hypolimnion becomes anoxic (Wetzel 2001; Jones 2001). This can cause many problems, such as fish kills of cold water fish (Jones 2001). Also, under anoxic conditions nutrients such as nitrogen and phosphorus are released from the sediment. This promotes more algae production and decomposition of organic matter, which leads to even greater oxygen depletion (Wetzel 2001; Jones 2001).

On September 8, 2009, the first sample date, dissolved oxygen was around 8 mg/L in the epilimnion for all sample sites, and showed the common summer pattern for dissolved oxygen in

Raystown Lake (Figure 7). This was consistent with data collected in previous years. A clear negative heterograde could be seen in the metalimnion at a majority of the sites. Dissolved oxygen concentrations in the metalimnion and hypolimnion decreased down the lake from the dam to the river input. The three sample sites nearest the river input, MM18, MM20, and MM24, had less than 1 mg/L of dissolved oxygen in the hypolimnion. This means that the hypolimnion was likely anoxic and cold water fish were probably not living in the hypolimnion in these areas. However, there still may have been fish that can tolerate warmer water living in the epilimnion and the metalimnion. In the middle of the lake at MM9 and MM13 dissolved oxygen level in the hypolimnion ranged from 2 mg/L to 7 mg/L. Dissolve oxygen levels in the hypolimnion at the dam end of the lake (MM6 and MM0) were 8 mg/L to 9 mg/L.

Most of the patterns seen in the first set of data continued in the second data set taken on September 22, 2009 (Figure 8). Dissolved oxygen levels in the metalimnion and hypolimnion all showed a slight decrease. However, the dissolved oxygen levels were no longer as similar as they were previously, in the epilimnion. There was a distinct difference between the dissolved oxygen levels in the epilimnion between MM0, MM6, MM9, and MM13, and MM18, MM20, and MM24. This may have been due to sampling time, or the location of the sample sites themselves. The samples that were taken in the morning, MM0, MM6, MM9, and MM13, still all had a dissolved oxygen level of around 8 mg/L in the epilimnion, while the samples taken in the afternoon, MM18, MM20, and MM24, were all around 10 mg/L. This level of dissolved oxygen was equivalent to a percent saturation of about 117%, making the water super-saturated in the epilimnion. The sites sampled later in the day were exposed to sunlight for longer periods of time before the data was collected. This could have caused more photosynthesis to take place, and therefore yield higher dissolved oxygen concentrations. MM18, MM20, and MM24 are also near the river input end of the lake. The river end of Raystown Lake has been previously show to have higher nutrient concentrations (Yohn, pers. comm.). This may be due to run-off from nearby agricultural fields; this causes more algae and other aquatic plant life to grow in the lake near the river. The abundance of plant life could cause super-saturation of the water with dissolved oxygen due to increased photosynthesis.

In the data from October 6, 2009 a larger decrease for each meter of depth in the metalimnion than in previous data can be seen (Figure 9). This may have been due to the dissolved oxygen levels following the temperature stratification, in which there was similar pattern.

If temperature and dissolved oxygen data from October 23, 2009 are compared it can be seen that although the temperature in the epilimnion was very similar at all sites, dissolved oxygen did not follow this same pattern (Figure 10). Dissolved oxygen ranged between 7-10 mg/L at each site in the epilimnion. It is unclear why these results are seen. Also on October 23, changes occurred in the metalimnion and hypolimnion. MM0 20 is no longer anoxic in the hypolimnion, although it is anoxic in all previous data. Also, most of the sample sites are no longer showing a clear negative heterograde in the metalimnion.

Dissolved oxygen levels in the epilimnion remained similar over the course of the study, while levels in the metalimnion and hypolimnion showed a slight decrease. Overall, there were not many changes that were observed for dissolved oxygen that could conclusively be tied to the drawdown. However, there were observations that could be attributed to seasonal changes. One example of seasonal change was the decrease of dissolved oxygen over time in the hypolimnion at MM0 (Figure 11).

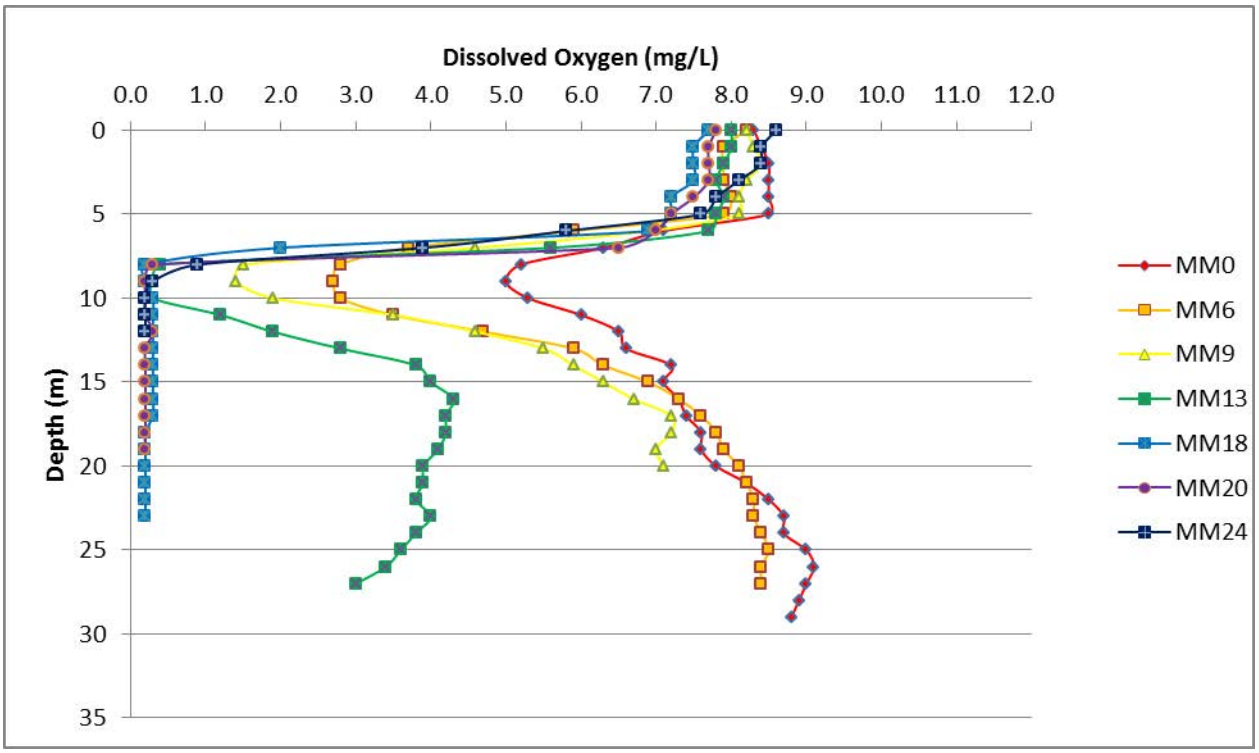


Figure 7. Dissolved oxygen concentrations (mg/L) from September 8, 2009 on Raystown Lake, PA.

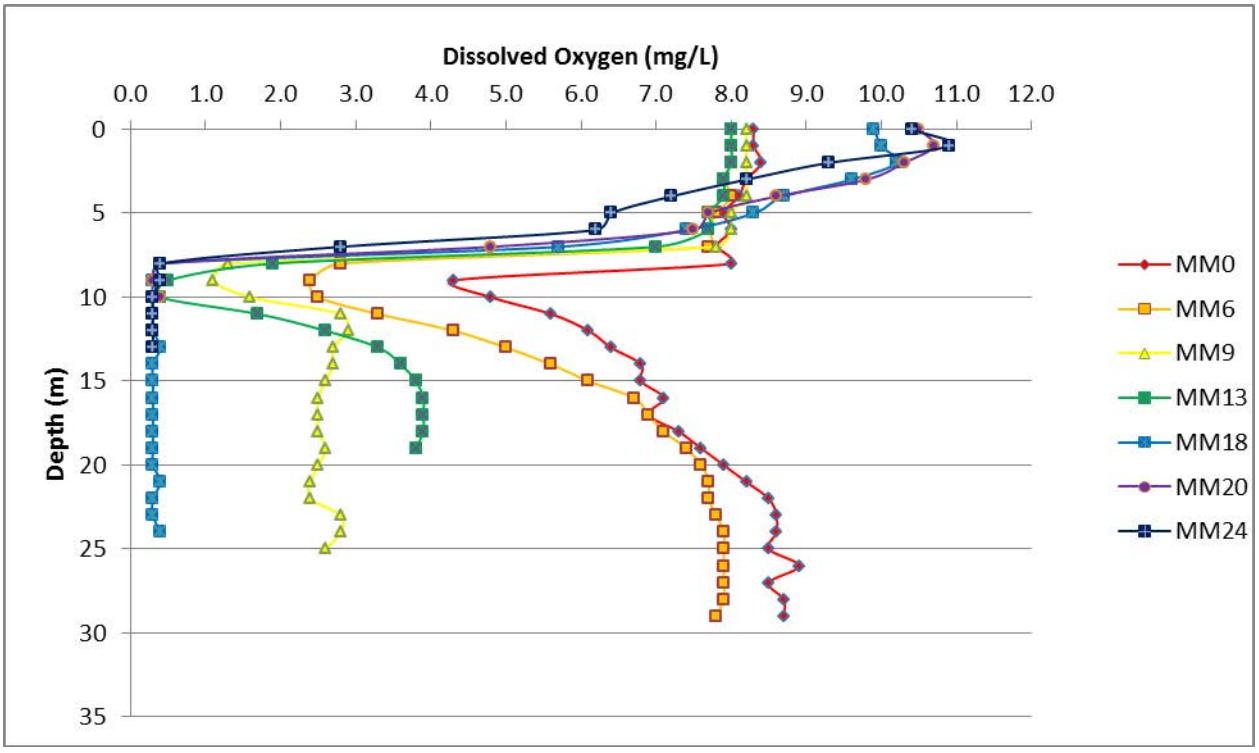


Figure 8. Dissolved oxygen concentrations (mg/L) from September 22, 2009 on Raystown Lake, PA.

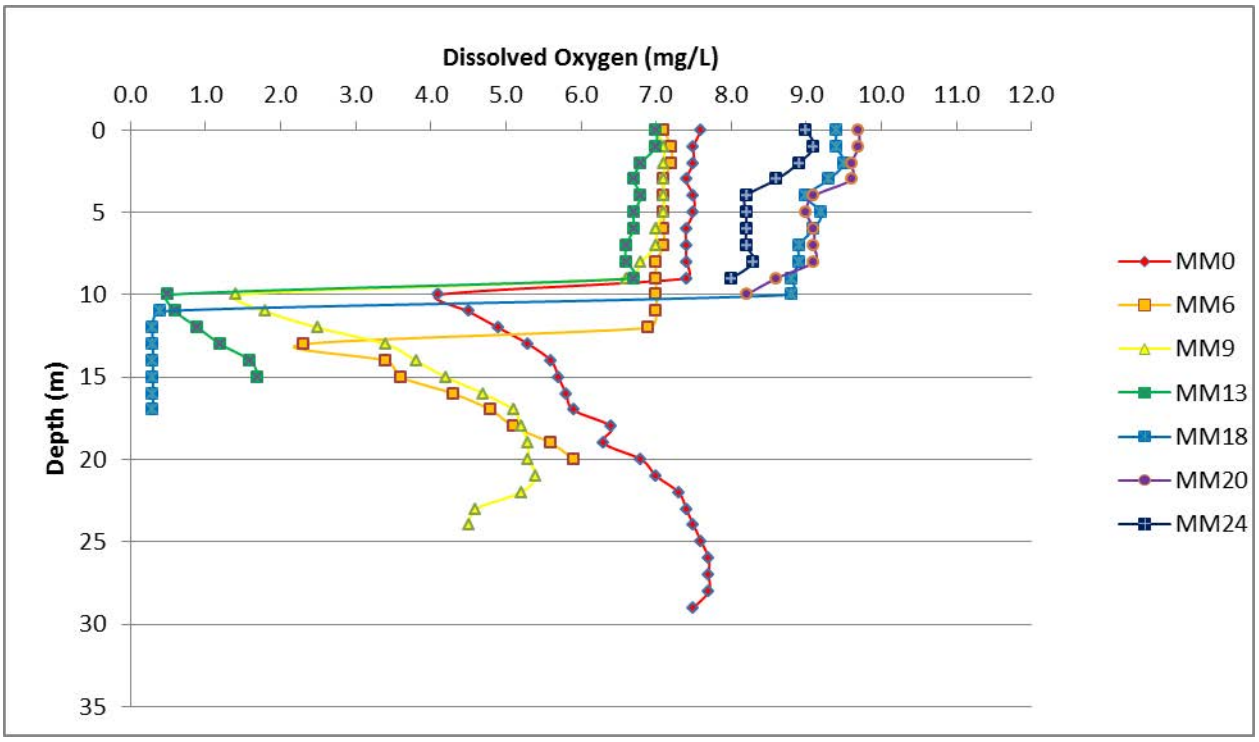


Figure 9. Dissolved oxygen concentrations (mg/L) from October 6, 2009 on Raystown Lake, PA.

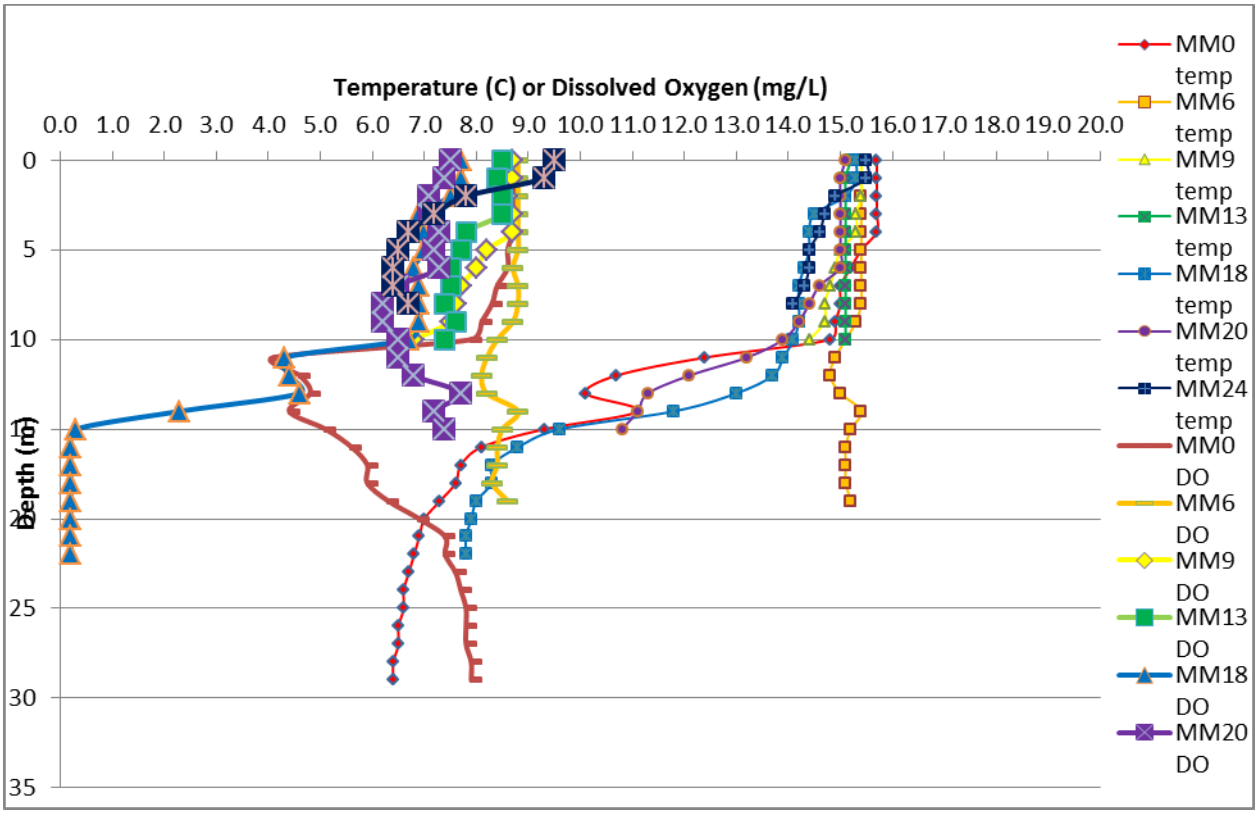


Figure 10. Dissolved oxygen and temperature data from October 23, 2009 on Raystown Lake, PA.

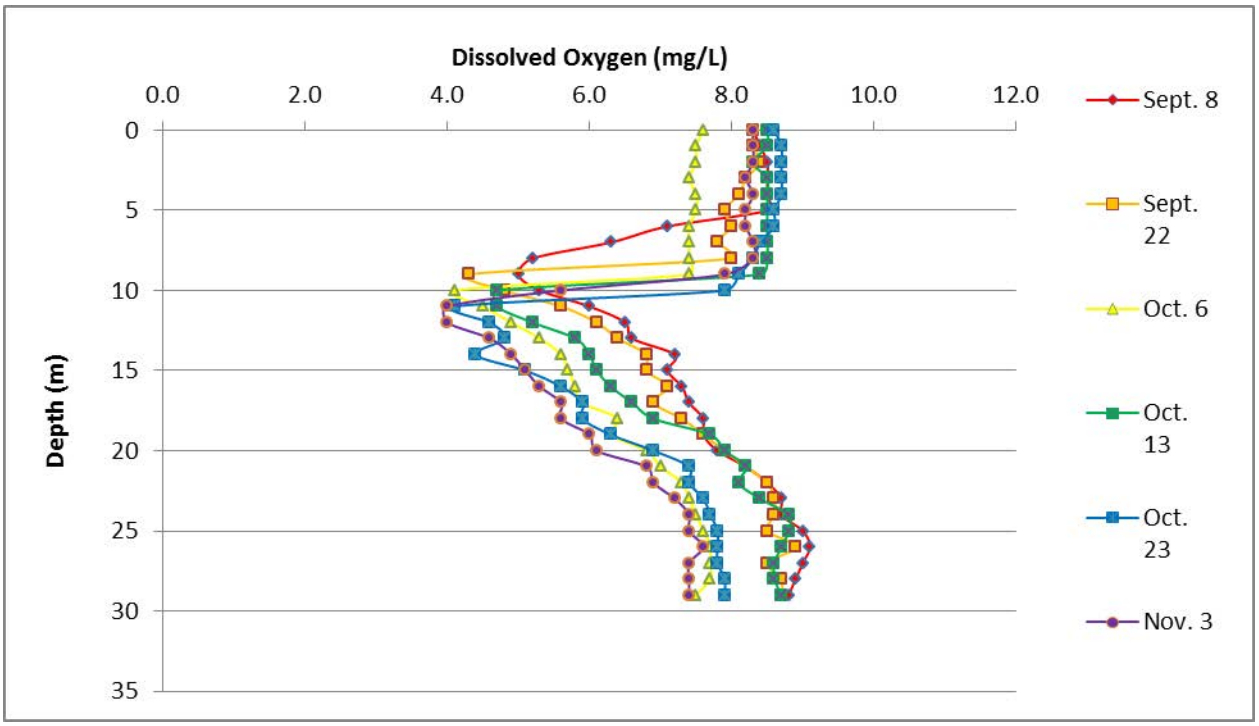


Figure 11. Dissolved oxygen data at MM0 for Raystown Lake, PA over time.

Nitrates

Nitrates in water are usually input from an anthropogenic source or from the atmosphere (Yohn, pers. comm.). The most common source of nitrates, especially in rural areas, like that of Raystown Lake, is from agriculture (Woodard 2002). The majority of fertilizers on the market today contain nitrates. When fertilizer is applied to an agricultural field, many times some of it will be washed away by precipitation, and will eventually make its way directly into lakes or reservoirs, or may be input into reservoirs by the river that feeds them (Woodard 2002). Nitrogen can also be released into the water when anoxic conditions occur, but usually in much smaller amounts (Jones 2001).

Although phosphorus is usually the limiting factor for algae and other aquatic plant growth in a lake or reservoir, an increase in nitrates in a lake or reservoir can signify an oncoming increase in the growth of plant life because nitrogen and phosphorus are both found in similar sources (Yohn, pers. comm.). Basically, the aquatic plants are being fertilized by the phosphorus and nitrogen; this will increase productivity of plants, and often causes algal blooms. Algal blooms, and increased plant life in general, can be detrimental to animals living in the lake because of loss of habitat, and can interfere with recreational activities such as boating or swimming (Wetzel, 2001; Jones, 2001; Army Corps at Raystown Lake).

The results of the nitrate tests in the study showed no clear pattern over time, or when moving along the length of the lake (Figure 12). In fact, nitrate concentrations stayed constant at MM0 and MM9. However, there was an increase near the river input end of the lake at MM20 and MM24 from the first sampling date on October 6, 2009 to the second sampling data on November 3, 2009.

MM20 and MM24 are located near where the Juniata River comes into the lake. This potentially accounts for why an increase in nitrate concentrations was seen at this area; the change seen between sampling dates at MM20 and MM24 may have been due to runoff from nearby agricultural fields. A few large rain events took place within the weeks prior to the second time nitrates were tested. This may have caused an increase in the amount of fertilizers being washed from agricultural fields within the watershed, and thus, an increase in the amount of nitrates coming into Raystown Lake.

Water Clarity

Water clarity can be measured with a Secchi disk by determining particulate levels and productivity. The more organic matter in the water, the less clear the water is; therefore more productivity is occurring (Wetzel 2001). Erosion also has an impact on water clarity; the more particulates that are in the water, the lower the clarity is. On Raystown Lake, water clarity consistently showed a trend of decreasing from the dam to MM 24. This trend was likely caused by nutrient input from the river at the end farthest from the dam. Between October 13 and October 23, however, there was a sharp decline in water clarity over all the sites. This was most likely due to inorganic particulates caused by a heavy rain event. Otherwise, water clarity remained fairly constant over the time period of data collection.

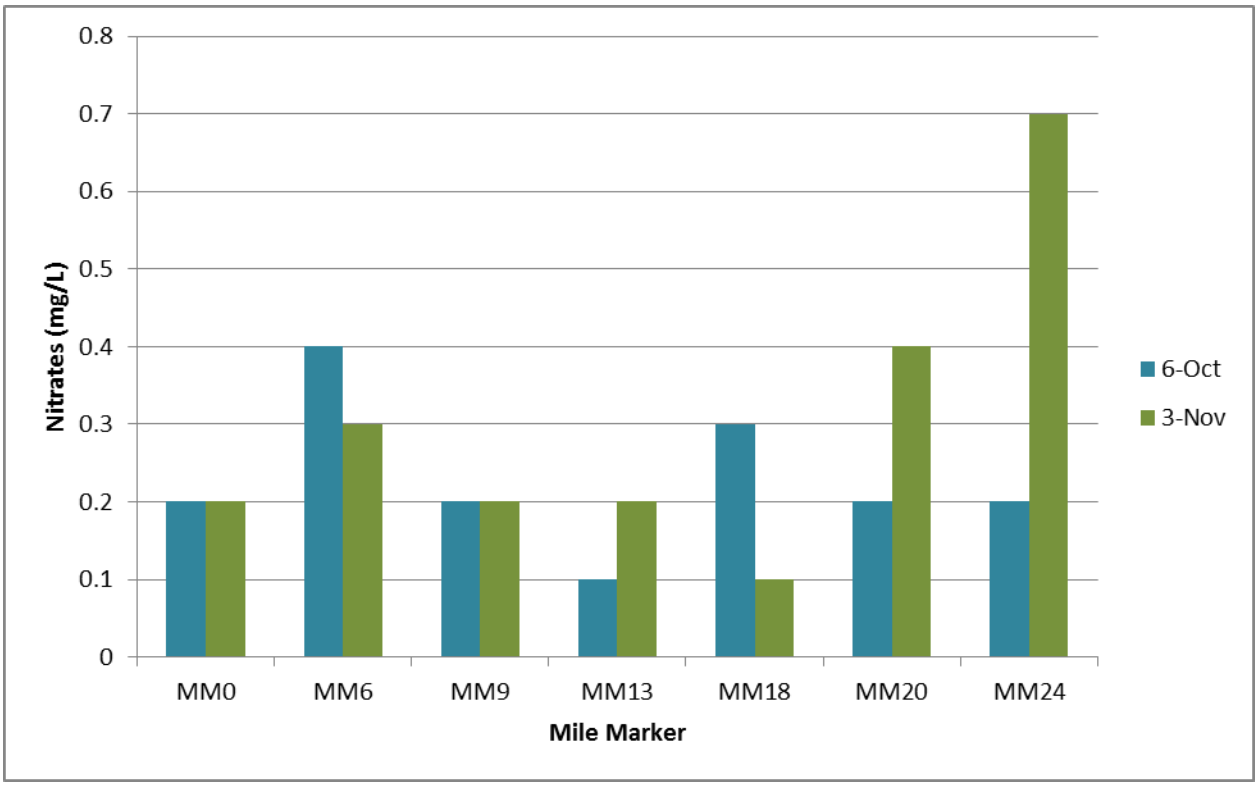


Figure 12. Nitrate data on October 6 and November 3, 2009 on Raystown Lake, PA.

Conclusions

Seasonal changes in both temperature and dissolved oxygen were observed during this study however no results were conclusively a result of drawdown. The same follows for nitrate concentration and water clarity results.

Natural environmental changes impacted the results, which had to be differentiated those effects from that of the drawdown. These natural changes included a 10 degree Celsius decrease in the epilimnion as well as de-stratification occurring near the Juniata River input and the dam. Dissolved oxygen levels in the epilimnion remained similar, but levels decreased in the metalimnion and hypolimnion. Nitrate levels increased and water clarity decreased near the river, which was most likely due to rain events.

Recommendations

If further studies are conducted, we suggest that data continue to be collected through fall as late as possible. Data should be collected at consistent times of the day. If there is another drawdown, it may also be beneficial to examine the effect on submerged invasive plants, such as Eurasian watermilfoil. To further study nitrate levels, water samples should be collected on a more consistent basis. Weather observations should be recorded on days leading to sampling as well as the days of sampling in order to better determine the effects of short term weather.

Acknowledgements

We would like to thank Sharon Yohn and Lane Loya for their guidance and input throughout the research process, Chris Bomgardener for his mechanical assistance, the Raystown Field Station and Juniata College for providing equipment and facilities for our use.

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Saxton Nuclear Experimental Facility

From 1962 to 1972, the second privately owned nuclear reactor in the United States was functional in Saxton, PA. Because the reactor was established in Saxton it became known as the Saxton Nuclear Power Plant. While it was able to generate power, it was primarily used for experimentation. Some of the research that came out of Saxton has greatly contributed in several technological advancements that are used in today's nuclear power industry. This paper will be discussion in better detail about the nuclear reactor in Saxton, how a pressurized-water reactor works, and finally end on how radioactive waste produced by a nuclear reactor is disposed of.

The Saxton Nuclear Power Plant was owned by the Saxton Nuclear Experimental Corporation (SNEC) and additionally supported by GPU Nuclear Corporation[1]. The construction of the facility began in April of 1962. By November of that year it was fully operational and generating power. The

facilities were functioning till May of 1972. Both the reactor and facilities were located in Saxton, PA.

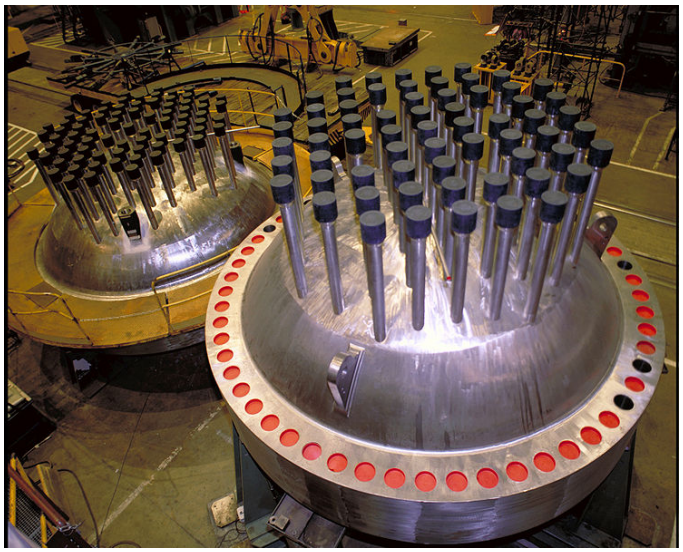


Saxton is located about 100 miles northwest of Harrisburg. The entire facility was commissioned on less than two acres of land and was adjacent to the Saxton Steam Generating Station[1]. The facility functioned primarily operated for research purposes, but like any reactor of the day, it too had to capabilities to produce small amounts of power. Rutgers University from NJ and Pennsylvania State University also used the reactor in their research; on how to improve pressurized water reactor designs, control rod clusters, and chemical shim reactivity controls[1].

Over the course of a ten year span, SNEC had found a way to use boron in the cooling water to help control the nuclear chain reaction. In addition, it became the first privately owned reactor to use plutonium as its fuel source. Before the use of plutonium, nuclear reactors primarily used Uranium-235 as the

fuel source. I will take a brief moment to talk about the significance of the boron and how it is being implemented. Today, a modern day nuclear chain reaction is controlled by using neutron absorber, such as boron. By either: moving boron-containing control rods in and out of a reactor core or by changing the boron concentration in the cooling water.

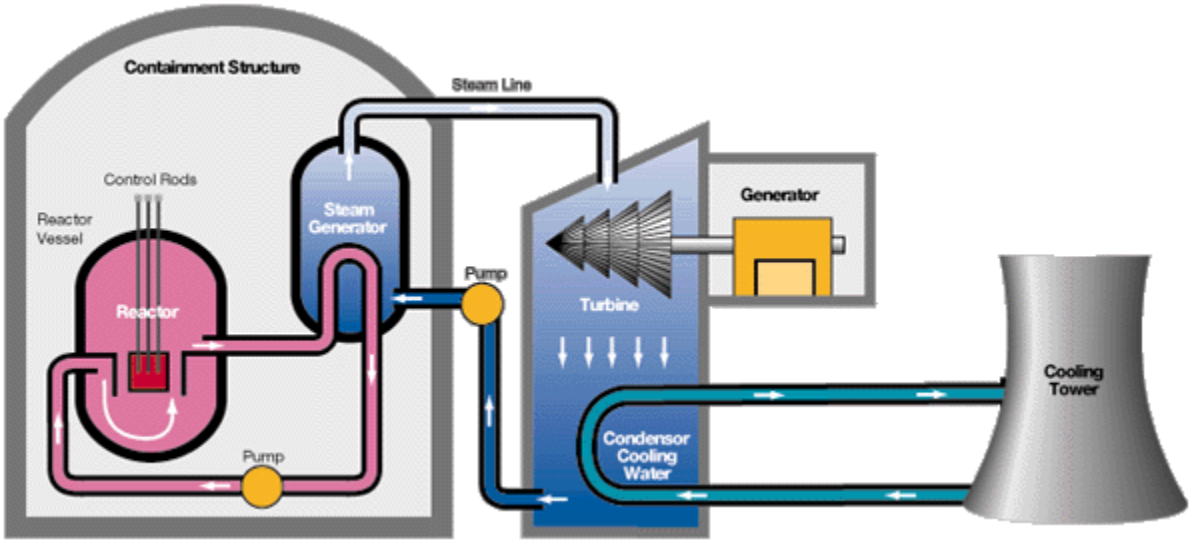
The Saxton nuclear power plant used a 23.5 megawatt pressurized water reactor[1].



Depicts how a PWR reactor vessel looks.

This would supply the steam need to operate a 10 megawatt turbine generator[1]. The container that held the reactor was a vertical steel cylinder and was 58 feet in diameter, with an over-all height of 110 ft[1]. The thermal shield was a stainless steel cylinder that nested on supported legs attached to the outside of the nuclear container's wall. These containers were enclosed in concrete and sat with in a hole cut into the bedrock.

As was mensioned in the previous paragraph, the Saxton nuclear reactor was a pressurized water reactor or PWR. This type of reactor is commonly referred to as a light-water reactor, opposed to a heavy-water reactor. The main difference between the two types is that a heavy-water reactor uses deuterium oxide for coolant. Deuterium oxide is a special type of water in which the hydrogen nuclei contain a neutron as well as a proton[3].



Depicts the process of how a PWR works

These light-water reactors were originally designed and intended for use on nuclear submarines. The water pressure in these reactors can reach about 2,000 pounds per square inch[3]. Such high pressure allows for the water to be heated to 620 degrees Fahrenheit, which is nearly 3x the temperature of boiling water[3]. The water then goes from the reactor and flows through pipes to the steam generator. It is here where the water is converted to steam and is used to turn a giant turbine and create electricity. After the water passes through the

turbines, it is cooled and condensed back into water. This water can then be reused in the same process again. Additionally nuclear reactors have cooling towers. There massive structures are used to release the heat used for condensing the steam back into water. Contrary to popular belief, these cooling towers do not release radioactive fumes into the air.

The nuclear facility was shut down in 1972. It took about two years for a majority of the equipment, like tanks and piping, to be removed. All parts of the facility that were supporting any reactor operations were only partially decontaminated. The remains of the facility were placed in a monitored SAFSTOR condition. SAFSTOR is a method of decommissioning in which the nuclear facility is placed and maintained in such condition that the nuclear facility can be safely stored and subsequently decontaminated to levels that permit release for unrestricted use[2].

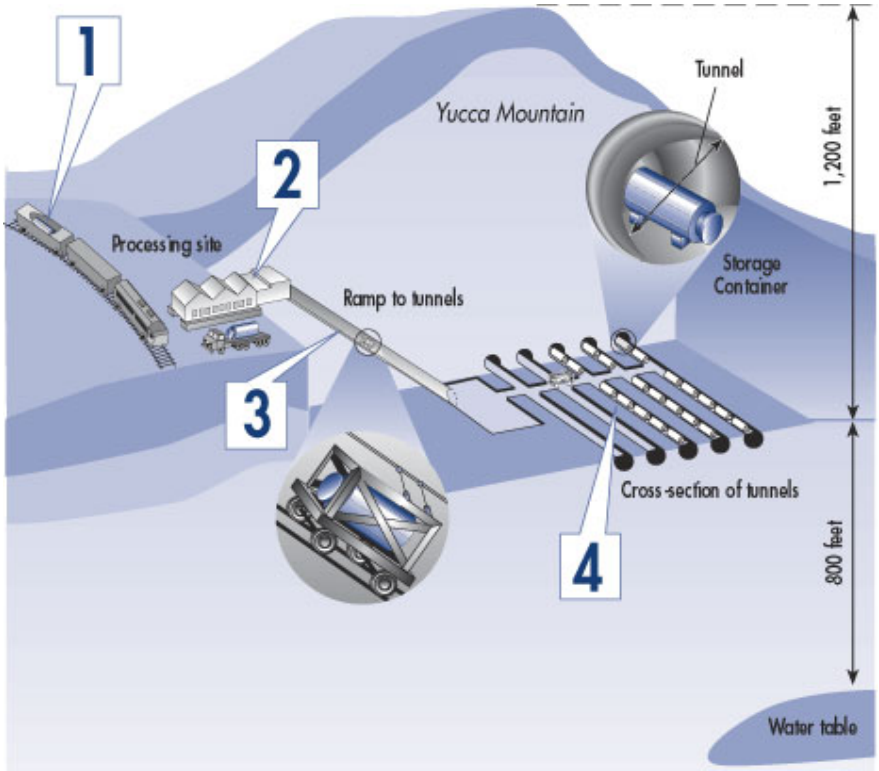
In 1975, the radiological condition of the facility was documented and forwarded to the Nuclear Regulatory Commission (NRC). All parts of the facility that were supporting reactor operations were decontaminated again from 1987 to 1989. This was followed by an eight month final release survey, in which any facility remains were verified to see if the residual contamination was within NRC guidelines.

Almost an additional ten years had passed till the nuclear reactor itself was removed and in 1998, the NRC approved the transitional phase of moving from SAFSTOR to DECON. DECON is the active decontamination and

dismantling of nuclear reactors. During the process the reactor was removed and transported to Barnwell, SC for direct disposal. Much of the contaminated components were thought to have been removed and disposed of as radioactive waste. One last thorough search of the facility was done, when more contamination was found in concrete. Upon further investigation, it became clear that the contaminated concrete could not be removed because it could compromise the entire facility's structural integrity. As a result the entire project was delayed and continued to drag on. It wasn't until the spring of 2002 that all the contaminated concrete was removed. The following year in 2003, the site was restored and the project reached completion.

Nuclear waste can be classified at either low level or high level radioactive waste. Low level waste is comprised of materials used to handle highly radioactive parts of nuclear reactors, such as cooling water pumps. This low level waste is pretty easy to dispose of because the half life of radioactive isotopes and radiation levels is small. Usually storing this kind of waste for a period of 10 to 50 years will allow for much of the radioactivity to decay. At that point the "radioactive" waste can be disposed as regular trash. High level radioactive waste comes from the core of the nuclear reactor. This type of waste is made up of uranium, plutonium, and other elements made during nuclear fission. These materials have very high levels of radiation and extremely long half life of radioactive isotopes. Some half lives can extend beyond 100,000 years. There are three different ways of dealing with high level radioactive waste, which are short term storage, long term storage, and transmutation.

Short term storage can reduce radioactive spent fuel substantially. If the waste spends only ten years in short storage, that can reduce its radioactivity by hundred times. Therefore, it is recommended that waste is stored here for at least ten years. After the nuclear waste spends the required time in short storage it is ready to move on to either long term storage or transmutation.



Yucca Mountain Nuclear Long Term Storage Facility

The concept of long term storage is exactly the same as short term storage. The only difference being that in long term storage, the waste remains undisturbed for very long periods of time. These areas are usually somewhere above ground that can protected from any foreseeable accident, malevolent action, or geological activity. Additionally these areas must create an obvious

warning telling people of what is being stored there, in case the people or country associated with the area no longer exist. Why is this needed? Well when you take into account that only 3,000 years passed since the Egyptian empire and there exists radioactive waste that will take more than 20,000 years to break down. So to avoid unnecessary harm in the future, people need to be aware of its existence, so they can steer clear from such areas.

The final way is through transmutation. Transmutation is the process of transforming one element into another. The goals of this process it to transform long life radioactive elements into shorter life less radioactive ones. Currently there are two methods used to achieve this, the fast nuclear reactor and the hybrid nuclear reactor. Fast nuclear reactors take used plutonium rods and consume it as a fuel source. As an added benefit, the isotopes of the elements created as byproducts generally have shorter half lives than the initial plutonium used as fuel. Hybrid nuclear reactors can almost transmute any high level radioactive waste. To achieve this, a reactor must be brought to sub-critical point and bombard the reactor fuel with neutrons. These neutrons then would break apart the large radioactive elements and as a result release energy. This energy is then used to start a fission reaction. While this process does produce high levels of radioactive waste, it is nowhere in the quantity that was used at the start of the process. This high level waste would have to be placed in long term storage, as it couldn't go through the same process again.

Now you have a better understanding of the local history around the Raystown Field Station. You can clearly see how important of a role the Saxton Nuclear Reactor played in the local history. It allowed for important scientific discoveries to employing the local population. While the facilities are unused now, they will continue to stand there and serve as a reminder to what to what happened in the 60s and early 70s. While I was not able to find any definate information about the topic, the facility will continue to stand until it falls apart due to natural reasons.

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Jamie Hersh

Dr. Yohn

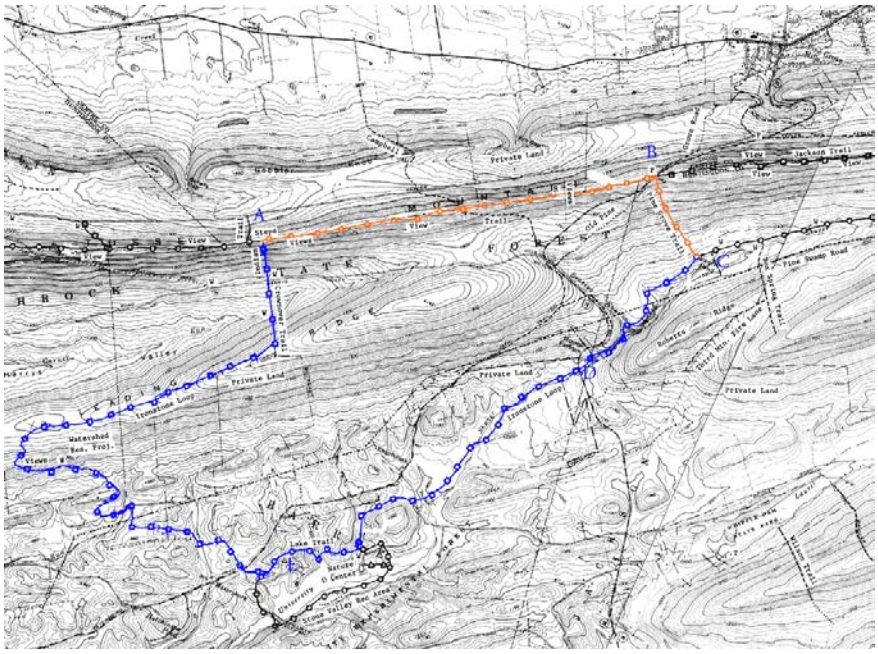
Sense of Place

October 12, 2009

Indian Steps

There are old steep steps that run up and over the tall Tussey Mountain. These steps are made of local stone, and are known as the Indian Steps. The following covers the history of the Indian Steps to include their location and background, description, reason for being built, and their present condition.

The east side of Tussey Mountain runs parallel to route 26, Raystown Lake, and Terrace Mountain. But, it was not the east side of the mountain that the Indians were concerned with. The steps were built up and over Tussey Mountain to the west. Tussey Mountain has two ridges with the summit reaching 700 feet (Youmans, 2). At this summit is where the Indian steps were created and built. The trail goes up Tussey Mountain and descends into Shavers Creek Valley (Youmans, 2). It is, "between Rock Spring and Pine Grove Mills" (Minnick, 1). Specifically in this valley, the trail starts on the Miller farm. The Miller farm is located at the base of Tussey Mountain two and a half miles west of Pine Grove Mills (Minnick, 1).



Map of the Indian Step Trail

Photo Courtesy of: Thwaited, Tom. "Indian Steps Train." *The Lionhearted*. Back Country Publications Woodstock, Vermont, 2009.

At the time the Indian Steps were built the area was inhabited by the Delawares (Leni Lenape), Monseys, Shawness, and Tuscaroras (Youmans, 1). Not only did Indians inhabit the region but settlers did also. The Indian Step Trail passed the Campbell Trail. The Campbell Trail was a wagon road that lead people and trade from Stone Valley to a tavern. This tavern was John Campbell's tavern built in 1811. It kept Campbell competing with the tavern in Pine Grove Mills (Minnick, 2). So at the time both Indians and settlers witnessed the use or reason for the Indian Steps.

There have been some disputes over different theories for the purpose of the Indian Steps' architecture and placement. The description of the steps alone would indicate the steps were built for war. It is a trail, "that leads straight up the side of Tussey Mountain" (Youmans, 1). Most Indian trails lead along streams or rivers and if they did cross a mountain they switched

back and forth. As one author stated, “Native American paths usually took easier routes and an easy route ran across Tussey Mountain less than 5km away, called Standing Stone Path” (Thwaited, 1). Instead of a smooth path, as stated before, this trail shot straight up to Gobblers Knob. The slope of this path had a steep drop of about 200 meters. Another unusual thing about the Indian Step Trail is that it had steps (Youmans, 2). Because of the steepness where the trail was made, steps most likely had to be incorporated. To expand on the location of the Indian steps in terms of topography and placement one source stated that the steps seem like, “a white man’s boundary” alluding to the randomness of the steps (Thwaited, 1). The steps of course were constructed by hand, “many generations ago” (Minnick, 1). Through research it is found that the actual building of the steps began at the summit of Tussey Mountain. This is where the rock outcroppings were actually found. The knob on the west end of Tussey Mountain has a, “ledge of solid rock four or five hundred feet long” and 30 to 50 feet high boulders at the bottom of the rock escarpment (3). In order to make stone steps, material is needed so, “this is undoubtedly the source of the material used in the construction of the steps” (Minnick, 2). The steps extend down 300 – 400 feet from the crest of the knob. The steps themselves are large slabs, probably cut from the outcropping. These slabs were placed in the appropriate position and, “supported beneath by smaller flat pieces” (Youmans, 2). The steps are very wide steps which again support the theory that they were built for war, so they could be traveled when running. Also the Indian Steps Trail was heavily used



Picture if the Indian Step Trail

Photo Courtesy of: Minnick, J.L. *The Indian Steps of Tussey Mountain*. Huntingdon Historical Society. Print.

which conclusion can be drawn by the indentations in the ground. In some places these indentations were one to two feet deep (Minnick, 3). So if it was built for a war why was it traveled so heavily? But the location of the steps would clearly support the construction for war as seen later in the paper.

Therefore, the main question is why and what was the purpose of the Indian Steps Trail? There are three main stories or theories for the construction; the first being war. One legend speculates that the Kishacoquillas Indian tribe built the steps, "over 300 years ago" (Youmans, 1). The steps in this story were built for war which was spurred by a love triangle between two chiefs. In that time, as mentioned before, both the Susquehannocks and Delawares inhabited the

region, and this is where the story begins. The Susquehannock's tribe was very strong at the time and in their raids and wars from the happy hunting grounds they, "abducted an infant Princess by the name of Meadow Sweet, from the Delawares" (Youmans, 2). Meadow Sweet was a very bold and beautiful young lady. The chief of the Susquehannocks held affection for the young Meadow Sweet, "fatherly affection" for her "intelligence and beauty" (Youmans, 2). The Susquehannock chief also had a blood borne son named Pipsisseway. After many years together Pipsisseway and Meadow Sweet began to love each other in their accustomed life together. Some years later, after animosity had calmed down between the tribes, an athletic event was scheduled. The Delawares insisted on this athletic event with the Susquehannocks. The Susquehannocks on the other hand did not want to participate because they knew the Delawares were bad losers and they did not want to stir up strife. But the Susquehannocks finally agreed to the event but were ordered from their chief, "not to win their events by too large a margin", in order to sequester animosity (Youmans, 2). So, the athletic event was agreed upon and the two tribes met. These athletic events happened over many weeks and during this time the chief of the Delawares, Silver Eagle, fell deeply in love with Meadow Sweet and proposed. But at the same time Pipsisseway was in love with Meadow Sweet also. So Pipsisseway told Silver Eagle that Meadow Sweet was to become his wife. Silver Eagle did not take this too well and took offense. He then promised Pipsisseway that he was going to get revenge on him and his tribe. Silver Eagle then gathered up his tribe and left the event. Meadow Sweet and Pipsisseway were then married shortly after. Silver Eagle and the Delawares began building the Indian Steps to prepare for war so Silver Eagle could seek his revenge on Pipsisseway and the Susquehannocks. Then in the winter of 1635 the Delawares made their move. 5,000 soldiers of the Delaware tribe poured over the Indian Steps. But much to their dismay on the other side they were met by prepared

Susquehannocks. The Susquehannocks, being the stronger tribe, met the Delawares with a wall of arrows and only 1,000 out of the original 5,000 Delaware soldiers made it to the other side of the mountain. Silver Eagle was one of the warriors to make it over and in battle he and Pipsisseway came face to face with one another. It is said that, "before Silver Eagle could draw weapon, his head was split open by the tomahawk of Pipsisseway" (Youmans, 3). The battle continued through the day but by night it had ended. All the Delaware warriors were killed. A year after the war Pipsisseway. He and Meadow Sweet had a young son named War Bonnet. He was to grow up to be as great a warrior as his dad. Over time, the Delawares were slowly eradicated from the region. One source states that, "The great battle of the stone steps marked the beginning of the rapid decline of the Delawares" (Youmans, 3). The Susquehannocks were also driven out later by the Iroquois. This story reasonably supports why the Indian Steps were constructed. The steps were made on a steep ridge; they were built wide to accommodate many people traveling over them at a running pace. The steps were, "constructed for sudden attack and retreat in case of defeat" (Minnick).

Another similar story of Meadow Sweet was a poem written by Henry W. Shoemaker called, *Story of the Indian Steps*. Shoemaker at the time was the president of the Altoona Tribune and his good friend John H. Chatham versified Shoemaker's original piece. This story is very similar to the one mentioned previously and also suggests the steps were made for war. In this account, young Meadow Sweet is kidnapped by a neighboring tribe. Meadow Sweet's dad is furious and seeks to find his young princess.



The Altoona Tribune in 1914

Photo Courtesy of: Google

His tribe runs down the Indian Steps after young Meadow Sweets abductor. The chase is accounted in the following verses:

LXXV.

Like sleuths and hounds

That know no bounds,

They madly charged the hill;

As panthers rage

In pent up cage,

Their very blood was chill……..

LXXVIII.

“Make haste, make haste,

No time to waste;

We have the day ahead;

We’ll chase our foe

Where’er they go, “

Is what the father said.

(Shoemaker, 35 and 36).

Meadow Sweet’s dad never did catch up with her abductors and Meadow Sweet was taken farther and farther away from her home. Over time, as Indian captives do, Meadow Sweet was integrated into her new tribe. She was then married to the prince, Eagle Eye of her latest tribe. The prince knew Meadow Sweet was not happy. She would cry every night and hope to be back home again. So Eagle Eye did something very brave. He traveled back to Meadow Sweet’s tribe with her.

CCCIX.

Now Eagle Eye

Decreed to try

To have the Princess go

To native land,

On southern strand,

Where Juniatas flow.

(Shoemaker, 113).

On his return with Meadow Sweet, war broke out between the two tribes, but Eagle Eye finally got Meadow Sweet back home. Meadow Sweet's dad was happy again and war was settled down. This account, as seen again, is very close to the previous love triangle.

A second theory is that the Indian Steps were used for fast raids. During hard winters or drought condition summers the steps were used as a quick route to acquire food. The Spruce Creek and Nittany valleys had very rich farmland and were able to grow more food in these times of hardship. Therefore the tribes of the Juniata Valley would raid the agriculture fields in Spruce Creek and Nittany Valley when food was hard to find (Minnick, 3). Because these raids were happening very frequently, the Spruce Creek and Nittany Valley region placed guards on Tussey Mountain. These guards were suppose to stop the raids before they got down into the valley. The guards' shortcomings though, were that they were only placed on the used parts of the mountain. There were no guards on the steep rock outcroppings and escarpments because they thought it was unlikely that the Juniata Valley Indians would be able to cross this area of the ridge. So, the Juniata Valley Indians constructed the steps in a way to avoid the enemy while still securing food from the valley below. They constructed the steps right where the rock cliffs were.

The third possible reason for the Indian Steps does not have to do with the Indians at all. It has to do with the settlers of the region. It is suspected that the trail was made as a fast route for local settlers to visit friends in Stone Valley (Minnick, 3).

Whatever the reason the Indian Steps were made, no one will know for sure. They could have been made for war; this is the most reasonable reason for the steps. This theory also holds all the in-depth stories of the steps and the people who were influenced by them. They could have been built for agriculture raids in order to avoid guards set up on the mountain or they could

have been made by settlers just for a leisurely, but quick walk to visit friends. There is not much information about the last two mentioned theories but are viable possibilities considering the region and economics of the time.

What about the steps now? Only four to five steps remain. Some of them were still in the original place. All of the other steps had weathered away and had been pushed to the side through logging operations. It is stated that, “the old Indian path is deteriorating rapidly through neglect and carelessness” (Youmans, 1). Later, reconstruction on the steps was planned and underway from Work Plan for camp S-61 (Youmans, 2). Presently, there is hiking information for the Indian Steps. The actual trail connects with the Mid – State trail. It can now be traveled, like so many other Indians or settlers did, but this time it can be enjoyed.



Current Picture of Nittany Valley

Photo Courtesy of: http://static.panoramio.com/photos/original/680754.jpg

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The Legend and Biology of The Broadtop Snake

Brianna O'Malley

Intro:

Legends have always been a part of the American culture. From Johnny Appleseed, to Bigfoot; people enjoy sharing these stories of seemingly impossible events. Since the 1880s the Broad Top area has been rumored to house a giant snake, known as 'The Broad Top Snake' (Baughman, 1987). Said to be at least twenty feet long, the Broad Top Snake is a local legend that has staying power. Since the first sighting of a giant snake, many others have spoken about their own encounters with this mysterious creature. With all this circumstantial evidence, one must ask if it's possible for a snake that size to survive in the area

The Broad Top Township was founded in 1834 as a part of Hopewell in the northeastern corner of Bedford County (Bedford County Geneology Project, 2008).

"Bigger than a stove pipe, black as coal, and about twenty feet long. The snake was located in The Knob back of Cassville and the cemetery."

PA Budget Crisis

Drilling for Natural Gas

Matthew Parks

10/11/2009

Governor Rendell approved the 2009-10 Pennsylvania state budget 101 days late. Why was Pennsylvania without a comprehensive budget since the fiscal year began on July 1st? The primary issue that has divided Rendell and legislators is how to fill a multibillion-dollar, recession-driven shortfall in tax collections. Perhaps one of the most disputed debates over the budget proposal has been drilling for natural gas in state forests. Many argue that a reasonable amount of natural gas drilling on public state parks and forests is necessary to help our economy and to access a much needed resource. Others argue that opening up Pennsylvania's state forests to drilling is not the way to solve the state's budget crisis. It is important to know the implications of drilling; do the benefits outweigh the consequences?



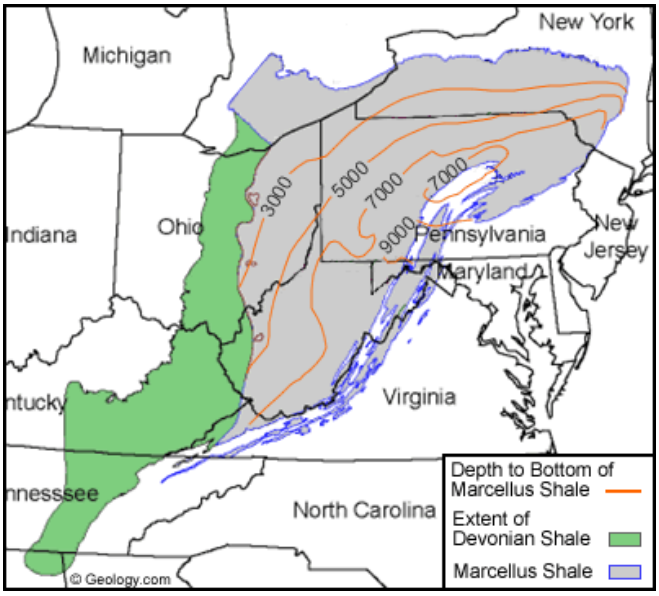
Drilling will certainly hold many environmental consequences. It should be noted that approximately 660,000 acres of Pennsylvania's 1.5 million acres of state forest land in the Marcellus shale play is already available for natural gas drilling (The Mercury; Shannon). A recent budget agreement offered as much as 100,000 additional acres in 2009, and called for the same amount again in 2010. This level of drilling on state forest land has the potential to



irreversibly damage the character of our state forests (The Mercury). Drilling requires the construction of roads, sediment basins, and other infrastructure. It is impossible to construct the miles of road associated with gas wells and not cause severe forest defragmentation (Kotala; Pennsylvania Biological Survey). These adverse effects of forest fragmentation include "reduced habitat area, habitat isolation and loss of species from an area, disruption of dispersal, increased edge effects and loss of core habitat, and the facilitation of alien invasive species" (Kotala; Pennsylvania Biological Survey). In other words, drilling would disturb sensitive habitats and have a threatening impact on our state forests from not only an ecological but also an aesthetic point of view by making our state forests less desirable places for sportsmen, hikers, and tourists (The Mercury). Natural resource agency lands are among the last remaining large areas of unfragmented land in Pennsylvania, making them in particular need protection (Pennsylvania Biological Survey). The Pennsylvania Department of Conservation and Natural Resources produced a publication that

emphasizes the importance of preserving these last remaining large blocks of unfragmented habitat in the state (Pennsylvania Biological Survey). Both conservation and best forest management practices should be taken into consideration before using energy extraction as a means of reducing the PA state budget.

In addition to our forests, clean water is another vital resource expended from drilling for natural gas. . The Marcellus Shale is nearly a mile or more below the surface throughout most of its extent (Geology.com). This gas has become accessible because of an innovative technology developed by Halliburton called hydraulic fracturing, which shoots vast amounts of fluid underground to break up the rock and release that gas (Lustgarten). Fractures created by this process extend from the well bore into the rock formations, allowing gas to travel more easily from the rock pores to the production well (Earthworks). Proppants and chemicals are mixed water and injected with extreme force to the Marcellus Shale (Hedges; Earthworks). An estimated 3 to 5 million gallons of water is needed to drill down to these depths (Hedges).



Many fracturing fluids contain chemicals that can be toxic to humans and wildlife, as well as chemicals that are known to cause cancer (Earthworks). These toxic substances include

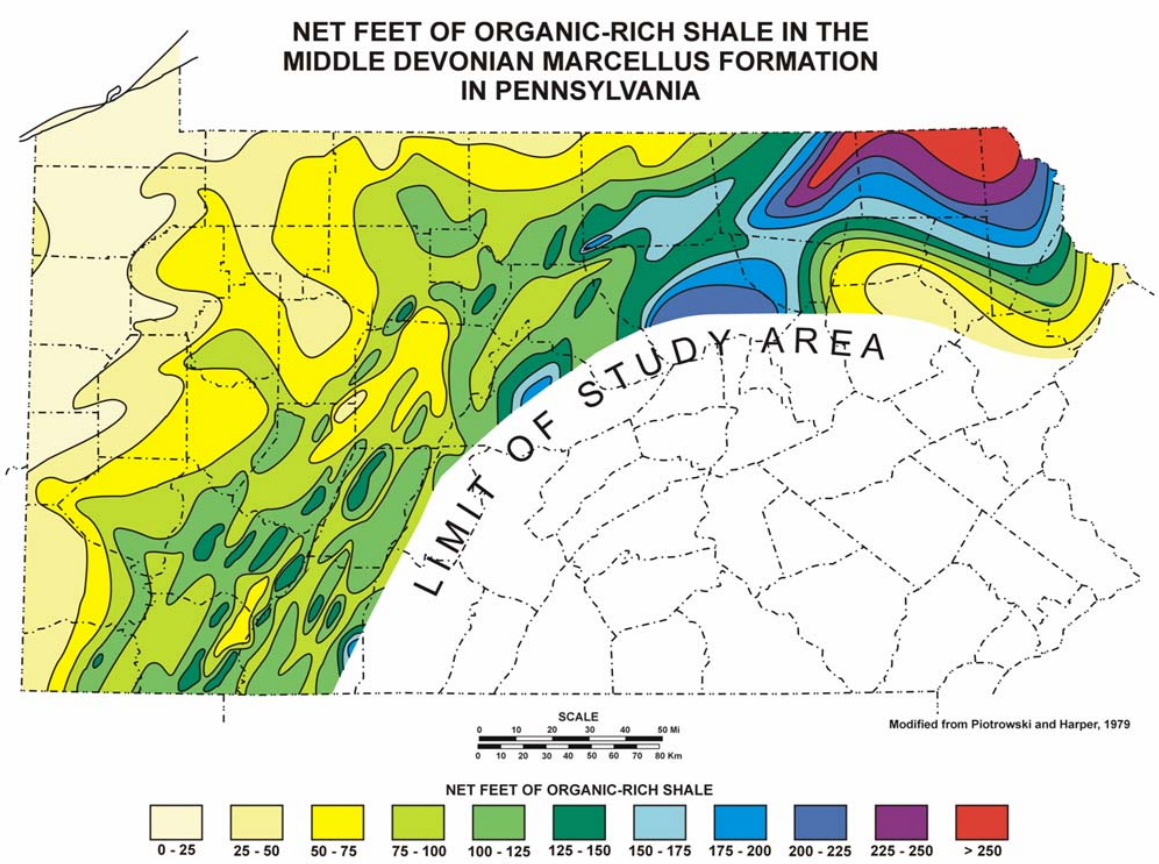
"diesel fuel, which contains benzene, ethylbenzene, toluene, xylene, naphthalene and other chemicals; polycyclic aromatic hydrocarbons; methanol; formaldehyde; ethylene glycol; glycol ethers; hydrochloric acid; and sodium hydroxide" (Earthworks). Very small quantities of the cancer causing chemical "benzene" are capable of contaminating millions of gallons of water (Earthworks). Calculations performed by the EPA indicate that at least nine hydraulic fracturing chemicals may be injected into or close to USDWs at concentrations that pose a threat to human health. These chemicals may be injected at concentrations that are anywhere from 4 to almost 13,000 times the acceptable concentration in drinking water (Earthworks). Not only does the injection of these chemicals pose a short-term threat to drinking water quality, but according to the EPA study, and studies conducted by the oil and gas industry, between 20 and 40 percent of these fracturing fluids remain in the formation. These fluids could continue to be a source of groundwater contamination for years to come (Hedges; Earthworks). The main concern is the release of these poisons into the environment and the impact it will have on all life in proximity to the drilling activity (Hedges). Drilling has already poisoned wells in western Pennsylvania, along with Colorado, Alabama, Arkansas, New Mexico, Kansas, Montana, Virginia, Washington, West Virginia and Wyoming (Hedges). Americans get over half their drinking water from underground sources. The drilling industry was granted an exemption from the Safe Drinking Water Act in 2005—making it the only industry allowed to directly inject toxic fluids into your drinking water without oversight from the EPA. Few of the chemicals used in fracturing are required to be reported. Therefore, neither the government nor the public can evaluate the risks or the consequences of exposure to these chemicals (Unbossed.com).

Despite the major environmental consequences involved with drilling, there can also be significant benefits as well. One of main benefits is job creation. Pennsylvania's economy has been hit hard by the recent economic downturn. Unemployment is at record high levels, families are struggling, and the government response has not stimulated much more than our national debt. New hope is found through some in the Marcellus Shale development—not only will this developing natural gas industry make us energy independent; it will also create jobs and offer opportunities for local residents (Farm and Dairy; D. Thompson; G. Thompson). Some scientists suggest that it is the largest natural gas reserve in the world (G. Thompson). If the energy industry is allowed to continue harvesting gas from the Marcellus Shale, it has the potential to bring more jobs and wealth to Pennsylvania than any industry in the history of the state.

A recent economic study completed by the Penn State University for the Marcellus Shale Committee, natural gas production had a 2.3 billion dollar direct impact on Pennsylvania's economy in 2008; more than 29,000 new jobs and 240 million dollars in state and local tax revenue were generated (G. Thompson; NaturalGas). Estimates claim the industry will continue to contribute a cumulative economic impact of 265 billion to the state by 2010, as well as nearly 15 billion dollars in state and local revenue. The study includes direct, indirect, and induced jobs, and economic activity from the Marcellus Shale development of Pennsylvania. It also notes a consistent increase in annual drilling and projects a 25 million dollar contribution to the Commonwealth's economy by 2010. This level of activity would generate almost $1.4 billion in state and local tax revenue in addition to more than 176,000 new jobs. These economic benefits would be lower if the state places a severance tax on gas drilling (NaturalGas).

Clearly, the exploration and development of Marcellus Shale holds much potential in terms of positively affecting the Pennsylvania economy and reducing its dependence on foreign energy. The Barnett Shale of Texas should serve as a good comparison to the benefits we may experience from the Marcellus Shale since the geology between the two is virtually the same (Kelsey). A report generated by the Perryman Group, a Texas-based economic consulting group, estimates that Barnett Shale accounts for 8.2 billion in annual output (8.1 percent of total output in the regional economy) and 83,823 jobs (8.9% of total jobs). This is a significant number, mostly because the Barnett Shale region is largely an urban area. Potential impacts in northern Pennsylvania could be much higher on a percentage basis since the economy is much smaller comparatively (Kelsey).

Perhaps going hand in hand with job creation, another significant benefit to drilling for natural gas in Pennsylvania is to become energy independent. Approximately 75% of Pennsylvania's natural gas consumption is currently imported. If Marcellus activity continues as expected, Pennsylvania could shift its position as a natural gas importer to a net natural gas exporter by 2014 (NaturalGas). The Energy Information Association states that natural gas usage is expected to increase more than 20% through the 2020 in the United States and 40% worldwide. The EIA also indicates that natural gas will make up 57% of all new electric generation—more than all other sources combined (NaturalGas).



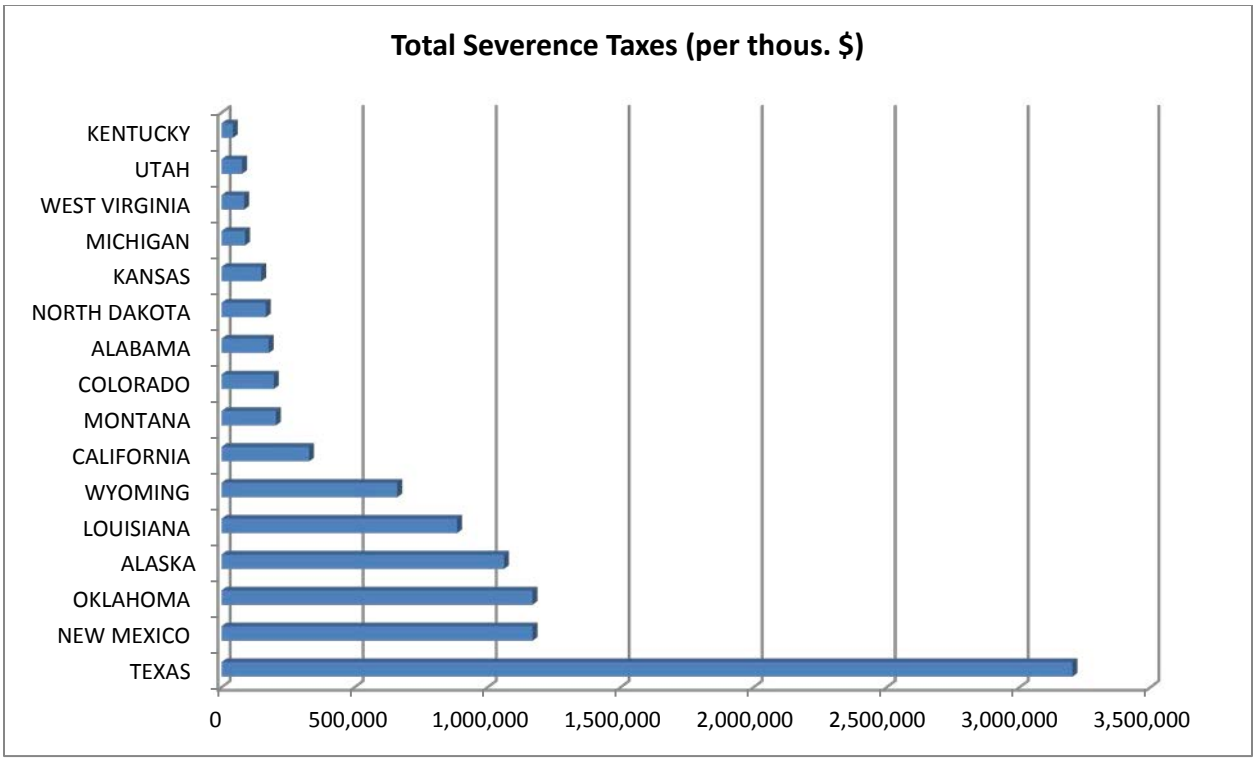
The PSU study estimates that the Marcellus Shale may contain up to 2,445 trillion cubic feet of natural gas reserves in place, with recoverable reserves totaling 489 trillion cubic feet (NaturalGas). In comparison, the United States Geological Survey had estimated that the Marcellus to contain only 1.9 trillion cubic of recoverable natural gas in a 2002 publication (Gold). In April 2009, the United States Department of Energy estimated the Marcellus to contain 262 trillion cubic of recoverable gas (US Department of Energy). Assuming the conservative figure used by the PSU study, there would be enough natural gas to last the entire United States for more than 20 years. When considering the other vast reserves of domestic natural gas, the Marcellus Shale could more than likely support Pennsylvania's economy for 100 years or longer (NaturalGas).

In these desperate economic times, drilling has caught the attention of many; one of the principal reasons why PA was so late with creating a 2009-10 budget plan. However, the true debate has shifted from whether or not to drill—to whether PA should tax or lease. Supporters of a severance tax argue that is it fair to the citizens of Pennsylvania and will help protect the environment and natural resources. Those who favor leasing say that taxation will slow the development of the industry and reduce the economic benefits that would otherwise be gained from drilling.

One side of the natural gas drilling debate would require gas drillers to pay a severance tax. Jan Jarrett, President and CEO of Citizens for Pennsylvania's Future said, "We agree with [Governor Rendell] that these are desperate economic times, and they call for everyone to bear their share of the burden, but we cannot miss this opportunity to invest in the future of our land and water." She continued to add, "The Marcellus shale gas deposit has the potential to make Pennsylvania the Saudi Arabia of natural gas" (PennEnvironment). The point she is trying to make, along with many conservationists, is that the natural gas needs to be "recovered responsibly." The Marcellus Shale offers an incredible opportunity to expand our supply of domestic energy, but it also offers a dire risk to the land, water, and wildlife (Keystone Trails Association). To responsibly recover the natural gas, we need to utilize the best forest management practices and institute a severance tax so that drillers are paying their fair share of fixing any damage that occurs to Pennsylvania's natural resources from drilling (PennEnvironment; The Mercury). Andy Loza of the Pennsylvania Land Trust Association adds, "These economic times call for shared sacrifice, but in the proposed budget conservation programs have lost far more than others" (PennEnvironment). Looking at the numbers, the

Environmental Stewardship Fund has been reduced by 40 percent; 29 million dollars annually. In other words, our environmental infrastructure needs are not being met, but a severance fee will help us reinvest to "protect our streams, safeguard our drinking water, restore our parks and conserve our productive farms and community open spaces" (PennEnvironment).

Jarrett also address the other major importance of implementing a severance tax, claiming that leasing our state lands is a "tax-payer ripoff" (Shannon). She comments, "This budget gives a big sweetheart deal to the multi-national gas drilling industry, but it gives nothing to the average Pennsylvania taxpayer" (Shannon). The proposed budget deals would allow any multi-national energy corporation to drill on public forest land and reap a huge profit without contributing back to the land where the natural game came from. A severance tax would bring in money every year, and it could be generating half a billion dollars for Pennsylvania's treasury, environmental programs, and compensating communities where drilling has caused damage by 2014 (Shannon). Last year the DCNR conducted an auction for leases on 74, 000 acres of public land when natural gas prices were at an all-time high. The winning bids averaged 2300 dollars an acre, but today gas prices are at an all time low; gas drillers are now paying an average of 250 to 500 dollars an acre for leases on the open market. If DCNR is forced to hold lease auctions now, taxpayers lose. Even with an optimistic estimate of 1000 dollars per acre, the state would need to open up 100,000 acres of land; if leases go for current market rates they would need to open 200,000 acres. As mentioned earlier, there are already 660,000 acres of land under lease for gas drilling, and the DCNR estimates that there are an additional 250,000 acres suitable for drilling. Drilling at that scale could permanently compromise recreation, wildlife habitat, and logging (Shannon).



The chart above contains data found at energyindepth.org that was provided by the Independent Petroleum Association of America. It shows an estimate of the total amount of severance taxes that have been collected by the top gas producing states in the United States.

The other side of the debate argues against the tax and in favor of leasing. The Pennsylvania Oil and Gas Association President Stephen Rhoads has urged caution in approaching and tax proposal that can influence exploration and production company investment decisions (NaturalGas). He noted, "In this economic environment, companies actively involved in the development of Marcellus Shale must carefully determine where their manpower, equipment, and resources should be committed and operated for an extended period of time. Pennsylvania is competing against states around the country for that investment, and a severance tax, imposed just as the industry is getting a foothold on this important shale development, will have a considerable negative impact on the state's ability to

compete with those states" (NaturalGas). By not implementing a severance tax, Pennsylvania has a competitive advantage against other states. Rhoads says that such a tax could weaken the economic practicality of the state's indigenous shallow gas industry. Currently, Pennsylvania's natural gas production comes from economically shallow wells. Producers that operate these wells are making a significant economic contribution to many rural communities. Rhodes continues to emphasize the needs to consider the efforts by the natural gas companies to work with communities and individual property owners rather than implement a severance tax. He claims the industry has a "strong track record and continuing commitment to repair and restore local roads that might be affected during the drilling process" (NaturalGas). Implementing a severance tax before the industry has had time to establish itself and realize its economic potential may prevent the industry from being able to expand and grow.

Drilling for natural gas provides Pennsylvania with an amazing opportunity to boost our economy and become energy independent. However, the benefits also come with irrevocable consequences—putting our land, water, and wildlife at risk. We need to make sure that we recover the natural gas responsibly and minimize our impact on the environment. This also means fixing any damage that will inevitably occur. The real issue that is now being debated is whether to lease or tax drilling. The 14 states that outrank Pennsylvania in natural gas production have all implemented a severance tax, with the exception of California, which has a conservation fee (The Mercury). Should PA follow suit and implement a severance tax, or should we hold a competitive advantage over other states?

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2010

DO ACID MINE DRAINAGE STREAMS HAVE A LOW FISH DIVERSITY THAN STREAMS NOT AFFECTED BY ACID MINE DRAINAGE?

Tinamarie DelValle & Michael Bresnahan

ABSTRACT

This research was conducted to see how well the remediation ponds that were made in Joller Town are working for Roaring Run. Roaring Run is known as an acid mine drainage stream and for having a low diversity of organisms living within the stream. On the other hand, Tatman Run has not been influenced by acid mine drainage and will serve as the control stream in this research. Tatman Run is known for having a diversity of organisms living in the stream. While conducting our research we discovered that with a p-value of 0.02 there was a significant difference between fish found in the two streams of interest. That Tatman Run has a higher number of fish and that there is fish populations living in Roaring Run.

Key words: acid mine drainage

INTRODUCTION

Tatman Run is known as a healthy stream that has been unaffected by acid mine drainage. Tatman Run has a well defined fish population that has been able to establish itself over the years. Roaring Run is a stream that has been effect by acid mine drainage. Acid mine drainage is formed when water table contacts residual pyrite in underground mine workings, and then flows to the surface (Klemow 2010). Acid mine drainage can enter a stream in 2 possible ways. The first way is in the form of seeps that often discharge from the bases of culm banks. The second way is in the form of deep mine outfalls that flow into receiving water bodies. These outfalls exist at the points of old mine shafts or ventilation holes (Klemow 2010). Streams effected by acid mine drainage will have a lower pH of anywhere from 2.0 – 4.5 and is responsible for physical, chemical, and biological degradation of stream habitat organisms (Reclamation Research Group 2008).

Acid mine drainage streams are completely devoid of invertebrates and of fish life. This is because the streams have elevated concentrations of metal and these metals are toxic living organisms (Reclamation Research Group 2008). When fish are exposed directly to these metals and H+ ions through their gills fish will experience impaired respiration from chronic and acute toxicity. Fish are also exposed indirectly to metals through ingestion of contaminated sediments and from their food sources (Reclamation Research Group 2008). Streams that are healthy and unpolluted by acid mine drainage will generally support several species and have a more moderate abundance of individuals. On the other hand, streams impacted by the acid mine drainage are dominated by fewer species and often will have low to moderate numbers of only a few organisms. Streams affected by acid mine drainage are rather poor in taxa richness and abundance (Reclamation Research Group 2008).

The remediation ponds of Joller Town were completed in 1998. Since then the ponds had to be fixed because they were leaking and water was not flowing through the entire system before going to Roaring Run. In 2000 a construction crew was able to do some major repairs to the remediation system, which included lining the cells with clay found on the site and repairing the embankments (Milavic 2010). By doing this they were able to make the system work properly in cleaning the water before it enters Roaring Run. Since 2000 fish sampling has been taken and it has shown an immediate beneficial impact in the stream. Fish populations started to improve indicating that the improved system is properly working (Milavic 2010). With this in mind we decided to see how the fish diversity was doing now in Roaring Run. It is hypothesized that Tatman Run will have a greater fish diversity than an acid mine drainage impacted stream, Roaring Run.

FIELD SITES

Tatman Run is a stream that is located in Huntingdon County, Pennsylvania. Tatman is a stream that has a rocky substrate. Some algae were seen growing on the rocks in the water. The areas of Tatman Run that was look at were mostly in the woods and some points were of deciduous trees and others were of coniferous trees. There were also a few points that were visited where the stream was in an open field. However there was shrubs that grew on the bank of the stream and they grew over the stream. The first picture in image 1 is the point with the shrubs growing over the stream. There were a few areas visited where the forest was a mix of both deciduous and coniferous trees.

Tatman Run has well defined banks and has a steep hill defining either one of its banks, sometimes both sides at certain points. Considering the time of year that the research was conduct there was an abundant of leaf litter on the ground and in the stream as well. This leaf litter is the main food source for many organisms that live in the stream. There were several pools of different sizes present throughout the stream where we visited. Some pools were large or small and the pools were either shallow or deep (~3 ft deep). The pools of water that were used for sampling were at random. We used our judgment, as to where we believed the fish would be in, to pick the pool size that we wanted to sample.

The headwater of Tatman Run is located behind a house and the spring starts next to a goat cage. The goats in this cage contribute to the nutrients that get put into the stream through their waste; it gets to the stream as water runoff. Due to the fact that the headwaters are behind a house there is a possibility that the runoff from the house may contain fertilizer, if the yard is treated by the owners. The owner also has a flower bed on the right bank that may or may not get a growth hormone, such as miracle grow, to help the plants grow during the summer time. This could affect the organisms that live in that immediate area. The headwater has a vegetation of tall grasses and small shrubs growing on the banks. It was not fast flowing with water but instead it was a slow flow of water and when you stepped in it you sank from all of the sediment that built up at the headwater. Image two is a picture of the headwaters. The end of Tatman Run went into Raystown Lake where there was a boat launch for the public to use and is near the Raystown Lake Resort. The last half mile or so of the stream picked up in the flow of water. It was moving at a rather quick paste when compared to the others areas that was look at. As we got closer to the end of the stream it got wider before the stream went into the Raystown Lake. Image three is a map with the points that was looked at for the research.

The other stream that we looked at for our research was Roaring Run, which is an acid mine drainage stream. This stream is very similar in appearance as Tatman Run. Roaring Run has a mix of sand and rocks as a substrate. The points that were looked at were in a deciduous, coniferous, or a mix of both tree growths around the stream. There were also a few areas that were in an open field with growth of shrubs and tall grasses near the banks. Just like Tatman there was a lot of leaf litter in the stream. Roaring Run had areas where the water would trickle over the rocks and areas where there was a steady flow of water going over the rocks. The pools of water

were followed by riffles in the stream or there were riffles before the pools of water. The pools of water varied in size and depth, some were shallow or deep and some were small or large.

The areas that were looked at were mostly on someone's property. The stream ran right through their backyard and we had to ask permission from the owners to use their yard as an access point to the stream. Image four shows a few of the sample points of the stream. The headwater of Roaring Run is just above Joller Town, PA; which is where the remediation pounds were made to help correct the problem from acid mine drainage.

The end of Roaring Run goes into Sideling Hill Creek. Roaring Run goes behind several houses before it goes into Sideling Hill Creek. As it goes behind the houses it will get the runoff from the yard that may contain fertilizer if the owners treat their yards. It could also get sewage runoff if the house sewage system is not working properly. About fifty feet before the confluence of the two streams Roaring Run goes under a road bridge, which has a concrete slab as the left bank. This slab of concrete goes to the top of the bank when it is even with the land. The right bank has shrubs and grasses growing. As the water flows into the confluence the flow picked up. There was a descent current of water, you could feel the water pushing against you as you walked through the stream. Image five shows the confluence of the two streams. Image six represents the points of Roaring Run that was visited for the research.



Image1: These images were taken at Tatman Run and represent three different points that we stopped at to conduct our research.



Image 2: Tatman Run Headwaters



Image 3: The purple points on this map represent the areas on Tatman Run that was used for research.



Image 4: Here are several of the areas visited on Roaring Run.



Image 5: Here is the confluence where Roaring Run goes into Sideling Hill Creek.



Image 6: These blue points represent the areas that were visited on Roaring Run.

METHODS

The sites within the were chosen at random The sites were scanned for one meter to three meter pools by one meter to three meters for the depth that we thought had a possibility of fish. Once we found a pool of water one of us went into the water and put the kick net into the water to catch the fish as they went by. Small rocks were placed on the end of the net to help keep the net in the water. The other person went into the water about 20 feet in front of the person holding the net. Then he would walk towards the person holding the kick net. In the process of walking he would kick the rocks in the stream around in an attempt to scare the fish into swimming into the net. By have kicked the rocks around it stirred up the sediments that were in the stream and they made the water murky. When the water was murky it was harder for the fish to see the net and since it was harder for them to see the net they will swam into the net. Otherwise they would swim to avoid the net. Once the walker reached the person holding the net, the net was lifted out of the water. If leaves got in the net they were removed so that we could see what we caught in the net. Sometimes we had crayfish and macroinvertebretes in the kick net. When fish were caught we took pictures of the fish and counted how many of that specie was found. Then we used the *Roger Tory Peterson Field Guide to Freshwater Fish* to identify the fish that was found. Stat methods

RESULTS

The data that was collect was counted data and of a small sample size. However, the poisson test is a more sufficient test to run. The p-value for the poisson test was 0.020, which indicates that the findings are of significant difference between the fish found in the two streams of concern. Figure 1 show the results from the poisson test. Table 1 shows the number of fish and the fish species that was found in each stream.

Number of Fish Found in Roaring & Tatman Run

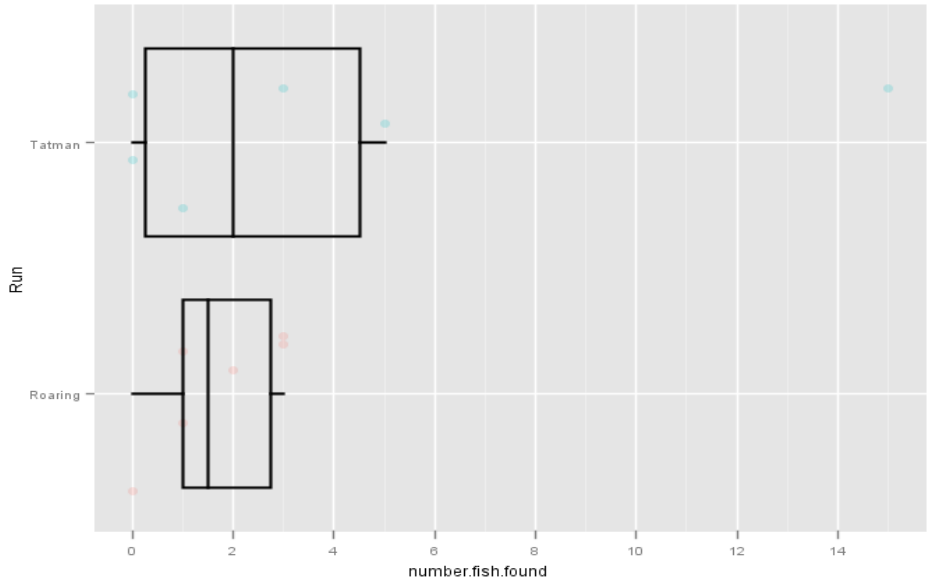


Figure 1: This graph shows the relationship between the number of fish found in both Tatman and Roaring Run. The p-value that was provided by the poisson test is 0.02.

Run	Point	Latitude	Longitude	# fish found	Species
Tatman	pt 1	401532	781122.6	0	
Tatman	pt2	401610.7	781041.6	15	blacknose shiner (*Notropis heterolepis)*
Tatman	pt3	401628.7	781025.4	5	blacknose shiner (*Notropis heterolepis)*
Tatman	pt4	401711.6	781009.1	3	blacknose shiner (*Notropis heterolepis)*
Tatman	pt5	401724.3	780957.6	0	
Tatman	pt6	401822.9	781017.8	1	brook trout *(Salveninus fontinalis)*
Roaring	pt1	401145.3	780330.7	2	blacknose shiner (*Notropis heterolepis)*
Roaring	pt2	40084.68	78059.28	3	bluntnose minnow (*Pimephales notatus)*
Roaring	pt3	401140	780349	1	bluntnose minnow (*Pimephales notatus)*
Roaring	pt4	400824.2	780504.7	3	2-slimy sculpin (*Cottus cognatus)*; 1-blacknose shiner (*Notropis heterolepis)*
Roaring	pt5	401112.1	780342.9	0	
Roaring	pt6	400849.7	780449.4	1	bluntnose minnow (*Pimephales notatus)*

Table 1: The data that was collected from the two streams.

DISCUSSION

Tatman Run had a greater number of fish found when compared to Roaring Run. However, Roaring Run had greater fish diversity than Tatman Run. It is assumed that when the acid mine drainage, from Joller Town, was entering the stream that the organisms living in the stream died from the increased acidity of the water. The findings of this research project indicate that the remediation ponds in Joller Town are in fact working. The ponds are lowering the pH level of the water and fish are able to live in the water. Roaring Run had more fish species than

Tatman Run. It would be expected for Tatman Run to have more fish species than Roaring Run because Tatman Run has not been affected by the acid mine drainage like Roaring Run has been. We did go back out to Tatman Run to see if we could find more fish and were unsuccessful. Tatman Run has a bigger fish population than Roaring Run has which indicates that its fish populations are more established. Our hypothesis of Roaring Run having low fish diversity can be neither rejected nor accepted. This is because both Tatman and Roaring Run had relatively low fish diversity; Tatman Run had 2 fish species and Roaring had 3 fish species. Further research on both streams is needed to successfully answer the hypothesis.

RECOMMENDATION

In the future this would be a more effective study if the person was certified to use electro-fisher equipment. This is because it is a more efficient way to collect fish than it was using a seine net. Electro-fishing will allow you to catch a greater number of fish in a smaller time frame. You will also obtain different species of fish that you would otherwise not have gotten with a net. Another thing that I would have changed in this research is to have it dine when the streams are at a steady flow. When the streams are very low it is hard to find a pool at a descent size where fish can stay. There were a lot of tiny pools or there were areas where there were no pools or water even flowing over the rocks due to the lack of rain. With these few modifications of the study there should be a greater data set obtained as well has a greater diversity of fish found.

ACKNOWLEDGMENTS

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A COMPARATIVE ANALYSIS OF THE MACROINVERTEBRATES IN ROARING RUN AND TATMAN RUN

Melissa Tesauro and Logan Fischer

ABSTRACT

Many streams in central Pennsylvania have been adversely affected by acid mine drainage (AMD). These affected streams display poor water quality and lack of species diversity. We examined the difference between macroinvertebrate communities in Roaring Run, a stream historically effected by acid mine drainage (AMD) that has undergone remediation, and Tatman Run, a healthy non-AMD-effected stream. The macroinvertebrates were used as an indicator of water quality. Macroinvertebrates were collected from both streams with kick nets in October 2010. Species density in Tatman Run was slightly higher than Roaring Run but there was no significant difference between populations in either riffles ($t = 0.15$ $p = 0.45$ $df = 6$) or pools ($t = 0.45$ $p = 0.33$ $df = 7$). Additionally, there was no significance between diversity of macroinvertebrates between riffles ($t=0.46$, $df=26$, $p=.65$) and pools ($t=0.34$, $df=27$, $p=.74$) Thus, as measured by macroinvertebrate communities, Roaring Run has been remediated to the point of recovery. This remediated stream is almost indistinguishable from the unaffected stream.

KEYWORDS

acid mine drainage, macroinvertebrates, water quality

INTRODUCTION

Acid mine drainage (AMD) causes poor water quality, and has been known to reduce species diversity in aquatic communities (Beltman et al. 1999). The macroinvertebrate community is severely affected by AMD which results in a decrease in abundance of metal-sensitive taxa, an increase in pollution tolerant taxa, and an overall decrease in number of macroinvertebrates, total abundance, or biomass (Clements 1991). Macroinvertebrates readily bioaccumulate metals thus providing a potential pathway for pollutants to reach higher trophic levels (Newman and McIntosh 1991).

Aquatic macroinvertebrates present an excellent way to assess water quality in streams. Macroinvertebrates live in water for all or part of their lives so their survival depends on water quality. By observing the abundance and diversity of macroinvertebrates, it is possible to evaluate the presence and intensity of pollution in a stream (Malmqvist, B. and P. Hoffsten 1999). Most benthic macroinvertebrates found in streams are the immature aquatic stages of insects. They live on submerged material or on the bottom substrate of a river or stream (LaMotte Sampling Company). Benthic macroinvertebrates are relatively sedentary which makes them demonstrative of local water quality conditions.

Macroinvertebrates are good indicators of water quality because they are sensitive to changes in the ecosystem, are found worldwide, and they are easy to collect (Rosenberg and Resh 1993). Some macroinvertebrates such as stoneflies, mayflies, and caddisflies require a high level of dissolved oxygen to survive so their presence is an indication of good water quality. Worms are more pollution tolerant and as such they are indicators of low water quality. Macroinvertebrates are divided into three classes according to the amount of pollution they can endure. Class I is pollution intolerant. These organisms are highly sensitive to pollution. Class II is somewhat pollution tolerant. These organisms will be found in clean and slightly polluted waterways. Class III is pollution tolerant. These organisms will be found in polluted, as well as clean aquatic ecosystems (Cleveland A.J. 1998). (Appendix 1).

The purpose of this study was to compare two streams using macroinvertebrate density and species diversity to determine the water quality of these streams. We studied two streams in Huntingdon County Pennsylvania; Roaring Run, which has a history of AMD, and Tatman Run which has not been affected by AMD. We hypothesized that Roaring Run would have lower macroinvertebrate density than Tatman Run, and the species present would be pollution tolerant indicators of bad water quality. It is standard practice to assess the impact of pollutants in watersheds by using diversity and biotic indices that interpret changes in the macroinvertebrate community (Rosenberg and Resh 1993). Because Roaring Run has been remediated we used these indices to determine if macroinvertebrate populations had fully recovered from the effects of AMD pollution.

FIELD SITE

Our field sites were two streams, Roaring Run and Tatman Run, which are located in Huntingdon and Fulton Counties in southcentral Pennsylvania (Fig. 1). These streams are in the Raystown Branch of Juniata River Basin. Sites chosen for the sampling of macroinvertebrates were randomly distributed throughout the streams from the headwaters to the confluence (Fig. 2).

The landscape around Tatman Run is predominately shaded hardwood deciduous forest (*Acer, Querces*). There are some evergreen stands in the area where a Christmas tree farm is located next to a portion of the stream. The entire stream corridor is mainly forested with little to no farming occurring around the stream. There is also no housing influence.

The land around Roaring Run is more varied than that of Tatman Run. It primarily consists of scattered hardwood deciduous forest (*Acer, Querces*) and farmland, but there are also residential areas and small areas of coniferous forest (*Pinus, Conium*). Roaring Run has a history of pollution due to acid mine drainage. Remediation of the stream began in 1998. Signs of successful remediation began to be seen in late 2000 after leaks in the remediation system were fixed (Milavec 2010).

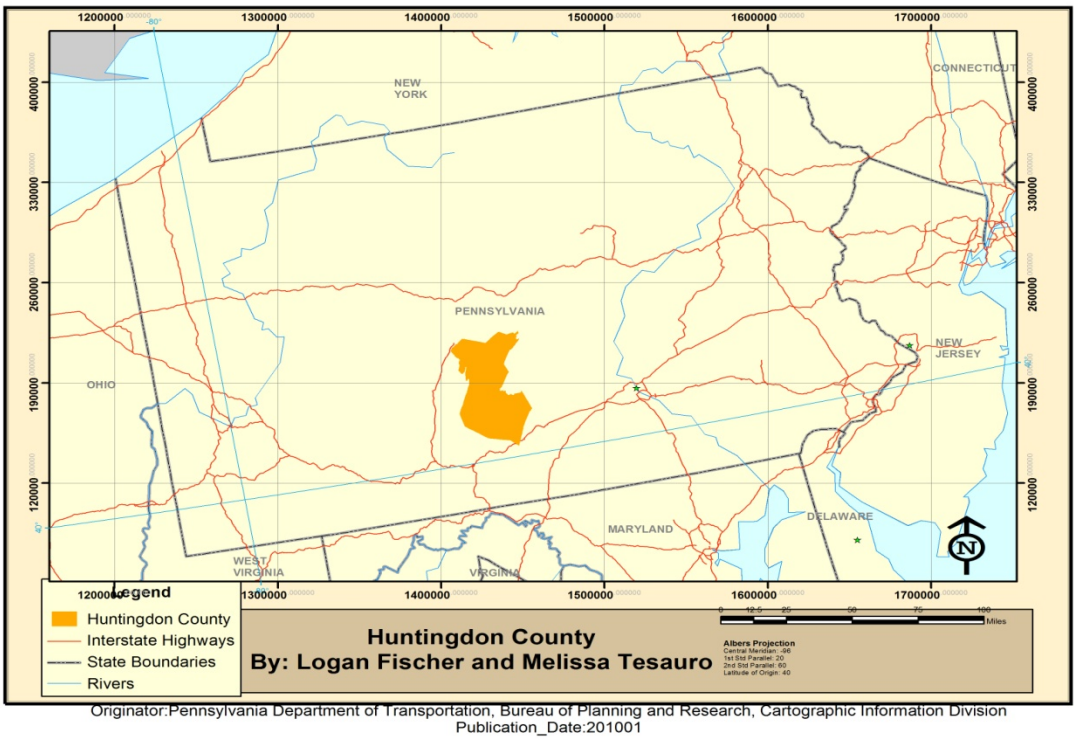


Fig. 1. Location of research in Huntingdon County, Pennsylvania. 2010.

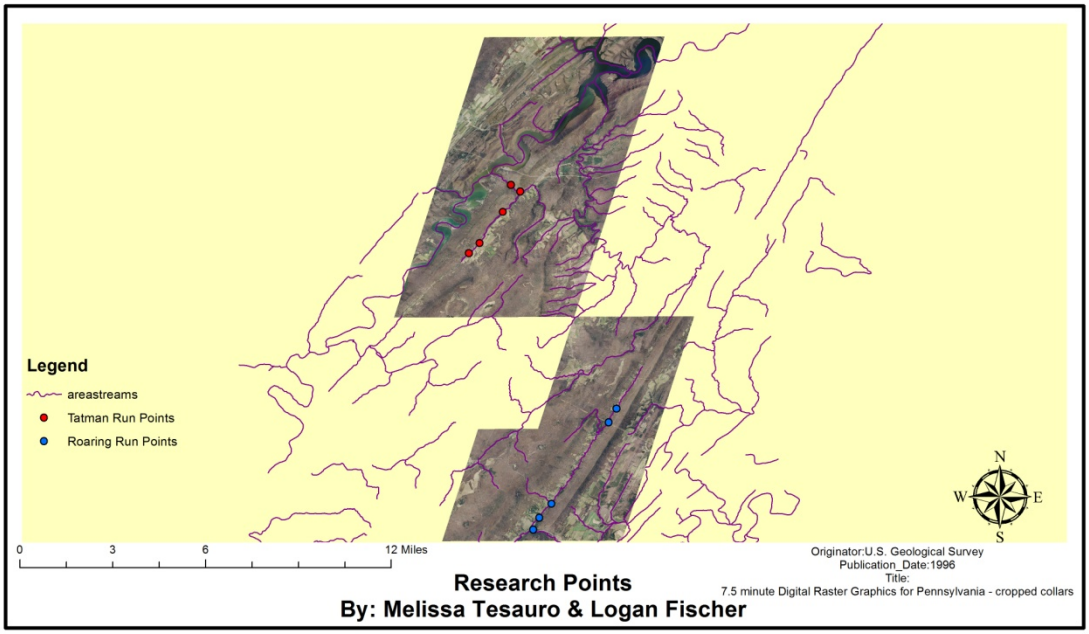


Fig. 2. Sample sites for macroinvertebrates on Roaring Run and Tatman Run. Sampling took place in October 2010.

GEOMORPHOLOGY

Tatman Run's headwaters are located at an elevation of 428 m, and the confluence is 239m high. The stream length is approximately 7.6 km. The rough channel slope of Tatman Run is .024. The upper 30 percent of Tatman Run is not a very sinuous, but the further you go down the stream the more sinuous it gets. Tatman headwaters start out the same as Roaring showing 25-50 percent gravel, cobble, and boulder substrate and decreases to 75 percent substrate downstream. Somewhere around the middle of the watershed the amount of gravel, cobble, and boulder present increases up to 0-25 percent until it reaches the confluence then it goes back down to 75 percent.

Tatman Run's land use is mainly composed of mixed hardwood deciduous and scattered coniferous forest. There are a few open grassland areas that are only used for grazing purposes. Timber cutting in the area is also present but shows no visual or immediate impact on the creek. The few residential areas in the watershed are scattered throughout.

Roaring Run's headwaters are at an elevation of 326 m, and the confluence is at an elevation of 268 m. The length of the stream is approximately 8 km. The rough channel slope is .007. Roaring Run is not a very sinuous stream. This is because Roaring primarily follows a straight path along the Sidling Hill range allowing little movement. Roaring Run's substrate in the headwaters has 25-50 percent gravel, cobble, and boulder sized particles, surrounded by fine sediment. The further you move downstream toward the confluence the smaller the particle sizes become.

Roaring Run's land use primarily consists of mixed hardwood deciduous and sparse coniferous forests. Compared to Tatman, Roaring has more open grassland areas. These areas are pasture land, hay crops, or free growing meadows. The upper portions of the creek, near the headwaters, are PA State Game Lands. Also, some timber cutting is present but there are no adverse effects on the creek. The watershed is populated with more residential areas than Tatman along with a small town near the confluence.

Both streams exhibit a good riffle-run sequence throughout the watershed. Both streams have little to no living vegetative life. The riparian zones are well-vegetated, and the floodplains are well defined. Tatman and Roaring's stream banks are moderately stable with infrequent and small areas of erosion.

Drainage and Hydrology

Tatman Run is located in Southwestern Huntingdon County, Pennsylvania in Penn, Todd, and Carbon Townships. The stream follows North along SR 3001 (Little Valley Rd.) until 994 then it flows West through Tatman Park and empties out into Raystown Lake which is the West Branch of the Juniata River. Then it flows into the Little Juniata River to form the Juniata River. The Juniata River flows into the Susquehanna River which flows into the Chesapeake Bay. The Chesapeake Bay flows into the Atlantic Ocean. Tatman Run lies in Little Valley with the left boundary Terrace Mountain and the right boundary is Bunn Mountain and Broad Top Mountain. Roaring Run is located in South-central Huntingdon County Pennsylvania (Clay Township) and Northwest Fulton County Pennsylvania (Wells Township). It flows along South along SR 3021 (Groundhog Valley Rd.) to 913, where it meets the confluence with Sideling Hill Creek. Sideling Hill Creek flows into Aughwick Creek, which then flows into the Juniata River. From the Juniata River the water flows into the Susquehanna River which flows into the Chesapeake Bay then makes its way into the Atlantic Ocean. Roaring Run lies in Coles Valley with the left boundary being Sidling Hill and the right boundary being Rays Hill (Natural Resources Conservation Services).

Geology Bedrock

The bedrock in Tatman Run is from three different rock formations in two different periods. The oldest formation is the Catskill Formation formed during the Devonian period. It consists of shale, mudstone, and some sandstone. Approximately 80 to 95% of the unit is red in color. Few sandstone strata exceed 50ft in thickness and most are between 5-20 ft thick. The second geologic formation is the Rockwell Formation formed during the Devonian and Mississippian periods. It consists of impure sandstone and subordinate siltstone and shale. The youngest rock formation is the Pocono Formation formed during the Mississippian period. It consists of thick-bedded sandstone and gray sandy shale. There are some beds of gray and red sandstone and red shale in the formation (Kuchinski, J.G. 1982).

The bedrock in Roaring Run is composed mostly of the Mauch Chunk Formation and slightly touches the Pocono Formation. Both of these formations were formed during the Mississippian period. The Mauch Chunk Formation is almost entirely red shale. There is some thin red and green sandstone around Broad Top Coal Field. There is gray sandstone and minor amounts of red and green siltstone and mudstone along the Appalachian Plateau. The Pocono Formation consists of thick-bedded sandstone and gray sandy shale. There are some beds of red sandstone and red shale (Kuchinski, J.G. 1982).

All well water quality is moderately soft with high iron and manganese concentrations for both (Kuchinski, J.G. 1982).

Climate

The climate of Southern Huntingdon and Northern Fulton Counties is “humid continental” which means that it has four distinct seasons throughout the year. During the summer months the average high temperature is 82 degrees Fahrenheit, and the average low temperature is 59 degrees Fahrenheit. In the winter months the average high temperature is 39 degrees Fahrenheit, and the average low temperature is 21 degrees Fahrenheit. The county experiences approximately 37 inches of rain and 33 inches of snow fall per year (Huntingdon County Chamber of Commerce 2007).

MATERIALS AND METHODS

Roaring Run and Tatman Run were compared to test for differences in density and diversity of macroinvertebrates. Roaring Run has a history of AMD pollution; Tatman Run is a relatively healthy stream without a history of AMD so it was therefore used as our reference. To sample macroinvertebrates kick sampling was used on both streams. A net was placed downstream from the kicker who was removing rocks and disturbing the substrate with their foot in a sideways shuffling motion towards the net (Peckarsky et al 1990). We used a meter by meter LaMatte kick net to sample a meter by meter section of the stream.

There were 5 sampling sites in Tatman Run and 5 sampling sites in Roaring Run (Appendix 2). Each sampling site followed a pool-riffle sequence where the first kick was done in a riffle and the second kick was done in the adjacent pool for a total of two kicks per site. Each kick was done in a meter by meter area of the stream. Every site on each stream was sampled twice.

After all macroinvertebrates were removed from the kick net they were identified and counted. The identification of macroinvertebrates went down to the taxonomic family level. Any species that could not be identified in the field would be brought back to the lab to be observed under the microscope. Reference books were used to identify macroinvertebrates (Peckarsky et al. 1990, Pennak 1953).

The density of organisms per square meter at each site was estimated from the average of the samples collected there. This data was then used to calculate the Shannon-Weaver index to compare diversity between pools and riffles, and between Roaring Run and Tatman Run. Two-smaple T-tests (Minitab) were used to compare diversity between the two streams. We considered differences to be significant if p, 0.05.

The EPT index used the three most pollution-sensitive orders of macroinvertebrates as indicators of water quality. These macroinvertebrates are Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The more EPT macroinvertebrates in a stream the higher the water quality. Mann-Whitney Rank-Sum test were done on the macroinvertebrate density of the two streams using the EPT index (Minitab).

RESULTS

There were 19 species of macroinvertebrates found in Roaring Run, and 20 species of macroinvertebrates found in Tatman Run. The scientific and common names of each species found are located in Table 1. The identification and classification of these macroinvertebrates were derived from reference books (Peckarsky et al. 1990, Pennak 1953).

Table 1. Macroinvertebrate species found at Roaring Run and Tatman Run by using kick nets as sampling tools. Samples in Roaring Run were taken on October 13, 20, and 28, 2010. Huntingdon County, PA. Samples in Tatman Run were taken on October 6, 12, 13, and 27, 2010.

Macroinvertebrates Found in Roaring Run and Tatman Run

Order	Family	Common Name	Site
	Annelida	Segmented Worm	T
	Oligochaeta	Earthworm	T
Amphipoda	Gammaridae	Scuds	T
Decopoda	Cambaridae	Crayfish	R and T
Ephemeroptera	Ephemeridae	Burrower Mayfly	R and T
Ephemeroptera	Heptageniidae	Flathead Mayfly	R and T
Ephemeroptera	Leptophlebiidae	Prong-gilled Mayfly	T
Plecoptera	Peltoperlidae	Roach-like Stonefly	R and T
Plecoptera	Perlidae	Stonefly	R and T
Plecoptera	Pteronarcyidae	Giant Stonefly	R and T
Odonata	Calopterygidae	Damselfly	R and T
Odonata	Gomphidae	Dragonfly Larva	R and T
Odonata	Libelluidae	Dragonfly	T
Megaloptera	Corydalus	Helgramite	R and T
Megaloptera	Sialidae	Alderfly	T
Coleoptera	Dryopidae	Long Toad Water Beetle	R
Coleoptera	Elmidae	Riffle Beetle	T
Coleoptera	Psephenidae	Water Penny	R and T
Trichoptera	Brachycentridae	Humpless Case Maker Caddisfly	R
Trichoptera	Hydropsychidae	Net-spinning Caddisfly	R and T
Trichoptera	Limnephilidae	Northern Case Making Caddisfly	R and T
Trichoptera	Philopotamidae	Finger-net Caddisfly	R and T
Trichoptera	Rhyacophilidae	Green Caddisfly	R
Diptera	Athericidae	Fly Larvae	R
Diptera	Chironomidae	Fly Midges	R
Diptera	Tipulidae	Cranefly	R and T

Tatman riffles and pools contained more individuals than Roaring riffles and pools (Fig. 3 and 4). The p-values do not have a significant difference (riffle p=0.45; pool p=0.33). The Shannon-Weaver Index t-test based on diversity means, illustrates that Roaring riffles and pools consist of slightly more species than Tatman's riffles and pools (Fig. 5 and 6). This p-value shows no significant difference between the Tatman and Roaring's pools and riffles(pool p=0.34; riffle p=0.93) The Mann-Whitney rank sum test on density medians shows that there is no difference between pollution intolerant macroinvertebrates between Roaring Run and Tatman Run (Fig. 7 and 8). This p-value shows no significant difference (riffle p=0.4034; pool p=0.9168).

Two-Sample T-Test and CI: Tatman Riffle vs. Roaring Riffle

Site	Mean	Standard Deviation
Tatman Run	5.22	3.76
Roaring Run	4.94	2.17

P-Value	0.445

Fig. 3 Analysis of Variance in diversity among riffles between Tatman Run and Roaring Run.

Two-Sample T-Test and CI: Tatman Pool vs. Roaring Pool

Site	Mean	Standard Deviation
Tatman Run	3.08	1.29
Roaring Run	2.7	1.36

P-Value	0.331

Fig. 4 Analysis of Variance in diversity between riffles and pools in Roaring Run and Tatman Run.

Two-Sample T-Test and CI: Tatman Run pool vs. Roaring Run pool

Site	Mean	Standard Deviation
Tatman Run	1.016	0.288
Roaring Run	1.179	0.41

P-Value	0.336

Fig. 5. Analysis of Variance of the Shannon-Weaver Diversity Index T-test for pools.

Two-Sample T-Test and CI: Tatman Run riffle vs. Roaring Run riffle

Site	Mean	Standard Deviation
Tatman Run	0.926	0.433
Roaring Run	0.943	0.375

P-Value	0.929

Fig. 6. Analysis of Variance of the Shannon-Weaver Diversity Index T-test for riffles.

Mann-Whitney Test: Tatman and Roaring Riffle

Site	Median
Roaring	3
Tatman	5.5

W-Value	23
P-Value	0.4034

Fig. 7. Analysis of Variance of the EPT Index rank-sum test for riffles.

Mann-Whiney Test: Tatman and Roaring Pool

Site	Median
Tatman	2.17
Roaring	3

W-Value	26.5
P-Value	0.9168

Fig. 8. Analysis of Variance of the EPT Index rank-sum test for pools.

DISCUSSION

We found that Roaring Run and Tatman Run had the most macroinvertebrate species in Class I. Thus, Roaring Run and Tatman Run both appear to be healthy streams. If Roaring Run was still AMD effected it would not have Class I species present. It would have relatively few species, but the species present would either be in Class II or Class III.

The communities in both streams are very similar which suggests that Roaring Run has been successfully remediated and the macroinvertebrate community is currently recovering from AMD pollution. It has been so well remediated that instead of having low diversity, species richness, and an abundance of low water quality macroinvertebrates it has normal species diversity and richness comparable to a healthy stream.

The family richness of Ephemeroptera, Plecoptera and Trichoptera (EPT) (Class I), has been found to be a useful indicator for acidity and also AMD because Ephemeroptera are sensitive to low pH and metals while Plecoptera are largely tolerant (Malmqvist, B. and P. Hoffsten 1999). An EPT index showed that Roaring Run had a higher mean value of macroinvertebrates in both riffles and pools (riffle mean=6.22, pool mean=3.53) than Tatman Run (riffle mean=4.18, pool mean=3.10) (See Fig.7 and 8). Although, the p-value for both riffles (0.80) and pools (0.61) were not significant. Thus, the two streams have a miniscule difference indicating that Roaring Run is no longer AMD affected, and has reach a healthy level of water quality and pollution intolerant species.

Most research on aquatic macroinvertebrates is done in areas heavily affected by acid mine drainage. Neither of our sample sites fit into this category because Tatman Run was never affected by AMD, and Roaring Run has been remediated. A study by Ross et al. 2007 relates to our study because it studied AMD remediated streams. The results showed that EPT is significantly higher in limestone and freestone remediated streams than AMD polluted streams ($f=23.57, p<0.001$). They also found that the Shannon Weaver index was significantly lower in AMD streams ($f=7.29$, $p=0.008$). One of the study sites, Wilson Creek was once so heavily AMD polluted that there was no life and since remediation the stream is comparable to other healthy streams in the area. This is similar to Roaring Run, which used to have no fish living in the streams because of severe pollution. Because Roaring Run has been remediated its pattern is related to the species type and abundance found in freestone streams in Wilson Creek (Ross, R.M. 2007).

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APPENDIX

Table 1. Macroinvertebrate classes for water quality. Class I is sensitive to pollution, Class II is somewhat sensitive to pollution, and Class III is tolerant of pollution. (Cleveland, A.J. 1998)

Class I	Class II	Class III
Stonefly nymph	Beetle larva	Midge fly larva
Mayfly nymph	Sowbug	Snails
Dobsonfly larva	Scud	Leech
Caddisfly larva	Clams, Mussels	Aquatic worms
Riffle beetle	Crayfish	
Water penny	Cranefly larva	
	Dragonfly nymph	
	Damselfly nymph	
	Black fly larva	

Table 2. GPS for each sample site on Tatman Run and Roaring Run.

Site #	Tatman GPS Points	Roaring GPS Points
Site 1	N 40° 16’ 11.4”	N 40° 11’ 45.3”
	W 078° 10’ 41.8”	W 078° 3’ 30.7”
Site 2	N 40° 16’ 29.3”	N 40° 11’ 13.2”

	W 078° 10’ 25.4”	W 078° 3’ 41.9”
Site 3	N 40° 17’ 24.2”	N 40° 8’ 49.7”
	W 078° 9’ 57.5”	W 078° 4’ 47.9”
Site 4	N 40° 18’ 00.0”	N 40° 8’ 24.2”
	W 078° 9’ 34.6”	W 078° 5’ 4.7”
Site 5	N 40° 18’ 11.7”	N 40° 8’ 3.9”
	W 078° 9’ 59.1”	W 078° 5’ 9.2”

Table 3. Number of macroinvertebrates in each pollution tolerant class in Roaring Run sample 1.

	Roaring Run Sample 1		
	Class I	Class II	Class III
Total	472	70	0

Table 4. Number of macroinvertebrates in each pollution tolerant class in Tatman Run sample 1.

	Tatman Run Sample 1		
	Class I	Class II	Class III
Total	190	130	1

Table 5. Number of macroinvertebrates in each pollution tolerant class in Roaring Run sample 2.

	Roaring Run Sample 2		
	Class I	Class II	Class III
Total	184	23	0

Table 6. Number of macroinvertebrates in each pollution tolerant class in Tatman Run sample 2.

	Tatman Run Sample 2		
	Class I	Class II	Class III
Total	166	72	3

Mean (±SE) counts of macroinvertebrates in Roaring and Tatman, Huntingdon County, PA, Fall 2010.

	Tatman Pool		Roaring Pool	
	Mean	STDEV	Mean	STDEV
Scuds	21.5	±4.9	2	±2.8
Crayfish	13	±9.8	8.5	±6.3
Mayflies	28	±1.4	53.5	±13.4
Dragonfly/Damselfy	10	±5.6	7	±5.6
Stoneflies	6	±0	5.5	±2.1
Beetles/Water Penny	2	±1.4	4.5	±2.1
Dobsonflies & Alderflies	3.5	±0.7	5	±5.6
Caddisflies	23.5	±23.3	8.5	±6.3
True Flies	2.5	±0.7	1.5	±0.7
total	110	±41.0	96	±45.2
	Tatman Riffle		Roaring Riffle	
	Mean	STDEV	Mean	STDEV
Scuds	41	±14.1	0	±0
Crayfish	4	±5.6	5	±2.8
Mayflies	35.5	±19.0	59.5	±53.0
Dragonfly/Damselfy	3	±1.4	4.5	±4.9
Stoneflies	31	±15.5	22	±5.6
Beetles/Water Penny	0.5	±0.7	5	±7.0
Dobsonflies & Alderflies	10.5	±4.9	20	±9.8
Caddisflies	38	±4.2	147.5	±102.5
True Flies	5.5	±0.7	15	±5.6
total	169	±16.9	278.5	±191.6

Stream	Class I	Class II	Class III
Tatman Run	190	130	1
Roaring Run	472	70	0
Tatman Run Sample 2	166	72	3
Roaring Run Sample 2	184	23	0

MEASURE OF PHOSPHATES AND NITRATES BETWEEN TWO CENTRAL PENNSYLVANIAN CREEKS

Sean Petrick and Christopher Heckler

ABSTRACT

We examined phosphate and nitrate concentrations in two streams located in Central Pennsylvania. One stream was heavily affected by acid mine drainage and has since been remediated while the other was unaffected by acid mine drainage. We measured pH in the soil as a measure of stream health. It was hypothesized that the acid mine effected creek would have less phosphates and nitrates than the healthy stream. We also hypothesized that the soil pH in the acid mine creek would be lower than the healthy creek. Soil and water samples were taken along each creek in correlation with several of our classmate's study sites. Our phosphate, nitrate, and pH results showed no significant correlations between the two creeks. There was no significance between pH, phosphate, and nitrate between soil types as well.

INTRODUCTION

Roaring Run and Tatman Run are two streams located in central Pennsylvania. Roaring Run has been historically affected by Acid Mine Drainage, a common problem in Pennsylvania where abandoned mines fill with water, which reacts with pyrite to form sulfuric acid which then enters the watersheds (USGS). This has significant detrimental impacts on biotic communities and leads to deposition of iron and aluminum along the stream substrate. Our hypothesis is that AMD will lead to a cascade of effects resulting in altered soil and water chemistry along the stream as compared to a non-affected stream. Roaring Run, according to the the Pennsylvania Department of Environmental Protection, has been successfully remediated through the Joller Remediation System. The source of the AMD pollution in Roaring Run is the Joller Mine near Cooks, PA. Joller was the site of a mining town and a moderately successful mining site of bituminous coal in the Pennsylvania Broad Top. Remediation efforts began in 1998, but were not successful until 2000 (Milavec). However, due to the buffering capacity of soil, we expect that there may still be some residual affects in the soil chemistry. The primary tests we are employing are free phosphate in water, free nitrate in water, free nitrate in soil, free phosphate in

soil, and pH in soil. We also examined the water capacity in the soils we collected based on the amount of water in the soil at the time of collection. The goal here is to see if there is a difference in chemistry between the affected and the non-affected stream.

Goal?

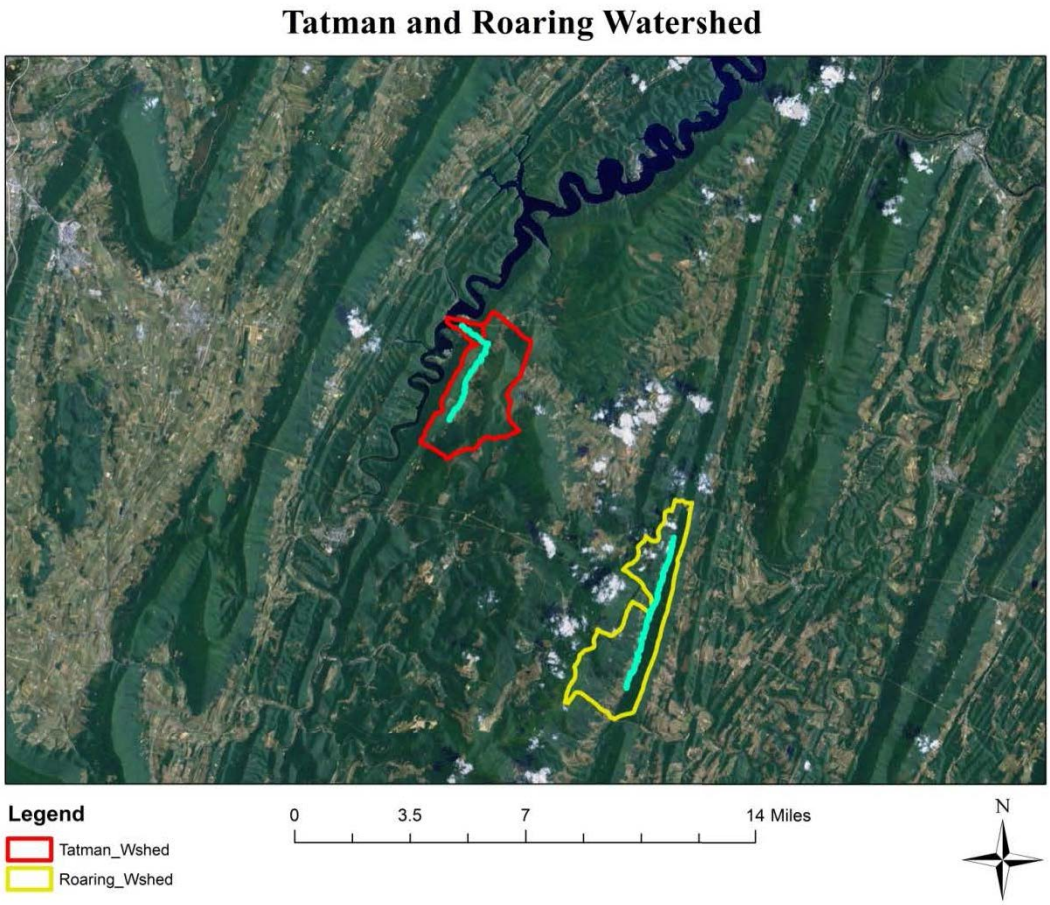


Figure 1. Map of two research watersheds. Tatman Run watershed is adjacent to the Juniata Branch of Raystown Lake. Tatman Run is shown running northeast along the watershed and flowing into Raystown Lake. Roaring Run watershed is approximately 8 miles southeast of Tatman Run. Roaring is shown flowing south along its watershed. Map was projected using WGS 1984 coordinate system

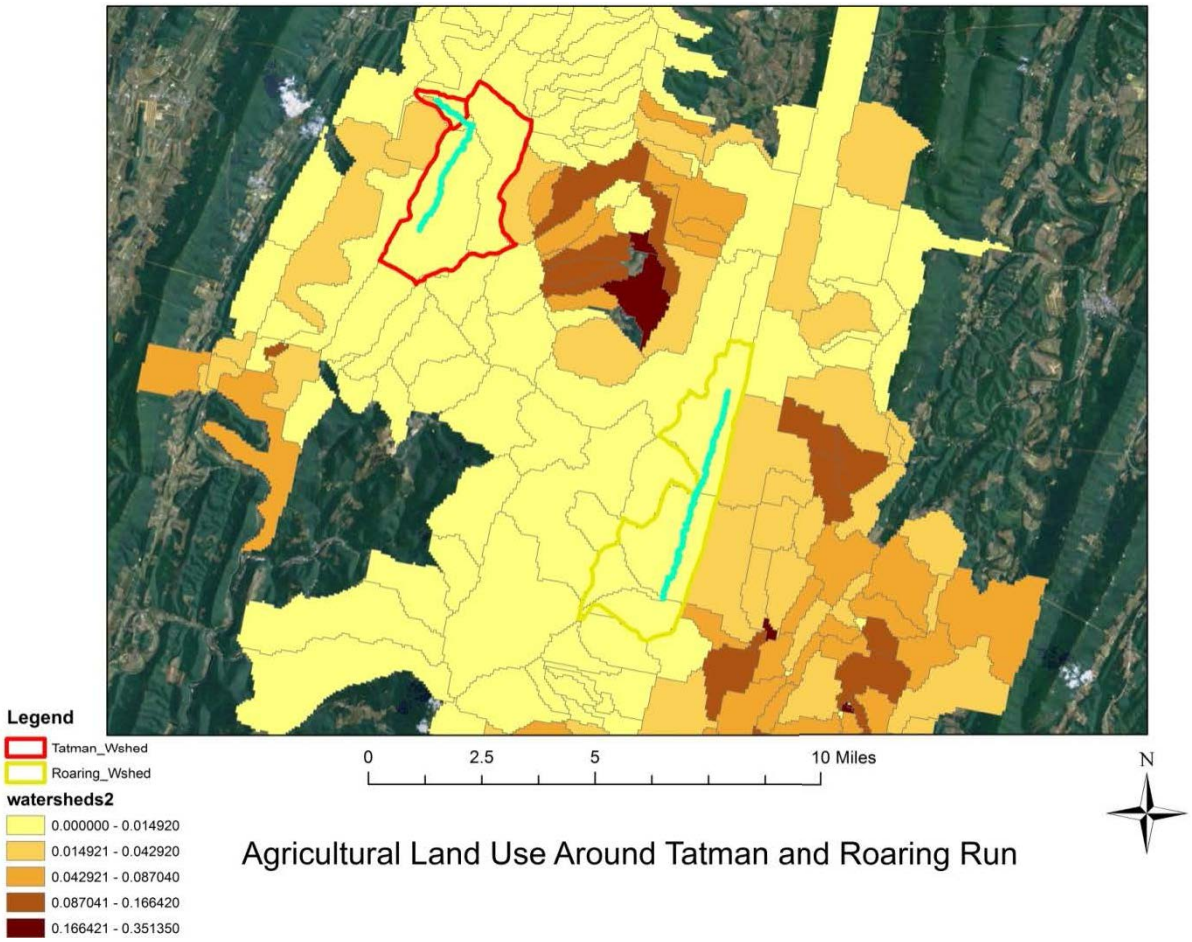


Figure 2. Map showing densities of agricultural land use surrounding the two watersheds. Densities of row-crops and hay pastures were layered together to create a combined agricultural density layer. Dark areas represent highest densities of agriculture while light areas represent low densities of agricultural use. Roaring Run and Tatman Run are located in the lowest density agricultural areas; therefore there would be little effects of nutrients in the soil and water

GEOMORPHOLOGY

At the headwaters Tatman Run has a slope between 0 and 8 degrees, but most of the stream is between 0 and 3 degrees (PA Soilmap). Roaring Run by comparison has significant portions of the stream where the average slope is between 8 and 25 degrees (PA Soilmap). The climate of the Ridge and Valley Province is characterized by an average temperature of about 57 degrees Fahrenheit and an average yearly rainfall of about 40 inches. Yearly snowfall in Huntingdon County is about 37 inches (NCDC). Geologically, Tatman Run passes through the Catskill and Pocono sandstone formations and Mauch Chunk shale formation (PA Soilmap). Roaring Run passes through the Pocono formation and the Mauch Chunk formation (PA Soilmap). Tatman Run runs into Raystown Lake which empties into the Juniata River (PA Soilmap). The Juniata enters the Susquehanna which flows directly into the Chesapeake Bay. Roaring Run flows into Sideling Hill Creek, which flows into Aughwick Creek, which flows into the Juniata(PA Soil Map).

MATERIALS AND METHODS

Materials used were a Hach Spectrophotometer for testing Nitrates and Phosphates, a filtration tower to separate water from the soil samples for testing, heat lamps to dry out samples for water capacity, a core sampler to retrieve samples from the ground, and a pH meter.

Water samples were taken from moving water within the stream in areas where there was a change in vegetation or some other major alteration in the ecosystem to allow for a spread of data across various land uses. Water sampling locations were also chosen based on soil substrate, since soil needed to be available to sample. Soil samples were taken no more than three feet from the stream, off the bank, but well within the flood prone zone. Soil samples were taken using a core sampler and stored in ziplock bags to prevent water loss or contamination of the samples. The close proximity was chosen with the hope that more stream water would have infiltrated the soil in that location as compared to precipitation than farther away; however testing the soil within the stream itself would not have answered questions about whether or not AMD affects soil chemistry. Samples were brought back to the lab and water samples were analyzed according to the Hach instructions (Hach). Soil samples were separated and 100 grams of soil from each site were placed under a heat lamp in order to determine how much water was in the sample. Samples were also saturated with water and mixed well before being filtered. The distillate was then tested for pH, phosphates, and nitrates using a pH probe and the Hach phosphate and nitrate tests.

Stats approach?

RESULTS

The soils that occur near the banks of Tatman and Roaring Run were classified and the water capacity was analyzed (Table 1). The soil samples were analyzed for difference in mean pH, phosphates and nitrates using a One-Way Anova test. No significant differences were found betweenthe pH, free phosphates, and nitrates in the soil (Table 2). We also compared pH, phosphates, and nitrates to the three distinct soil types which have no correlation (Table 3). Several samples of soil were not able to be analyzed for phosphates and nitrates due to suspended solids in the water samples. This is visible when examining the mean of nitrates between Tatman and Roaring Run (Table 4).

Table 1. Total water capacity of the soils was measured by the difference between the weight of the soil wet (Wet(g)) and the weight of the soil dry (Dry(g)). Soil/RX/OM is a measure of total dry soil present after drying and %Water refers to the amount of water that was present in original wet soil

Stream	Wet(g)	Dry(g)	% Soil/Rx/OM	%Water	Soil_Type	%Water _Loss
Tatman	100	46.5	0.465	0.535	Clay	53.50
Tatman	100	75	0.75	0.25	Clay	25.00
Tatman	100	76	0.76	0.24	Clay	24.00
Tatman	100	72	0.72	0.28	Clay	28.00
Tatman	100	63.5	0.635	0.365	Silt	36.50
Tatman	100	85	0.85	0.15	Silt	15.00
Tatman	100	71	0.71	0.29	Clay	29.00
Tatman	100	74.45	0.7445	0.2555	Clay	25.55
Tatman	100	76	0.76	0.24	Clay	24.00
Tatman	100	86	0.86	0.14	Silt	14.00
Tatman	100	93.5	0.935	0.065	Sand	6.50
Tatman	100	78	0.78	0.22	Sand	22.00
Roaring	100	76	0.76	0.24	Sand	24.00
Roaring	100	91	0.91	0.09	Silt	9.00
Roaring	100	60.5	0.605	0.395	Silt	39.50
Roaring	100	82.5	0.825	0.175	Sand	17.50
Roaring	100	85.5	0.855	0.145	Sand	14.50

Roaring	100	81	0.81	0.19	Sand	19.00
Roaring	100	86	0.86	0.14	Sand	14.00
Roaring	100	79	0.79	0.21	Sand	21.00

Table 2. The p-value for pH, nitrate, and phosphate compared between the two streams was found using a One-Way Anova

	DF	Sum SQ	Mean SQ	F	Pr(>F)
pH	1	0.4563	0.45633	0.6651	0.4254
NO3	1	35.712	35.712	1.0242	0.3411
PO4	1	0.0215	0.02146	0.0702	0.7944

Table 3. The p-value for pH, nitrate, and phosphate compared between the three soil types, clay, sand, and silt, was found using a One-Way Anova

	DF	Sum SQ	Mean SQ	F	Pr(>F)
pH	2	1.0325	0.51623	0.7454	0.4894
NO3	2	32.466	16.233	0.4027	0.6831
PO4	2	0.6227	0.31135	1.0883	0.362

Table 4. Comparison of means of pH, nitrate, and phosphate between the two streams

	Tatman	Roaring
pH	6.408	6.1
PO4	0.703	0.7725
NO3	6.257	3.164

pH of Soil Compared Between Tatman and Roaring

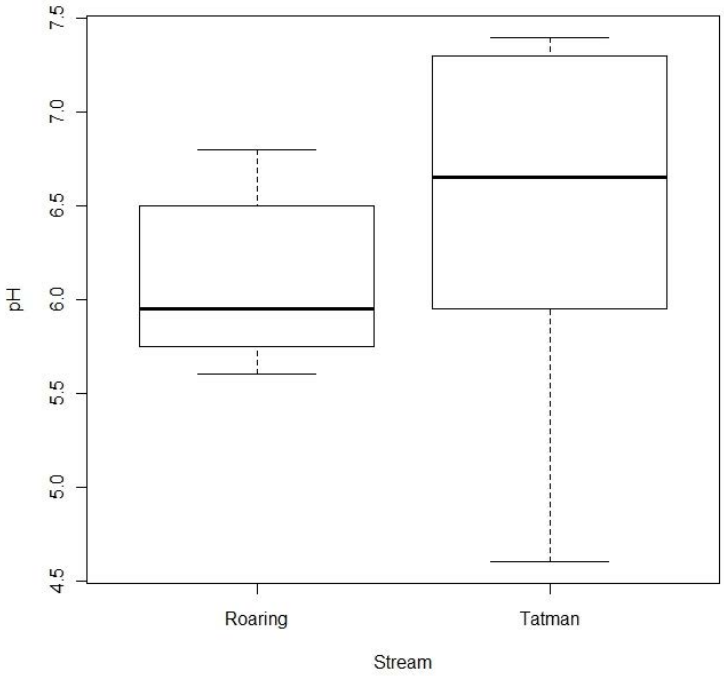


Figure 3. Boxplot showing the comparison of pH of the soil samples between the two streams

Phosphates in the Soil Compared Between Tatman and Roaring

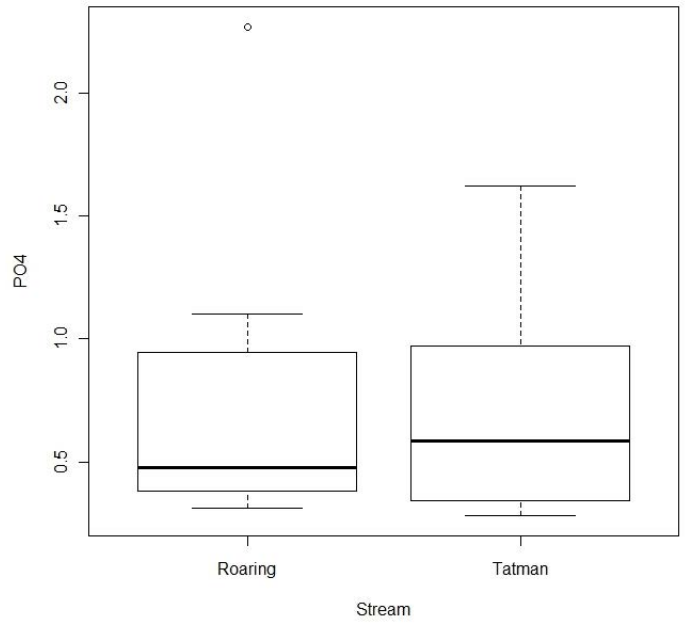


Figure 4. Boxplot Showing the comparison between free phosphates in the two streams

Total Nitrates in the Soil Compared Between the Tatman and Roaring

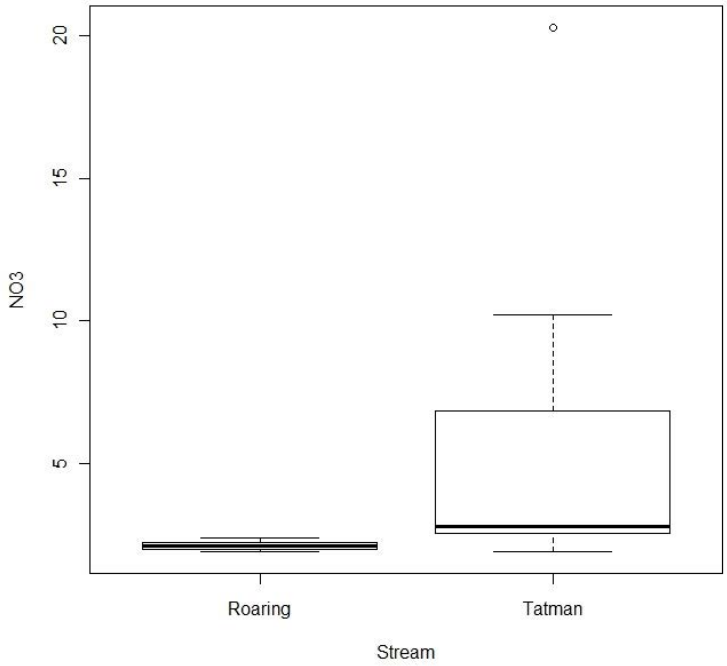


Figure 5. Total Nitrates found in the soil samples compared between the two streams. The plot looks significant due to lack of data present in Roaring Run

Water samples collected from the two streams showed no significant results when comparing nitrate and phosphate using a One-Way Anova test. These samples were divided among each creek and had no relevant significance in regards to location from the headwater of the creek.

Table 5. Comparison of nitrates and phosphates in the two streams

	DF	Sum SQ	Mean SQ	F	Pr(>F)
NO3	1	0.3393	0.3393	0.6439	0.4379
PO4	1	0.2522	0.2521 9	0.5192	0.485

Table6. Data collected from water samples among the two streams. Location represents distance from headwater (R1 refers to headwater, R6 refers to mouth)

Creek	Location	Sample	NO3	PO4
Roaring	R1	R1_2	0.6	0.09
Roaring	R2	R2_2	0.6	0.08

Roaring	R3	R3_2	0.4	0.07
Roaring	R4	R3_1	0.4	0.13
Roaring	R5	R2_1	0.7	0.002
Roaring	R6	R1_1	0.7	0.007
Tatman	T1	T1_2	3.1	2.59
Tatman	T2	T2_2	0.5	0.01
Tatman	T3	T3_2	0.05	0.04
Tatman	T4	T4_2	0.6	0.01
Tatman	T5	TU_2	0.5	0.02
Tatman	T6	T3_1	0.4	0.003
Tatman	T7	T2_1	1	0.001
Tatman	T8	T1_1	0.9	0.001

DISCUSSION

The major soil types in Tatman Run are Philo and Basher Silt Loams, which are Fluvaquentic Dystrudepts, Andover Extremely Stony Loam, which is a Typic Fragiaquult, and Atkins Silt Loam, which is a Fluvaquentic Endoaquept (Soil Survey Staff). The major soil types in Roaring Run are Philo and Basher Silt Loams, Atkins Silt Loam, Meckesville, which is a Typic Fragiquidults, and Buchanan, which is an Aquic Fragiudults (Soil Survey Staff).

The descriptor for Philo and Basher Silt Loams as well as the descriptor for Atkins say essentially that the slope must be less than 25 %, and that within 60cm of the mineral soil surface there are redox layers with a chroma of less than two. It also says that at least part of the year the soil experiences aquic conditions. At 125cm below the mineral soil surface without contact with a densic, lithic, or paralithic contact the total organic carbon is less than 0.2%. Alternatively there is an irregular decrease in organic matter from 25cm to 125cm below the mineral soil surface or the first contact with a densic, lithic, or paralithic layer, whichever comes first (Soil Survey Staff). Andover and Meckesville are simply Ultisols with a Fragipan within 100cm of the soil surface. Buchanan's description shows that in at least one subhorizon above the fragipan, there are redox depletions with a chroma of 2 or less. It also experiences aquic conditions for at least part of a normal year (Soil Survey Staff). Philo and Basher Silt Loams and Atkins Silt Loam are Inceptisols, which are characterized by semiarid to humid environments, and are generally young soils which have not experienced much weathering and development (Hillel). Andover, Meckesville, and Buchanan are all Ultisols, characterized by humid areas that have undergone a great deal of weathering and leaching and are therefore low in minerals. Typically Ultisols are acidic, and they do not take well to soil amendments (Hillel).

The three principal macronutrients which all plants require to sustain life are Nitrogen, Phosphorous, and Potassium. Because our research focused on the watersheds and not the soil, and Potassium is not meaningful in the water, and also because of the costs and difficulties inherent in testing for Potassium, it was excluded from our experimental design. Nitrogen is the single most important macronutrient, being part of the energy production cycles and amino acid chains in virtually every species. The form of Nitrogen that is available to plants is NO_3 (Nitrate) or NO_4 (Ammonium). Because of the high solubility of these forms of N, they are easily transported into waterways. The importance of N in plant growth also means that it accounts for a great deal of agricultural amendments are done to increase N. Usually, the form of N added in fertilizer is Nitrate (Hillel). For this reason, we chose to look specifically for Nitrate in both the soil and the water.

Phosphorous is one of the key pieces of adenosine triphosphate, also known as ATP, which is the main energy source for metabolism. Because of this, Phosphorous is vital to all plants. Although H_2PO_4 and HPO_4 are

the forms of Phosphorous available to plants, we measured PO_4 so that we would get a measurement in the water (Hillel). If we had measured an available form of P, we would have likely obtained a result in the soil, but there would have been none free in the water. We also made that decision because free P is rapidly converted to insoluble forms by reacting with Calcium and other minerals. Since there is a great deal of Calcium Carbonate in the area, we expected to find insoluble PO4.

Our data did not show any significant differences between Tatman Run and Roaring Run. The most likely cause of this is that there is no difference between the two streams in terms of Nitrogen and Phosphorus or soil pH. Because Roaring Run has been successfully remediated for about ten years (Milavec), and because the soils in question are primarily acidic in nature anyway (Soil Map) and strongly buffered against change, it makes sense to see similar soil pH between streams. Based on the similarity between stream nutrients, we did not expect that we would see a significant difference in soil nutrient levels; however we were unable to test this due to suspended solids that prevented the nitrate test from proceeding as planned. The fact that both streams were relatively similar implies that both streams probably have a healthy biotic community which is using the available Nitrates and Phosphates at about the same level. This is further evidence of the successful remediation of Roaring Run.

ACKNOWLEDGEMENTS

We would like to thank Dr. Doug Glazier for letting us borrow his filtration tower and Dr. Dennis Johnson for being our advisor and lending helpful tips. We would also like to thank Dr. Chuck Yohn for his assistance with journal writing.

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EFFECTS OF DETRITUS ON COMMON CRA FISH POPULATION DENSIT

Edward Sinnes and Joe Aultman-Moore

Abstract

The common crayfish species of the northeast: *Orconectes obscurus*, *Cambarus bartonii* and *Cambarus diogenes* are key organisms in the nutrient cycle and food web of small streams, breaking up detritus, preying on other macro-invertebrates and in turn serving as prey. Although crayfish are omnivores, one of their main food sources is plant detritus that they break up into small pieces to consume. (Maurice Burton & Robert Burton 1970). We compared crayfish populations among several detritus types in two streams in central Pennsylvania. We hypothesized that food type will be a controlling factor in population density of crayfish in these streams. The mean total of crayfish per 10 ft reach (C/10ft) in Grass was 4.45 , 1.66 C/10ft in deciduous detritus and 1.41 C/10ft in Coniferous Detritus. Roaring Run had a higher mean of crayfish (3.19) than Tatman Run (1.8). We found a significant difference in populations between detritus types regardless of stream ($F= 9.93$, $df=2$, $p<0.01$) and between detritus types taken in each stream separately ($F=10.27$, $df=2$, $p<0.01$). grass detritus reliably held the highest number of crayfish and Roaring had a higher number of crayfish on average.

Keywords: Crayfish, Detritus, Orconectes, Cambarus

Introduction

Crayfish are freshwater crustaceans that range between 10-15 cm in length and are usually a red or brown color. Crayfish can live up to 15 years in the right environment and are found in streams, rivers, canals, lakes and reservoirs. (Maurice Burton & Robert Burton 1970) Crayfish prefer shaded areas and are more frequently active toward the evening. (Thomas Henry Huxley 1880)

In fact, in Appalachian streams over 50% of detritus processing occurs when other leaf shredders are inactive (Mitchell & Smock 1991). They are also voracious omnivores, feeding on insects, worms, snails, tadpoles, algae, vegetation as well as scavenging on dead animals (Deitz 2003). This versatility makes them an important link between the trophic levels in aquatic ecosystems. (Momot et al. 1978, p.11)

We predicted that food type would be a controlling factor in crayfish population size. From field observations, we determined that the three major detritus varieties were deciduous tree leaves, coniferous tree needles and grass/ herbaceous plants. The high density of grass litter in the water seemed to be the ideal food source and we expected it to hold the highest populations in both streams.

Field Sites

We conducted this study on Roaring Run and Tatman Run, two streams in Huntingdon County, PA. The two streams are of relatively the same size and flow but are located in different watersheds. (*Fig 1,*) These two streams served as two separate sample sites to study the crayfish populations in the area by detritus type. The crayfish species occurring in the areas studied include: devil crayfish (*Cambarus diogenes*), Eastern crayfish (*Cambarus bartonii),* and Allegheny crayfish (*Orconectes obscurus*). The feeding strategies of all species are similar, as is their location and behavior (Deitz 2003).

Roaring Run: Roaring Run is found in southern Huntingdon County PA Flowing along the west side of State Game Land 121. Roaring Run is of particular interest because of its history of Acid Min Drainage (AMD). To the northwest on Wrays Hill is an old mine site called Joller. Joller was a company town and mine in the early 1900's. In 1998 it underwent AMD remediation consisting of a passive treatment unit for two mine discharges and pilings. After being treated the water flows into the upper quarter of Roaring Run**.** (PA DEP 2010)

Geomorphology: The land along Roaring is owned both privately and by the state, flowing through forested, residential and farm lands. It flows predominantly southwest and is slightly sinuous. The average depth from five sample sites along the stream was 6.066 inches and the average bank full width was 11.15 feet. Sediment towards the northern headwaters started out as 80% fine grain sand with rocks clast size being about 4-10 inches in diameter, progressing to larger clast size towards the confluence with Sideling creek where the substrate was 90% or more rocks of 10 inches to ft in diameter as seen in *Figure 3.*

Tatman Run: Tatman run is also located in southern Huntingdon County, PA. It is part of the Raystown Reservoir watershed and flows directly into the lake . Tatman is not AMD affected. It flows through Trough Creek Wilderness, private residential lands and some wooded game lands.

Geomorphology: For much of its path Tatman flows from a small pond headwater northeast until it meets Terrace Mountain and then turns west until it flows directly into Raystown Lake. The average bank full width from five sites for Tatman is 13.2 feet and the average depth is 5.4 inches. The upper reaches of Tatman has a silt and sand based substrate with occasional rocks, further down it

cuts across a rock bed and the rest of the creek has a rocky substrate with clast size ranging from 10 inches to 1 foot in diameter as seen in *Figure* .

The study sites are first- and second-order streams, where detritus plays a dominant role in the energy cycle. The streams had a mixture of vegetation growing around them that would contribute to different types of detritus input into the streams. The sites were broken up by detritus types of Coniferous (White pine and Virginia pine), Deciduous (Maple, Oak, Poplar, and Beech), and Grass (Bluegrass, Rye, Fescue).

METHODS AND MATERIALS

Both streams were traversed for suitable locations to sample crayfish populations. To be considered suitable, 80% of the detritus in the stream had to be either grass, coniferous or deciduous. We chose two sites of each detritus type per stream for a total of twelve sites .

Once the sample sites were chosen on each stream they were broken up into four sections of ten ft reaches, following the channel. The method we chose to use for collecting population data was spotting. Standing side by side we walked down the stream in hip waders looking for signs of crayfish. Each reach had a predetermined start and stop point. We would walk slowly in this fashion for each of the sections and record the number of crayfish spotted. A steady pace was kept in all observation sessions of about one minute per foot of stream. The crayfish's movement style in itself prevented recounts, as each swims backward when disturbed and out of our study area. We returned on two additional days to repeat the counting process.

The population per stream, detritus type and the interaction between the two was analyzed using a two-way ANOVA test with Minitab (Minitab Inc. 1997).

Results

The total number of crayfish in this study came to 362 crayfish in both streams, with 132 crayfish in Tatman Run and 230 in Roaring Run. Among the detritus types there were 68 crayfish found in Coniferous dominant reaches, 80 in Deciduous and 214 crayfish in Grass dominate reaches between both streams.

There was a mean of 4.45 crayfish per 10 ft reach (C/10ft) in Grass, 1.66 C/10ft in Deciduous detritus and 1.41 C/10ft in Coniferous Detritus. Comparing streams, Roaring Run had a higher mean of 3.19 than Tatman Runs 1.8 crayfish. This shows that Grass detritus reliably held the highest number of crayfish and Roaring had a higher number of crayfish on average.

The mean crayfish populations were significantly greater in the Grass detritus compared to Deciduous and Coniferous. In an individual 95% CIs For Mean Based on Pooled Standard Deviation, Grass had a mean of 4.5833 where Coniferous and Deciduous had means both lower of 1.41667 and 1.66667.

Both the Grass detritus sites displayed the highest single sample counts per 10ft reach and also the highest mean population for the combined four 40 ft reaches in both sample streams, showing a positive correlation between grass detritus and crayfish population density in the study over all.

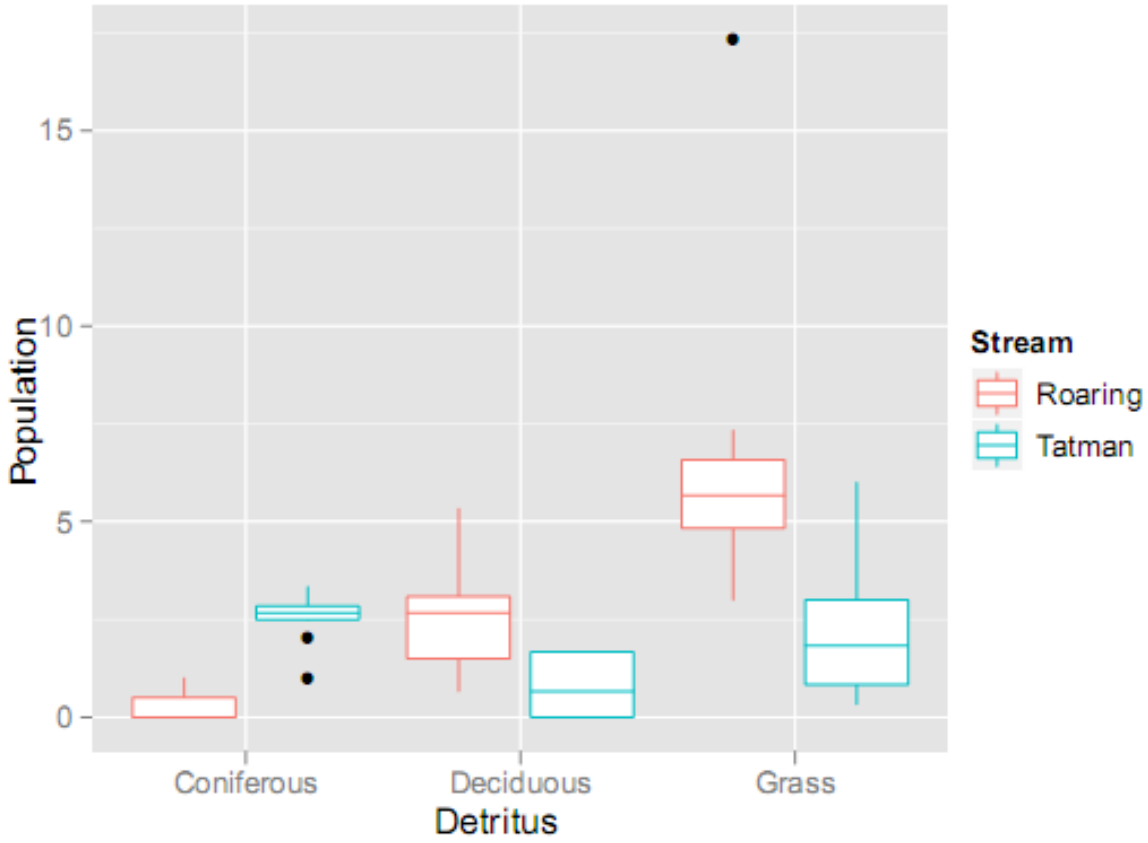


Figure) The two streams separately show that the Grass Detritus in either stream had the highest sample numbers of crayfish. Tatman shows a Grass mean of 6.0 per ten ft. reach and Roaring 1 .3 per ten ft. reach.

Discussion

Our findings support the hypothesis that there is a relationship between detritus type and crayfish population. The densities observed in this study

appear to be lower than normal, but not low enough to significantly affect the results. Other studies observed 0-8 crayfish/m^2. (Zhang et al. 2004)

Grass detritus demonstrated the highest positive correlation with population. We conclude that there is a relationship between the predominant type of detritus in a stream and the crayfish population density, inferring that crayfish prefer or thrive more off of one type. The crayfish could prefer certain kinds of detritus rich stream reaches for several reasons: nutrient levels of each type differ in their amounts of N, P, Ca, S and Mn and have different cellulous structures that all could play into the health and fecundity of the crayfish and therefore effect the population in that reach. (Berg & McClaugherty 2003) Tannins in some deciduous leaves like oak have been shown to be detrimental to the digestive systems of ruminants (Kumar & Vaithiyanathan 1990), it may have the same effect on crayfish. Grass and maples leaves do not have these chemicals, which would make them preferable as a food source.

In addition, studies show that high protein diets are best for crayfish growth (Ackefors et al. 1992). Grass and maple leaves have the highest levels of nitrogen, which provide the highest protein levels for crayfish (New Mexico Climate Center 2008)

The results of this study do not definitively show that detritus is the controlling factor for crayfish populations in these two streams as they are omnivores and also prey for other organisms. The factors contributing to total crayfish population density is a wide range of interconnected food webs and energy cycles. Although more than one species may have entered the study, this should not have affected the results because species in this range are functionally similar. (Helms & Creed 2005). The results from this study display that there is a relation between the factors of population and detritus, specifically grass, to be taken into account for the overall factors that determine crayfish populations.

The data from this study indicates that for unknown reasons crayfish prefer environments with certain types of detritus. It should be noted that although our study did not show a strong relationship between different detritus types it did have a significant result. Although many other factors could contribute to a population, a trend towards grass is a definitive factor to be considered for other research work. This could be included in future research that will study the factors that contribute to crayfish populations in northeastern streams and other bodies of water. If considered in conjunction with all aspects of crayfishes environment, it could lead to a good way of indicating stream health. Since crayfish are opportunistic omnivores and eat a wide array of materials from decaying matter they are key species to look at to see how the food web of the stream is working from one trophic level to the next. (Australian Museum 2010)

Crayfish populations are vulnerable to fish predation (Garvey et al. 2003), which could affect population counts, but fish observed in both study streams were not large enough to prey on adult crayfish.

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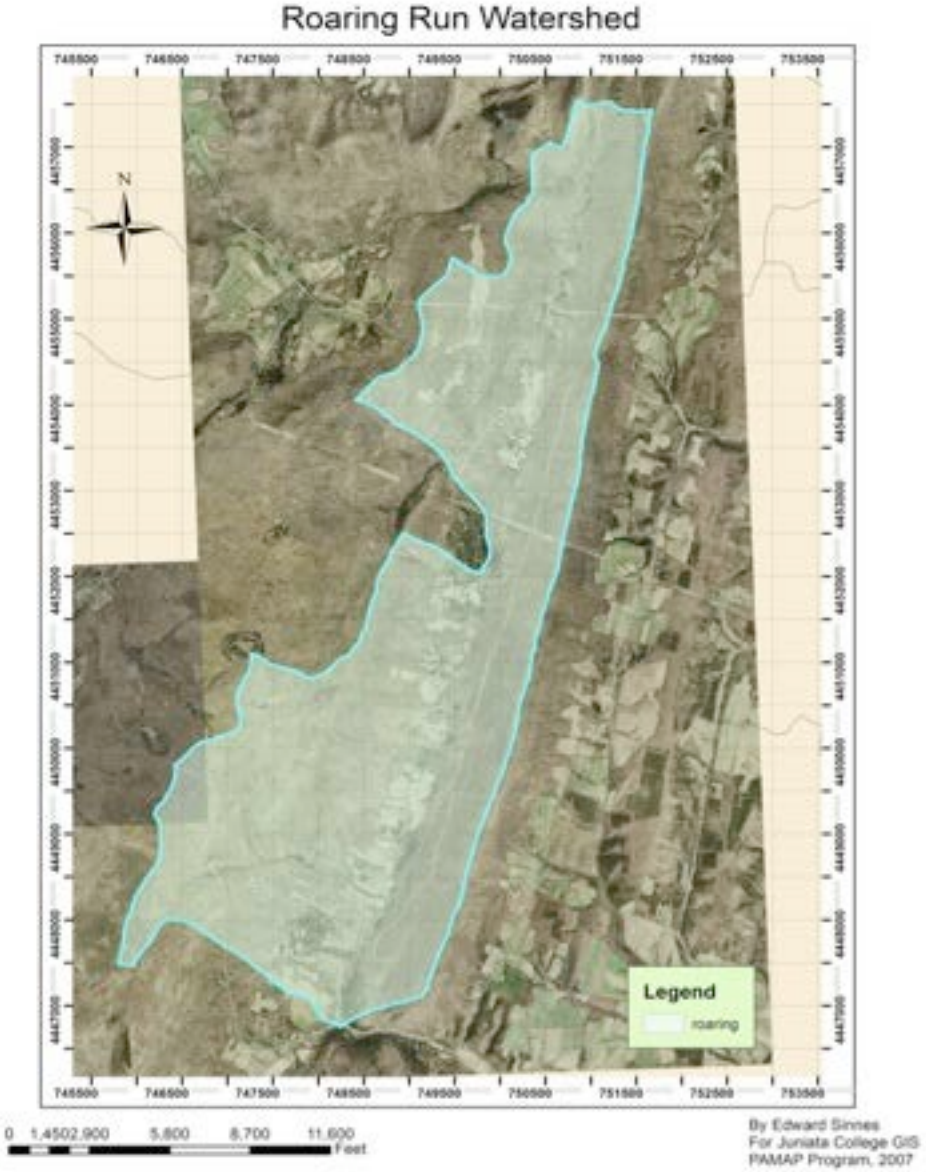


Figure 1: map of the watershed of Roaring Run, depicting in teal the area that contributes to the stream flow, also showing the land use around the run.

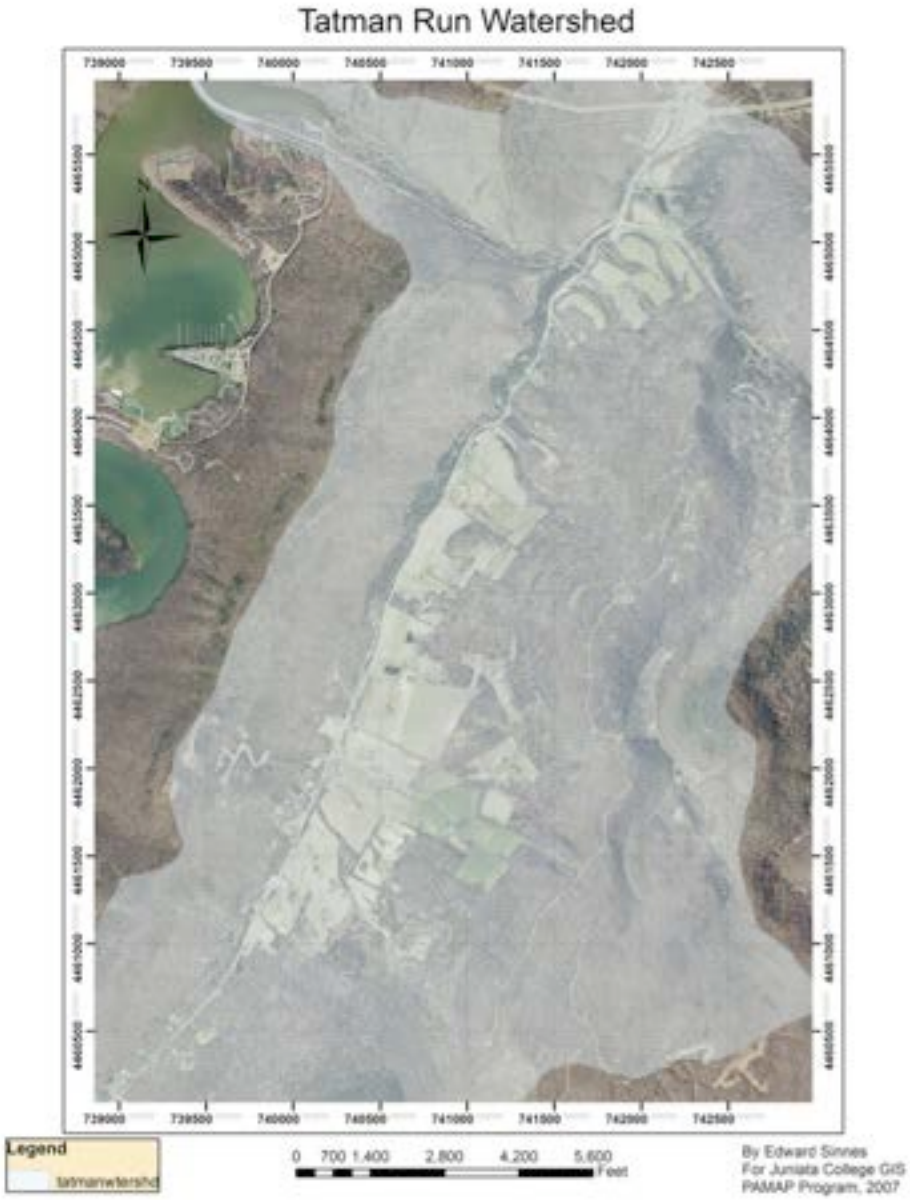


Figure 2: The Tatman Run watershed showing in teal the land that contributes to the stream flow. Land use along the stream can also be seen.

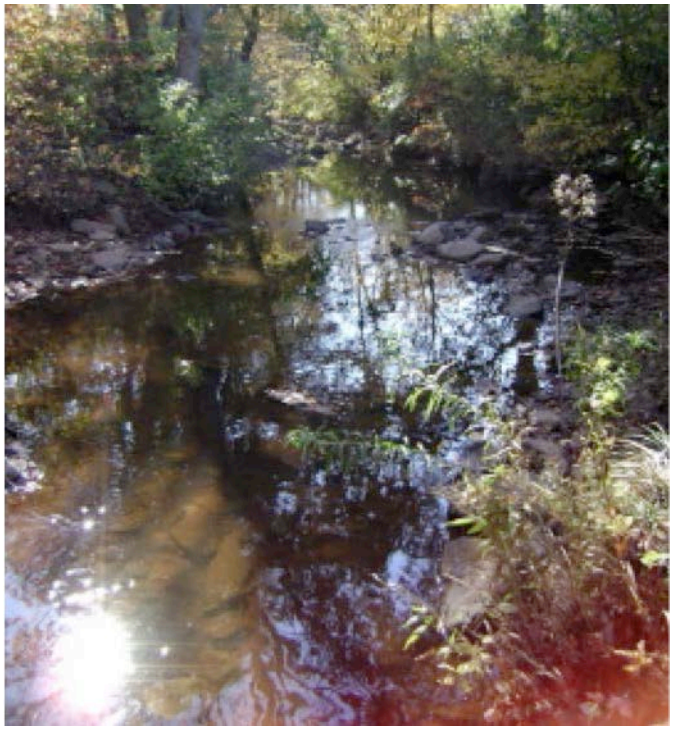


Figure 3: A section of Roaring Run showing the substrate, plant life and general characteristics of the stream.



Figure : A section of Roaring Run before its confluence with Sideling Creek. The substrate seen here is a prime example of crayfish habitat.

Figure : A section of the more boulder predominant substrate of Tatman Run down stream towards the west turn, deciduous detritus seen.





Figure 6: A section of Tatman run where the grass can be seen dominating the vegetation and, in turn, detritus of the stream.

A COMPARATI E STUD OF THE WATER UALIT AND GEOLOGICAL ASPECTS OF TATMAN AND ROARING RUN

Kristin L. Rodkey and Tyler D. Thomas

ABSTRACT

We examined the difference in water quality between Tatman Run, a pristine stream, and Roaring Run, an AMD impacted stream, in Huntingdon County Pennsylvania. We also studied how the local geology affected stream water chemistry. We predicted that, because of the historic AMD impacts, Tatman Run would have higher water quality then Roaring Run. We compared the pH, conductivity, temperature and alkalinity of the two streams at five different locations. Both streams had high water quality differening significantly only in , with Tatman having a higher alkalinity then Roaring. Additionally, Alkalinity and pH increased downstream, while conductivity decreased downstream. .

Key words: alkalinity, conductivity, pH, Tatman Run, Roaring Run,

INTRODUCTION

Pennsylvania has been highly affected by acid mine drainage (AMD) in streams throughout recent decades due to the coal industry of the early 1900's. AMD has resulted in acidification of streams (Tiwary, 2000). AMD affected streams will commonly have a reduced "macroinvertebrate species richness, density, and biomass," (McClurg et al., 2007). Not all acidified streams will show a reduction in the density of macroinverebrates this may be due in part to an increase in acid-tolerant species (McClurg et al., 2007). Fish populations may also decrease due to a reduction in food sources due to acidification or they may simply not be able survive in such acidic condition (McClurg et al., 2007). One fish species that has been particularly affected by the acidification of streams is the brook trout (McClurg et al., 2007). To help treat streams that are affected by AMD and acidification, limestone can be added to help buffer the acid. Limestone is one of the most common ways to treat acidified streams because it is practical and inexpensive (Kenner and Sharpe, 2005). When limestone is added to streams over time it has been shown to increase pH, and in turn increased macroinvertebrate and fish populations (McClurg et al., 2007). Adding limestone to streams helps to reduce the aluminum and sulfate concentrations and it increases the pH, alkalinity, and calcium concentrations of the streams (Kenner and Sharpe, 2005). It is limestone's ability to improve water quality that allows for species richness to increase.

Roaring Run, a stream found in Huntingdon County Pennsylvania (Fig. 1), is a prime example of a stream that has been affected by acid mine drainage (Pennsylvania Departmend of Environmental Protection). Due to the high acidity found in Roaring Run, remediation ponds were constructed in 1998 at Joller to help neutralize the water coming out the mine affected area (Pennsylvania Departmend of Environmental Protection). To better assess the water quality of Roaring Run we

compared our data to Tatman Run, a healthy stream in the area. This comparison also allowed us to measure the effectiveness of the Joller treatment ponds. We predicted that Tatman Run would have higher water quality then Roaring Run. We rationalized that since Roaring Run is an AMD impacted stream that it would have a lower water quality and pH then Tatman Run. The geology of the area could be one environmental aspect affecting the water quality of the stream. The rock formations that lie beneath streams have the ability to affect conductivity and alkalinity. Conductivity will be higher if the stream is above carbonate bedrock, limestone, then it would if the stream was above shale or sandstone (Kney and Brandes, 2006). We tested the pH, alkalinity, temperature, and conductivity of each stream. Conductivity is the measure of dissolved ions in solution and alkalinity is a measure of the acid buffering capacity of a stream. The bedrock of an area has the ability to affect the conductivity of a stream because different rock types will weather at different rates (Kney and Brandes, 2006). We chose to conduct our research on the impacts the geology of an area can have on the water quality of a stream, because we both have an interest and background in geology.



Figure 1. Location of Huntingdon County Pennsylvania

FIELD SITES

Geomorphology

Roaring and Tatman Run are located in Huntingdon County Pennsylvania. Samples were collected from five sites along Roaring and Tatman Run (Fig. 2). Much of the land around the streams is deciduous forest, but there are also several points at which the streams run though agricultural land. Both Roaring and Tatman Run are relatively shallow streams measuring at a foot or less in depth. While Tatman Run flows directly into Raystown Lake, Roaring Run flows into Sideling Hill Creek (Fig. 3 & 4). The section of Roaring that was studied has a valley length of approximately 4.4 miles long. Our sites were not along the whole stream because we began studying the steam after the AMD affected tributary came into Roaring. Tatman had a valley length of approximately 4.3 miles. Both streams are highly sinuous, this is due in part to the mountainous topography of central Pennsylvania. While the valley lengths may be similar, the directions of flow could not be more different. Tatman flows North Northeast and then as it gets closer to its confluence with Raystown it takes a sharp turn and begins to flow North Northwest. Roaring travels in the opposite direction flowing South Southwest. The elevation of the Tatman Run watershed is between 600 and 1200 feet. On the other hand, Roaring has a slightly higher elevation between 1200 and 1800 feet. Based off of stream data from the pasda website we determined that both Tatman and Roaring Run are second order streams (Pennsylvania Spacial Data Access). Beneath Roaring lies the Mauch Chunk Formation, which consist mostly of red shale along with thin beds of red and green sandstone (Fig. 2). Tatman runs through several geological formations the most prominent one being the Pocno Formation, which contains thick beds of sandstone and gray sandy shale. Other formations include Mauch Chunk, Rockwell and Catskill Formations. The Rockwell Formation is made of mostly sandstone along with siltstone and shale. The Catskill Formation contains shale, mudstone and some sandstone (Fig. 2) (Taylor, et al, 1982). To better understand the size and shape of the channel a cross section of each stream was constructed (Fig. 5 & 6). A rock sample from each stream was collected and analyzed using an x-ray diffraction machine. An x-ray diffraction machine analyzes the mineral content of a rock sample. Quartz sandstone was the common rock seen throughout both streambeds (Fig. 7 & 8).

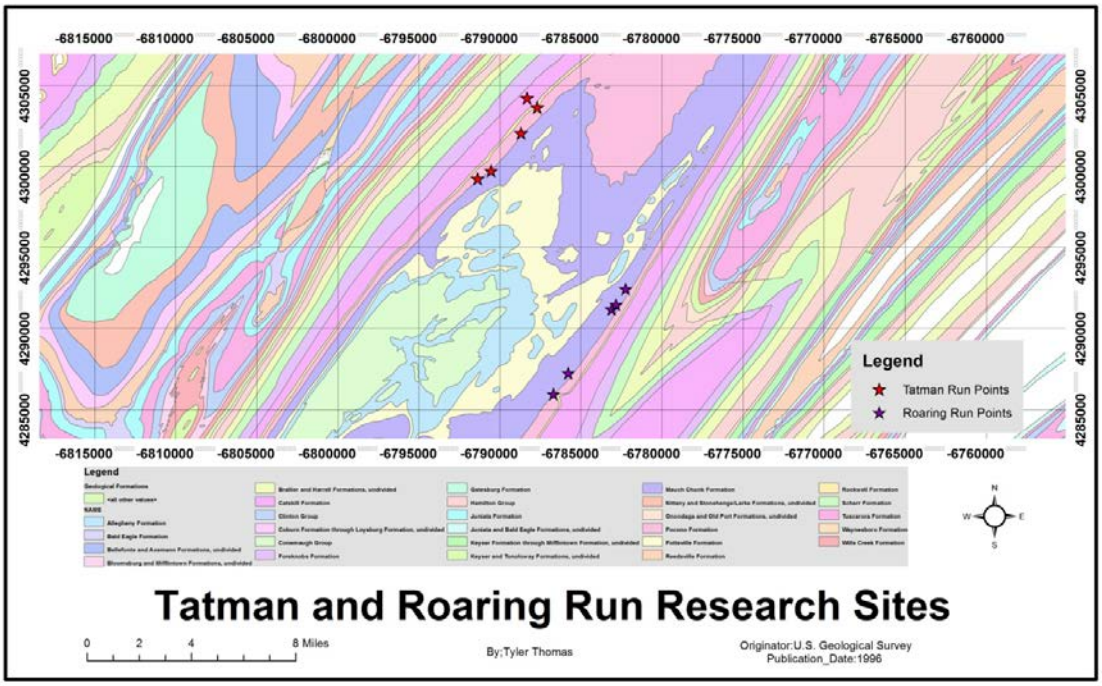


Figure 1. Geological Formations of central Pennsylvania that are present below our research sites on both Tatman Run and Roaring Run

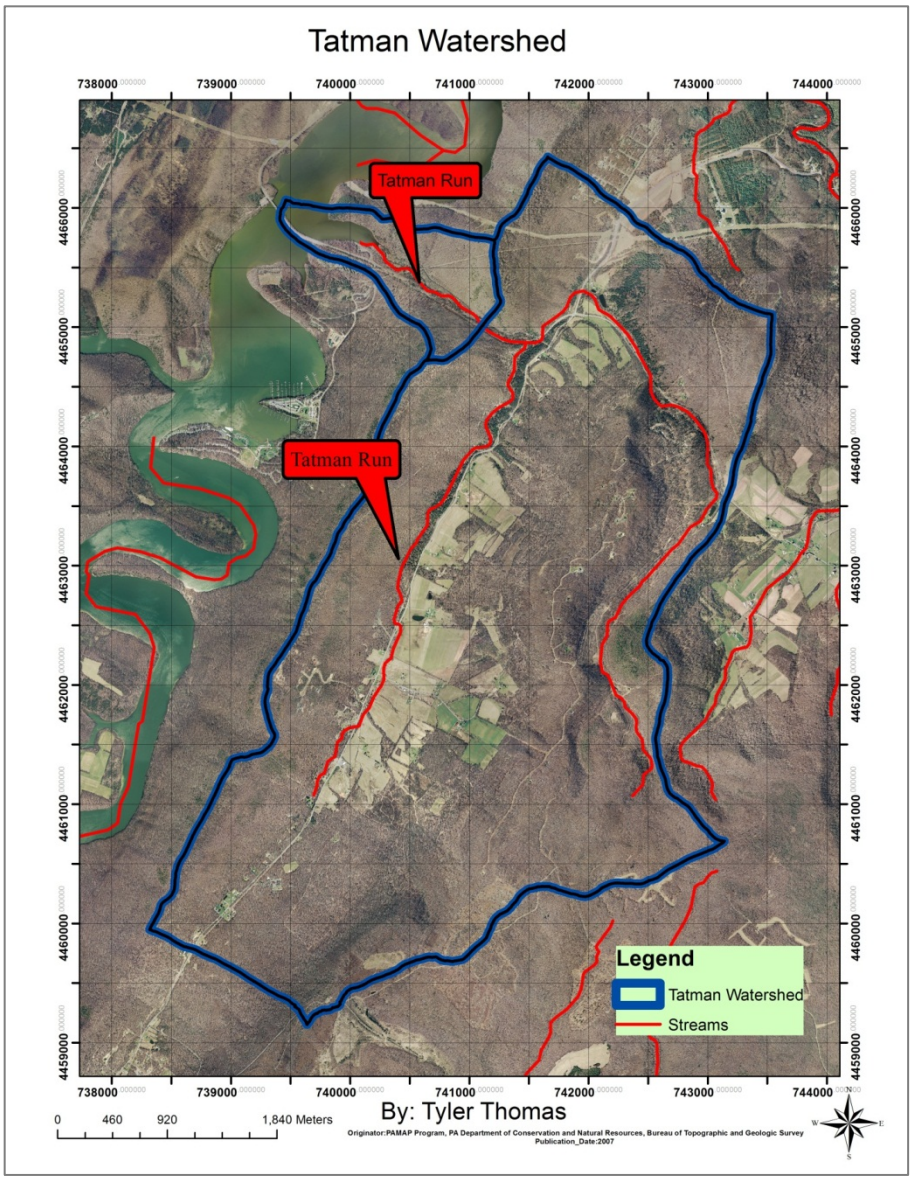


Figure 3. Watershed of Tatman Run along with area streams

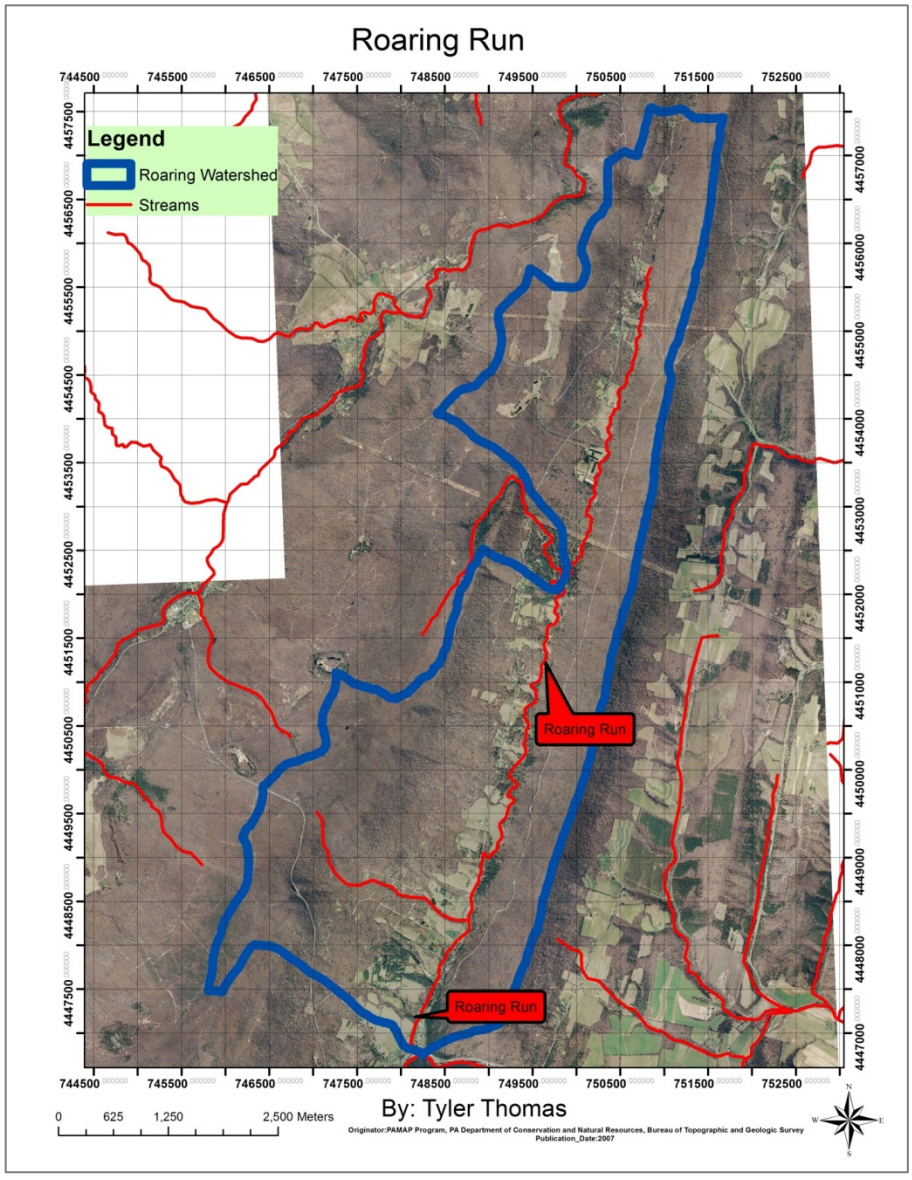


Figure . Watershed of Roaring Run along with area streams

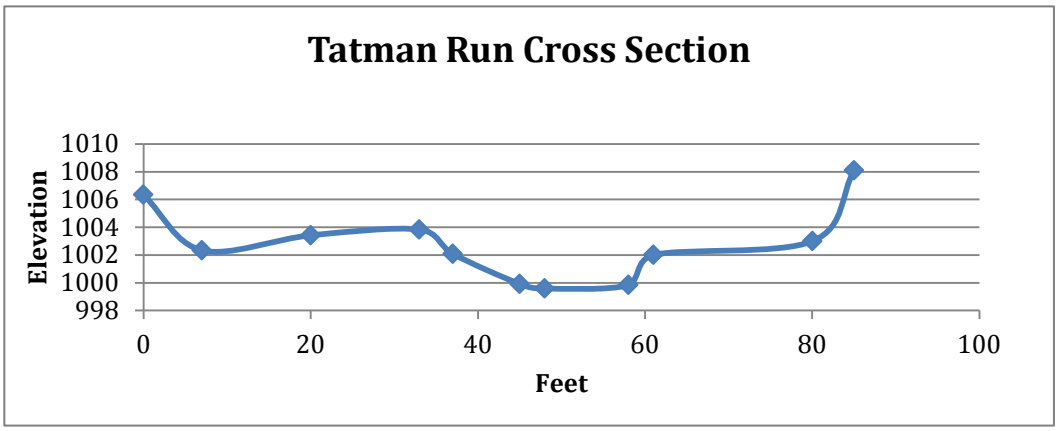


Figure . Cross section of Tatman Run taken ust above the confluence.

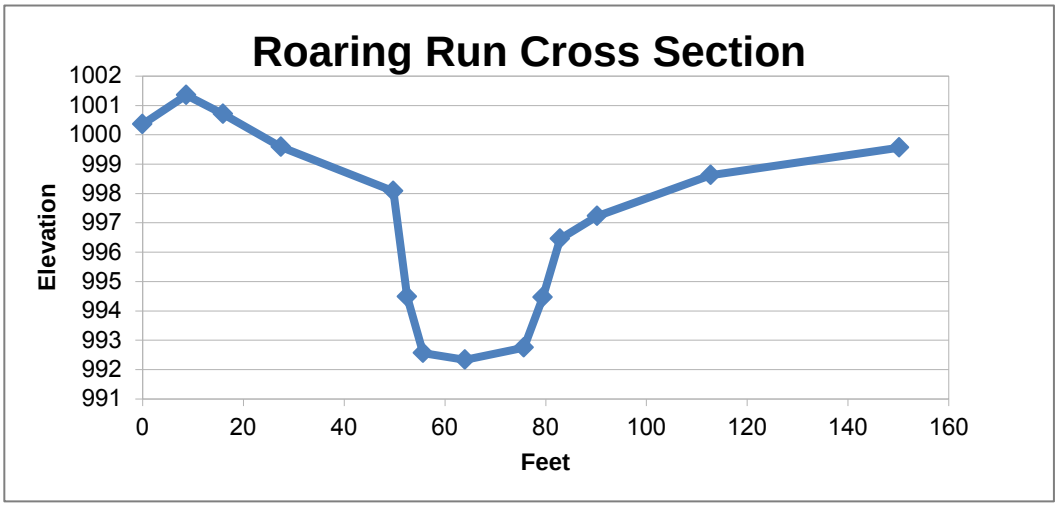


Figure 6. Cross section of Roaring Run taken at the location ust above the confluence of Roaring with Sideling Hill Creek

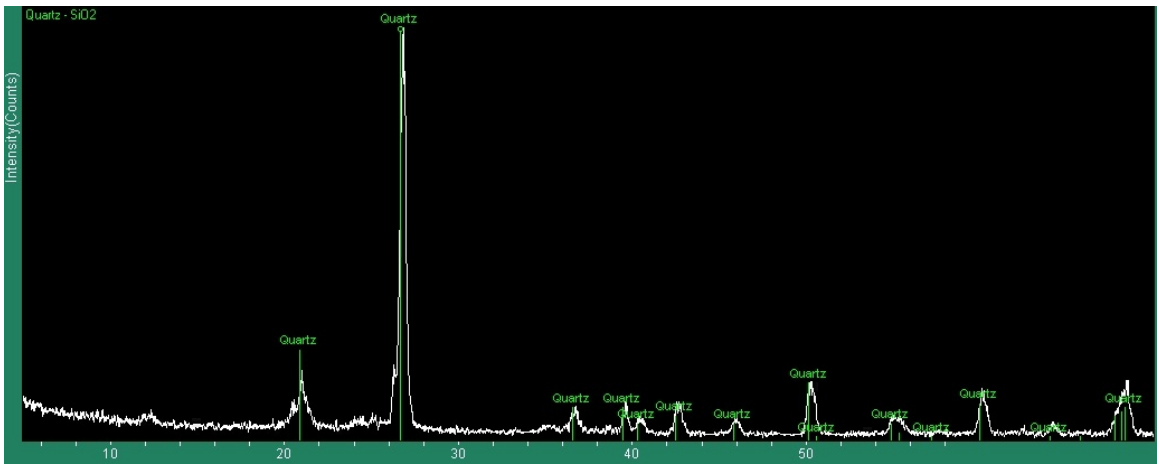


Figure . ray diffraction analysis of a rock sample from Tatman Run, uart is the main mineral found in the rock sample

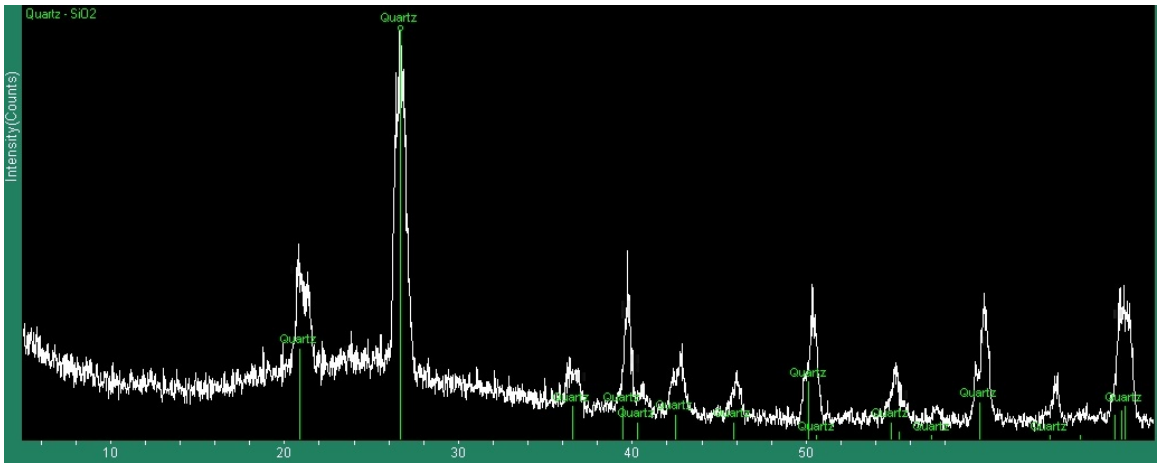


Figure . ray diffraction analysis of a rock sample from Roaring Run, uart is the main mineral found in the rock sample

METHODS AND MATERIALS

To compare water quality between Tatman and Roaring Run we collected data on the pH, conductivity, temperature, and alkalinity. To measure pH we used a Hanna instrument pHep pH meter, model HI 98127 (pHep Instruction Manual). A YSI 30 multi meter was used to measure conductivity and temperature (cite). To measure and calculate alkalinity we used a Hach alkalinity test kit, model 16900-01(Digital Titrator Manual, 1992). Each of these measurements was collected twice at each of the sites. Conductivity, pH, and temperature were taken at the streams, and alkalinity was measured in the lab, from field samples. All of our data was collected between September 26 and November 11, 2010. The person collecting and recording the data remained consistent. We compared pH between the two streams using a two- sample T test (Helbig et al. 2009). We considered a difference to be significant if $p < 0.05$. We compared conductivity, temperature and alkalinity between the two streams in a like manner.

RESULTS

We found no significant difference between the pH, temperature, and conductivity between Tatman and Roaring Run (Table 1.). However, Tatman Run had greater alkalinity than Roaring Run ($p = 0.001$). Alkalinity levels increased downstream for both Tatman Run and Roaring Run (Fig. 9). As we moved downstream several trends could be seen in pH, conductivity and alkalinity. In both streams pH increased downstream (Fig. 10). The trend for conductivity was not as clear for the two streams, but a decrease in conductivity was still observed as we moved down the streams. (Fig. 11).

Table 1. pH, temperature, conductivity, and alkalinity SD) in Tatman and Roaring Run, Huntingdon County, PA October and November 2010.

Stream	pH	Temperature °C	Conductivity (uS/cm)	Alkalinity (mg/L as $CaCO_3$)
Tatman	7.3 ± 0.15	8.07 ± 0.49	197.95 ± 13.39	37.38 ± 4.78a
Roaring	6.87 ± 0.24	7.5 ± 0.73	153.15 ± 18.31	15.19 ± 1.38b

1. *Mean was significantly different among sites t= . df=10. 3 p=0.001). Dissimilar letters among sites indicate statistically significant differences.*

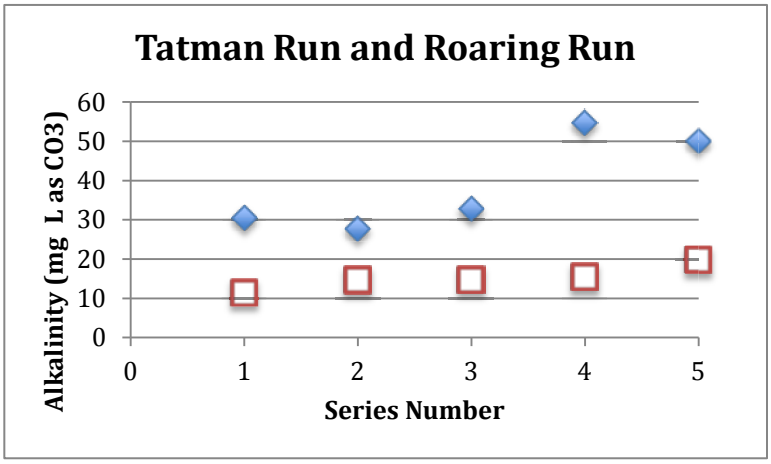


Figure . Tatman Run and Roaring Run alkalinity increased as we moved downstream. The numbers represent the series number on the stream, 1 being the headwaters and being the confluence.

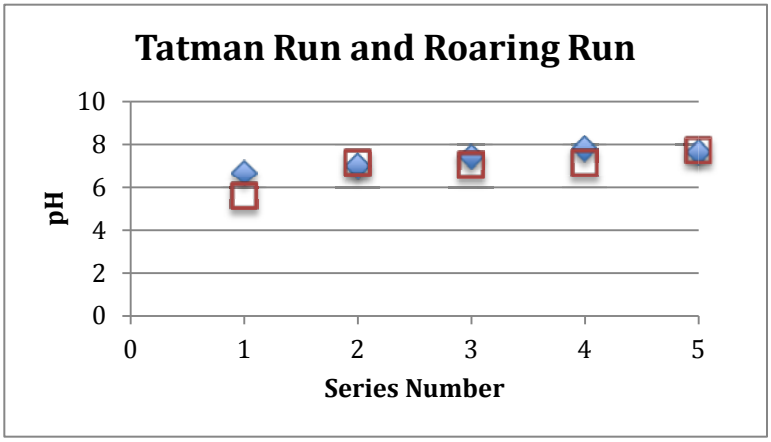


Figure 10. Tatman Run and Roaring Run pH increased as we moved downstream. The numbers represent the series number on the stream, 1 being the headwaters and being the confluence.

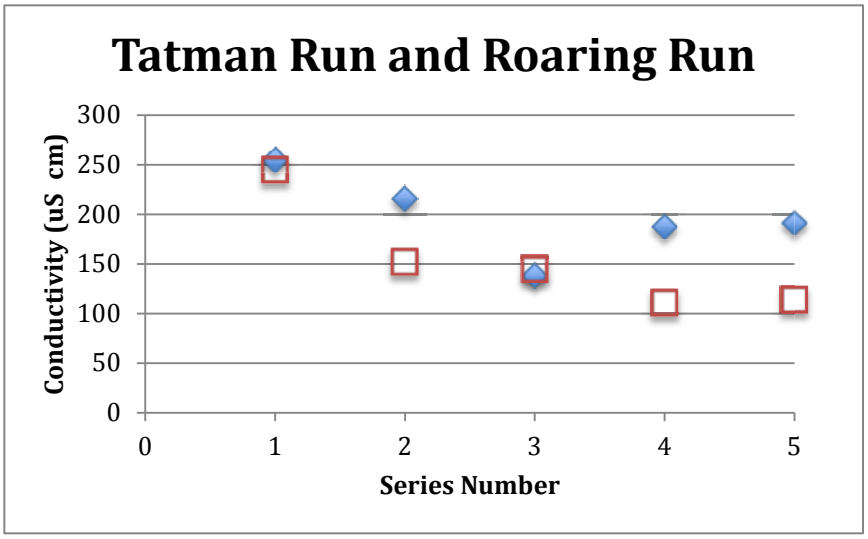


Figure 11. Tatman Run and Roaring Run conductivity has a slight decreasing trend as we moved downstream. The numbers represent the series number on the stream, 1 being the headwaters and being the confluence.

DISCUSSION

We hypothesized that there would be a difference in stream water quality between Tatman and Roaring Run. Both streams were fairly similar in water quality, except for alkalinity. Tatman has a greater capability for buffering acidic water conditions. A potential explanation for Roaring's lower alkalinity could be due to the fact that it was once a heavily affected AMD stream.

When moving from the headwaters of the streams to the confluence there was an increasing trend in pH and alkalinity. This same trend was seen in the study done by LeFevre and Sharpe on Bear Run in Southwestern Pennsylvania (2002). In Bear Run the pH at the headwaters was 3.9 and then increased to 5.35 further downstream. Photosynthesis can have a great affect on the pH of a stream it may be possible that more photosynthesis is occurring further down stream in Roaring Run (Department of Ecology State of Washington, 2010). Roaring is less shaded as you move from the headwaters to the confluence due to the increase of fields surrounding the stream. More sunlight increases photosynthesis, which in turn increases the pH. CO_2 causes water to increase in acidity photosynthesis removes CO_2 from the water giving it the ability to increase the pH of a stream (Yohn, 2010). CO_2 combines with two H ions to form carbonic acid. Alkalinity and ph are closely related so it is not surprising that they would have similar trends. Conductivity decreases as you travel further down the stream from the headwaters. This could be due to particles falling out of solution.

Compared to other streams found in Pennsylvania, Roaring and Tatman Run have average water quality for the state. the average pH for Pennsylvania to be 7.4 and the conductivity was 385.323 uS/cm. (cite here)The average temperature was 5.5°C. This data was taken on December 3, 2010 (*USGS Real Time Water Data for Pennsylvania, 2010)*. This would explain why there is a difference in temperature between our data and this data, since we gathered our data in October and November. Our pH is just below the state average and the conductivity was a little below average for the state. To be considered a high quality stream by the state of Pennsylvania a stream must have a pH between 6.0 and 9.0. The alkalinity for of a stream must be a least 20 mg/L as $CaCO_3$ (Chapter 93. Water Quality Standards). Based on these two tests, Tatman would be considered a high quality stream, but there are many other test that go into accurately deciding whether a stream is of high water quality. Tatman has a pH of between 6.7 and 7.8 it has a minimum alkalinity of 27.8. Roaring Run does not meet the state high water quality standards for alkalinity or pH. Roaring's maximum reading for alkalinity was 19.8. All of Roaring's pH readings were above 7 except for the headwaters, which had a pH of 5.6.

Both Tatman and Roaring Run streams flow over mostly shale and sandstone bedrock. The type of bedrock under a stream has the ability to affect the conductivity of a stream. Streams that are above carbonate bedrock, such as limestone, will have a higher conductivity. In streams that run over carbonate bedrock conductivity can be as high as 500 uS/cm (Kney and Brandes, 2006). Our highest conductivity measurement recorded was 255uS/cm. The rocks in the beds of both the streams are also sandstone (Fig. 6 & 7). If these rocks would have been limestone then they may have had the ability to affect the conductivity, ph and alkalinity of the stream. This is due to the fact that limestone can be easily weathered and because it is made out of carbon it has the ability to raise pH.

The water quality of a stream will determine what species are able to live in the stream. Acidic streams are low in biodiversity because many species need neutral or slightly basic water conditions to survive. Freshwater clams and snails are two examples of highly sensitive species for they cannot live in water with a pH of less then six. Bass, crayfish and mayflies are somewhat sensitive because they cannot live in streams with a pH of less then 5.5 (United States Environmental Protection Agency, 2000). Roaring was once highly acidic due to the acid mine drainage that ran into the stream. However, today Roaring Run is a healthy stream that supports many fish, amphibians and macroinvertabrates this improvement in stream water quality leads us to believe that the treatment ponds at Joller are working well.

AKNOLEGMENTS

We would like to thank Dr. Dennis Johnson, Dr. Douglas Glazier, and Dr. Neil Pelkey for their assistance with our research.

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SALAMANDER DENSITIES OF TATMAN RUN AND ROARING RUN IN HUNTINGDON COUNTY, PENNSYLVANIA

Michele Seroskie and Talia Valencia

ABSTRACT

Acid mine drainage (AMD) and how it affects water quality and stream health has been an increasing topic of concern in Huntingdon County, Pennsylvania over the past decade. Salamanders are considered an indicator species of stream health due to their reproductive habits and other traits. We studied how acid mine drainage affects the density of salamanders by comparing two stream systems: Roaring Run, an AMD remediated stream and Tatman Run, an un-impacted stream. The density of salamanders differed significantly between the two streams; Tatman Run had a mean density of 0.325 salamanders per meter^2 and Roaring Run had a mean density of 0.133 salamanders per meter^2 (d.f. = 70.3, p = 0.0384). Two species of salamanders were found in this study, the Northern dusky salamander (*Desmognathus fuscus fuscus*) and the four-toed salamander (*Hemidactylium scutatum*). According to our research, Roaring Run is still slightly affected by the AMD.

Keywords: acid mine drainage, Desmognathus fuscus conanti, Hemidactylium scutatum, salamander, vegetation

INTRODUCTION

Historically, Huntingdon County, Pennsylvania has been an active area for coal mining. The large availability of bituminous coal encouraged workers to move into the area to harvest the valuable resource. Demand for coal continued to grow in demand until the end of the Second World War when the need for large amounts of bituminous coal plummeted (Yohn 2010). The mines were abandoned, allowing them to flood with water. In the mines, water came in contact with pyrite which oxidized and acidified the water before it was released into the environment (Todd and Reddick 2010).

Roaring run is an example of an acid mine drainage (AMD) affected stream, coming from the Joller mine. AMD in Roaring Run caused the pH to decrease to 3.99 (PA CleanWays). A remediation system was completed in 1998 to address the "highly acid, high-metal deep mine discharges into Roaring Run" (Milavec 2010). It was reconstructed in 1999 and again in 2000 to address leaking issues. The project was declared a success in Spring 2000 (Milavec 2010). To test the effects of historical AMD on the present stream ecosystem, we studied the salamander population.

Salamanders are considered indicators of water quality and stream health because they are long lived, return to their birthplace, and exist in relatively stable populations (Welsh and Ollivier 1998). The reproduction phase of salamanders, such as courtship, spawning, fertilization, and the development of the embryo and larvae generally take place in or around a body of water. Varying stream quality and low pH have had extreme negative effects on the eggs and larvae of salamander species. Decreased pH values at spawning sites cause fungus to grow on the eggs, increasing their mortality rate. In most instances, a pH between 4.0 and 5.0 results in 50% mortality, and a pH value below 4.0 is lethal. Some salamander species are able to deal with slightly lower pH values while others cannot. For example the Jefferson salamander (*Ambystoma jeffersonianum*) has a lethal pH tolerance of 4.0-5.0 and a critical limit (50% mortality rate) of 4.0-4.6. The spotted salamander (*Ambystoma maculatum)* has the same lethal pH tolerance of 4.0-5.0, a critical pH tolerance limit of 5.0-7.0. (Leuven et al. 1986).

Our null hypothesis is that AMD will have no significant effect on the Roaring Run salamander population compared to that of a healthy stream.

FIELD SITES

Six sample areas were chosen along Roaring Run and Tatman Run of Huntingdon County, Pennsylvania in Fall 2010 (Fig. 1). To assess the density of salamander populations, we selected locations along Tatman Run and Roaring Run depending on the dominant vegetation type of the area (Figs. 2 and 3). We selected two deciduous dominated locations on each stream. We considered a location to be suitable if both banks of the riparian zone were dominated by deciduous vegetation. We also selected two coniferous locations along Tatman Run but only one coniferous location along Roaring Run because a second suitable site could not be identified. We looked at three grassy locations on Roaring Run; the extra point was to make up this lost point due to the lack of conifers and to survey the complete length of the stream

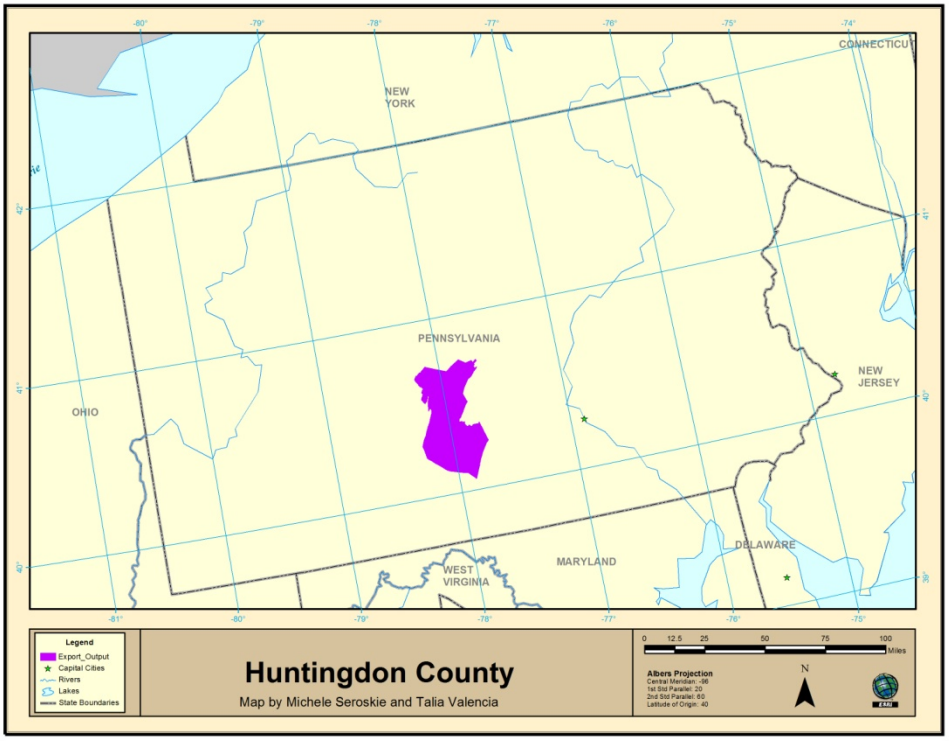


Figure 1. Map of Pennsylvania displaying Huntingdon County highlighted in purple.

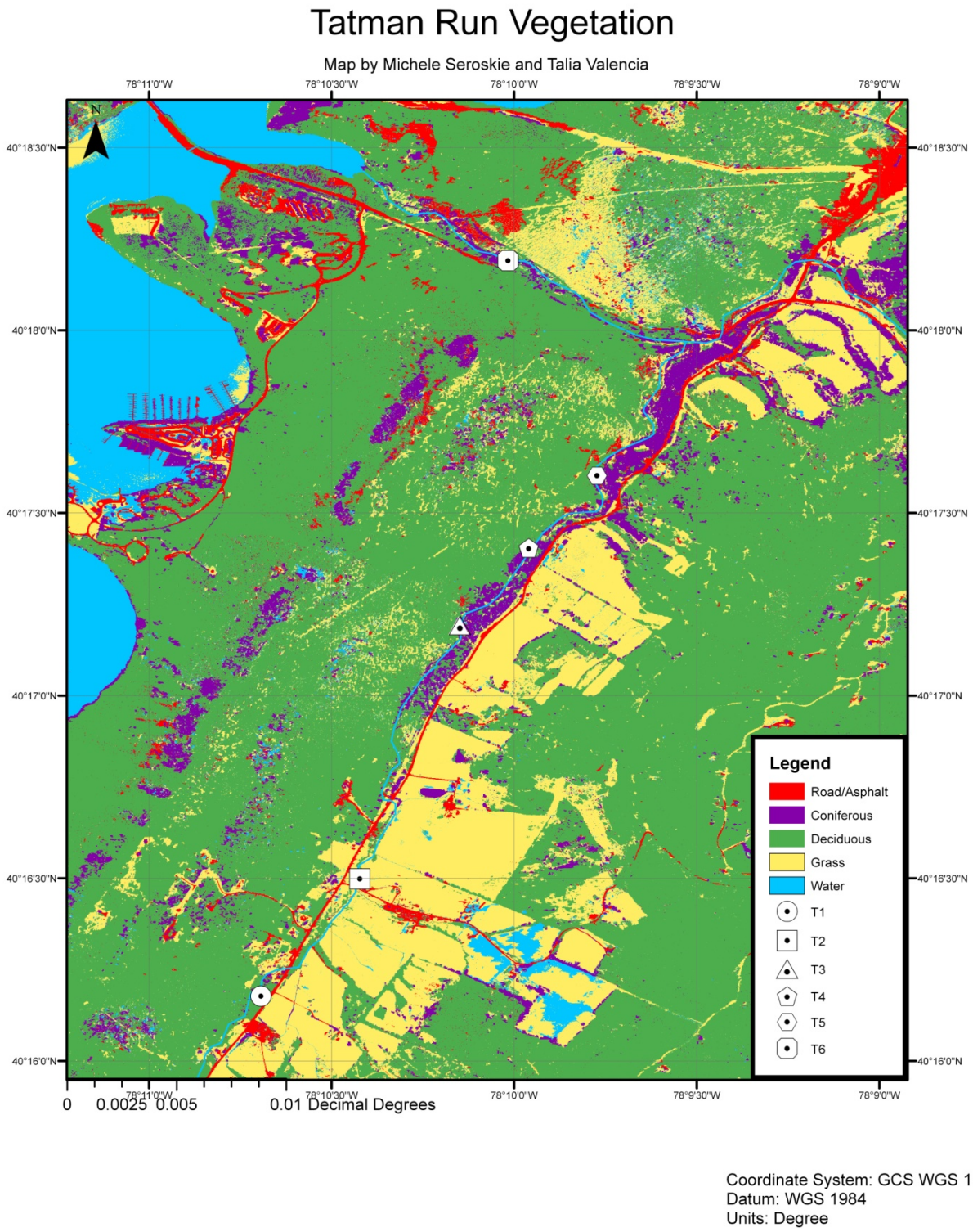


Figure 2. Vegetation classification along Tatman Run located in Huntingdon County, Pennsylvania during Fall 2010.

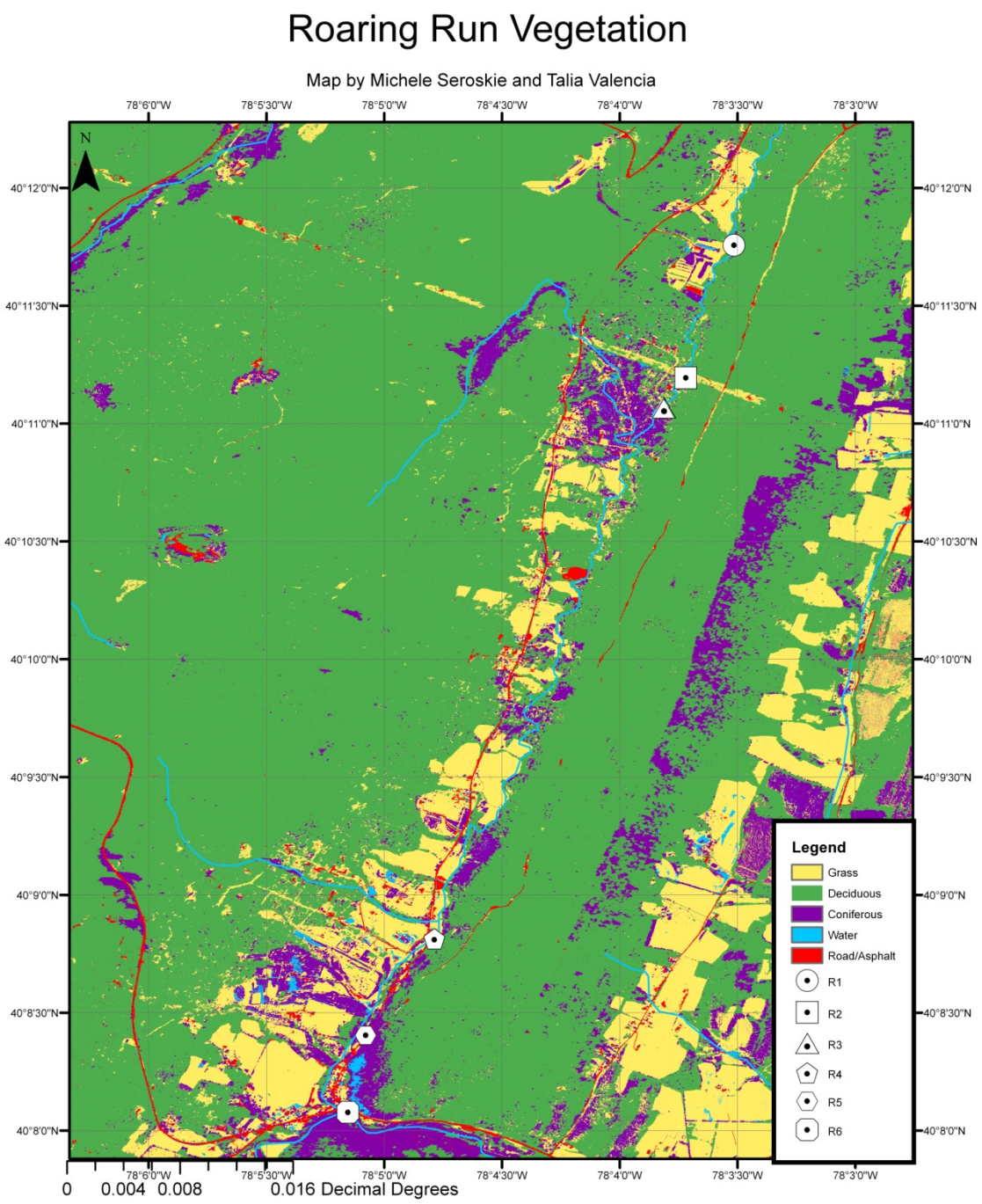


Figure 3. Vegetation classification along Roaring Run located in Huntingdon County, Pennsylvania during Fall 2010.

GEOMORPHOLOGY

The minerals in the rock formations listed above contribute to the "moderately hard (50-100 mg/L)" groundwater of both streams (Taylor 1982). The average pH of Tatman Run was 7.30. The average pH of Roaring Run was 6.87. The average mean pH for Pennsylvania's water is 7.3 with the mode and median both being 7.0 (Kelly 2010). The historical average pH of Roaring Run was 3.99, confirming the remediation process is working (PA CleanWays of Huntingdon County). According to the class measurements taken at R4, the average dissolved oxygen level of Tatman Run was 9.80 mg/L. The average dissolved oxygen level of Roaring Run was 11.5 mg/L.

Both Tatman Run and Roaring Run watersheds (Fig. 4) are a part of the Susquehanna/Chesapeake Bay Drainage Basin (PA DEP). Tatman Run empties into Raystown Lake which empties into the Juniata River. Roaring Run drains into Sidling Hill Creek which leads to Aughwick Creek that meets with the Juniata River. From the Juniata River, the water goes to the Susquehanna River then to the Chesapeake Bay and ends up in the Atlantic Ocean (Google Earth).

The channel length of Tatman Run is 24,196 feet and the valley length is 15,334 feet. The sinuosity of Tatman Run is 1.58. The channel length of Roaring Run is approximately 30,984 feet and the valley length is 23,644 feet. The sinuosity of Roaring Run is 1.31.

Tatman Run and Roaring Run are located in Huntingdon, Pennsylvania. Huntingdon encompasses 888 square miles. Of that, 69 percent of that land is forested and 24.3 percent agricultural land. The remaining 6.7 percent includes development and other miscellaneous land cover (Pennsylvania State of Innovation 2005).

The climate of Huntingdon County, Pennsylvania is temperate where all four seasons are distinct. The county receives an average of 30.1-40.00 inches of precipitation each year. The average daily temperature is 50.01-55.00 degrees Fahrenheit and the average annual wind speed in 8.0-8.9 miles per hour. Moisture and warmer temperatures are essential for salamanders' lifecycle (Conant 1998).

The geology of Tatman Run's bedrock consists of the Mauch Chunk Formation, Catskill Formation and the Pocono Formation, falling in both the Mississippian and Devonian geologic time periods. The land surrounding Tatman Run is primarily shale and sandstone. The substrate of our points along Tatman Run consisted mainly of medium to large rocks and sand. Roaring Run's geology consists of the Mauch Chunk Formation and a small portion of the Pocono Formation of the Mississippian geologic time period and is nearly all shale with some sandstone. In our research areas, the substrate of Roaring Run was primarily small to medium rocks and gravel. The course substrate of both these streams make for ideal salamander habitat. Salamanders, particularly nymphs, use the space between rocks to hide from predators (Barr and Babbitt 2002).

Both Roaring and Tatman streams run though clay loam soil. Tatman runs primarily through Philo and Basher silt loams, Atkins silt loams, and Andover extremely stony loam. Basher and Philo silt loams have a slope of 0-3% (USDA 2010). Basher silt loams consist of deep, moderately well drained soils that have formed from recent alluvial deposits. These alluvial deposits are derived from siltstone, sandstone, and shale. Philo silt loams are in the same family as Basher loams, but Philo have a yellower hue in the solum (NRCS 2010). Andover, an extremely stony loam, consists of deep, poorly drained soils formed in a colluviam. The Roaring Run area also consists of Philo and Basher silt loams. Also in the area are Buchanan, a very stony silt loam, Meckesville, a very stony silt loam, and Atkins silt loams. Buchanan soil series are deep, poorly and moderately well drained and slowly permeable. This soil is formed in colluviums on mountain foot slopes, side slopes, and in valleys deprived from sandstone, quartzite, siltstone, and shale (NRCS 2010). The slope of this soil type is 8-25% (USDA 2010). Meckesville soils are deep, well drained soils formed in colluviums, glacial till, or congeliturbate from sandstone, siltstone and shale. Atkins series are deep, poorly drained soils of slow to moderate. These soil types were formed in alluviums washed from soils formed from shale and sandstone (NRCS 2010). They have a slope of 0-3% (USDA 2010).

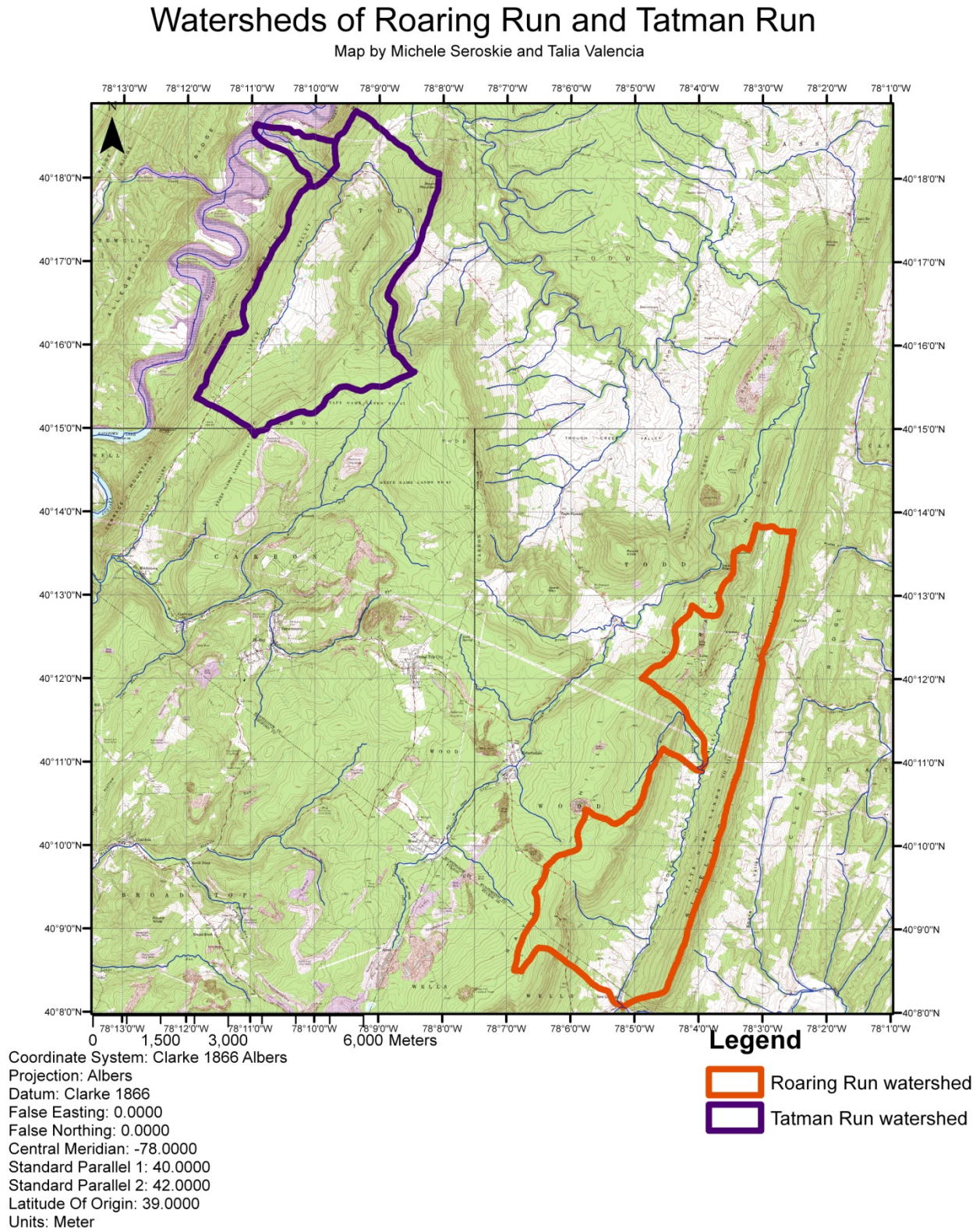


Figure 4. The watersheds of Tatman and Roaring Runs in Huntingdon County, Pennsylvania.

METHODS AND MATERIALS

We chose six sample sites along both Tatman Run and Roaring Run. The sites were chosen based on vegetation type best characterizing the stream: deciduous (maple, oak and tulip popular trees), coniferous (hemlock and pine trees), and grass. Tatman had two deciduous, two coniferous and two grass sites. Roaring Run lacked in coniferous vegetation so we chose two deciduous, one coniferous and three grass sites. We only compared results within the same vegetation types to eliminate vegetation type as a source of variability. The sites stretched, in no particular order, along the entire length of the two streams.

At each site, five 1-m quadrats were selected using a collapsible one-meter square frame. These quadrats were then inspected for salamanders. The location of each quadrat was chosen based on ideal salamander habitat as outlined in *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians* (McDiarmid 1994). We looked for salamanders using two techniques. First, we used dip-nets to sift through detritus in the water. Second, we flipped over every rock in each quadrat as demonstrated by (Jaeger and Inger 1994). Captured salamanders were placed in a bucket containing some water until the rest of the square was searched. We then identified the species using *Peterson Field Guides: Reptiles and Amphibians of Eastern/Central North America* (Conant 1998). Though all of the sample areas were in the water, we still took note of whether they were in the nymph stage or an adult by looking for gills (Duellman and Trueb 1994). Salamanders were returned to the spot where they were captured immediately after the data was gathered. Approximately 30 minutes was spent searching for salamanders in each site.

We compared densities of salamanders between the two streams using a two-sample t-test; any p-value less than 0.05 was considered significant (Helbig 2009 and OpenGeoDa 2009). We compared the densities of salamanders between the two streams including the differences in vegetation using a one-way ANOVA test (Minitab).

RESULTS

Tatman Run had a higher density of salamanders compared to that of Roaring Run (Table 1). The mean density of Tatman Run was 0.33 ± 0.47 SD. The mean density of Roaring Run was 0.13 ± 0.34 SD. There was a significant difference in density of salamanders between the two streams (d.f. = 70, p = 0.038).

The difference in density between vegetation type in Tatman Run was highly significant ($p < 0.001$; $F = 15.56$) (Table 2). The difference in density between vegetation types in Roaring Run was not significant ($p = 0.186$; $F = 1.75$) (Table 3).

The differences in density, excluding the stream type, between deciduous, coniferous and grasses vegetation types was significant ($F = 2, 46$, $p \leq 0.002$) (Table 4).

The differences in density of salamanders between deciduous vegetation of Tatman Run and Roaring Run were significant, while differences between other vegetation types were not (Table 5).

Table 1: Relationships of vegetation type to Northern Dusky and Four-toed salamanders between Tatman Run and Roaring Run located in Huntingdon County, Pennsylvania during Fall 2010. Computed using a One-Way ANOVA test.

Site	Northern Dusky		Four-toed		Total
	Adult	Nymph	Adult	Nymph	
Deciduous					
Tatman	0	5	0	1	6
Roaring	0	0	0	3	3
Coniferous					
Tatman	0	1	0	0	1
Roaring	0	0	0	0	0
Grass					
Tatman	0	1	0	0	1

Roaring	1	1	0	1	3

Table 2: One-Way ANOVA test results for Tatman Run located in Huntingdon, PA during Fall 2010. The Individual 95% CIs for mean based on pooled standard deviation show the overlap of densities; the more overlap, the less significance. Computed using a One-Way ANOVA test.

Vegetation Type	Mean	Standard Deviation	Individual 95% CIs for mean based on pooled standard deviation
Deciduous	0.733	0.4577	(-----*------)
Coniferous	0.067	0.2582	(------*-------)
Grasses	0.100	0.3162	(-----*-----)

Table 3: One-Way ANOVA test results for Roaring Run located in Huntingdon, PA during Fall 2010. The Individual 95% CIs for mean based on pooled standard deviation show the overlap of densities; the more overlap, the less significance. Computed using a One-Way ANOVA test.

Vegetation Type	Mean	Standard Deviation	Individual 95% CIs for mean based on pooled standard deviation
Deciduous	0.300	0.483	(--------*--------)
Coniferous	0.000	0.000	(----*----)
Grasses	0.100	0.305	(-----------*-----------)

Table 4: Mean densities (# individuals/m2) of the different vegetation types of Tatman Run and Roaring Run. Computed using a two-tailed t-test.

Vegetation Type	Tatman Run	Roaring Run
Deciduous	0.73 ± 0.46	0.30 ± 0.48
Coniferous	0.07 ± 0.26	0.00 ± 0.00
Grasses	0.10 ± 0.32	0.10 ± 0.31

Table 5: Differences in densities between Tatman Run and Roaring Run by vegetation type. Values were considered significant if $p \leq 0.05$ and $z \geq 2.0$. Computed using a two-tailed t-test.

Vegetation type	Values
Deciduous	d.f= 19 p= 0.037 z= 2.1
Coniferous	d.f= 15 p= 1.0 z= -0.68
Grasses	d.f= 14 p= 0.33 z= -1.32

DISCUSSION

Tatman Run, a pristine stream, has a significantly higher salamander population than Roaring Run, an acid mine drainage affected stream. The general health of Roaring Run is still not ideal for salamanders because of the acidic water. The average pH of Tatman Run was 7.30, while the average pH of Roaring Run was 6.87 (Rodkey and Thomas 2010). The average mean pH for Pennsylvania's water is 7.3 with the mode and median both being 7.0 (Kelly 2010). Optimal pH for salamander survival is approximately 7.0 and greater. A pH between 4.0 and 5.0 results in 50% mortality and a pH value below 4.0 is lethal for salamanders. Lower pH values increase the probability that salamander eggs will be infected with fungus, killing the embryos inside (Leuven et al. 1986).

The density of salamanders we found in Tatman Run (0.325/ m^2) was normal for the time period during which our study occurred. Northern dusky salamanders stabilize in density to around 0.500/ m^2 in the early summer. This density drops in mid-August as the salamanders begin to hibernate for the winter months (Orser and Shure 1975). Previous data on Four-toed Salamander density in central PA streams could not be found. In Pennsylvania, they are considered a species of concern due to unknown status and spotty distribution (PA Herp Atlas 2010). Roaring Run showed a less dense salamander population (0.133/ m^2). In Roaring Run, there were more four-toed salamanders than northern dusky salamanders. This could possibly be explained by the acidity of the water. Lower pH values increase embryonic salamander mortality, enabling fungal infections. Some female four toed salamanders are able to produce anti-fungus bacteria on their skin (Banning et al. 2008). The four-toed salamanders also show a tendency toward communal nests rather than solitary nests. Females sharing a communal nest move through each other's embryos. Even if only one of the females of the nest has the anti-fungus bacteria, the bacteria from the female are spread to all of the embryos of the nest (Banning et al. 2008). If this type of fungus resistance is occurring in Roaring Run, the four-toed salamanders may have a slight advantage toward surviving in the slightly acidic water.

The most salamanders were found in areas of deciduous growth. In another study, the type of canopy was not found to affect the salamander populations in central PA (Hawkins et al. 1983).Within these areas, however, it was observed that there was more leafy detritus, with a greater number of nymphs found in these pockets of detritus compared to other locations. Salamanders eat detritivores. Leaves provide safer hiding places for nymphs and create a larger food source of macroinvertebrates. Aquatic salamanders tend to lurk in leaf litter where they find macroinvertebrates feeding on detritus (Harper and Guynn 1999). The fewest salamanders were found in areas with coniferous canopies. In these spots there were some fallen needles in the streams but there was significantly less needle detritus and more growth on the trees compared to that of areas with deciduous canopies. Grassy areas did not have any detritus but it was common to see grasses on the stream banks that grew out and over the water allowing some cover for salamanders to hide within.

Our results suggest that Roaring Run's salamander density is still slightly affected by AMD when compared to a healthy stream.

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AN ANALYSIS OF ~~NORTH AMERICAN~~ PORCUPINE (*ERETHIZON DORSATUM*) WINTER FEEDING PATTERNS ~~DURING THE WINTER SEASON~~ IN CENTRAL PENNSYLVANIA

Arielle C. Webster and Timothy J. Zador

ABSTRACT

The North American Porcupine, *Erethizon dorsatum*, is often cited for forest damage during the winter season because it feeds on the inner bark of trees. The purpose of this study is to determine which tree genera in the Huntingdon County area are at high risk for Porcupine damage during the winter by looking at which trees are being selected by Porcupines. Preliminary results support previous research that Porcupine preference varies by location, with the general trend being that Porcupines will eat the most abundant genus of tree in their feeding range. This implies one of two conclusions: the Porcupine chooses the location based on the abundance of their favorite tree, or the most abundant genus determines the Porcupine's primary food source. In either situation, the most abundant genus within a porcupine feeding range is in the most danger of Porcupine damage.

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INTRODUCTION

The North American Porcupine, *Erethizon dorsatum*, is often cited for forest damage in regions the species is known to inhabit. During the winter, the Porcupine feeds primarily on the inner bark of trees and coniferous leaves, since other sources of food are not available. This diet, which is low in essential nutrients, requires the Porcupine to feed almost constantly (Roze et al. 2003).

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Chewed trees are typically clustered around the Porcupine's winter den, usually rocky outcrops where the porcupine can find shelter from the weather and predators (Roze et al. 2003). Their winter feeding habits have been linked to structural damage and stunted growth in trees, though chews rarely girdle and kill a tree (Curtis 1941). Forest damage is less severe in other seasons because the Porcupine's diet widens to encompass most types of vegetation, including leaves, nuts, seeds, and berries. Their feeding ranges are also much broader because they are not restricted by the availability of shelter sites (Roze et al. 2003).

~~Research has shown that, in~~ In the winter, Porcupines seem to prefer Eastern Hemlock (*Tsuga canadensis*) over other tree species (Shapiro 1949), though they have been known to also feed on sugar maple (*Acer Saccharum*), striped maple (*Acer pensylvanicum*), beech (*Fagus*), birch (*Betula*), aspen (*Populus*), oak (*Quercus*), and linden (*Tilia*) in mixed deciduous forests in the northeastern and Great Lakes regions (Griesemer et al. 1998). Other studies ~~argue~~ conclude that Porcupine winter feeding habits are determined by the relative abundance of trees within their feeding ranges (Roze 2009). A suggested cause for this is variation~~s~~ in the types of gut microflora in individual porcupines. This "Specific Microflora" hypothesis essentially states that these microflora help digest the bark and protect against specific plant defenses (Hungate 1966); however, the microflora's specialization limits the porcupines' diet to one or two tree species (Roze 2009). Another possible cause for the difference in food preference is that it allows

Porcupines to have overlapping feeding ranges without competing with one another. ~~Since~~ Because their diets are so limited, preferred food is either determined by relative availability or the feeding range is determined by abundance of preferred food. Roze found that Porcupines seemed to pick locations where their preferred tree was the most abundant and that this preference was specific to each Porcupine and could vary among individuals, thus suggesting an active choice of preference of one species to another (2009).

The purpose of this study is to determine which tree genera in the Huntingdon County area are at high risk for Porcupine damage during the winter.

METHODS

Using area maps from Google Earth and previous knowledge, we determined possible feeding ranges of porcupines based on forest type and large rock availability. We used a Garmin GPSMAP 60CSx to mark out the boundaries of the feeding range, which extended to the furthest recently chewed trees. We selected two points within each feeding range as the central point of a 10m radius ~~test~~ sample? site. These points were determined by a stratified random walking pattern that took in to account differences in terrain across feeding sites, relative chew density, and safety concerns.

Within each 10 m radius test site, we identified all trees more than three inches in diameter to genus and determined their status as "chewed" or "not chewed". Trees that split less than one foot from the ground were counted as separate individuals. "Chewed" trees showed clear signs of bark feeding from the 2009-2010 winter season while "not chewed" trees did not

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show such signs ~~of bark feeding from this winter~~, but could show damage from previous winters or no damage at all.

We used Minitab 15 to analyze the difference in chews by relative abundance of total trees and by genus for each feeding site to determine ~~which was more important to the Porcupine: relative abundance or specific genus~~ if feeding was random or non-random.

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2011

THE AFFECT OF ENVIRONMENTAL CHARACTERISTICS ON DISTRIBUTION OF *Quercus prinus* (CHESTNUT OAK) AND *Robinia pseudoacacia* (BLACK LOCUST) IN TWO STUDY SITES AT LAKE RAYSTOWN

By Elly Engle, Eleanor Provias, Joel Rhodes

I. Abstract

Distribution describes the spatial arrangement of taxonomic groups across their geographic ranges. There are several environmental factors that may affect where or where not a tree species may be found. We studied how the distribution of *Quercus prinus* (chestnut oak) and *Robinia pseudoacacia* (black locust) in central Pennsylvania was affected by plot characteristics, such as site age, aspect, slope in addition to soil texture, moisture and pH. The abundance and diameter size of the two species differed greatly between the two forestry plots. Black locust mean abundance in the young plot (15.2 ± 11.45 *SD* trees per hectare) was significantly greater than in the old plot (2.5 trees per hectare) ($t = 2.68$, $DF = 4$, $p = 0.03$). The diameters of chestnut oaks in the young plot were on average 6.39 inches smaller (mean = 7.9) than those at the old plot (mean = 14.3). The mean DBH of black locusts at the young plot was estimated to be 8.8 ± 2.6 in. and 12.8 in. at the old plot, and there was a significant difference between the two ($t = -6.74$, $p < 0.001$). Slope percentage, soil moisture and pH compared between the plots did not turn out to be significantly different in a way that would affect either chestnut oak or black locust. While soil texture and site aspect may have played a role, I concluded that the main factor affecting chestnut oak and black locust distribution was ecological successional stage of the forest plots based on age and other site attributes, like canopy cover and soil organic matter.

Introduction

One of the most basic and fundamental concepts to be studied within the field of ecology is the distribution of species. Species distribution is described as the spatial arrangement of taxonomic groups across their geographic range (Krebs 2009). Some species can be found in a variety of places, having what is known as a cosmopolitan distribution. Other species may only be found in one specific area, termed as an endemic distribution. Species are constantly trying to expand their distributions where possible in order to better their populations' chances of survival (Pidwirny and Jones 2009).

Understanding the distribution of tree species is of great importance to anyone concerned with plant geography, such as taxonomists, ecologists, and foresters (Keever 1973). Many factors can influence where a tree species may or may not be found. The most prominent explanation for why a species may be present in an area is the species intrinsic ability to disperse and colonize (Keever 1973). Trees and other plants have a variety of properties to aid in dispersing their young to new habitats, including characteristics of their propagules and methods of transport (Pidwirny and Jones 2009).

In order to guarantee successful colonization by a tree's young, the environment must meet requirements necessary for the survival of the specific species. This can include abiotic elements of the habitat, such as soil, water, and sunlight or natural occurrences like fires and floods (Keever 1973). This can include attributes like soil moisture and composition, water availability and chemistry, and steepness and aspect of the site's slope. Factors affecting colonization affect can also include the biotic interactions of competition, predation, and

parasitism (Pidwirny and Jones 2009). The age and ecological successional status of a forest can also greatly affect competition between trees by determining the forest's vegetation composition (Krebs 2009).

Tree distribution patterns may be better understood by studying trees with similar ranges but different environmental requirements (Abrams 1996). Two such species are *Quercus prinus* (chestnut oak) and *Robinia pseudoacacia* (black locust). Chestnut oak is a long-lived, slow-growing deciduous species native to most of the United States. While they grow better in moist, nutrient-rich soils near streams, they also dominate dry, rocky slopes with infertile soil proving its superior resilience in unfavorable conditions. Though it can be found on all aspects, it prefers south- and west-facing upper slopes. It has an intermediate shade-tolerance, but its seedlings will only persist when light can reach the forest floor (US Forest Service 2011). On poor sites, the chestnut oak is considered a successional climax species and can grow codominantly with white oak, but in areas with good moisture and nutrient availability, they are usually succeeded by red maple and other more shade-tolerant tree species (US Forest Service 2011).

Black locust is a native, nitrogen-fixing woody leguminous tree that grows quickly and has a relatively short lifespan. It can be found across much of the eastern United States. It thrives in full-sunlight situations and can capture nutrients rapidly, traits which allow it to swiftly dominant clear sites (Boring and Swank 1984). Black locust also reproduces by root suckering and stump sprouting to form clones formed by a common root system. For these reasons, it is hard to control and is considered an invasive species. Its characteristics make it an

early successional species that often colonizes disturbed areas like old fields, roadsides and cleared forests. It prefers well-drained soils, none to moderate slope, and little competition from other species, but can tolerate very nutrient-poor sites (PCA 2005).

Chestnut oaks and black locusts are important to forests, both economically and ecologically (US Forest Service 2011, PCA 2005). Because of this, understanding why a tree species may or may not be found in a certain area can be of great importance. Therefore, my research hypothesis is that there are significant differences in the environmental attributes of our two selected forest sites that are causing a variation in chestnut oak and black locust distributions in the Lake Raystown area.

II. Field Sites

Our study took place within Huntingdon County, Pennsylvania, USA in the Fall 2011 (Fig. 1). Specifically, we examined two 100 by 200 meter plots located in two of the Lake Raystown US Army Corps of Engineers designated forest compartments (Figs. 2 and 3). These forest compartments are about 8,700 hectares in area combined (U.S. Geological Survey 2000) and experience average central Pennsylvania weather. They are within the Mid-Atlantic temperate climate with an average annual rainfall of about 40 inches and average minimum and maximum temperatures of 45^{o}F and 65^{o}F, respectively (NOAA National Weather Service 2007). The forest compartments are also host to large white-tailed deer populations (Army Corps of Engineers 2010) (Fig. 4).

The two plots exhibited two very different types of forests. The young plot (Fig. 5) was established only 38 years ago when the Raystown Dam was built. The plot was formerly cow

pasture (personal communication), as indicated by the presence of barbed wire and a large amount of sunlight-loving species. Prominent tree species included *Cercis canadensis* (red bud), black locust, mostly dead *Fraxinus americana* (white ash), and some mixed oaks. The canopy of the site was relatively open (~30% cover), as many of the trees were young or dead, and the tallest healthy trees reaching an average height of about twelve meters. Thanks to the high sunlight availability, the young site had a high amount of ground cover. Much of the ground was dominated by a variety of pest and/or invasive plants, such as *Toxicodendron radicans* (poison ivy), *Rosa multiflora* (multiflora rose), and species of *Smilax* (greenbrier) and *Brassica nigra* (mustard). There was also some oak regeneration present. The plot was located along a southeast-facing hill next to a gravel road (Fig. 6). Slope ranged from 6-35 percent rise, with the steeper slope nearest the road and the flatter area farthest away (U.S. Geological Survey 2000) (Fig. 7). The older trees in the plot could be found along the road at the top of the slope, while the younger trees and smaller plants became more prevalent as one moved down the hill (personal observation).

The exact age of the old plot (Fig. 8) was previously undetermined. The dominant tree species included mixed oaks (mostly chestnut and white oak), *Acer saccharum* (sugar maple), *Acer rubrum* (red maple), and *Liriodendron tulipfera* (tulip poplar). There were also a significant amount of dead white ash and black locust trees present. The canopy provided nearly full coverage to the site (~80% cover), as the trees had much larger diameters than those in the young plot and reached heights of about twenty meters. There was almost no ground cover in the old plot probably due to the lack of sunlight. The majority of the forest floor was covered in

leaf litter and loose rocks. This site was also located on a northwest-facing slope (Fig. 6) with percent rise value range of 28-54 (Fig. 7) (U.S. Geological Survey 2000).

According to soil data provided by the Natural Resource Conservation Service's Soil Survey Geographic Database (2011), the young plot consisted solely of two different types of soil: a Berks-Weikert association and a Brinkerton silt loam. The Berks-Weikert association is a shaly silt loam known for being on steep slopes and highly erodible land while the Brinkerton silt loam is on very low slopes and not erodible land. The old plot's soils include: a Hazleton-Dekalb association, an Albrights very stony silt loam, and a Meckesville very stony silt loam. All three soil types are considered highly erodible. The Hazleton-Dekalb association and Mecksville are not regarded as prime farmland, but the Albrights soil is good for agriculture (SSURGO 2011) (Fig. 9).

III. Methods

In our two 100 by 200 meter plots, abundance of black locust and chestnut oak trees were counted using two different methods. We measured chestnut oak numbers in the old and young plots and black locust numbers in the old plot by direct count, resulting in absolute abundances. We estimated black locust abundance in the young plot by taking counts from five randomly selected 25 by 25 meter sub-plots. We measured the diameter at breast height (DBH) of all our trees in each age class using a Biltmore stick (Burton 2008).

To determine soil texture, we collected four soil samples from the young site and five samples from the old site taken from randomly selected subplots at each plot (NRCS 2011). We determined soil pH of the samples with the Markson Digital pH Meter model 88 (Brown 1988).

We determined soil moisture of the sample using a wet weight/dry weight method (Schneekloth et al. 2011).

To estimate the age of the old plot, we took a tree core sample from the largest black locust tree using an increment borer (Haglöf Sweden 1988) and used its DBH to approximate the tree's age (Burton 2008).

We used the ArcGIS 10 Software (ESRI 2011) to create and analyze all maps. We compared the diameters of the black locust trees at the young site from the five subplots to that of the average diameter of the black locusts at the old site using a One-Sample t-test (Minitab 2010). We also compared estimated plot abundance of black locusts at the young site to the total abundance at the old site using a One-Sample t-test (Minitab 2010). For soil moisture, we compared unequal variances in the data between the two plots using a Levene's test (Minitab 2010). We then compared the soil moisture between the two plots using a Two-Sample t-test (Minitab 2010). For all tests we considered a *p*-value of equal to or less than 0.05 to be significant.

IV. Results

n the young plot, we counted a total of 15 chestnut oak trees and an estimated 122 black locusts. In the old plot, we found 35 chestnut oaks and 5 black locusts. Mean abundance of black locust at the young plot (mean = 15.2 ± 11.5 *SD*) was significantly greater than at the old plot (t = 2.68, DF = 4, $p = 0.03$). The young plot had a higher estimated density of black locust trees (14.4 ± 1.4 *SD* trees per hectare) as compared to the old plot (2.5 trees per

hectare). The old plot had a higher density of chestnut oaks (17.5 trees per hectare) than the young one (7.5 trees per hectare).

The chestnut oaks at the young plot ranged in size from 3-12 in. with a median value of 9 in. while chestnut oaks at the old plot they ranged from 9-22 in. with a median value of 15 in. The DBH of chestnut oaks in the young plot were on average 6.39 inches smaller (mean = 7.9) than those at the old plot (mean = 14.3). The black locusts at the young plot ranged in size from 3-13 in. with a median value of 9 in. while the black locusts in the old plot ranged from 8-21 with a median value of 9 in. The mean DBH of black locusts at the young plot was estimated to be 8.8 ± 2.6 *SD* in. and 12.8 in. at the old plot, and there was a significant difference between the two ($t = -6.74$, $p < 0.001$).

We found the soil in each plot to consistently have a clay loam texture. The mean pH of the young site was found to be 4.9 while the old site was 5.2, and these were found to be significantly different ($t = 2.3$, $DF = 7$, $p = 0.05$). We did not find a significant difference between the two sites' soil moisture contents ($t = 0.94$, $DF = 16$, $p = 0.359$).

The age of the old plot was estimated to be about 120 years old based on a 3.25 in. tree core sample that contained 33 seasonal rings taken from a 21 in. diameter black locust.

V. Discussion

Several environmental factors of the forest plots could explain these distribution and size patterns. Both species of tree prefer loamy soils (Brown 1973, US Forest Service 2011), but

as chestnut oaks also grow well in rocky soils (McQuilkin 2011) then the higher density of chestnut oaks at the old plot can be justified based on its rocky soils (SSURGO 2011). Though there was a significant difference between plots' mean soil pH value, both fall within chestnut oak's and black locust's tolerable pH ranges (Haas Outdoors Inc. 2011, Brown 1973). Since soil moisture was not significantly different between the two plots, it does not appear to affect the tree species' distributions. Nor did the moisture content itself appear to be affected by the differing slopes and aspects at either plot, traits that are often important in determining soil moisture (USDA 2011). Aspect may have affected the tree species distribution in that chestnut oaks grow well on west-facing slopes, like at the old plot, and black locust thrive in sunny, south-facing slopes, like at the young plot (US Forest Service 2011, Brown 1973, U.S. Geological Survey 2000).

Perhaps the most notable difference we found between the plots was age, based upon prior knowledge and our black locust tree core at the old plot. Because the old plot was established much earlier than the young plot, it can be inferred that the old plot may be in a later forest successional stage. The high percentage of canopy cover and the trees with larger DBHs also indicate that the old plot is in a later forest state, but since the chestnut oaks have not yet been fully replaced by maple species, I classified the old plot as not quite a climax community but instead an intermediate forest (Martin and Gower 1996, US Forest Service 2011). The species compositions of each forest plot also indicate their successional stage; mostly intermediate and climax species like mixed oaks and maples are in the old plot while the young plot is dominated by pioneering species like black locust and red bud (US Forest Service

2011). We also observed a higher soil organic matter content in the old plot's soils, once again indicating it's in a later successional stage (Petrides and Wehr 1998).

Since many of the characteristics within the plots are the same or very close in nature, it is my conclusion based on what data was known in this study that ecological successional stage/age of the forest plots is the most significant characteristic in determining the distribution of chestnut oaks and black locusts, followed by soil texture and site aspect. Because chestnut oaks are an intermediate successional species and black locusts are a pioneering species, this attribute accounts for their relative abundances in the young and old plots, respectively (US Forest Service 2011).

Based on the similarities between the plots and their biggest discrepancy being age, one may wonder if some day the young plot will resemble the forest type found in the old plot. It is my opinion that it will not for a variety of reasons. First, the presence of large deer populations in the Lake Raystown area can have a huge impact on the development of the young forest (Rawinski 2008). According to the data collected by the US Army Corps of Engineers, there are much higher deer numbers within the proximity of the young plot than are near the old plot (2010). The young plot is also host to a large number of invasive plant species as stated in the field site description. Species like multi-flora rose can form dense thickets, replace native vegetation, and stop the regeneration of trees (Forest Invasive Plants Resource Center 2005). There are also new pests that were not present in Pennsylvania forests decades ago when the old forest was developing. Pests include insects like the emerald ash borer, which could possibly account for the premature death of the white ash trees in the young forest plot (Moser

et al. 2008, personal communication). Overall, since the young plot is growing in much different conditions than the old plot did due to the presence of deer, invasives, and pests, I do not believe it will turn out the like the old plot is today.

VI. Acknowledgements

I would like to thank my Raystown Field Station colleagues for their help on collecting and analyzing the data necessary for this paper: Julie Glass, Matthew Lear, Maxwell Martin, Cory Mattas, Dale Motley, Eleanor Provias, Joel Rhodes, Christopher Rodgers, Joshua Sabulsky, Charles Sedor, Rebecca Strohm, and William Young. I would also like to thank my instructors Dr.'s Doug Glazier, Denny Johnson, and Chuck Yohn and Mr. Chris Bomgardner for their help and direction in writing this paper. Lastly, I would also like to thank Mr.'s Jeff Krause and Glenn Werner of the US Army Corps of Engineers for taking the time to share with us their knowledge of the area.

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VIII. Images

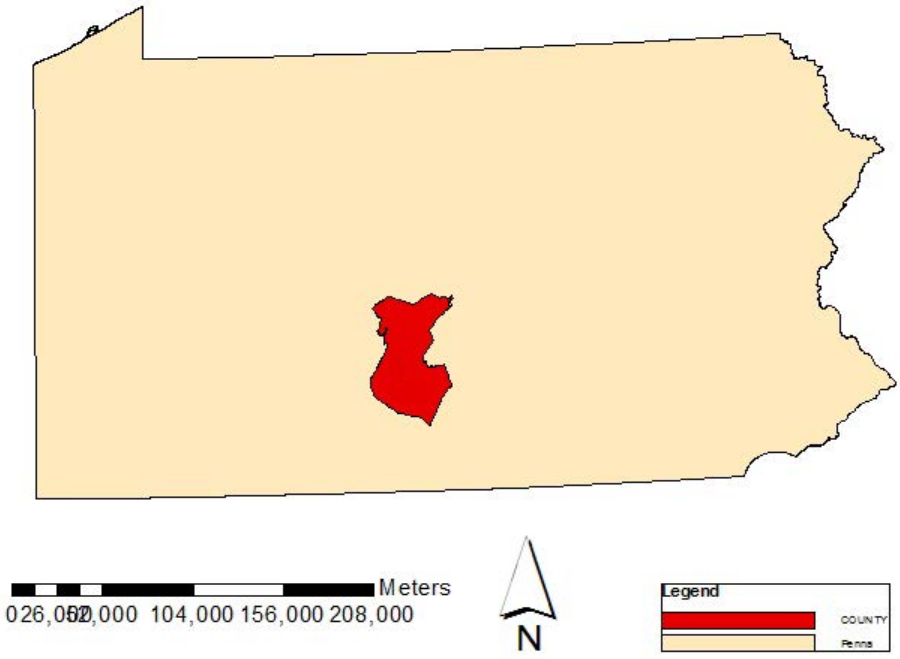


Figure 1. Huntingdon County, Pennsylvania, USA

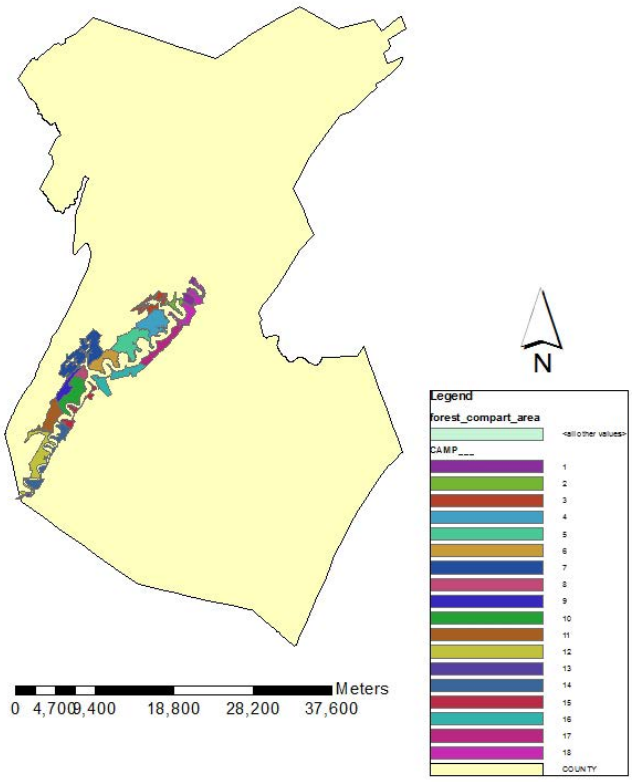


Figure 2. Location of Lake Raystown in Huntingdon County, PA. Colors denote different management units around the lake.

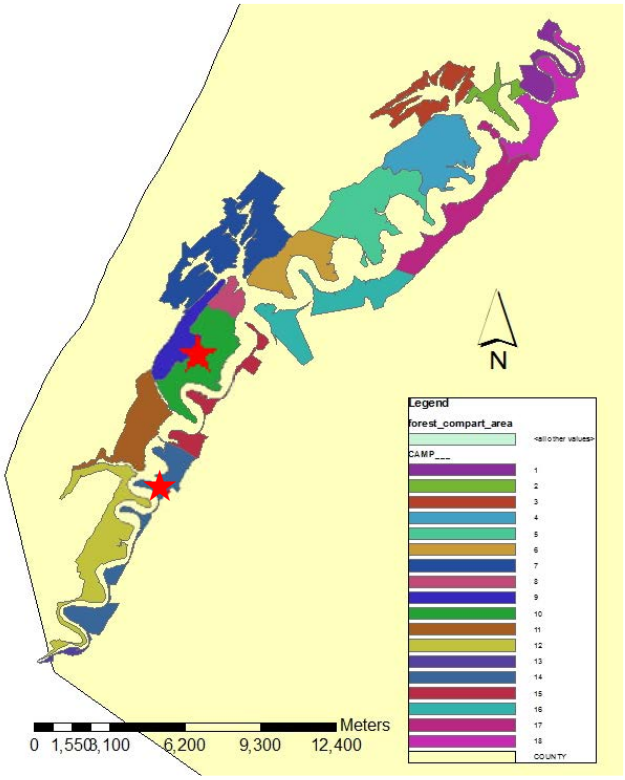


Figure 3. Lake Raystown Forest Compartments in Huntingdon, PA with red stars indicating the location of our two study plots.

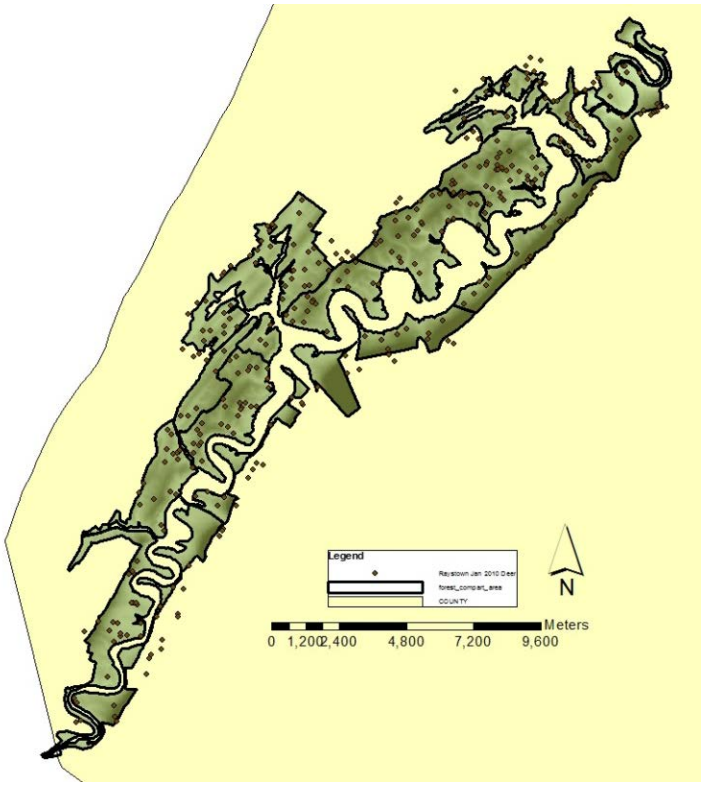


Figure 4. Deer population counts done by the US Army Corps of Engineers in the Lake Raystown area. Each dot represents a spot in which one or more deer were spotted during a aerial count done 2010.

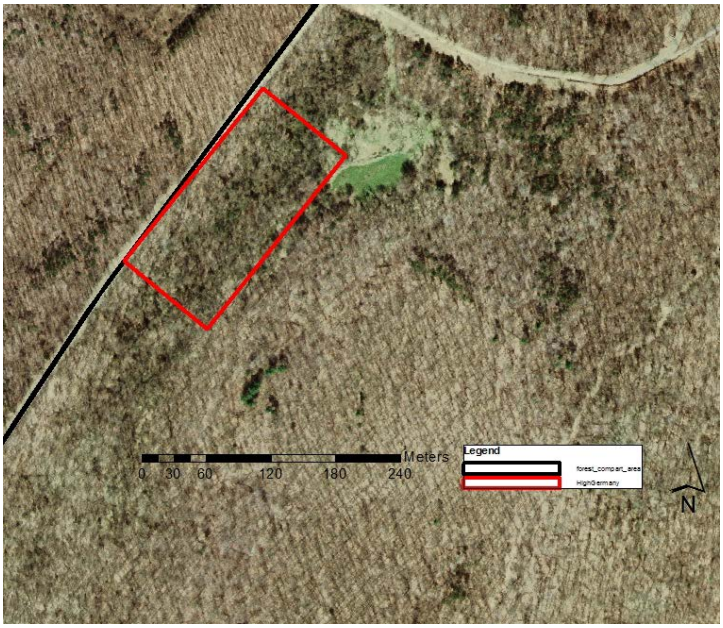


Figure 5. The young study site within the Lake Raystown area as indicated by the red outline.

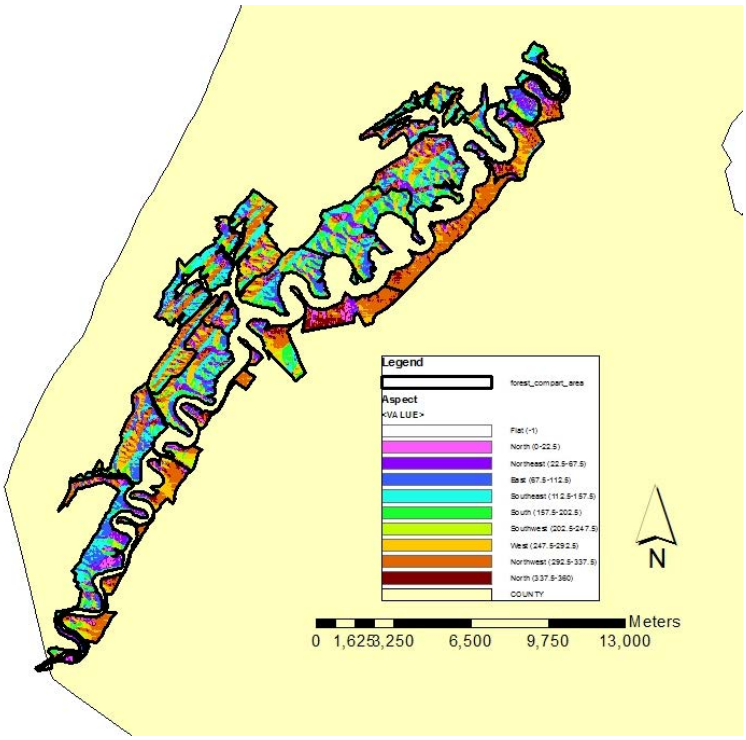


Figure 6. Aspects of slopes within the Lake Raystown area

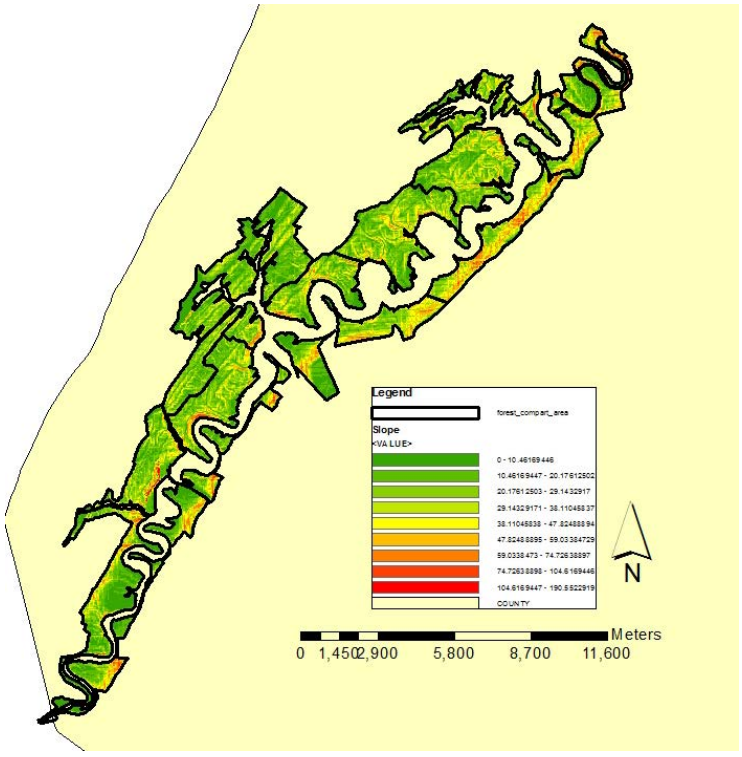


Figure 7. Percent rise of slopes within the Lake Raystown area

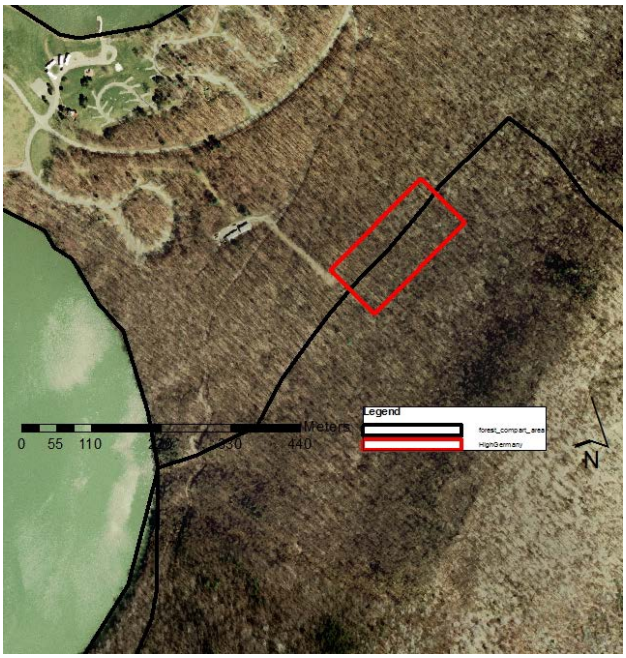


Figure 8. The old study plot in the Lake Raystown area as indicated by the red outline.

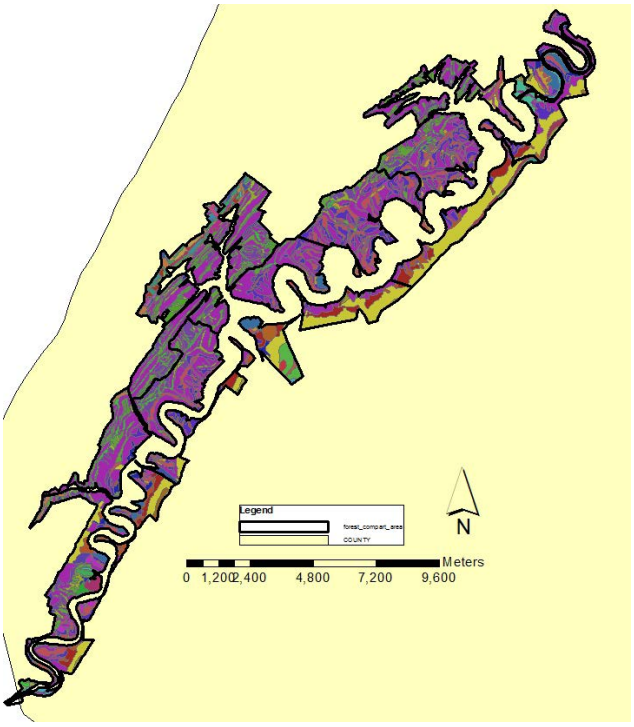


Figure 9. Soil types within the Lake Raystown area according to the Natural Resource Conservation Service's Soil Survey Geographic Database (accessed 2011).

The Effects of Environmental Factors on the Abundance of *Cercis canadensis* in Two Different Aged Forests

Julie Glass and Rebecca Strohm

Abstract

We conducted this study to determine how different environmental factors between two forest plots affected the distribution of *Cercis Canadensis* (eastern redbud). The study was conducted on two forest plots around Raystown Lake in Huntingdon County, Pennsylvania. Data was collected in October 2011. We found an average of 71.2 redbud individuals per hectare in the younger forest plot where redbud was also the dominant tree species. Zero redbud individuals were found in the older forest plot ($p=0.01$, $t=3.8$, $SD=41.9$, $df=5$). These findings indicated that the redbud individuals show typical redbud distribution patterns given the variations between the two forest plots. We also concluded that sun exposure is more important than slope and soil moisture in redbud distribution patterns.

Keywords: Cercis Canadensis, succession, distribution

Introduction

Because multiple factors affect the distribution of *Cercis* Canadensis (eastern redbud) in a forest, studying two forests with varying characteristics is useful in identifying which factors affect the distribution of this species. The eastern redbud is tolerant of a

broad range of soil moisture, but it prefers mesic soils (Federal Sylvics Manual). The tree tends to be more abundant in areas with slopes with a smaller incline because smaller slopes tend to have mesic soils as a result of slower drainage (Banner 2011). Redbud is also a sun loving species, so it is more abundant on southern facing slopes where there is greater sun exposure. Because the tree can only grow up to a maximum of thirty feet (Federal Sylvics Manual), it is not found in forests with a high percentage of canopy cover or in forests with competition for light. Redbud also becomes less light tolerant as it matures (Auburn University).

Both of the forest plots we studied were in different successional stages. Succession is the progression of a disturbed forest to a climax community which is a forest displaying characteristics that are ideal to a region based on the region's climate (Kimmins 1997). The eastern redbud is a mid-successional species, so it does not persist as a forest matures because it cannot compete with later and taller successional species (Federal Sylvics Manual).

Because redbud is a species associated with disturbed habitats and younger forests, a difference in the abundance of this species between the two forest plots can be useful in explaining what factors affect the distribution of redbud. Therefore, our hypothesis was that there would be more redbud in the young forest plot because it has more sunlight exposure.

Study Area

We conducted this study in October, 2011 on two forest plots around Raystown Lake. Raystown Lake is located in Huntingdon County in central Pennsylvania. The Army Corp of engineers owns and manages the property surrounding the lake (Fig. 1).

One of the sites, the old forest (Fig. 2), is partially located on state land while the remainder is located on a campground leased by the Army Corp of engineers (Fig. 1). One boundary of the plot is next to a water storage tank amongst a clearing. A second boundary of the old forest plot is bordered by a recent forestry cut. It is a mature forest that has been growing for approximately 120 years probably since the last logging boom in the area (Yohn 2011). It is composed predominately of maples and mixed oaks especially chestnut (*Quercus prinus*) and white oaks (*Quercus alba*). The trees grow to approximately 70 ft with very little regeneration or understory species. No invasive plant species were observed in the plot. It has a northwest facing slope with an approximate percent rise ranging from 34 to 53% (Personal Observation). The average soil pH is 5.2 (unpublished data set 2011)

The second plot, the young forest plot (Fig. 3), is located entirely on Army Corp property in forest compartment 10 (Fig. 1). The plot had once been a pasture as evidenced by the barbed wire fence that borders part of the property. The land had been abandoned approximately 30 years ago when the Army Corp acquired the land, so the forest has been growing for about 30 years. The plot is bordered on one side by a gravel road. The dominant tree species in the young forest plot are redbud, black locust (*Robinia pseudoacacia*) and some mixed oaks with trees reaching approximately 40 ft with little canopy cover (Personal Observation). The understory is dominated by invasive species including autumn olive (*Elaeagnus umbellate*), multiflora rose (*Rosa multiflora)*, grapevine

(*Vitis vinifera)*, honey suckle and Japanese honeysuckle (*Lonicera*) (Jackson 2011). The young forest has a southeastern facing slope with a slope ranging between 0 and 43% rise (U. S Geological Survey 2000). This forest plot is also 150ft higher in elevation than the old forest plot (Personal Observation). The soil pH is the young forest plot is approximately 4.9 (Unpublished Data Set 2011).



Figure 1. Location of Army Corp property and the forest plots in Huntingdon County, Pennsylvania,



Figure 2. A representative photo of the understory in the old forest plot, Huntingdon County, PA



Figure 3. A representative photo showing the understory of the young forest plot in Huntingdon County, PA

Materials and Methods

We chose two 100 by 200 meter plots to conduct the study. One plot was an older aged forest and the second plot was a younger aged forest (Fig. 1). The plots were chosen based on a number of differing characteristics including species type, species abundance, understory growth and forest maturity. Within each plot we established 5 100 meter transects and randomly selected 5 25m x 25 m subplots (Fig. 4 and 5)

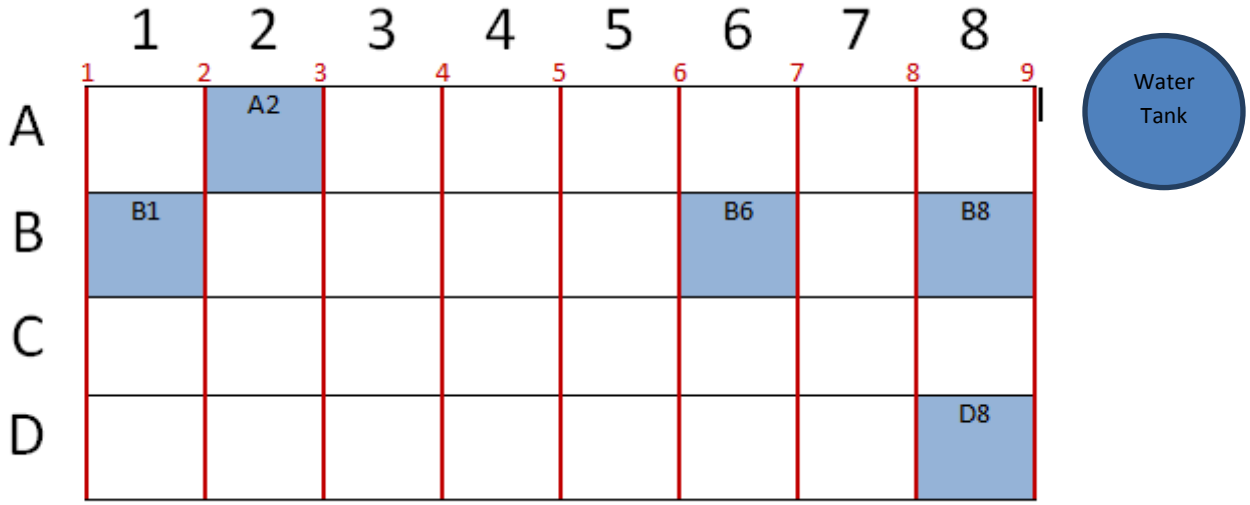


Figure 4. The 5 randomly selected subplots in the old forest

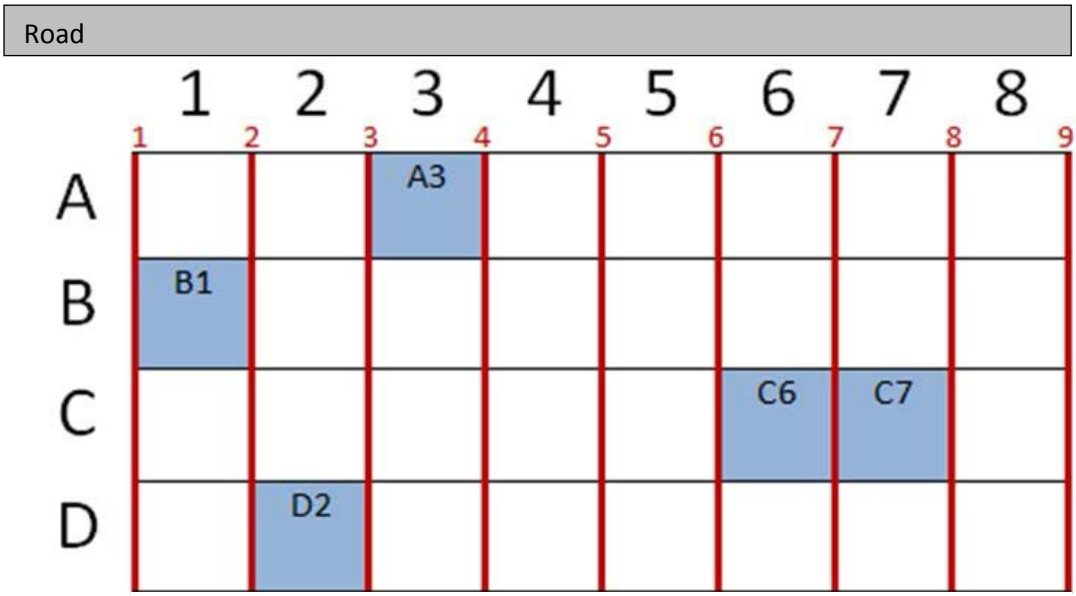


Figure 5. The 5 randomly selected subplots in the young forest

To calculate the population of redbud within each forest plot, we used two different methods. In the old forest, we found a total count of redbud because of their low density and counting was easy due to the open nature of the understory. In the young forest plot, there was a very high density of redbud, so we counted the number of redbud individuals within the five randomly selected subplots and calculated an approximate density. We

compared the known plot density of the old forest to the estimated density of the young forest with a one sample t-test (Minitab 2010).

We used the 5 subplots in each forest plot to collect soil samples. Soil was taken from the center of the 25 by 25 meter area. In order to measure the moisture content, we used a grviometric method (Schneekloth 2011). We compared the variances in site soil moisture using a Levene's test and then compared soil moisture of the two plots using a two sample t test (Minitab 2010).

Slope was found using a clinometer manufactured by Suunto. We read the angle of the slope using the clinometer every 25 meters along the five randomly selected transects and converted the angles into percent rise. We used a Levene's test to compare variances in slope between both forest plots, and then we performed a two sample t test (Minitab 2010).

Canopy cover was measured using a homemade densiometer. We walked through each randomly selected subplot in each research area and every two steps recorded when a leaf fell in the crosshairs of the densitometer. We used these data to determine the percent canopy cover in each research plot. We compared variances in canopy cover between each plot using a Levene's test and then performed a two sample t test on the data (Minitab 2010).

In order to compare the aspects of each forest plot, we used the aspect function in ArcGIS to create a map of aspect on a Huntingdon County raster file (ArcGIS 2010). We also verified these findings using a compass.

Results

We found no redbud individuals in the old forest plot and found a mean density of 71.2 redbud individuals per hectare (41.9 ±SD) in the young forest plot . There was a significant difference between the numbers of redbud individuals in the young forest plot versus the number of individuals in the old forest. (t= 3.8,DF=5 p =0.01).

The average mean soil moisture in the old forest plot was 3.6 mL of water lost per gram (SD ±0.64). The average mean soil moisture in the young forest plot was 3.90 mL of water lost per gram (SD± 0.82). The difference between soil moisture was not significantly different (t=0.94, DF=16, p=0.36).

The average percent slope in the old forest was 36.4% (±8.41 SD). The average percent slope in the young forest was 27.96% (SD±18.49). The differences in slope were not statistically different (t=0.93, DF=5, p=0.4)(Table 3).

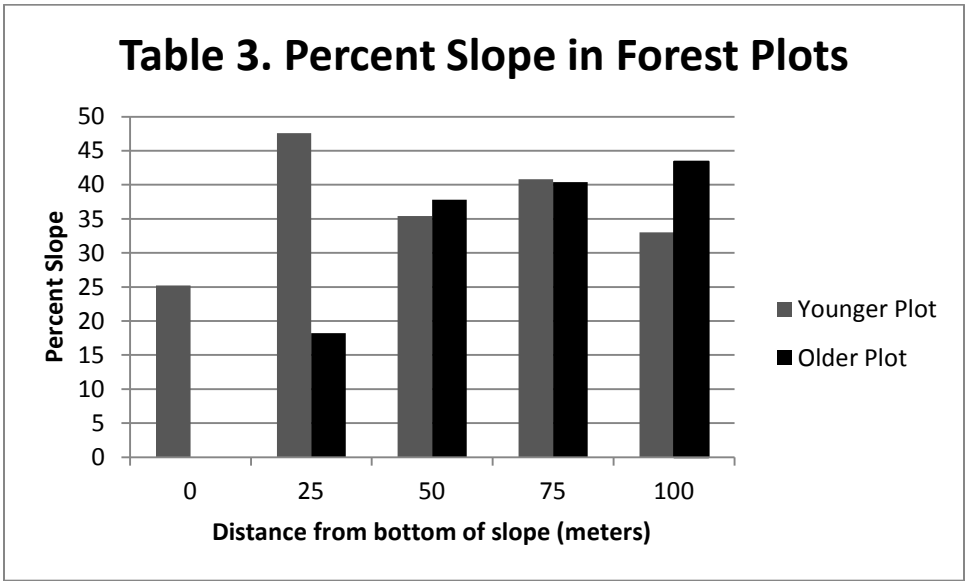


Figure 6. percent slope along the 25 meter transects of each forest plot

The mean canopy cover in the old forest plot was 80.6% cover (SD± 7.4). The mean canopy cover in the young forest was 59% cover (SD±4.93). There was a significant difference between canopy cover in the two forest plots (t=-5.23, DF=6, p=0.01).

We determined that the aspect of the old forest to be northwest and the aspect of the young forest plot to be southeast (Fig. 7).

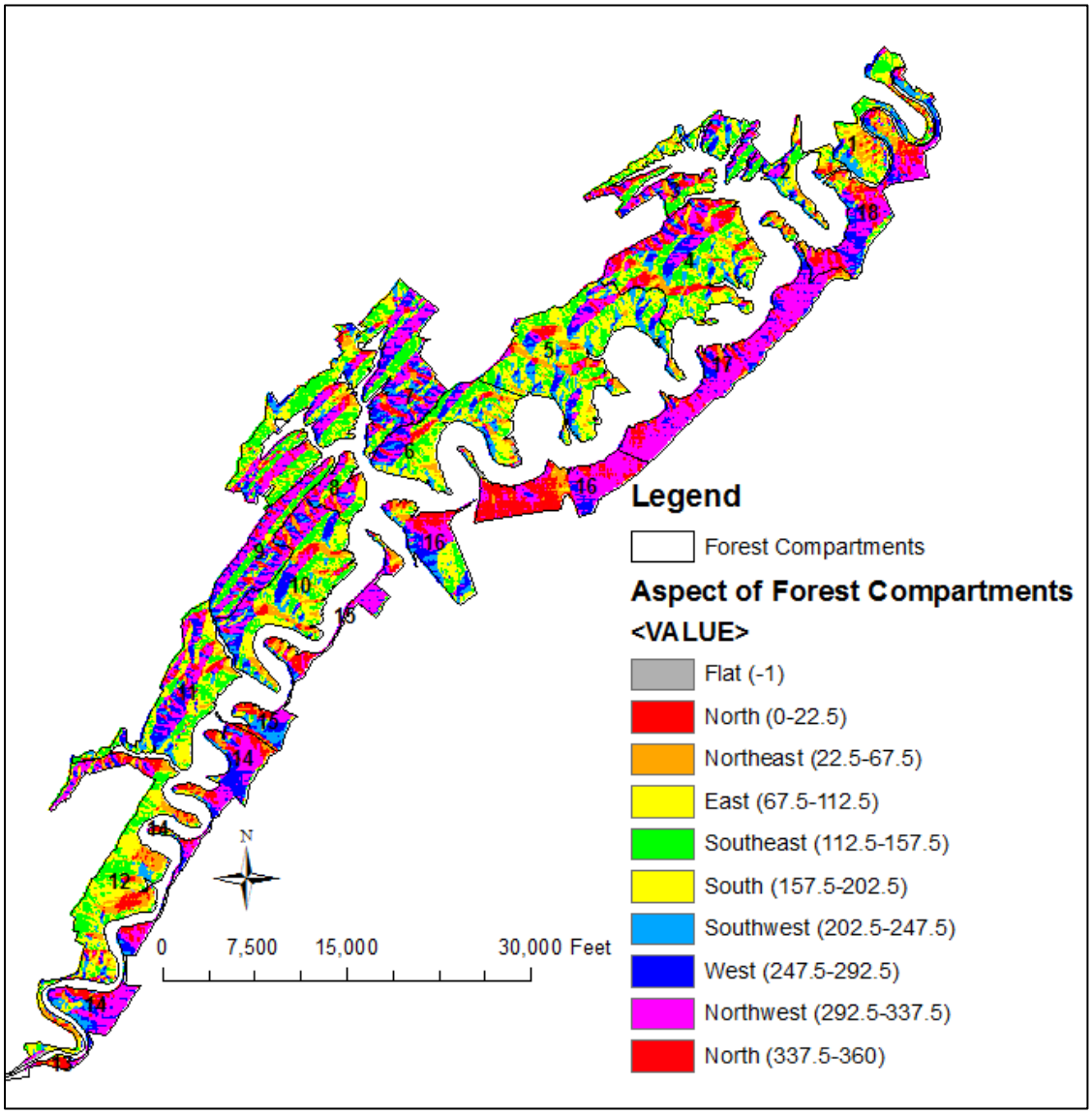


Figure 7.Aspect of the forest compartments identifying the down slope direction in relation to North, South, East and West and in degrees where 0° and 360° is North in Huntingdon County, PA (U.S. Geological Survey)

Discussion

There were no redbud individuals found in the old forest plot where, in contrast, redbud was one of the dominant species in the young forest. Because redbud is a midstory species that colonizes disturbed areas, the distribution of redbud indicates that redbud in the forest compartments around Raystown Lake demonstrate a typical redbud distribution pattern (Federal Sylvics Manual).

There was no significant difference between the soil moisture content of the two plots, so soil moisture between the two forest plots had no influence on the distribution of redbud. This indicates that other factors were more influential in determining the distribution of redbud in the two plots.

Slope also had no affect on the distribution of redbud in each of the forest plots because there was no statistical significance between the slopes indicating that slope was not an important limiting factor of redbud distribution. This indicates that there are other environmental factors present in these forest plots that are more influential in determining the abundance of redbud in the forest plots.

Our study did show that canopy cover between the two plots was significantly different. There was higher canopy cover in the old forest than in the young forest. This finding is consistent with known distribution patterns of the eastern redbud. Because the redbud is a sun loving species, the species is more successful in the young forest where there is more light exposure (Federal Sylvics Manual). Outside of the old forest plot by

approximately two meters, we found two redbuds where the plot transitioned to a clearing further supporting the importance of sun exposure for the distribution of redbud.

Another environmental factor affecting sun exposure is the aspect. The old forest had a northwestern facing slope in contrast to the southeastern facing slope of the young forest. Because the study site had a southern facing slope, it also would have greater sun exposure supporting the success of redbud in the young forest plot because of their need for abundant sunlight (Federal Sylvics Manual). This is consistent with our findings of redbud distribution.

Overall, these findings supported the known distribution patterns of the redbud because more redbud individuals were found in the younger forest at a younger successional stage. We also found that certain environmental factors were more important in the distribution pattern of redbud. Sunlight proved to be the most important factor in the tree's distribution patterns because redbud individuals were more abundant in the young forest where aspect and canopy cover promoted greater sun exposure. In contrast soil and slope showed no significant difference between the two plots, so they were not important in the distribution of redbud for this study.

Because redbud is prominent in disturbed forests, it could be valuable to study how the presence of redbud and other pioneering species in each of the forest plots will affect the characteristics of each forest in the future.

Acknowledgements

We would like to thank Dr. Chuck Yohn for his continued guidance throughout the project. We would also like to thank the other professors at the Raystown Field Station for their continued support on this project, and we appreciate the assistance of the students at the Raystown Field Station for collecting the data used in this study.

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"Effect of Dairy Farming on Local Stream Nitrate Levels"

KaLynn Kline
Raystown Field Station
Saint Francis University

Abstract

This study investigated the influence of dairy farming on nitrate levels in streams surrounding several dairy farms near Lake Raystown in Huntingdon County. Water samples were collected at a natural spring on a dairy farm, at two sites in between the first farm and a second smaller dairy farm, and finally at a creek that was just past a third farm. By sampling at different points in this interconnected waterway I predicted the levels of nitrates would rise as a direct result from the nitrate runoff associated with farming and livestock. The water samples were analyzed using the HACH test for nitrates and a statistical analysis was conducted using the Minitab program. Preliminary results show that the highest nitrate levels are concentrated around the first and largest dairy farm and then decrease slightly as they approach the second and third farms. Additional water sources actually helped dilute the level of nitrates at the final sampling site before the water reaches Lake Raystown.

Comment [E1]: what test

Comment [E2]: keep tense constant

Introduction

Nitrate (NO_3) is a naturally occurring, odorless and colorless compound that is essential to plant growth and can be found in soil.[1] Nitrates are a valuable part of the nitrogen cycle and essential for the survival of many organisms, but keeping health levels of nitrates is an ongoing task. Nitrates form when microorganisms break down fertilizers, decaying plants, manures or other organic residues. Usually plants take up these nitrates, but sometimes rain or irrigation water can leach them into groundwater.[1]

Comment [E3]: citation style

Nitrate levels are characteristically higher in farming regions that use fertilizers on their fields or have large numbers of livestock. Fertilizers that contain potassium nitrate or ammonium nitrate greatly increase the level of nitrates if they are applied in excess and run off into surrounding creeks.[2] Livestock also contribute to this problem as manure and feedlots are also sources of nitrates. One final point to think about when considering nitrates is how many compounds can break down into other forms such as nitrites and ammonia which eventually break down into nitrates.

Comment [E4]: unclear point

Monitoring the levels of nitrates in water is also valuable because high levels of nitrates in drinking water can be detrimental to human health. Excess levels of nitrates is harmful for animals especially cattle who which can suffer from nitrate poisoning.[3] A recent United States Geological Survey study showed that more than 8,200 wells nationwide were contaminated with nitrate levels above the U.S. Environmental Protection Agency (EPA) drinking water standard of 10 parts per million (ppm).[2] This statistic especially rings true for wells within such close proximity of farms that regularly use fertilizers on their fields and have large numbers of

Comment [E5]: is this a result?

livestock. The first dairy farm in this study, Farm A, had upwards of 300 dairy cows and at some point every field has been regularly fertilized.

I tested the ~~The~~ hypothesis ~~in this study was~~ that the levels of nitrates would increase as the waterway was exposed to an increasing number of farms. I predicted that as the creek was exposed to more fields and pastures that support livestock, the nitrate levels in the water would increase. This type of study is valuable to local farmers as they are being encouraged to find out what type of impact their work is having on creeks and water surrounding them. However many times these farmers may lack the time or means to conduct this type of research but are still concerned about the effect their farming is having on the environment.

Comment [E6]: put is discussion

Materials and Methods

All water samples were collected within one hour of each other on warm, sunny day in late March. Ten samples were collected at each of the four sites and stored in 50 mL Nalgene bottles. The samples were collected ~~at the relatively the same point at each site making sure it was an~~in areas with good water flow and no standing pools of water. The samples were then stored in a refrigerator ~~until they were~~ and were analyzed within 48 hrs. ~~It was important to keep the samples refrigerated and process them within 48 hours of collection in order to preserve any nitrates in the samples.~~ The sites were determined by initially identifying the water source on the first dairy farm, Farm A, and then following the water as it traveled through their property, under Route 26, past another two farms (Farms B and C) on the opposite side of the road, and finally to creek that would eventually lead to Lake Raystown. The first collection site was the spring where the water originated from at the property line of Farm A. The second sampling site was at the other end of Farm A, downstream from their fields and pastures for the cows. The third sampling site was across Route 26 and adjacent to a second dairy farm, Farm B. The fourth and final sampling site was downstream from a third farm, Farm C, which had a considerable lesser amount of livestock than the first two farms.

Comment [E7]: between what times

Comment [E8]: cite

Comment [E9]: maps and diagrams would help here

Samples were analyzed using the HACH test kit and accompanying procedures. After the samples were retrieved the spectrophotometer was set for the nitrate testing program. 10 mL of the first sample was poured into the cuvette and the contents of one NitraVer 5 Reagent powder pillows was emptied into the cuvette. A timer was set for one minute during which the cuvette was repeatedly inverted. After this it was allowed to sit for five minutes after which another cuvette was filled with 10 mL of the sample and programmed to serve as the blank. During this time the cuvette with the reacting turned a light shade of amber to indicate the presence of nitrates. After the blank was zeroed in the spectrophotometer the sample was read and the amount of nitrates present recorded in mg/L NO^{-3} M. Once all of the samples were analyzed a statistical analysis of the data was performed using Minitab.

Comment [E10]: info not needed - just cite the proceedure

Comment [E11]: tell morw about the rest

Index of Images and Maps


Collecting samples


Sampling Site #1: Spring at Farm A


Sampling site #2: Lower half of Farm A


Sampling Site #3: Adjacent to Farm B



Sampling Site #4: Below Farm C



Collecting Samples



Figure 1: Map of Sampling Sites #1 and #2 and Farm A; Image taken from Google Earth



Figure 2: Map of Sample Site #3 and Farm B; Images taken from Google Earth



Figure 3: Map of Sample Site #4 and Farm C; Map Images taken from Google Earth

Sources:

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Study of the environmental effects on Pignut Hickory (*Carya glabra*) in two different habitats in Central Pennsylvania

Cory Mattas, Matthew Lear, Charles Sedor

Abstract

This study compared two sites in Central Pennsylvania between the months of September and November, 2011, for differences in Pignut Hickory (*Carya glabra*) abundance and Diameter at Breast Height (DBH). Soil moisture, soil texture, slope, and species density were the same between the two plots. DBH of the old forest plot was higher (43.6 ± 5.24 *SD*) than that at the young forest plot (25.3 ± 13.3 *SD*, p=0.043). Canopy cover differed between the old forest plot (77.4 ± 7.4 *SD*) than at young forest plot (56.6 ± 4.9 *SD*) (t= 5.32, d.f.=6, p= <0.01). No other differences were found between the two sites. Thus the two sites can be characterized as the same but in two different successional periods of forest regeneration.

Keywords: Carya glabra, Pignut Hickory, soil, forest succession

Introduction

Pennsylvania forest composition is primarily a deciduous hardwood forest. Pignut Hickories (*Carya glabra*) are the most common hickory tree found in the Appalachian Mountains, Pennsylvania's largest mountain range, as they tend to survive best in humid

climates on ridges with well-drained, loamy, limestone and shale rich soil (McCarthy 1984). Pignut Hickories in Pennsylvania grow quickly and close to 90 feet tall in their most preferred habitats (US Forest Service 2011). Deer browse on the nutritious parts, and small mammals and birds love the nuts produced (Sork 1983). Humans use the Pignut Hickory for many instruments including golf clubs and tool handles (Smalley 2011). Also Pignut Hickories are widely used to rehabilitate a recently disturbed area because of its ability to grow rapidly and provide habitat quickly (US Forest Service 2011).

When an area becomes disturbed, such as after a clear cut, the forest begins its regeneration cycle. "Each stage of succession creates the conditions for the next stage," (Martin 1996) starting with grasses and forbs taking over the exposed soil. In the Shrub-Seedlings stage, pioneer tree seedlings and shrubs begin to overtake the grasses. Once the tree seedlings begin to grow tall enough to overtake the shrubs and forbs, the forest is moving into the Sapling-Pole stage. Once the saplings wipe out the shrubs and start competing for space with other trees, the forest is considered to be a Young forest. In the next stage, the Mature forest, the shade intolerant tree species start to dominate the forest stand, causing mortality in tree competition. The last stage is the Climax stage, where the forest is mainly comprised of the tolerant species and only those species will be able to reproduce there. (Martin 1996)

This study compares Pignut Hickory in two different forest plots around Raystown Lake. Both plots were studied to determine if the two sites are the same forest type but in different forest succession stages or if they are two completely different forests.

Study Area

The study area was located in Central Pennsylvania, in land owned by Army Corps of Engineers surrounding Lake Raystown in Huntingdon County (Fig 1 and 2). This area is found in the Mid-Atlantic temperate climate region, with a mean temperature of 55 degrees Fahrenheit and total annual rainfall averaging around 40 inches (NOAA 2011).

Two general areas fairly close to one another, but different in many visual aspects, were chosen as the comparable test sites. The younger forest was located in Compartment 10 and the older forest was located in Compartment 14, both of which are on ACoE land (Fig. 3 and 4). The young forest plot was a generally Southeast facing plot, whereas the old forest plot was a Northwest facing plot (Personal observation). The young forest plot also was located on the west side of the lake, whereas the old forest plot was located on the east side (Fig. 2).

Within each compartment, a 100 meter by 200 meter rectangular plot was measured out and flagged at every 25 meter increment. The plot located in the young forest contained many pioneer species including Multiflora Rose (*Rosa Multiflora*), Japanese Honeysuckle (Lonicera japonica), and Black Locust (*Robinia pseudoacacia*), along with many small saplings and undergrowth (Fig. 6). The old forest plot was mainly a tall, mature, and even-aged stand including well established trees and very little to no undergrowth and saplings (Fig. 5). Soil samples collected showed no significant difference between the pH's of the two plots (Unpublished data). Soil texture data also showed a relatively insignificant margin between the young forest plot and the old forest plot (Unpublished data). The study occurred between October and November, 2011.

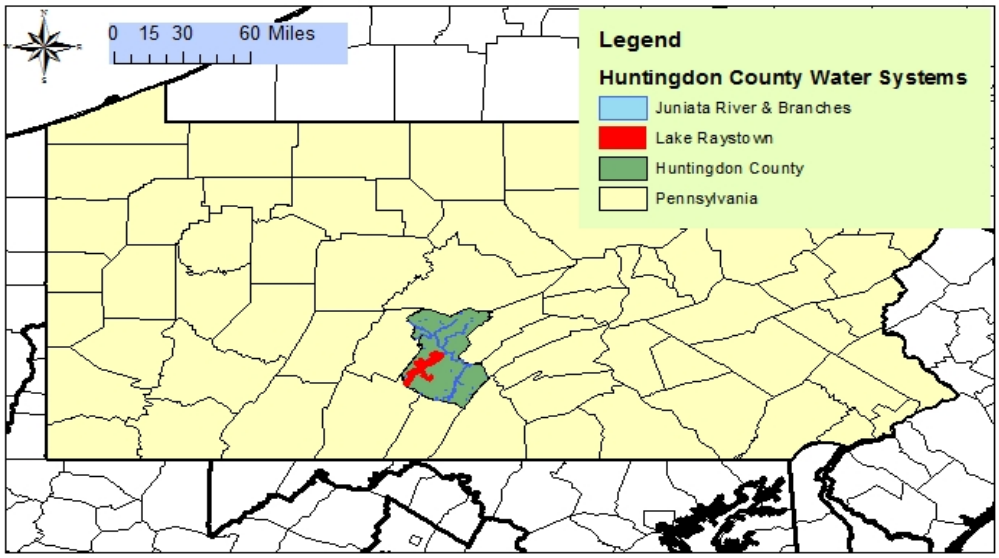


Figure 1: A map of Pennsylvania showing Huntingdon County and Lake Raystown highlighted in red.

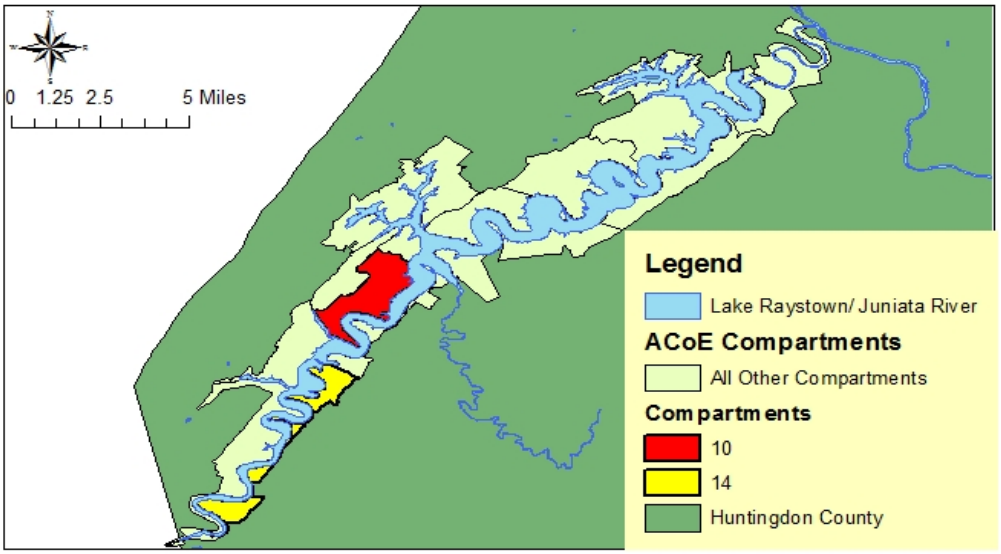


Figure 2: A map the shows Lake Raystown and the land Army Corps of Engineer's owns surrounding it. Compartment 10 and 14 are highlighted showing where the two sites are located.

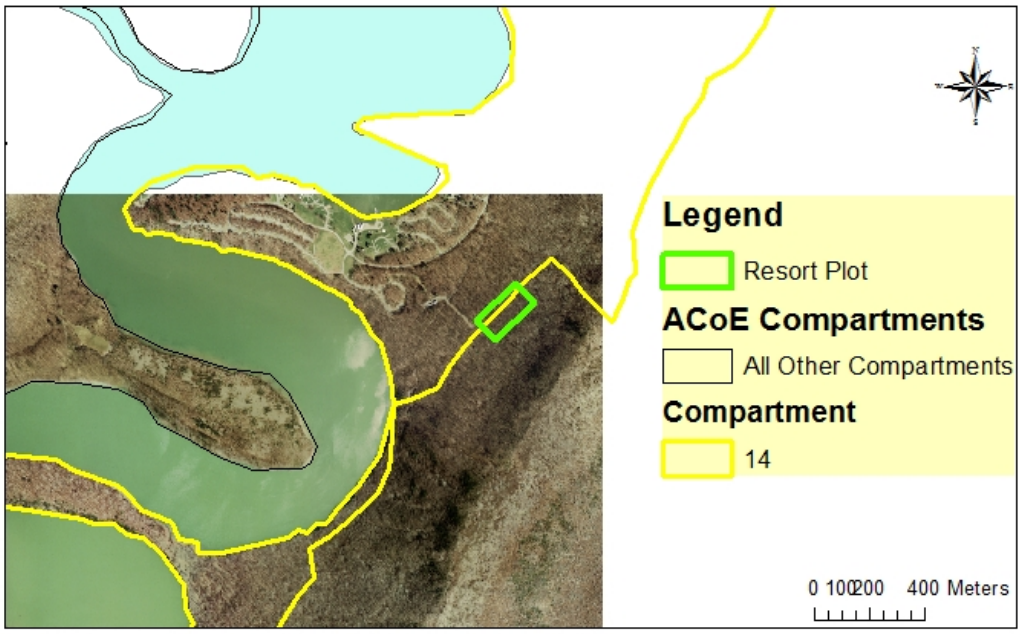


Figure 3: A map of Compartment 14 that encompasses the old forest plot.

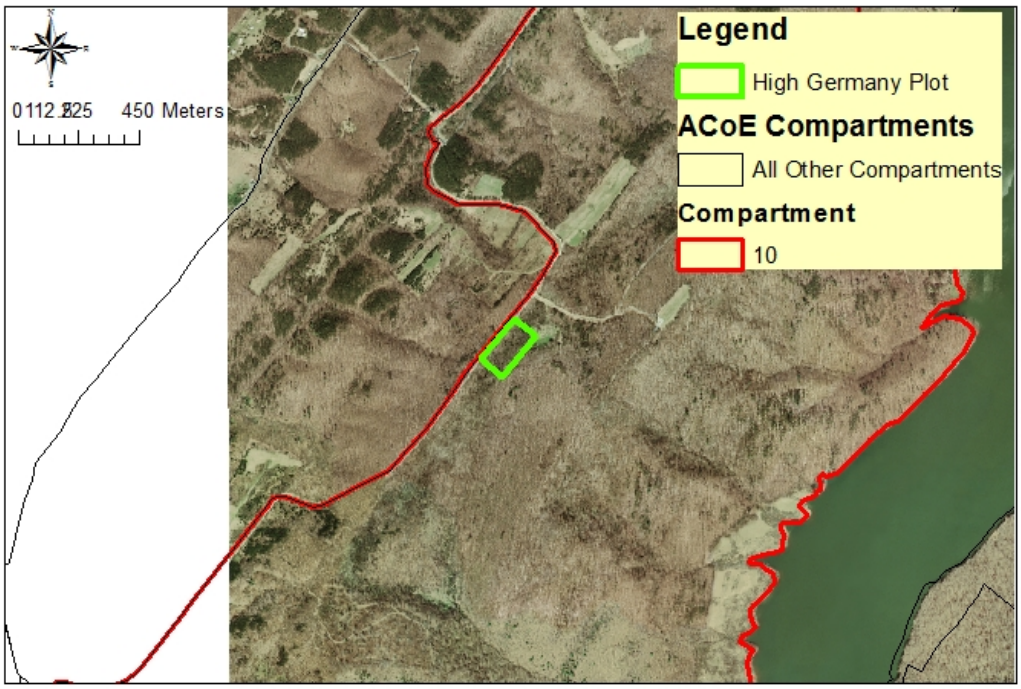


Figure 4: A map of Compartment 10 that encompasses the young forest plot.



Figure 5: A picture of the old forest plot on October 26, 2011, showing the mature trees and lack of undergrowth.



Figure 6: A picture of the young forest plot taken on August 30, 2011, showing the dense undergrowth and small trees.

Methods

Test sites

Two 200 meter by 100 meter rectangular plots were measured and flagged off, one plot in each site. Five 25 meter by 25 meter square subplots were randomly chosen in each forest for use in sampling.

Soil Sampling

To gather soil samples from both test sites and each subplots, collectors went to the center of each subplot and collected soil. All soil samples were collected within two hours on the same day so soil conditions stayed comparable.

Species Density

All Pignut Hickory trees in each subplot were counted and recorded. The trees that were considered pole timber or older were measured for DBH using a Logger's tape (Burton 2008). Using the density of the five plots, an estimated distribution of Pignut Hickories was determined by dividing total area over the density of the subplots. The species density of the young forest plot was compared to the old forest plot using a Mann-Whitney U test.

Soil Moisture

Soil samples from each subplot of both site plots were measured for soil moisture content based on the gravimetric method (Bauder 2011). The scale used was a OHAUS

Scout Pro. The soil moisture of the young forest plot was compared to the old forest plot using a two-sample t-test.

Soil Texture

Texture of the soil was determined using the flowchart outlined by the Natural Resources Conservation Service (NRCS), a department of United States Department of Agriculture (USDA) (NRCS 2011).

Canopy cover

To estimate canopy cover, each subplot was split using 8 transects. Along each transect, ocular tube readings were recorded every estimated three feet for the entire length of each transect. The recorder looked up randomly and recorded whether the crosshair on the ocular tube was over canopy or the sky (David 2010). The canopy cover of the young forest plot was compared to the old forest plot using a two-sample t-test.

Plot slope

To determine slope for each plot, some of the division lines dividing the plots into subplots were used as transects. The division lines that determined the five subplots randomly picked were used as transects in order to achieve a more accurate slope representation since the rest of the data collected used just the five subplots in each plots. A clinometer was used to read the slope at every 25 meter intersection on each transect, and the data was recorded for each collection point. The plot slope of the young forest plot was compared to the old forest plot using a two-sample t-test.

Results

The two forest plots had statistically similar densities (p=1.0). DBH, however, was significantly different between the two plots. The young forest plot had a mean DBH of 25.33 ±13.27 *SD* inches and the old forest plot's is 43.63 ± 5.24 *SD* inches (p=0.043). Soil moisture did not differ between the two plots with the young forest plot's at 3.9 mL ± 0.82 *SD* mL and the old forest plot's moisture at 3.6 mL ± 0.64 *SD* mL (t=0.94, d.f.= 16, p=0.359). Soil texture was found to be the same throughout the site plots. The old forest plot was shown to have a higher canopy cover versus the young forest plot. The old forest plot canopy had a mean of 80.6% ±7.4% *SD* and the young forest plot mean was 58.9% ± 4.9% *SD* (t=5.23, d.f.=6, p=<0.01). Both plots also had insignificant difference between the slopes. The old forest plot had a mean slope of 36.4 ± 3.4 *SD* and the young forest plot had a mean slope of 27.96± 18.49 *SD* (t=0.93, d.f.=5, p=0.395).

Table 1: Mean ± *SD* of environmental factors measured in the young and old forest plots located around Lake Raystown, Pennsylvania, October-November 2011. Tree densities and DBH measurements are those of Pignut Hickory (*Carya glabra*) trees found within the plots.

Location	Tree density (trees/ha)	DBH (in)	Canopy cover (%)	Soil Moisture (mL)	Slope (% rise)	Soil Texture
Old Forest	12.8 ±7.8	43.6 ±5.2	80.6 ±7.4	3.6 ±0.64	28.0 ±18.5	Clayloam
Young Forest	19.2 ±15.5	25.3 ±13.3	58.9 ±4.9	3.9 ±0.82	36.4 ±8.4	Clayloam
p value	1.0*	0.043	<0.01	0.359	0.395	

*Not enough data acquired to run accurate statistics

Discussion

The young forest plot's soil moisture, soil texture, and percent slope did not statistically differ. Statistics showed tree density to be similar, but insufficient data resulted in a poor *p* value, and more data collected could show a different result.

Pignut Hickory's moisture use is about medium, and it has a high drought tolerance (Conservation 2011). This means soil moisture can range greatly without affecting the

species ability to survive (Conservation 2011). The results of both the young forest plot and old forest plot show a relatively even amount of soil moisture in both. That coincides with soil texture, as soil texture for both is a clay and loamy mix. Based on the statistics of how the numbers of Pignut Hickories are indifferent between the two plots, it makes sense that the soil moisture and texture would be relatively indifferent as well.

Pignut Hickory is found to be a ridge species, which means it prefers to grow in well-drained ridge tops and sloped sides (Smalley 2011). The slope data collected from both plots show that the two sites have relatively the same slope. With both slope means similar, both plots should have similar Pignut Hickory density.

Canopy cover between the two plots differs greatly as the young forest plot has a lower percent canopy cover but a higher density of undergrowth including Multiflora rose, Greenbriers, and dense seedlings (Personal observation). The old forest plot on the other hand has a very high percent canopy cover and barely any ground cover.

Statistically the DBH between both sites was significantly different. The young forest plot had a dramatically lower DBH than that of the old forest plot.

Based on the results that species density, soil moisture, soil texture, and slope are the same and canopy cover and DBH differ between the two sites, the young and old forest plots can be said to be the same sites but in different successional timeline. The young forest plot is at an early successional stage in between a Sapling-Pole stage and Young stage, whereas the old forest plot is at the Mature stage. A Sapling-Pole stage can be characterized as a young forest with dense undergrowth and rapidly growing intolerant trees (Martin 1996). Just looking at the Figure 6, one can classify it as in the Sapling-Pole

stage, with the intense undergrowth and invasive species present (Personal Observation). DBH backs this up by having a smaller diameter in Pignut Hickories found in the younger forest plot. Also canopy cover was significantly lower in this plot because of the lack of tall, mature trees present. A Mature stage can be characterized as a tall forest with dominating tolerant and some intolerant tree species (Martin 1996). Looking at Figure 5, one can classify the old forest plot as at the Mature stage, just based on the lack of undergrowth, tall trees, and tree species present (Personal Observation). DBH in this plot solidifies this by having a higher diameter in the Pignut Hickories found in the old forest plot. Also canopy cover is significantly higher in the old forest plot, because of the tall, broadleaf trees.

Limitations

More data points would help with sampling error and solidifying statistics. The tree densities were greatly affected by the small amount of trees found in the plots. Testing a larger plot and including the samples found in the plot will result in a better statistic test. Also, testing for alkalinity would also help to improve the study because Pignut Hickory is affected by a soil's alkalinity (Smalley 2011). Pennsylvania is known for its limestone composition and its buffered soils (Laughlin 2003). Comparing these two plots to plots with measurable different alkalinity should give the study a stronger thesis.

Acknowledgements

I would like to thank Dr.'s Doug Glazier, Denny Johnson, and Chuck Yohn as well as Chris Bomgardner for their help and guidance in many aspects of this research and paper. I would also like to thank Elyzabeth Engle, Julie Glass, Maxwell Martin, Dale Motley, Eleanor Provias, Joel Rhodes, Christopher Rodgers, Joshua Sabulsky, Rebecca Strohm, and William Young for all their help in researching materials and analyzing data. Also, I would like to thank Jeff Krause and Glenn Werner of the US Army Corps of Engineers for their involvement.

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A Comparative Analysis of Red Maples (*Acer Rubrum*) & Environmental Factors in Two Different Aged Forests

By:

Christopher Rodgers, Dale Motley, & Joshua Sabulsky

Abstract

This study compared red maple (*Acer Rubrum*) abundance in two different aged forest plots with similar abiotic characteristics. The environment factors that were looked at included canopy cover, ground cover, soil texture, and soil moisture.

The young forest plot (apx 38 yrs old) had a significantly greater density in red maple (14.5/ha) than the mature forest plot (apx 120 yrs old) (6.4/ha) (T-value 0.78, P-value 0.476). Canopy and ground cover were significantly different at both sites. The young forest had an average 21.7% less canopy cover than the mature forest. The statistics for canopy cover support this (*t-value* = -5.24, *P-value* = 0.001, *DF* = 8). In the young forest there was an average of 32.4% more ground cover than the mature forest (*t-Value* = 4.53, *P-Value* = 0.004, *DF* = 6).

In both forests, clayloam was found to be the dominant soil type. Soil moisture was found not to be significantly different in both forests (*t-Value* = -0.94, *P-Value* = 0.359, *DF* = 16) and had a standard deviation of 3.9 +/- .82ml in the young forest and an standard deviation of 3.6 +/- .64ml in the mature forest. Forest age was the most significant driver behind the abundance of red maples and not the abiotic factors.

Keywords: *Acer Rubrum*, red maple, distribution, ecological succession

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Introduction

Native Americans and European settlers helped change the forest composition around the state of Pennsylvania. Native Americans changed the landscape by regularly burning the forest to drive game, improve visibility, facilitate travel, and provide browse for deer and cattle

(Black, Abrams, & Ruffner, 2006). Burning the forest helped mix oak species become more abundant (Abrams, 1992). The European settlers deforested the woods by logging and mining which also changed the forest landscape (Abrams, 1992). Due to the deforestation, European settlers cut mature forests which made it possible for regeneration of tree species to occur (Abrams, 1992). Probably the first event that modified the oak dominated forest landscape of the Eastern United States was the conversion of millions of acres of forest land to pasture for crops and farm animals (Smith, n.d.). The species of trees that were common back then included the American chestnut (*Castanea dentate*), mixed oak (*Quercus*) species, and mixed hickory (*Carya*) species (Yohn, 2011). The deforestation changed the landscape of central Pennsylvania's forest and transformed from oak species dominating in numbers into red maples (*Acer Rubrum)* outcompeting oak regeneration (Abrams, 1992).

Oak species held an important role in the Eastern United States for many years (Hartman and others, 2011). Oaks are a keystone species because over 5,000 species of insects, 58 species of reptiles and amphibians, 105 species of mammals and over 150 species of birds rely on oaks for some of their life cycle (Resource Conservation District of the Santa Monica Mountains, 2011). They also have an important economic role because they are one of the highest valued tree species in board foot. Although they are not as valuable as walnut (*Juglans)* species or cherry (*Prunus*) species, oaks are more abundantly used for making furniture and other accessories than the highest valued timber (Bomgardner, personal communication). A mixed-oak forest continues as the predominant forest type in central Pennsylvania forests, but since fire restrictions, land restrictions, and an increase in the deer population there has been little oak recruitment into the overstory (Abrams, 1992). Heavy oak regeneration is being

replaced by more shade tolerant species (Hartman and others, 2011). The most frequent competitor on oak sites in central Pennsylvania is red maple (Acer rubrum) (Hartman and others, 2011). If red maples take over as the dominant tree species they will have a negative affect on the economic industries (e.g. saw mills) and the ecological side. Compared to the oak species, red maple timber is often low in quality because of its sensitivity to defects and disease and poor form of individual trees (USDA NRCS, n.d.). The replacement of oaks by red maples is a major ecological disadvantage because so many animals depend on its bark and wood (Stevens, 1999). Numerous insects live in the crevice of the oak's rough bark, which birds depend on these for food (Stevens, 1999). Also, many nut eating species depend on the oak tree for food throughout the year (Stevens, 1999). Thus, understanding the factors that effect the abundance of red maple in the forest region around Raystown Lake thus has important economic and ecological implications. Therefore, this study looks at how different environmental factors effect the distribution of red maple (*Acer Rubrum)*.

Red Maple is one of the most widespread and abundant deciduous trees in the eastern half of North America (Abrams, 1998). Red maple is an early, mid, and late successional species (Abrams, 1998). It was once exclusively confined to low, wet areas (Stevens, 1999) Now they have moved out of the swamps and are now in the uplands (Stevens, 1999). In fact they can grow in poor or rich soil, in dry or wet land, in open sunlight or deep shade, in young or mature forest ones (Alexander & Arthur, 2010). It is likely to have the widest tolerance to climate conditions and can survive in a variety of soil types, pH, soil texture, soil moisture, and elevations than any other tree species in eastern North America (Abrams 1998). For the

prediction of the future composition of a young forest, it is important to understand the effects of successional stage and abiotic factors on the red maple.

Study Area

This study was conducted in a mature forest and young forest at Raystown Lake in Huntingdon County, Pennsylvania (Figs. 2-3). The climate around Huntingdon County has winters that are cold and dry and summers that are hot and humid (Nowacki and Abrams, 1994). Monthly average temperatures range from a high of 86.2 degrees to a low of 18.0 degrees (Netstate, 2011). Precipitation is normally abundant during the frost-free season; however, droughts periodically occur (Nowacki and Abrams, 1994).

The young forest is a 648 ha forest compartment located near Entriken, Pennsylvania (78°9'46"W 40°20'33"N) (Fig. 3). This is a relatively young successional forest that was once a pasture for livestock until the Army Corp. of Engineers bought the land in 1972 (Yohn, 2011). This forest is now abandoned and is approximately 38 years old (personal com.). It is located on the western side of Raystown Lake on a steep, southeastern-facing slope with an average 25% rise. This forest has dense ground cover that contains many invasive species such as multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), and honeysuckle (*Lonicera*). There are many tree seedlings that are also in the understory but it is questionable whether these seedlings are representative of the future forest because the dense invasive speices are shading them out.

The mature forest is a 475 ha forest compartment also located in Huntingdon County, Pennsylvania (78°10'45"W 40°17'23"N) (fig 3.) and is owned by the state of Pennsylvania. This

is a mature forest that has experienced no management since it was clear cut in the early 20th century (Yohn, 2011). We estimate this forest to be 120 years old, through tree coring. The mature forest floor is covered with small patches of hey scented fern and mostly large rocks Out of the 648 ha plot in the young forest and the 475 ha plot in the mature forest, our core study area was a 2 ha plot in both forest compartments (fig 3). The young and mature forest compositions consist of mixed oak and northern hardwoods (GIS).

Huntingdon County, Pennsylvania, USA

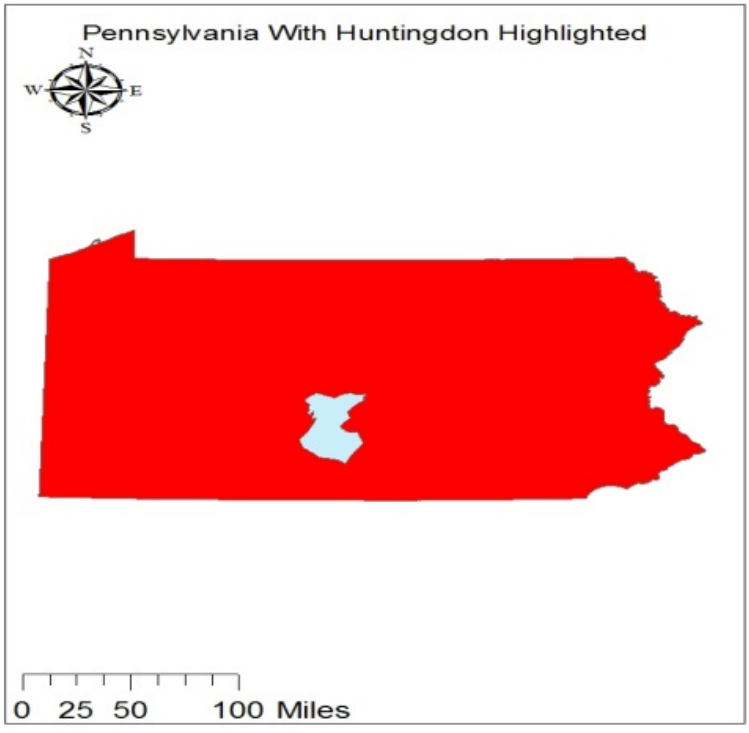


Figure 1: Huntingdon County in Pennsylvania.

Forest Plots Within the Raystown Lake

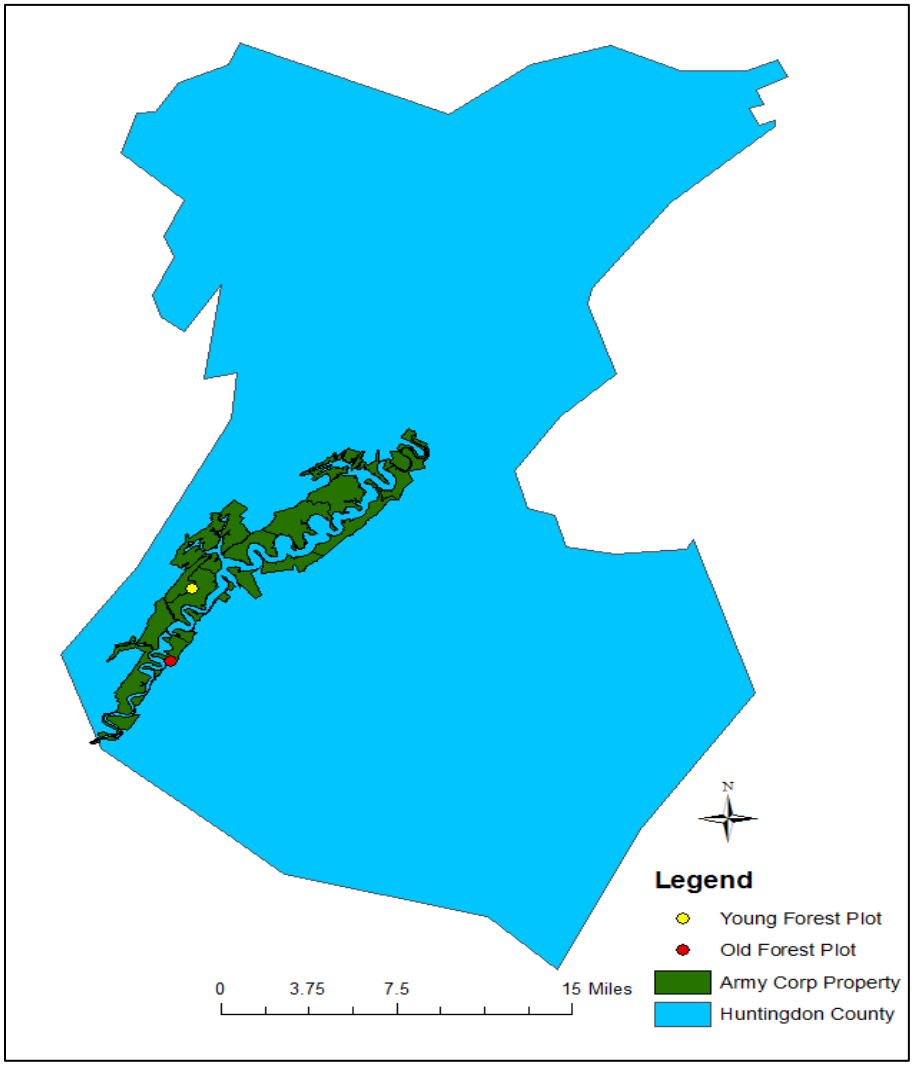


Figure 2: Location of younger and mature study plots at Raystown Lake, Huntingdon County, Pa.

Satellite View of Young & Mature Forest Plots

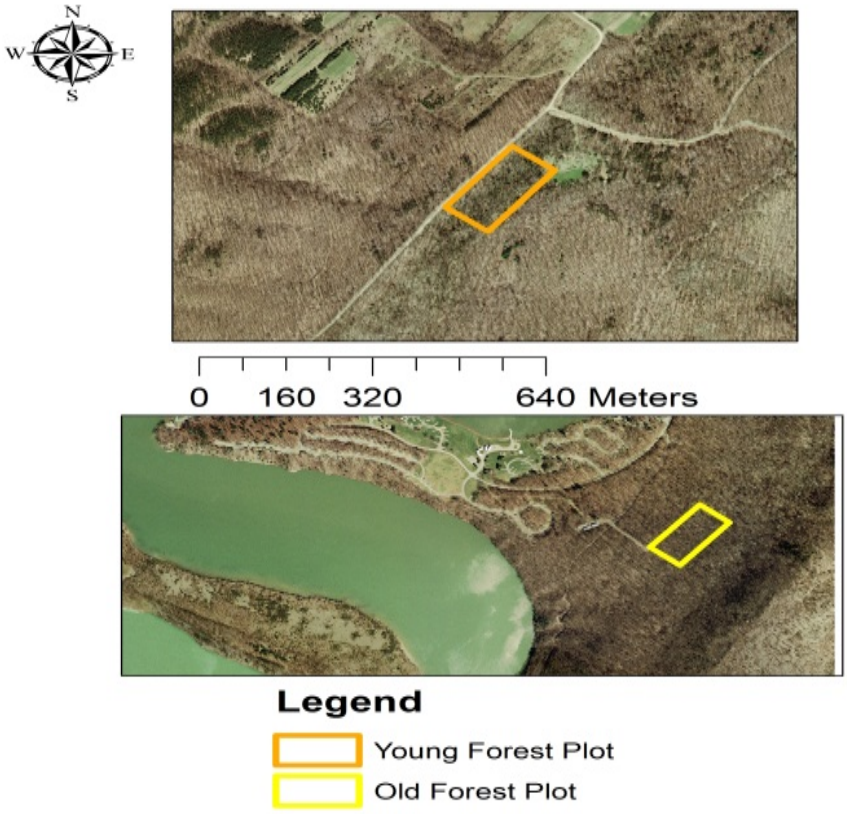


Figure 3: Satellite view of the young (top picture highlighted in orange) and mature (bottom picture highlighted in yellow) study plots.



Figure 4: An image portraying typical ground cover at the mature forest at Raystown Lake, Huntingdon County, Pennsylvania October, 2011. However, this picture does not depict the dense canopy cover that the mature forest exhibits because of the time the picture was taken.



Figure 5: An image portraying typical ground cover at the young forest at Raystown Lake, Huntingdon County, Pennsylvania September, 2011

Methods

The two forest plots were studied during the fall of 2011. In both plots we looked at soil moisture, soil texture, canopy and ground cover to determine the effects they have on the growth of red maple abundance. For both the young and mature forest plots we established five 25 x 25 meter subplots. Our group used the five random plots to determine ground and canopy cover. In each 25 by 25 meter plot, we took 96 samples of both ground and canopy cover using an ocular tube.

Soil texture and soil moister were also collected in the same five random subplots as previously described. We looked at the soil texture flow chart outlined by the United States Department of Agriculture (USDA) to determine the soil type present in both plots. For soil

moister, two replicate samples were collected for each subplot. Soil samples are analyzed using a standard gravimetric technique (DeAngelis, 2007**)**.

Our group used two different methods to determine the number of red maples in both forest plots. In the young forest we systematically counted every red maple tree within the two hectare plot. However, in the mature forest we only counted the red maples that were inside of the five random subplots within the two hectare border and estimated a density to represent how many red maples were in the entire of the two hectare plot. We gathered statistics by using the Minitab software. We tested normality of the data by running a graphical normality test to calculate the p-value. The one sample t-test was used to calculate the p-value so we could compare the relationship of red maples between the mature and young forests. Then we compared the density of red maples in the mature forest to the mean of red maples in the young forest. A p-value was calculated to compare the relationship of canopy cover between the two compartments among all ten randomly selected plots by using a Mann-Whitney test. Finally, a two sample t-test was used to compare value of soil moisture.

Results

Listed in table 1 is the average number of red maples for each of the five random plots in the mature forest. The mean of red maples in the young forest is 14.5 trees per ha. The 1 sample t-test between the average number of trees per plot in the mature forest and the mean per acre in the young forest were calculated (t= 0.78, p=0.476). Therefore, it rejects the null hypothesis that the two plots were significantly different.

Table 1 – the average number of trees per ha in each plot in mature forest

Plot	Average Trees Per Hector
1	0
2	32
3	0
4	16
5	90

The Two sample t-Test shows evidence that we reject the null hypothesis that the canopy cover for both the mature and young forest are not significantly different (t-Value = -5.24, P-Value = 0.001, DF = 8). The box and whisker plot illustrates the distribution of percent canopy cover in both forest plots.

Boxplot of Conopy For Young Forest, Canopy For Mature Forest

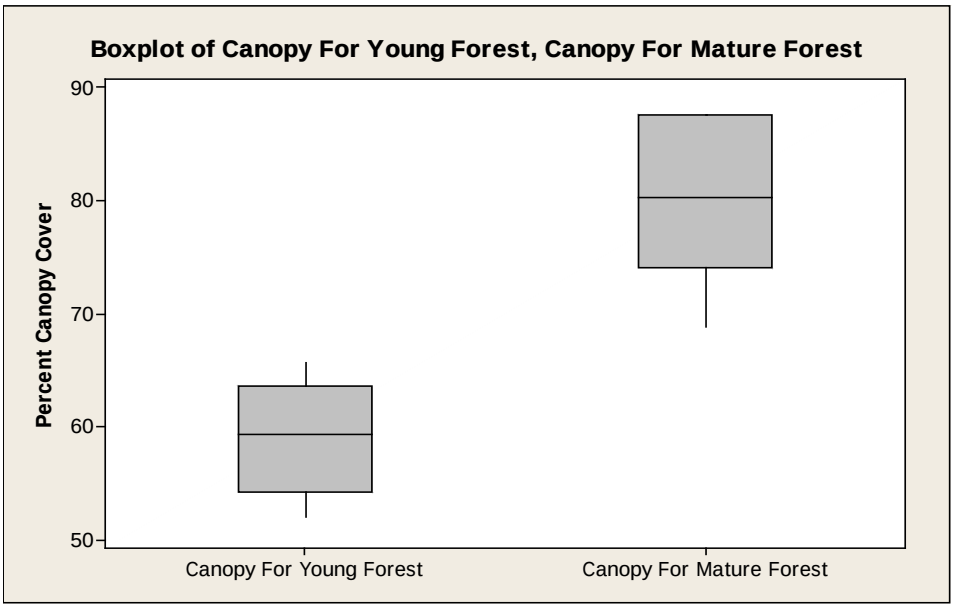


Figure 6.

The Two sample t-Test shows evidence that we reject the null hypothesis that the ground cover for both the mature and young forest are not significantly different (t-Value = 4.53, P-Value = 0.004, DF = 6). The box and whisker plot illustrates the distribution of percent ground cover in both forest plots.

Boxplot of Ground Cover For Young and Mature Forest

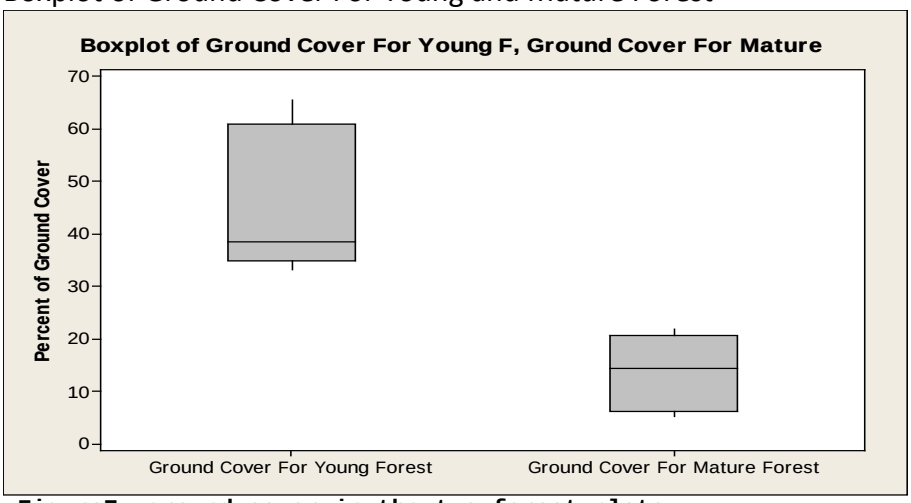


Figure7. ground cover in the two forest plots

Results and statistical analysis of soil moisture

The Two sample t-Test shows evidence that we reject the null hypothesis that the soil moisture for both the mature and young forest are not significantly different (t-Value = -0.94, P-Value = 0.359, DF = 16). The box and whisker plot illustrates the distribution of ML of water in the soils of both forest plots.

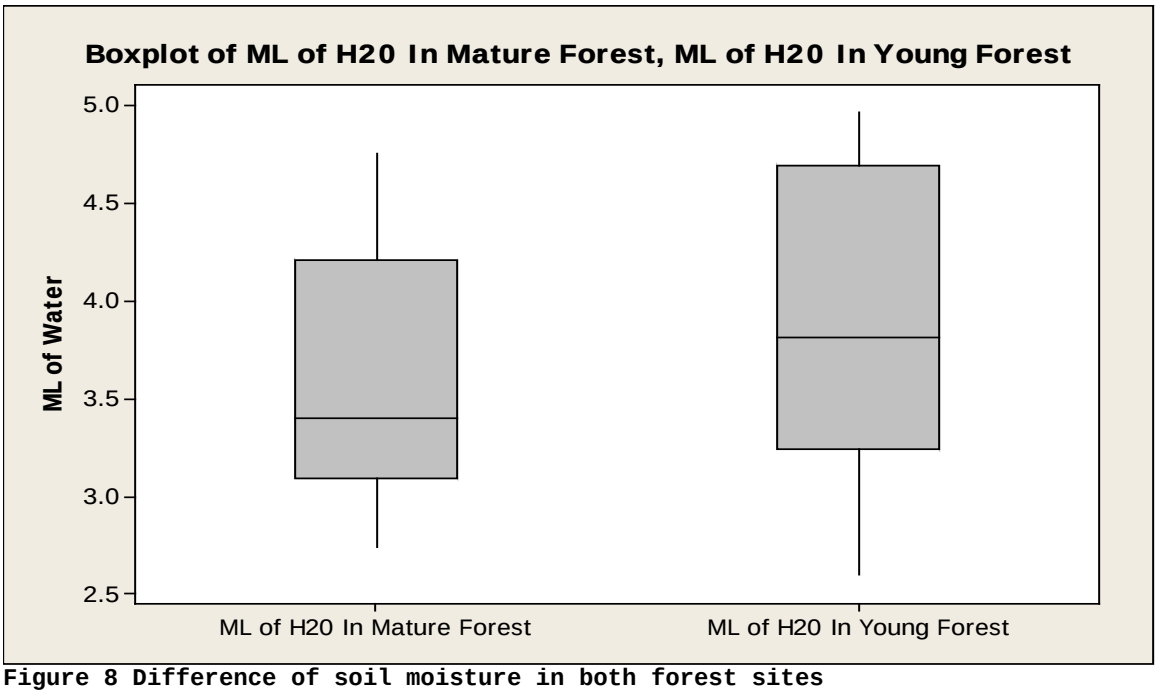


Figure 8 Difference of soil moisture in both forest sites

Soil Texture Results

Using the USDA's soil texture flow chart, we determined that in both forest sites the soil texture was clayloam.

Discussion

Discussion

Both plots were picked because we originally thought that these two forest sites would have different abiotic factors. However, when we looked at soil texture and soil moisture the statistics showed us that they were not significantly different. However, canopy and ground cover were significantly different in the two forest plots. The reason for this is possibly the age gap between the two forests. Through tree coring, the mature forest is estimated to be 120 years old and is an even aged stand. It's an even aged because the whole stand was clear cut at the same time (Yohn, 2011). Therefore, most of the standing trees are the same age and have similar characteristics. Whereas, the young forest stand is estimated to be 34 years in age and is at an early successional growth stage (Yohn, 2011). Early succession is the only period when tree canopies do not dominate the forest site (Swanson et. al, 2010). Therefore, early successional forests can be characterized by high productivity of plants and shrubs (Swanson et. Al, 2010) like the young forest.

The red maple has a wide range throughout the eastern part of the United States (Abrams, 1992). This is a drastic change from pre-European distribution (Abrams, 1992). During this time period red maple was a minor tree species in forest in the eastern United States. Red maples were once confined almost exclusively to low, wet areas (Abrams, 1992).

Now they are bursting out of the swamps and are moving into the uplands with force (Abrams, 1992). A possible reason that the red maple distribution is expanding so rapidly could be due to the implication of fire suppression (Abrams, 1998). Red maples are everywhere across different forest that varies in light, moisture, and nutrient availability (Abrams, 1992). Marc Abrams describes red maple as "the super generalist" because it does not require a lot of resources to thrive and it has characteristics of both early and late successional species (Abrams, 1992). Also, red maples also do many things well in wide variety of ecological conditions.

Oak species still persist as the predominant forest type in central Pennsylvania (Brose, 2011). However, oak regeneration is in decline due to some factors. A major factor is deer browse (Brose, 2011). Deer can drastically change the understory and the regeneration of many forests by eating shrubs, seedlings, and herbaceous plants (Tilghman, 1989). Oak species are highly desirable to deer especially when they are seedlings because it stands at a reachable height for deer to browse on (NRCS, 2007). However, red maples are undesirable to deer when they are seedlings (NRCS, 2007). This gives them greater odds to grow and become a mature tree. In the young forest plot, we saw evidence of deer browse on mix-oak species, sugar maple (*Acer saccharum)*, and other seedlings (personal obs.). Along with deer browsing the oak species also have to deal with a plethora of invasive species in the young forest plot. At the mature plot there is very little oak regeneration for the deer to browse on since it is a mature forest with a high canopy cover (personal obs.). Therefore, we saw little to no deer browse at the mature plot (personal obs.) However, the oak regeneration that occurs will be dominated by the deer.

Since the turn of the century invasive species have been a problem in central Pennsylvania's forest (Yohn, 2011). In the past couple decade's newer invasive species have entered the forest around the Raystown Lake area (e.g. multiflora rose) (Yohn, 2011). This is a major problem at the young forest plot. Since it is only a 34 year old forest that was once a pasture for livestock, it has been subjected to both older and more recent invasive species. These invasive are helping the red maples become the dominant species in this forest because they are shading out seedlings, like oak, that need maximum exposure to sunlight (DCNR, 2004). However, once the young forest reaches a mature successional stage, the canopy cover will block out the sun which will decrease the abundance of invasive species. Because of this there are few, if any, invasive species in the mature forest. This is due to the heavy canopy cover which provides enough shade that invasive species cannot grow and thrive.

Along with invasive species, forest pests are also contributing to the death of many trees. For example, the gypsy moth is now one of the most destructive pests of hardwood trees in the eastern United States (USDA Forest Service, 2003). Therefore, pests like the gypsy also have a drastic affect on our forests. Since gypsy moths kill mostly hardwoods, the red maple, which is a soft wood, will have a greater chance of becoming the dominate tree spices in our forest plots.

The best tactic for controlling the red maple is having a proper land management strategy. Red maples are very susceptible to fires because it is a soft wood tree. Since the enactment of fire suppression in the early 1900's more shade tolerant species, like the red maple, have been flourishing in our Pennsylvania forests (Hartman and others, 2011). Also, fire prevention programs teach people to how to prevent forest fires. For example, many kids are

introduced to characters like Smokey the Bear who has a slogan “only you can prevent forest fires.” However, recent thinking is that bringing back the fire regimes can help promote more desirable tree species, like oak, and impede the development of red maple competition (Hartman, 2011).

It has been found that the most effective way for controlling red maples by fire should occur during the spring and summer. This is due to the low carbohydrates that are in the rootstock which burned the fire more intensity (Hartman and others, 2011). A recent study recorded the affects of two low-intensity fires on maple regeneration across four different levels of canopy cover. The different levels of canopy cover included a clear cut, 25-percent residual canopy, 7-percent residual canopy, or uncut control. After two fires were set red maple densities dropped by 97.4% in the clear cut, 70.27% in the 25-percent residual canopy, 75.7% in the 75-percent residual canopy, and 103.3% in the uncut control (Hartman and others, 2011). Therefore this study supports the fact that to control red maples from competing with more desirable tree species controlled fires can have a major affect. Finally, if the management styles do not change in the mature and young forest we will see a drastic change from oak being dominant in these forests to red maple taken over in future years.

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The Effect of Environmental Factors on Shagbark Hickory, *Carya ovata,* Distribution Between Two different-age Forests in Huntingdon County In October, 2011

By William Young and Maxwell Martin

Abstract

Shagbark hickory, *Carya ovata,* is a species of hickory found throughout the eastern United States. It is of ecological importance for wildlife food and shelter. This study investigated why two forest sites on Raystown Lake (Huntingdon County, Pa) in relatively close proximity to one another have different distributions of this species. The younger site (38 yrs.) had greater abundance of hickory (32 indiv./ha ±23) than the older site(1indiv./ha±0) ($t=3.06$, $p=0.019$). Several environmental factors were also analyzed, including soil moisture, slope, and aspect. Soil moisture and slope did not differ between the sites. However, aspect was different, with the younger stand facing southeast and the older stand facing northwest. We conclude that aspect and relative soil types recorded by US soil survey of Huntingdon County were the driving forces behind the density differences in the sites.

Keywords

Carya Ovata, shagbark hickory, distribution, ecological succession

Introduction

Raystown Lake is a reservoir that was constructed by the Army Corp. of Engineers in the nineteen seventies. To construct the lake, the Army Corp. enacted eminent domain, which allows the government to acquire private land for public use, and a dam was erected (Raystown.org). When this happened, the agricultural lands and forests around the lake became abandoned and were relatively unmanaged. This abandonment produced many even age stands along the lake shore, and it affected the overall composition of the forests by allowing invasive and undesirable species to spread freely (personal communication). The forest composition is that of a central hardwoods forest, and is comprised primarily of oak, pine, and hickory, though many more species are present.

However, the forest is now actively managed. The forest surrounding the lake has been divided into compartments based on the specific needs of stands, or smaller groups of trees, around the lake. They are managed for wildlife, recreation, regeneration, and timber management.

The shagbark hickory is an important part of forest composition. While it is relatively low in abundance, it provides food for wildlife. Most notably, squirrels and deer use the nuts produced by these trees to survive (Belthoff 1990, Nixon et al 1968). They are also a very important and protected tree due to their use as habitat for bats (Humphrey et al 1970). Their shaggy, exfoliated bark provides excellent and abundant habitat (Humphrey et al 1970) for bat populations that are being diminished by the white-nose syndrome.

This study looked at environmental factors on the growth and distribution of the species. Soil moisture, slope, and aspect were analyzed to identify possible reasons for density differences between the two forest plots. These factors are important in identifying differences in growing potentials. It is hypothesized that the two sites are significantly different based on these environmental factors.

Field Site

Shagbark distribution varies greatly between the two forest sites in this study. There are only two individuals present in the older plot, while the younger has scattered individuals throughout, with some areas being denser than others.

The Research sites were located in different forest compartments at the lake (Fig. 2). The younger plot, known as High Germany, is located on the Tussey Mountain side of the lake. Given the presence of barbed wire and invasive shrubs, it was presumably an agricultural field used for animal grazing when it was abandoned. It has a southeastern aspect and has an average slope of 21.8 percent rise (unpublished). As a stand, it is being managed to produce oak regeneration (ArcGIS 2010), though the specific location of the study plot is not actively managed. This area is maintained by the Army Corps of Engineers.

High Germany is an active location on the lake with heavy human uses. It is segmented by roads, and is used heavily by hunters. The human presence in the area may affect the amount of invasive species in the area, as humans are a huge contributor to the spread of these forest pests.

One of the dominant invasive species found in the High Germany plot is Multiflora Rose (*Rosa multiflora*) and other invasive species (personal observation). Multiflora Rose has done a lot to change the landscape (personal communication). As it grows, it entangles all other plants around it, such as tree saplings. Once they are engulfed by the rose, they lose sunlight and nutrients causing them to die. For this reason, Multiflora rose is one of the more important shapers of the landscape at the High Germany plot.

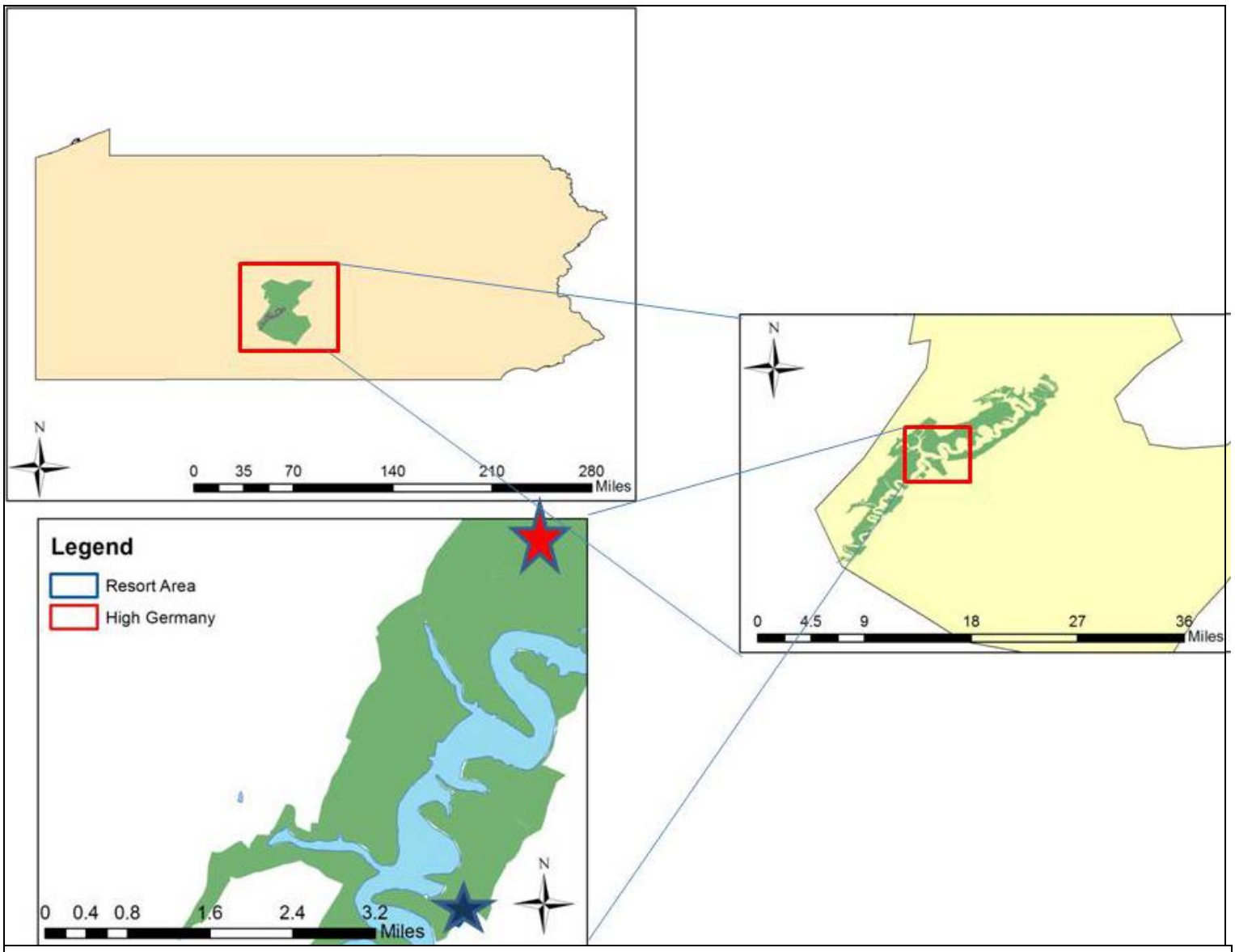


Figure 2: Location of Raystown Lake in Pennsylvania and Huntingdon County and locations of study areas.



Figure 3: Photo of High Germany. Note Thickness of understory brush.

The older plot, known as the Resort plot, is located on the opposing side of the lake. The Resort plot faces northwest and has an average slope of 28 percent rise (unpublished). The plot

is partly contained in Raystown Lake's forest compartment and partly contained in the state's forest land.



Figure 4: Photo of the Resort plot.

This plot is primarily older growth and there is relatively little understory. Because this site is out of Raystown Lake's forest compartments, it is not managed by the Army Corps. It is managed by the state's forestry program, and is a certified sustainable forest (Yohn 2011).

However, the specific location of the plot is unmanaged because of the location and slope. The species composition is primarily an oak-hardwood forest and it is in its climax stage. There are relatively few invasive plant species present (personal observation). This could be due to the lack of sunlight penetrating the canopy.

Methods

To begin this study, two one-hundred by two-hundred meter plots were measured out, with one plot at each forest location. Age class data was collected using random plots at the High Germany site, while all data collected at the Resort Area came from two individual trees. Trees were cored, and relative height was collected using a hypsometer and a clinometer, and tree diameter was measured using a forester's diameter tape, with the measurements being taken at breast height, or roughly 4.5 ft (methods attained through personal communication). Using the collected cores, rings were counted per centimeter and tree age was calculated by multiplying the number of rings/centimeter and the tree's radius (Atkins et al 1998). Median age was then compared between the two sites using a one-sample Wilcoxon test (Minitab 2010).Differences were considered to be significant if $p < 0.05$

Population data was collected in two ways. At the Resort plot, the total number of Shagbarks was counted. High Germany contained too many individuals to count, and thus random sampling was used. Subplots were constructed by dividing the two hectare plot into smaller, sixteenth-hectare plots. After these were constructed, five plots were randomly selected for density sampling. Individuals were counted in the plots, and the number of

individuals per hectare was calculated. Mean population density was analyzed using a one-sample t-test (Minitab 2011).

Soil samples were collected from five randomly selected plots at each site, with each plot having two replicates. The Resort Site had two extra replicates due to difficulties in soil collection at this site. Given the rockiness of the site, the extra replicates were taken in a location that contained more soil. These two extra replicates were sifted to remove access organic material and identify if the excess organic material affected the results. The sifted replicates were not different. Once collected, soils were examined for moisture content. Each replicate was weighed to record a beginning mass using a DHAUS scale. Measurements were taken over the next three weeks to find a definitive ending mass. Once ending masses were attained, the empty containers were weighted and recorded. Variance in soil moisture between the two plots was examined using a Levene's test (Minitab 2010). Mean soil moisture was then compared between the two plots using a two-sample t-test (Minitab 2010).

Slope was calculated using a clinometer. By walking transects previously laid out, measurements were taken every twenty five meters. Estimates were then converted to percent rise. Aspect was analyzed using GIS software (ArcGIS 2010). Variance in percent rise of the slopes of the two plots was examined using a Levene's test (Minitab 2010). Mean percent rise was then compared between the two plots using a two-sample t-test (Minitab 2010).

Results

Distribution

The median age varied greatly between the two plots. The High Germany plot had significantly younger trees (43yrs) than the Resort plot (143yrs) (w=0.0, p= 0.003). The mean age of trees at High Germany was 43± 40 years while the Resort mean age was 143±41 (Fig 5.).

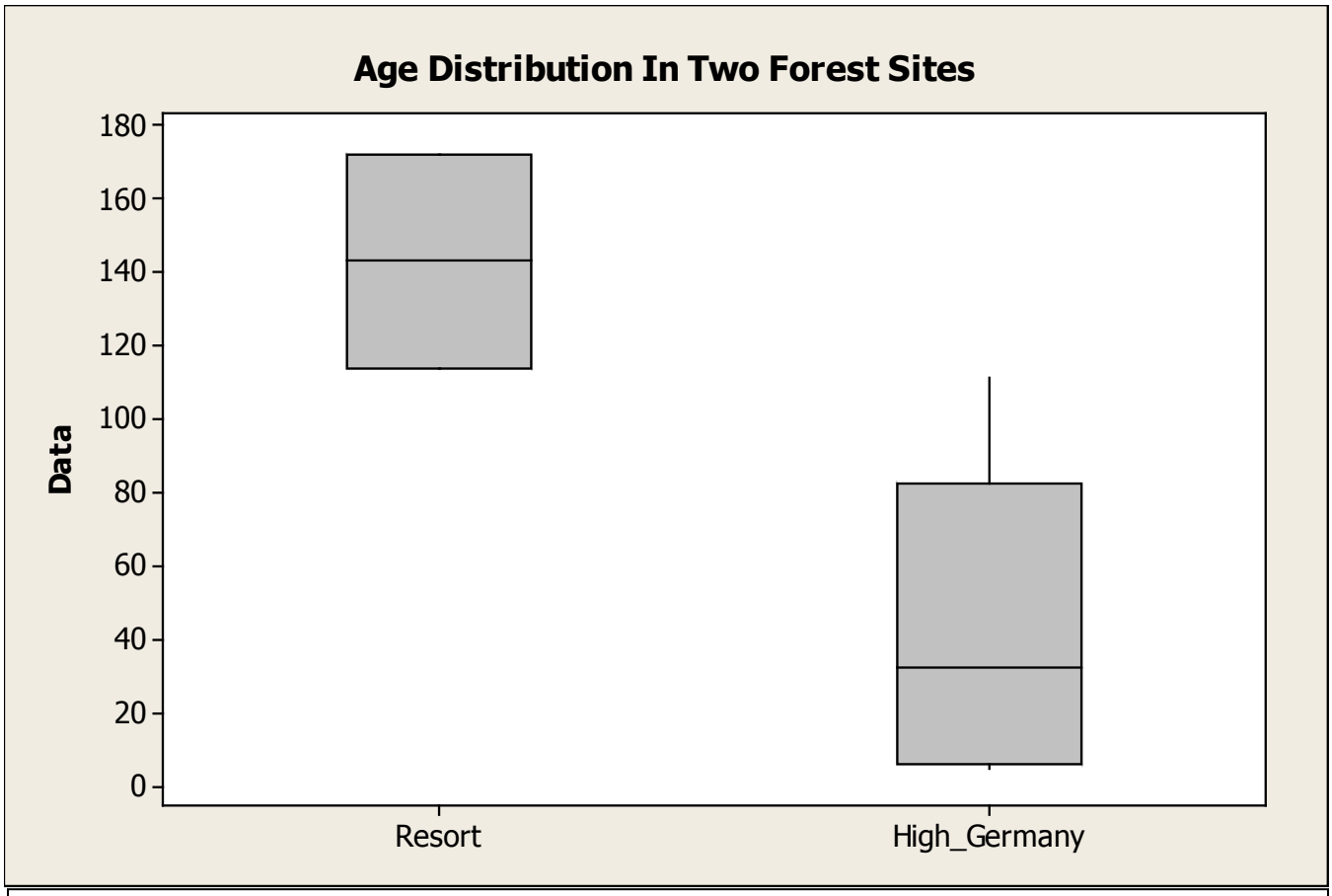


Figure 5: Box plot showing recorded tree ages recorded in the study areas at Raystown Lake in October, 2011.

We also found that there is a significant difference in the diameter measurements as well (Fig. 6). The individuals at High Germany were significantly smaller in dbh (12cm ± 11) than at the Resort plot (33 ± 19) (w=0.0, p=0.003).

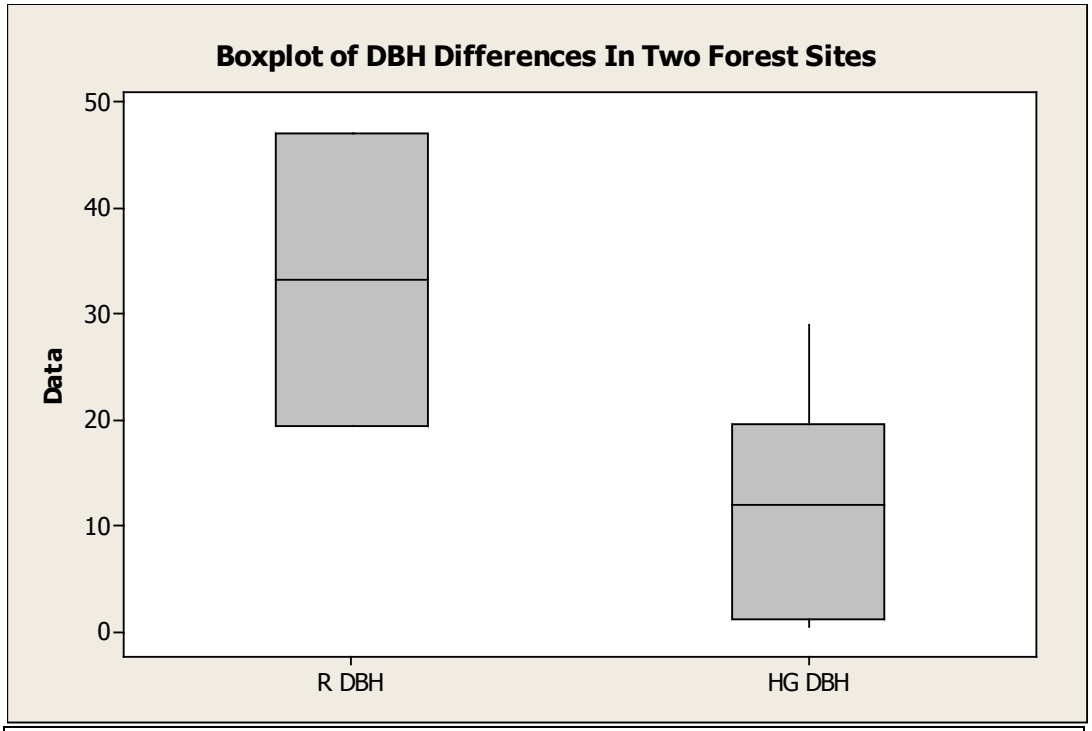


Figure 6: Box plot showing recorded tree dbh's in the two study sites on Raystown Lake in October, 2011.

High Germany also has more individuals per hectare (32±23) than the Resort site (1±0) (t=3.06, p=0.019). While High Germany had a high standard deviation, the difference was still significant.

Environmental Factors

The soil moisture at the two sites did not differ, (t=0.94, df=16, p=0.359). Using GIS software, soil types were analyzed. There are three types of soil present at High Germany. They

are Ernest silt loam, Brinkerton silt loam, and Berks-Weikert Association (ArcGIS 2010). These are all characterized as silt loam type soils. The Resort is also characterized by three soil types as well; however they are very different from High Germany. The soils present here are Hazelton-Dekalb association, Albright's association very stony silt loam, and Mecksville very stony silt loam (ArcGIS 2010). While the soil moisture does not statistically different, the textures present are. Even though the soil moistures are the same, High Germany has many more drainage locations than the Resort (ArcGIS 2010).

The slopes at the two forest sites are statistically similar ($t=0.093$, $df=5$, $p=0.395$). Despite this,, High Germany's slope is more variable (28.0%±18.5%) than the slope at the Resort plot (36.4%±8.4%). These measurements are consistent with those established by Huntingdon County surveys (Fig 7).

Aspect data was also examined using GIS. We found that High Germany faces southeast while the Resort plot faces northwest (Fig.8). This means that the trees are growing on two oppositely facing slopes at the two sites.

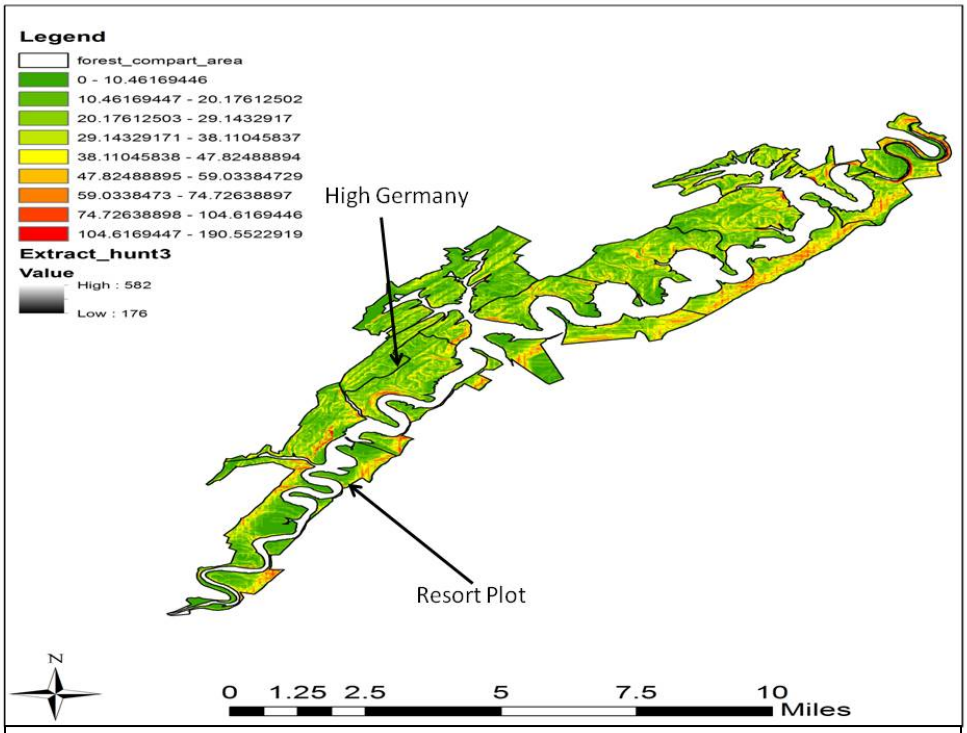


Figure 7: Slope in percent rise throughout the forest compartments. The arrows indicate approximate location of field sites.

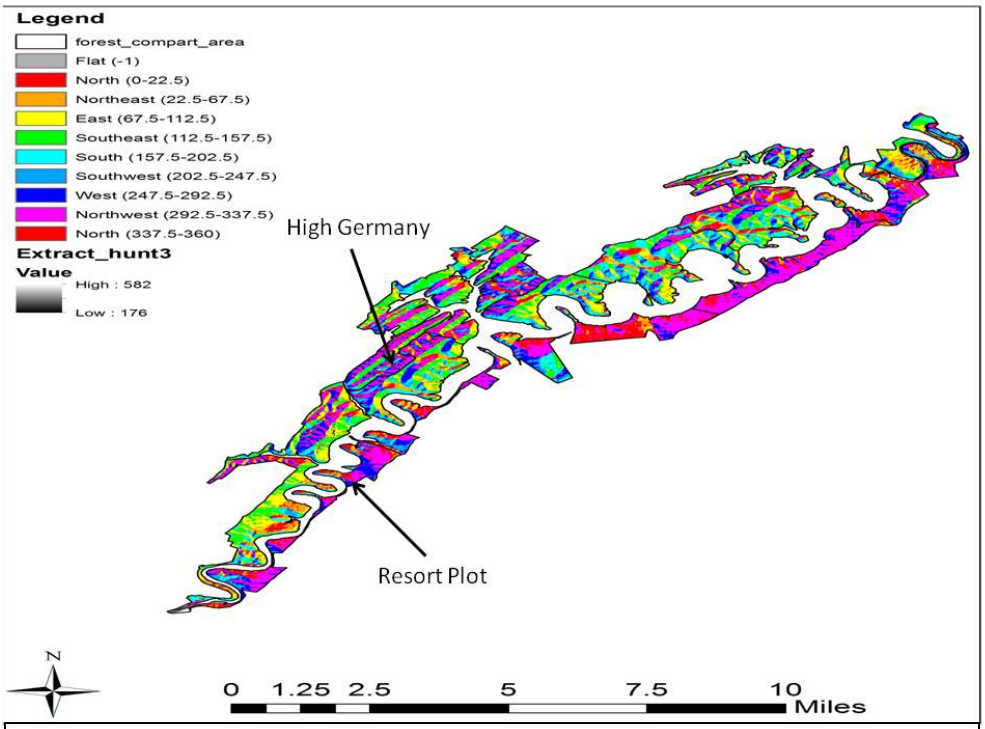


Figure 8: Map showing aspect of slopes throughout the forest compartments. The arrows indicate approximate location of field sites.

Discussion

Distribution

The age class distribution significantly differs between the two field sites. High Germany is a much younger forest and is in a different succession stage than the Resort plot is. This is most likely a result of High Germany's site history. As mentioned in the field site, High Germany was once agricultural fields (personal communication). The individuals here are younger because they began growing when the lake was established in the seventies, whereas the Resort site hasn't been managed for over 100 years (Yohn 2011). There were a few edge shagbarks along the road whose age reached one hundred, but these were presumably hedgerow trees during the agricultural period here.

The average dbh measurements also significantly differed with the location. The Resort individuals had a larger dbh than the individuals at High Germany. The average dbh for shagbark hickories is 30 to 60 cm (Koch). The trees found at High Germany are smaller than average, while the Resort trees are average. Again, this is attributed to the overall age of the two forest sites. Since the Resort site is older, it has experienced more growth, and thus has higher dbh measurements.

The population densities in the field sites also differed significantly. High Germany contained a higher density per hectare than the Resort plot did. However, shagbark hickory is still one of the lesser components of the forest compositions at High Germany. The literature states that shagbark hickory makes up five percent of oak hardwood forests (Koch). The Resort plot probably contains less than this amount, and that could be due to being outcompeted by

faster growing, shade-intolerant tree species, such as pines, birches, and walnuts (Nixon et al 1983). Another factor that could cause a smaller shagbark population maybe be the rockiness of the area. Shagbarks prefer mesic silt-loam soils (Adams 1980), but the Resort area is hard and rocky with little more than organic material present.

However, High Germany should be in the five percent range. This is likely a factor of the canopy cover and soil texture. Shagbarks are intermediately shade tolerant, but they do tend to grow better in higher light situations up to a certain extent (Nixon et al 1983). While clear-cutting has proven detrimental to shagbark health, edge growing is the most favorable (Nixon et al 1983). High Germany provides enough sunlight to assist in growth, but not too much that it becomes harmful. As previously mentioned, shagbarks prefer silt-loamy soils. High Germany provides this type of soil, thus helping to create higher densities.

Environmental Factors

Soil moisture data did not differ between the sites. This means that soil moisture has little, if any, affect on population densities between the sites. Literature suggests that shagbark hickories prefer deep, moist soils (USFS). The soils collected from both the Resort and High Germany were relatively moist, and therefore this is not a factor explaining the differing distribution of these trees between sites. However, during the collecting period the area experienced periods of heavy rain. This may mean that the soil moistures recorded may not have been reflective of the area's true moisture as the soil samples were most likely super saturated.

The slopes are also statistically similar. Both the Resort and High Germany are at elevations exceeding 1000 ft about sea level (ArcGIS 2010). In the north, shagbark hickory grows in highest abundance on upland slopes (USFS). Since both plots are consistent with this environment, slope is not a significant factor affecting distribution patterns between forest sites.

Since the forest plots face opposite directions, there is a significant difference in aspect. In the north, shagbarks are predominantly found on south facing slopes (Koch**).** This is consistent with the population density data we recorded. Also, south facing slopes receive more solar radiation, which also improves growth patterns. There were more individuals on the south facing slope, which means aspect does significantly affect shagbark growing conditions.

While several of the environmental factors analyzed in this study were not significantly different, there were key differences that directly impact the densities of shagbark hickories between the study sites. I found that the two plots were fairly similar, and mainly differed in their successional stage. The High Germany plot is younger, and therefore is in an earlier successional stage. This plot is aged at approximately 30 to 40 years, while the Resort plot is ages at about 120 years.

However, the literature states that shagbark hickory is a component of a mature forest (Koch). The densities recorded in this study are inconsistent with normal seral stages as there were greater densities in the younger plot. This may be due to other environmental factors acting on the plots, such as seed dispersal, aspect, soil types, sunlight exposure, and invasive plants. Seeds may have been dispersed from surrounding areas by squirrels and other

mammals that feed upon the nuts. The south facing slopes present at High Germany, paired with its silt-loam soil and higher sunlight exposure, have created a higher growing potential than the one found at the Resort plot. These environmental factors help to explain why there are more shagbark hickories present in a younger successional forest.

The presence of invasive species, such as multiflora rose, negatively impacts the forest plot at High Germany. These pests make tree growth and regeneration much more difficult. Without the presence of such invasive species like multiflora rose, High Germany would become a forest that matches the one found at the Resort plot. However, these invasive plants prevent High Germany from becoming a forest like the Resort. When the younger plot finally reaches maturity, it will be full of faster growing, shade intolerant species like maples, and the slower growing shagbarks will be all but eliminated.

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2012

Iron, Lumber & Blight:

A Study on the History of Forestry Conservation in the State of Pennsylvania

By Amidia Frederick

Juniata College

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Pennsylvania has a legacy of protecting and conserving its forests from commercial and environmental degradation. William Penn, the founder of Pennsylvania, set forth the decree that for every five acres cut, one acre will remain (DeCostar, 1995). Historically, Pennsylvania has been known as the state that led the nation in protecting the ecological, economic and aesthetic value of American forests. Today, sixty-two percent of the state is covered in forests, a drastic change from the pre-settlement forest coverage of ninety percent but a great improvement from twenty-five percent forest coverage in the late 1800s (Goodrich, 2012). Recently educational institutions of Pennsylvania such as Penn State and Juniata College have partnered with the American Chestnut Foundation in efforts to crossbreed generations of blight resistant chestnuts (Fitzsimmons, 2012).

Prior to European settlement, twenty-seven million acres of forest covered the state of Pennsylvania yet, the forests were not completely untouched by human modification (DeCostar, 1995). Native Americans utilized methods of burning and cutting to create areas for homes, agriculture and protection (DeCostar, 1995). Settlers adopted the Native American's techniques of clearing forests, stacking piles of dry wood and setting them aflame. Dutch and Swedish settlers built their homes out of the hardwoods of Pennsylvania. They introduced the log cabin which became the preferred style of house throughout early colonial America (DeCostar, 1995). However, whereas Native Americans settlements were small in populations and migrant, European settlements usually remained at one place, with populations growing to large numbers. As a result, massive clearings and burnings of multiple tracts of forests were used to accommodate the increasing colonial expansion (DeCostar, 1995). Uncontrolled fires were a popular method used by settlers when clearing land for farmsteads, ultimately destroying millions of acres of trees with no plans of forest remediation (DeCostar, 1995). From 1700 to

1735, the General Assembly of Pennsylvania passed legislation to deter the reckless fires with large fines and imprisonment. Yet, the policies were inadequate, since the Assembly was unable to implement rules without proper law enforcement and programs of educational outreach (DeCostar,1995). The moment European settlers arrived on the shores of North America, seeking a new life in a land of abundant resources; it quickly became apparent that reconciliation between colonial expansion and the conservation of natural resources was vital for the survival of Pennsylvanian forests.

Wood in Pennsylvania was such an abundant resource that it became widely used as fuel for woodstoves, heating for homes and a part of a method to smelt iron (Goodrich, 2012). Most of Pennsylvania forests are considered "second-growth" forest, having had most of its trees harvested near the close of the 19th century (Goodrich, 2012). The iron industry of Pennsylvania between the years 1765 and 1895 cleared 3.5 million acres of forests, relying on wood-charcoal for fuel (DeCostar, 1995). The Great Trough Creek gorge served as an ideal location for iron furnaces that needed the abundance of old growth wood for fuel. In 1780, Nicholas Crum, the first settler to reside within Trough Creek Gorge, utilized the rushing water of the creek to create a turbine powered gristmill. Ten years later, an iron furnace was built, producing up to 100 pounds of iron ore a day. By 1827, Rueben Trexler constructed a larger iron furnace called the Paradise furnace. Trexler exploited the large quantities of wood found in Trough Creek in order to increase iron production from 100 pounds to 12 short tons a day (Trough Creek State Park, 2012). The lumber boom of 1910 brought business back to the iron community of Trough Creek after advancements in iron ore production destroyed the local industry. A saw mill was built at Paradise furnace, supplying a local railroad company with railroad ties, lumber and fence rails (Trough Creek State Park, 2012). Yet, despite the economic gain, the forests of Trough Creek

were almost completely destroyed by fires when sparks from the locomotives would catch abandon timber on fire. The Gorge was left barren and scarred by wildfires until June 1933, the CCC was contracted to replant trees and restore Trough Creek back to its original glory (Trough Creek State Park, 2012). About 45 miles west of Trough Creek state park, rests the remains of another prominent iron furnace in Pennsylvania, the Greenwood furnace. First built in 1832, by 1866 the Greenwood Furnace produced up 3000 tons of iron annually, a greater rate of iron ore production than any other furnace in Huntingdon County. As with Paradise furnace and all other iron furnaces within Huntingdon County, by 1904 the Greenwood furnace closed as hot-blast technology became the preferred method of iron production (Greenwood Furnace, 2012).

In 1860, Williamsport, Pennsylvania became the lumber capital of the nation. The Susquehanna River provided the perfect float transportation for massive stocks of logs, attracting saw mills and lumber companies to the Lycoming County area (DeCostar, 1995). Only the best wood was cut for the lumber boom, leaving behind large quantities of brush, branches and small undesirable trees. These abundant plies of abandoned wood were perfect fuel for the fires that depleted the harvested forests (DeCostar, 1995). On March 13, 1895, Joesph Rothrock along with the PFA and fellow scholars pressured the government to pass an act that would create a forestry division of the Pennsylvanian Department of Agriculture (DeCostar, 1995). This became the first step towards sustainable harvesting and reforestation efforts within the state of Pennsylvania

Dr. Joesph Trimbel Rothrock, a botanist and medical doctor, grew up on a farm in Mcveytown, Pennsylvania. He became an advocate for forest conservation when he witnessed the white pine and hemlock from his childhood home had all but disappeared with the burning of

forests and industrialization (DeCostar, 1995). Dr. Rothrock lectured about the dangers of not conserving the forests, stressing the ecological and economical damage that would result from not allowing the cleared forest fields to replenish. His lectures focused mainly on educating the public as to why there is a vital need to protect the forests. In 1895, Dr. Rothrock became the first commissioner of forestry for the state of Pennsylvania. He created the first program for state owned land reserves and began the first forest academy to increase the amount of forestry specialists (DeCostar, 1995). Between the years of 1898 and 1899, the Pennsylvania State Forestry Reservation Commission bought 39,277 acres of land for watershed and fire protection as well as land for sustainable wood harvesting (DeCostar, 1995). By 1917 the Reservation Commission purchased a total of1, 017,773 acres for state forest lands (DeCostar, 1995). Rothrock along with like-minded colleagues persuaded the Pennsylvania Department of Agriculture to create educational programs for farmers in 1896. When Dr. Joseph Rothrock retired on May 31, 1904, his clerk Robert S. Conklin, became the new head of the Department of Forestry (DeCostar, 1995). Consistent burnings of forests destroyed much of the tree seeds available for natural reforestation. Once in office, Conklin began the first reforestation programs in an attempt to address the lack of tree nurseries. On October 1899 near Pike County, Pa, the first attempt to establish a nursery in Pennsylvania seedlings planted, failed because of poor soil and fires. In April 1902 near South Mountain, white pine seedlings became the first planted trees to survive to maturation. By 1909, state nurseries contained up to 5.8 million tree saplings (DeCostar, 1995). Over the next two decades, 45 percent of Pennsylvania was covered by forests and by 1936, a total of 179 million trees were planted on state and private lands. Despite the success of Conklin's seed reforestation programs, importation of European shrubs, seeds and

other foreign goods brought invasive species that decimated the hardwoods of American forests (DeCostar, 1995).

The American Chestnut was once a prominent native tree species within Pennsylvania (DeCostar, 1995). The Chestnut was once called the 'redwoods of the east' reported to grow to heights of 80 to 120 feet with widths of 1.5 meters (Money, 2007). The tree was easily the fastest growing and most versatile hardwood of Northeastern United States (Brewer, 1995). Since the disappearance of the American Chestnut from all but a few eastern states, oaks trees, maples and other trees species populations have increased in its absence (Goodrich, 2012). Reports of the chestnut blight were first reported in 1904 by Dr. H. W Merkel who noticed diseased chestnut trees outside the Bronx Zoological Park in New York City (Pennsylvania, 1912). The origin of the blight was not discovered until almost a century later at the Connecticut Agricultural Experiment station by a woman named Sandra Anagnostakis. Anagostakis traced the blight's first appearance to 1876, when Japanese Chestnuts were exported to a nursery in Flushing, New York, located a few blocks from the Bronx Zoo (Money, 2007).

The blight fungus infects open wounds of chestnuts, destroying the cambium and preventing new growth of sapwood and phloem, tree tissue that transports sugars to leaves. This process created a girdling around the trunk, spreading upwards from the area of infection, killing the tree within a matter of weeks (Money, 2007). Once the fungus has established colonies within the chestnut's bark, it reproduces spores that utilize wind, water and wildlife for transportation From 1908 to 1913, the American Chestnut trees of Pennsylvania underwent massive decimation by the blight fungus (*Crphonectria parasitica*) (DeCostar, 1995). Wealthy landowners of Philadelphia were the first to raise public concern over the destructive fungus (DeCostar, 1995). In 1909, the Pennsylvania Department of Forestry organized a program to

assess the devastation inflicted by the fungus on American Chestnut trees (DeCostar, 1995). By February 1, 1912, then Governor Tener estimated blight damages to the chestnut lumber industry within the state amounted to 10 million dollars. At the time, the chestnut lumber within the state had an estimated value of 60 to 70 million dollars (Chestnut Blight, 1912). The timber from the American Chest Nut tree was a favorite among the hardwoods, especially for its strength and durability, making it an ideal material for railroad poles, ties, fence rails as well as furniture (DeCostar, 1995). American Chestnuts were once a vital food source for wildlife, such as wild turkeys, squirrels, deer (Hepting, 1974). American Chestnuts, before coming in contact with the blight fungus, accounted for 20 percent of all hardwoods with the state of Pennsylvania (DeCostar, 1995). The blight had reached the southeastern counties of Pennsylvania by 1911, forming a border of infected trees across Susquehanna, Lycoming, Fulton and Huntingdon County (Pennsylvania, 1912).

The state of Pennsylvania provided funding of up to 275,000 dollars the create a Chestnut Commission in order to prevent further spread of the blight and collect all the seeds from the remaining healthy Chestnuts within the forests. A man named S.B Detwiler headed the commission, attempting to create a buffer zone along the New Jersey state line, but failed to stop the blight and by 1913, the fungus had spread throughout most of the state (DeCostar, 1995). In the early 20th century, two Pennsylvanian newspapers of Tioga County, The Wellsboro Agitator and the Wellsboro Gazette described the devastation of the blight across the state.

"*It is also well for the people to realize the disagreeable truth that the chestnut blight is so widely prevalent east of the Susquehanna River that it is impossible to control it as readily or as successfully as in the western parts of the state, where the infection is not general but appears sporadically*." (No Chestnuts in this County, 1912)

The Chestnut Commission sent out pamphlets of information for citizens on how to deal with the infected trees:

"The Commission urges that infected trees should be destroyed without delay, and that all diseased bark must necessarily be burnt to prevent the further dissemination of the disease bearing spores and postulates." (How to Save our Chestnut Trees, 1912)

On May 1, 1912, H. E Wells, a superintendent for the Chestnut Commission, organized and trained 20 men at the Brookside building in Cogan House Township. The men were assigned to Tioga and Bradford counties to search for signs of the Chestnut blight and remove infected trees (How to Save our Chestnut Trees, 1912).

The Wellsboro Gazette lamented the spread of the chestnut blight to the last untouched counties of Pennsylvania during the year of 1928. Twenty percent of the American Chestnut population within Tioga, Potter and Warren counties were infected. A year before, PA State Forestry officials believed that the northern counties would show resistance to the fungi. Yet despite their hopes, the chestnuts of northern Pennsylvania experienced the same devastation as the central and southern counties (Blight in North Tier, 1923).

In 1913, the USDA's Office of Foreign Seed and Plant Introduction assigned Frank Meyer to determine whether Chestnuts in China showed signs of the blight infection. Meyer not only discovered that Chinese Chestnuts (*Castanea Mollissima*) had symptoms of the blight but that trees showed a high resistance to the fungi and survived (Money, 2007). A few decades later, Meyer's discovery led to the solution to saving the American Chestnut, cross breeding blight resistant chestnut trees with susceptible chestnut trees (Money, 2007). In 1983, in the city

of Bennington, Vermont, a group of concerned scientists and volunteers gathered to create The American Chestnut Foundation (Money, 2007). TACF has led the efforts in creating a blight resistant Chestnut through a six generational backcross breeding program between Chinese Chestnuts and the America Chestnuts (Fulbright, 1991). Sara Fitzsimmons, a TACF Regional Science Coordinator for the North Central region, gave an interview from her Penn State office explaining the TACF research conducted in Pennsylvania:

"*I got my degree in biology from Drew University and then earned my Master's in forest ecology and Resource Management. My thesis for graduate school was based on American Chestnut conservation. I worked an intern for TACF and then was hired full time in 2003. The American Chestnut Foundation relies on partnerships between institutions and orchard managers all along the east coast. This allows TACF to have regional diversity for species restoration.*

We have over 300 registered orchards run by institutions such as the Army Corps of Engineers, Penn State, Ohio State and private citizens who grow the American chestnuts on their property. It's just too expensive and time consuming for TACF to reside over all 300 orchards. Typical orchards are checked for suitability. Are they available? Are they accessible? Are the soils suitable, we look soil characteristic, landscape aspects like ridge and mid slopes, like sandstone and in valleys basic limestone? Backcross breeding is part of a six generation system to produce blight resistant American Chestnuts. Basically you cross breed a Chinese Chestnut with an American Chestnut, then take the trees produced and backcross those trees with another American chestnut. We are trying to retain as much of the genetic traits of the American

Chestnut as possible only taking the blight resistant traits from the Chinese chestnut. It takes about a minimum of 30 years to create six generation American Chestnuts.

In 2000, we established a true American orchard, collect as many chestnut seeds around the state and put them into one space. This makes it much easier to access that seed diversity than from all over the state.

Near Entriken, Pennsylvania, a quarter mile up a gravel road, lined by a spring-fed stream and shaded by trees, four posts and a fence surround several plots of crossbred chestnut saplings. These chestnut trees are part of a partnership between the Army Corp of Engineers and the American Chestnut foundation, a six-generation research study to create blight resistant American Chestnuts (Fitzsimmons, 2012).

In 2007, Jeff Kruase wanted to expand, create another orchard, sent him seeds of crossbreed seeds from all over PA. Last year he had fifth generation and 6th generation out in the woods. The Army Corps of Engineers out at Raystown Lake has helped to coordinate one of the largest of partnerships in terms of number of trees, but Raytown Lake region is the single coordinator. Funding usually comes from private stakeholders, grants, stocks etc." (Fitzsimmons, 2012)

- Sara Fitzsimmons interview on April 25, 2012

An hour from Penn State, another institution of education, Juniata College has joined in the efforts of American Chestnut Restoration. Uma Ramakirshnan, an associate professor of environmental science at Juniata, received the SALSA (Southern Alleghenies Learn and Serve Alliance) grant in 2008 (Ramakirshnan, 2011). The goal of the grant was to promote a service

learning course based on the collaboration between student s and community partners on addressing goal-specific projects. Uma Ramakirshnan and students from Juniata College teamed up with the PA branch of TACF and identified three goals; research techniques to increase over-wintering success of chestnut seeds, increase chestnut orchards and to develop an educational outreach program about the American Chestnut (Ramakirhsnan, 2011). In 2008, the students created a 2.5 acre plot surrounded by eight foot wire fence and planted 30 seeds of six different species of Chestnut trees were planted behind the Brumbaugh Academic center on Juniata Campus. The six species were American Chestnuts, backcross hybrid American Chestnut, Chinese chestnut, European Chestnut, Japanese chestnut and the Chinquapin Chestnut. The orchard was created to allow for long term research to be conducted on the American chestnut for future generations of Juniata students as well as community volunteers. The students also created an indoor/outdoor presentation on the American chestnut, explaining the history and current research in American Chestnut restoration. Community members of Huntingdon as well as fellow students were invited to the presentation which took place at Juniata Campus. The SALSA grant finished in 2010, yet professor Ramakirshnan has continued to conduct research for TACF on the American Chestnut and its leaf morphology. This study focuses on identifying hybridization, regional distinction and genetic distress among American chestnuts within the region (Ramakirshnan, 2011).

The efforts of Penn State and Juniata College to restore the American Chestnut with Pennsylvania, are indicative of the influence that Pennsylvania's history in forest conservation principals has given to the United States. The drastic change of Pennsylvania's forests and the U.S forests are fortunately invisible to the unknowing individual. Without William Penn, Joesph Rothrock, Gifford Pinchot, deserts rather than forest may have been the common view through

North American states. Yet, because these great men knew the true ecological and economical costs of unsustainable forest management, they were able to make great changes within the consciousness of American society. Today, educational leaders such as Sara Fitzsimmons and Uma Ramakirshnan have contributed to Rothrock and Pinchot's legacy of creating and maintaining communal cooperation and educational programs in the effort to promote forest conservation. Despite the devastation wrought by the iron and lumber industry as well as invasive fungus upon Pennsylvania's forests, these disasters have allowed for the realization that our forests are not finite. Our forests are naturally renewable, but we as consumers of these forests we must become stewards who nurture these natural resources while using them.

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Study of the Attractant Effects of Salt Licks on White-tail Deer (*Odocoileus virginianus*) during the Early Spring in Central Pennsylvania

Matthew Lear and Cory Mattas

Abstract

Salt licks are used as attractants in environments to increase the area's population density of white-tail deer (*Odocoileus virginianus*). This study looked at two field sites, one that was managed as a wildlife restoration area and one that was not, and how introducing a salt lick changes the population density of white-tail deer in both fields. Data was collected one hour after sunset in March 2012 at fields located near Entriken, PA. Before introducing the salt licks, the managed restoration area showed an average white-tail deer density of 5.04 deer/ha (±2.54 *SD*) and the unmanaged field showed 0 deer/ha (±0 *SD*). After implementing the salt licks, there was no change in deer population density in both fields (p value 0.56, Mann-Whitney U). Due to this insignificant difference, white-tail deer were found to be not attracted to salt licks in early spring.

Keywords: Odocoileus virginianus, White-tail deer, salt, sodium

Introduction

Salt licks have been used as attractants for white-tail deer (*Odocoileus virginianis*) for many years. (MacGowan 2004) Salt licks are commonly used as attractants due to the observable salt drives in deer during the spring and summer months. (Atwood 2003) The specific reason for the salt drive is not known, but has been linked to the deer's seasonal diet changes.

Sodium in a deer's diet is vital for osmotic balance, blood pressure, and many other vital bodily functions. (MacGowan 2004) Without Sodium intake deer would not be able to function properly. (Weeks 1976) The salt drive usually is prevalent during late spring and through the end of summer. (Weeks 1976) During spring white-tail deer begin to shift their foraging habits towards fresh vegetation that is rich in Potassium and water. (Weeks 1976) This is speculated to cause instability in Sodium balance and can create excessive Sodium loss through urination and defecation. (Weeks 1976)

Once Potassium levels begin to rise and Sodium imbalance begins, deer begin to actively seek out Sodium supplements via natural or artificial licks. Natural licks can form when rain runoff forces sodium rich soils into low areas where the water can dry up and leave the high concentrations of minerals on the surface soil. Deer can then lick or ingest the soils in these natural licks for their natural concentrations of sodium and other minerals. Artificial licks have been a major tool in wild deer management, as well as deer farming. (Weeks 1976) Natural licks are usually around 300 ppm in Sodium concentrations and artificial licks can range anywhere from 300 or more ppm. (Weeks 1976)

An interesting connection has been made between artificial lick usage and winter months. During the winter months, deer do not require additional Sodium supplements. This is thought to be correlated with the seasonal use of road salts and the fact that their natural diet does not consist of Potassium rich vegetation at that time. (Atwood 2003) Between the excessive salt used as an ice deterrent on highways and lowered Potassium intake, white-tail deer do not have a sodium imbalance problem and thus are not forced to seek out additional Sodium sources in the winter. With the increase in salt drive in the late spring into summer, sources of sodium become very vital for a healthy diet. Since the natural vegetation, the main component of white-tail deer's diet, does not contain high levels of Sodium, these licks become vital for survival. (Weeks 1976) The purpose of this study was to determine the effectiveness of salt licks as attractants for white-tail deer in early spring, when supplemental sodium is not needed.

Study Area

Our study area was located in Central Pennsylvania, on land owned and managed by the Army Corps of Engineers near Entriken, PA. Within this area, one field managed for wildlife restoration and one field not managed for wildlife were chosen for testing. (Figure 1) Central Pennsylvania falls within the broadleaf deciduous forests of the Appalachian Mountains, but has a high content of agricultural fields. (Personal Observation) The wildlife restoration field included different forest edge cuts, field breaks that included trees and tall grasses, and agricultural fields (Personal

Observation). The non-wildlife-managed field only contained an abrupt forest edge cut and common forb grasses (Personal Observation). Data was collected during the month of March 2012. Weather for that area for the duration of data collection was an average temperature of 50 degrees Fahrenheit, with only two small rain storms during the study accumulating to 0.79 inches together. (History 2012)

Methods

We picked two fields that are in the same general area to keep weather, temperature, and other geological variances to a minimal. Prior to picking these fields, spotlight runs were conducted to insure white-tail deer were present in the area. Inside each of these general fields, we plotted out a small research site and one 20 meter radius circle with reflective stakes (Figure 1).

One hour after sunset for seven consecutive days we visited each site and recorded the number of white-tail deer in each research site and circle using a spotlight. Then we introduced one salt lick to both of the circles, keeping the research sites as a constant. The next seven consecutive days we spotlighted and recorded the number of deer inside each circle and field. The data collected from the research sites before the salt licks were introduced were compared to the data collected from those research sites after the introduction of salt licks using a Mann-Whitney U test.

Results

White-tail deer were not found within Research site 2, 3, or 4 during the spotlight counts every night. In Research site 1 before the implementation of salt licks in the fields, an average white-tail deer density was 5.04 deer/hectare (±2.54 *SD*). After the implementation of salt licks in the fields, there was a deer density in Research site 1 of 4.20 deer/hectare (±2.52 *SD*). Before and after salt implementation, deer density was not statistically different based on a Mann-Whitney U test (p value 0.56). (Table 1, Figure 2)

Discussion

It is obvious that the introduction of salt licks did not attract the local deer population. There was not a significant difference in deer density between before and after the salt licks were introduced. White-tail deer are not sodium deficient during the winter and early spring months when our data was collected. (Weeks 1976) This can be shown in our results with the insignificant attractant of the salt lick. During the early spring and winter months, white-tail deer are not consuming a high amount of Potassium in their diet which is speculated to cause an imbalance in Sodium regulation. (MacGowan 2004) This is the opposite of late spring and summer where they rapidly switch diets to forbs and other succulent vegetation that is rich in Potassium. (Weeks 1976) Natural Sodium quantity in food ranges from 35 ppm in September to 103 ppm in February. (Weeks 1976) White-tail deer can find natural licks

that form from rain runoff, and they can lick or ingest the soil in order to obtain the heightened Sodium concentration. (Weeks 1976)

In another study done in 2003, different artificial licks were used to determine which type of source was the main reason for deer visitations. It was found that male and female deer preferred specifically salt licks in the summer versus spring. The study also discovered that female deer preferred mineral licks over salt licks in the spring but then switched to salt licks in the summertime. (Atwood 2003) This further strengthens our results since our research was complete in the very early weeks of spring.

From a management perspective, our research coincided with the literature in that the employment of salt licks during early spring is not an effective tactic for deer management. During the early spring there is not enough Potassium in their daily food sources such as forbs to cause a Sodium imbalance. Without this imbalance the deer would not develop an increased salt drive which would make salt licks virtually useless as attractants during the early spring months.

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Figure 1: Aerial view of all research sites in Entriken, PA using ArcMap10

Table 1: Average white-tail deer density ± SD using numbers of deer spotted per hectare located in four research sites in land owned and managed by the U.S. Army Corps of Engineers near Entriken, Pennsylvania, during the month of March, 2012. P value was taken using a Mann-Whitney U test through Minitab.

	Research 1	Research 2	Research 3	Research 4
Avg. Density (deer/ha) Before	5.04 ±2.54	0	0	0
Avg. Density (deer/ha) After	4.20 ±2.52	0	0	0
p value	0.56			

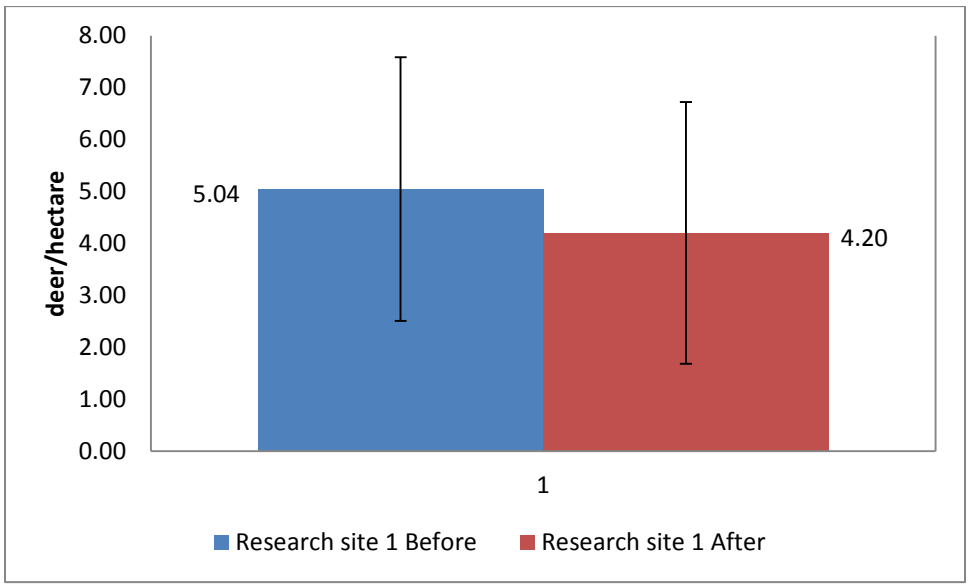


Figure 2: No significant difference found between the before and after implementation of salt licks in Research site 1. Error bars show standard deviation.

Comparison of Fungal Species Diversity Between Abrupt Edge and Border Cut Edge Habitats

Alex Pasqua and Amidia Frederick

Abstract

Forest management techniques have significant effects on the species diversity of fungi (Linder, 2006). We compared fungal species Shannon Diversity, Evenness and Richness among mature forests, Abrupt edge and Border cut habitats at the Raystown Lake, Huntingdon Co., PA in the spring of 2012. Prior to collecting field data, we predicted that Border cut edge habitat would have higher species diversity than the Abrupt cut, due to the higher quantity of detritus material found. When comparing the species diversity of the two Border cut plots, we found the results of plot 1 to be significantly different from plot 2. This deviation in values did not represent true species diversity of Border cuts, therefore we could not effectively prove our hypothesis. Abrupt edge and Mature forest transects showed no significant difference in fungal Shannon-Wiener diversity ($p=0.062$). We conclude that the species diversity in Abrupt edges are similar to that of Mature forests.

Keywords: Abrupt Edge, Border Cut, Detritus, Species Diversity/Shannon-Wiener Index, Species Richness, Species Evenness, Saprophrtic fungi, and Raystown Lake.

Introduction

Fungi are essential for nutrient cycling of detritus material as well as for providing access to complex nutrients for plant roots, within forest ecosystems (Ingham, 2012. Ectomycorrhizal fungi (ECM) use their hyphal root system to access minerals and insoluble nutrients like phosphorus for trees (Jones, 2003). Of the many species of fungi that play an important role in nutrient cycling, our study focused primarily on the wood-decaying saprophytic fungi. The saprophytic fungi are the largest group of fungi, their fruit bodies colonizing the substrates of dead organic matter throughout a forest ecosystem (Hou, 2011). Saprophytic fungi frequently develop fruit bodies, producing more colonies than Ectomycorrhizal fungi over a course of a year (Hou, 2011). These decomposers are particularly crucial for nitrogen cycling by releasing hydrolase, cellulose, laccase and proteinase into the soil, while breaking down dead wood (Hou, 2011). The role of fungi diversity on the productivity and biodiversity of forests has become a recent question and topic of research for forest management agencies (Lindner, 2006). Previous studies have sought to determine the significant effect forest management practices have on the species diversity of saprophrtic fungi. Little is known about the importance of fungi diversity on the rates of decomposition of detritus material (Bassler, 2010). Research has shown that as fungal species abundance increase so does the productivity of forests (Ingham, 2012). Our research focused on determining whether species diversity of wood-decaying fungi differed between Abrupt cut managed habitats and Border cut managed habitats. Border cut edge habitats differ from Abrupt cut in that the edge around a Border cut field undergoes a process of thinning and selective cutting so as to create a gradual transition from forest to field. The Border usually contains new tree saplings and left over detritus to provide a food source for wildlife (Lindner, 2006). Most wood decaying fungi colonize on sources of woody substrate such as

fallen trees and old logs, relying on spore dispersal to establish new colonies (Lindner, 2006). An Abrupt edge field usually requires little to no thinning and no selective cutting. The transition from forest to field is characteristic of what one would find if they were to leave a Mature growth forest and immediately enter a clear cut field (Carey, 2006). We assumed in the absence of thinning, the Abrupt cut would have very little detritus material, therefore less fungal species richness. Our hypothesis was that Border cut edge habitat have higher species diversity than the Abrupt edge, since Border cuts have a higher amount of detritus material than Abrupt.

Research Sites Descriptions

We conducted our study at High Germany, a section of forest managed by the Army Corp of Engineers at the Raystown Field Station, located in Raystown Lake, PA. We selected three sites containing plots of Border cuts, Abrupt edges and Mature forest habitats (Figure 1). The Abrupt edges faced towards the field from a southeastern direction and the Border cuts faced the field in a northwestern direction. The first Border cut surveyed (HG)-1 had a plot on the south eastern side that was primarily filled with hawthorn before transitioning into Mature forest. There was very little shade and most of the ground was covered with straw-like grasses (Figure 2). There was very little detritus material in this transect. The Abrupt cut transect, in the north western part of HG-1, had a small amount of bramble-like shrubs and mature trees grown to the edge of the field where a small knoll separated the field from the Abrupt cut (Figure 3). There was roughly 75% shade in this Abrupt cut and many dead branches contributed to the detritus in this transect. The Abrupt cut transect, on the northwestern side of HG-13, had mature forest growth up to the edge of the field and had very large bramble-like shrubs. This Abrupt cut was

very well shaded and had a large amount of detritus from the broken limbs of tall trees. The Border cut transect on the south eastern part of HG-6 was a gradual transition from field edge to bramble-like shrubs, juvenile trees, and then transitioning to Mature forest growth (Figure 4). This Border was well shaded by dense juvenile forest growth and large shrubs. There was a large amount of detritus in the area consisting of stumps of Mature trees and fallen juvenile trees. Both Mature Forest transects were located in the Mature forest around Grove Farm (Figure 1). This area was very well shaded and had a very large amount of detritus consisting of entire fallen trees and very dense leaf matter that retained moisture.

Methods

We created two transects per edge cut habitat, with two transect allocated to a section of Mature growth forest to serve as a control. Our research location consisted of two 100 m by 20 m plots within each site. Each plot overlapped the forest to edge border, running parallel to the forest edge. Five 10m x 10m subplots were randomly selected with each site plot. Data was collected in March and April of 2012. Samples were collected on a weekly schedule, each week devoted to completing fungi identification of two plots. Species identifications were based upon 'The Auburn Society Field Guide to North American' (1981). In addition to Species Richness, we calculated fungal diversity for each site using a Shannon-Wiener Diversity and Species Eveness.

Results

Overall we found 37 species of fungi and 323 colonies of fungi. Species Richness of all edge habitats did not differ (p=0.101) (Figure 5). The Shannon Wiener index was significantly different between the Border Cut and Mature Forest habitats (p=0.029). However, the Shannon Wiener index was not significantly different between Abrupt Cut and Border Cut edge habitats (p=0.137). In addition, the Shannon Wiener index was not significantly different between Abrupt Cut and Mature Forest habitats (p=0.225) (Figure 5). Species Evenness was found to be significantly different between all habitats (p=0.007). However, Species Evenness was not significantly different between the Abrupt Cut and Mature Forest Habitat (p= 0.062) (Figure 5). Separate analysis of both Border Cut plots found that the Shannon Wiener index, Species Richness, and Species Evenness were significantly different (p=0, p=0.003, and p=0.029) (Figure 6). When comparing the three habitats using the non-parametric Kruskal-Wallis test, Species Richness and the Shannon-Wiener Index were not significantly different (p=0.100 and p=0.136). Fungal Species Evenness did not show a difference between the three habitats (p= 0.025).

Discussion

We could not reject our null hypothesis. Although we cannot definitively prove or disprove our original hypothesis, according to Claus Bassler's study, fungal diversity depends on a larger amount of detritus left behind in forest management practices and logging operations (Bassler, 2010. 822). In Daniel Linder's study of fungi species richness among Northern hardwoods, thinned and selectively cut forests usually have an abundance of small substrate detritus as compared to large substrates found in Mature forests (Linder, 2006. 212). His study

found that managed forest habitats that are thinned such as our Border cut habitats have higher species diversity (Linder, 2006). When comparing the species richness, diversity and evenness between of the three uneven aged and old growth sites, Linder found the mean values not to be significantly different as well ($P > 0.10$) (Linder, 2006). When comparing our edge cut habitats and Mature growth, we also found there not to be significant difference for species richness and Shannon Weiner Index. Yet when he compared the sites based on the amount of small substrates over a course of five years, thinned even aged habitats had significantly different species richness (Linder, 2006). As previously stated we could not do an accurate statistical comparison of our Border Cut sites, which would have been the equivalent of Linder's thinned managed habitats. We believe this is due to the lack of detritus material left behind in the first Border cut in habitat HG-1 compared to the second Border cut habitat in HG-6. Due to the high variation among our collected Border cut data, we decided that more replicates are needed to determine the true nature of species diversity of fungi found in thinned Border cuts (Figure 6). Linder's study lacked a high number of replicates for his research sites, such as our own. In the event of not having enough data, Linder conducted statistical analysis with a 10% confidence interval rather than the 5% confidence interval test that we chose to do (Linder, 2006). In addition we discovered that Species Richness is not a good way to evaluate the diversity of fungi because they are usually concentrated to one area of detritus which makes the species richness very small. Since there is no statistical difference between the Mature forest and Abrupt cut habitats, we can infer that the two sites have similar conditions of detritus material and ideal soil nutrient content to support high fungal species diversity. Linder's study found that the sections of forest that were not thinned out had smaller amounts of decaying woody substrates (Linder, 2006).

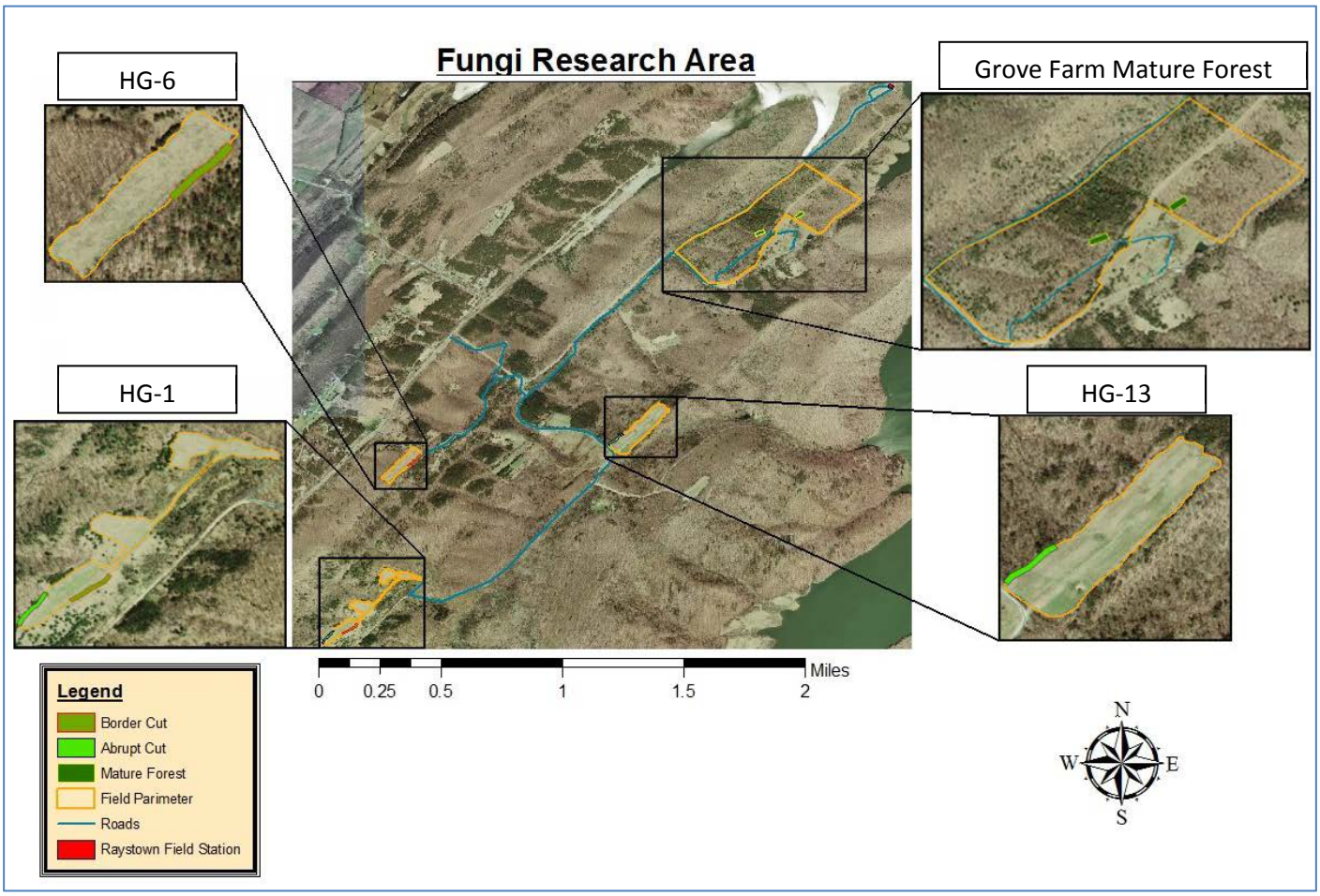


Figure 1: Study sites at Raystown Lake, Huntingdon County, PA, Spring 2012.



Figure 2: HG-1 Border Cut at Raystown Lake, Huntingdon County, PA, Spring 2012.



Figure 3: HG-1 Abrupt edge at Raystown Lake, Huntingdon County, PA, Spring 2012.



Figure 4: HG-6 Border Cut at Raystown Lake, Huntingdon County, PA, Spring 2012.

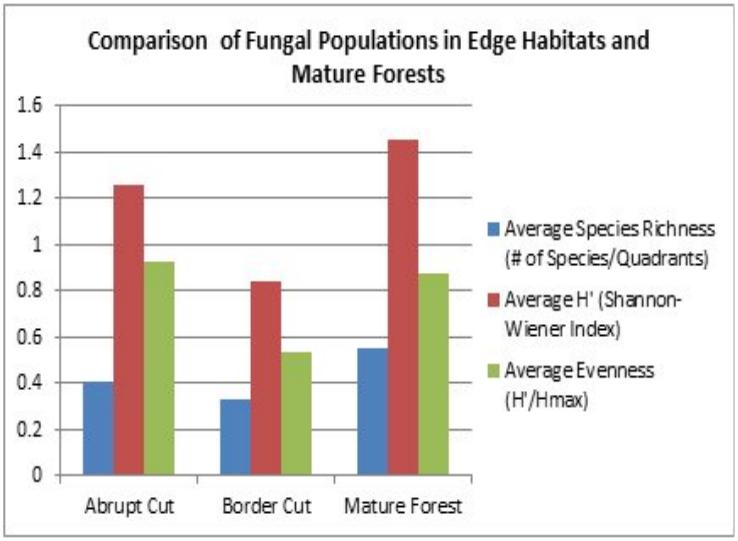


Figure 5: Average Shannon-Wiener Index, average Species Richness, and average Species Evenness between the three kinds of habitats surveyed at Raystown Lake, Huntingdon County, PA, Spring 2012.

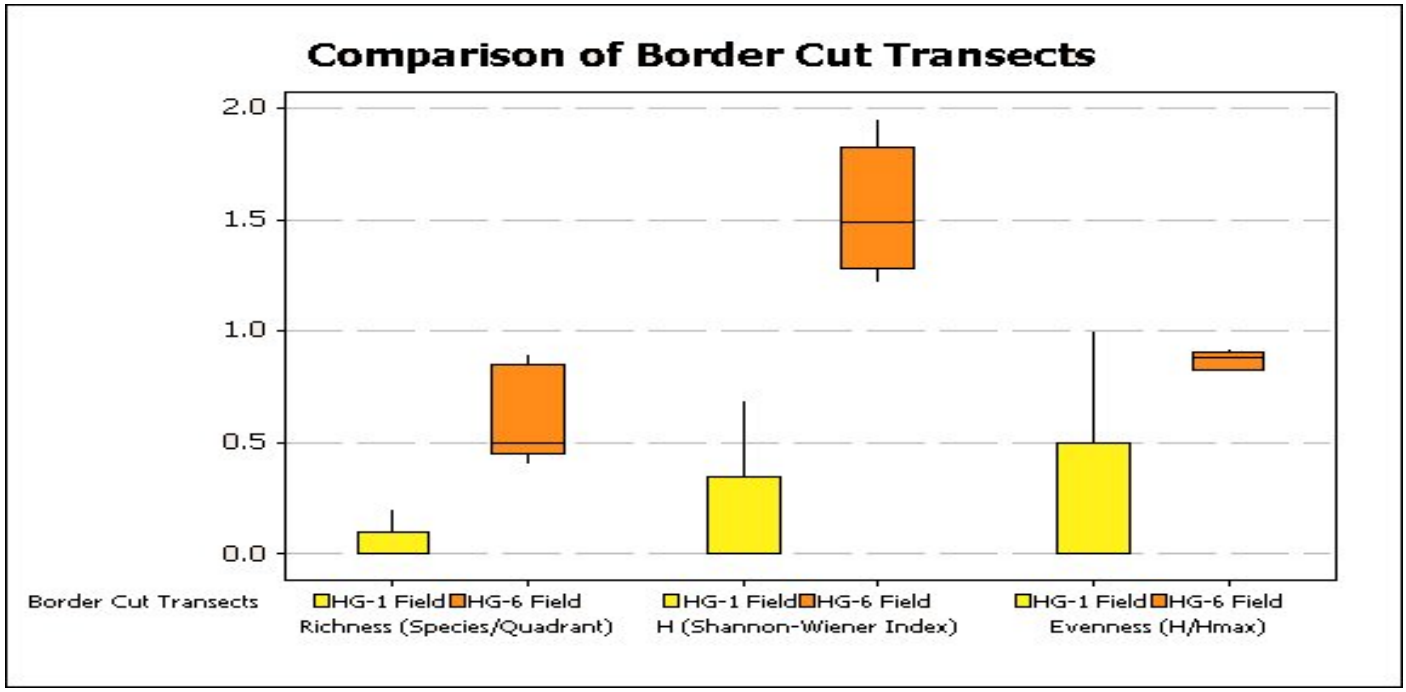


Figure 6: Differences in Shannon-Wiener Index, Species Richness, and Species Evenness between the two Border cut habitats surveyed at Raystown Lake, Huntingdon County, PA, Spring 2012.

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Understanding Groundhog, *marmota monax*, preferences between managed versus unmanaged fields for digging their burrows

Kristin Zupko

Abstract

In order to determine the preferences of where groundhogs (*Marmota monax*) excavate their burrows, I compared the distribution of groundhog burrows between several managed and unmanaged fields at Raystown Lake, Pennsylvania during the winter of 2012. Managed fields were differentiated from unmanaged fields by the presence of crops, such as clover. Going into the study, I hypothesized that I would see a higher density of groundhog burrows in managed areas.

I observed 20 burrows in total. The average densities of the managed fields were (5.35 ± 2.83 burrows/ha) and the unmanaged fields were (2.92 ± 2.45 burrows/ha) ($p = .19$). Distance between burrows and the fields varied, but no burrows were found beyond 50 m of a field. I found with my data, although a conclusive decision as to whether managed or unmanaged is absolutely preferred was not made, there was a tendency for groundhogs to aggregate towards managed fields.

Keywords: groundhogs, *Marmota monax*, field management, burrow

Introduction

Managing fields for the benefit of wild game species is a relatively new concept being put into place at Raystown Lake. Around 260 acres of land have been dedicated towards active land management and growing crops, such as clover, sorghum, buckwheat, etc., that are preferred by wild game species (National Wild Turkey Federation 2010). However, work to help support species such as wild turkeys (*Meleagris gallapavo*), white-tailed deer (*Odocoileus virginianus*), and other commonly hunted animals may also have brought about populations of some undesirable critters, like groundhogs (*Marmota monax*). Groundhogs, or woodchucks, are considered a nuisance species by farmers and homeowners alike. These burrowing animals are well known for causing property damages and are infamous vegetation disruptors (Jacoby 2004).

Groundhogs have been shown to cause an intermediate disturbance on the vegetation surrounding their burrows (English and Bowers 1994). In other words, the greatest effect that a groundhog has on the field biodiversity will be found at a medium distance from their burrow. For farmers they have earned a title of a "serious agricultural pest". Groundhogs are herbivores which will feed off of wild grasses, tree leaves, and even crops like corn, if the need arises (Jacoby 2004).

The data was gathered along Raystown Lake, Pennsylvania on land owned by the Army Corps of Engineers. Six fields in total were looked at: three managed and three unmanaged (Figure 1).

The three managed fields that were studied were all managed with plants like alfalfa and clover, then left to fallow, or left untouched, over winter. Field borders can be excellent habitat

for groundhogs during the summer months, when they prefer the open fields and a close proximity to their food for their dens (Purdue 1997).

On the other hand, the three unmanaged fields were clearly affected by human usage due to the relative proximity of tree orchards; however, it was observed that no further management was occurring on the field, such as growing crops. All three of the unmanaged fields had a commonality of large surpluses of wild grasses within the vicinity.

I predicted that the greatest density of burrows would be found in managed fields because of the proximity to a food source.



Figure 1: A satellite image depicting the six fields used during my study. The red denotes a field while each yellow dot depicts a single groundhog burrow found in the field.

Methods

My study was done by scouring the fields and counting each groundhog burrow I found. Waypoints were taken at each burrow by using a GPS to later calculate burrow densities. The burrows were differentiated from the homes of other burrowing species based on the burrow's diameter, proximity to the field, the slope of the burrow entrance, and any other markers (such as the skulls of other animals) outside the burrow entrance. The burrows of a managed (Figure 2) and an unmanaged (Figure 3) burrow generally differed in the types of vegetation surrounding the entrance.



Figure 3: A managed field burrow on Raystown Lake, PA.



Figure 4: An unmanaged field burrow on Raystown Lake, PA.

Using the ArcGIS program by ESRI, I calculated the mean field densities. The waypoints were plotted onto a map of the areas being studied.

In order to compare the densities of the two field types, a Mann-Whitney test was used with the aid of the Minitab program. For the Mann-Whitney test, I judged that a p-value of less

than or equal to 0.05 would signify a statistical difference between managed and unmanaged fields.

Results

The mean densities of the managed fields were (5.35 ± 2.83 burrows/ha) and the unmanaged fields were (2.92 ± 2.45 burrows/ha) (Figure 3). When comparing the two fields types, using the Mann-Whitney test, I found the p-value to be greater than 0.05 ($p = 0.19$). Thus, statistically there was no difference between managed and unmanaged fields.

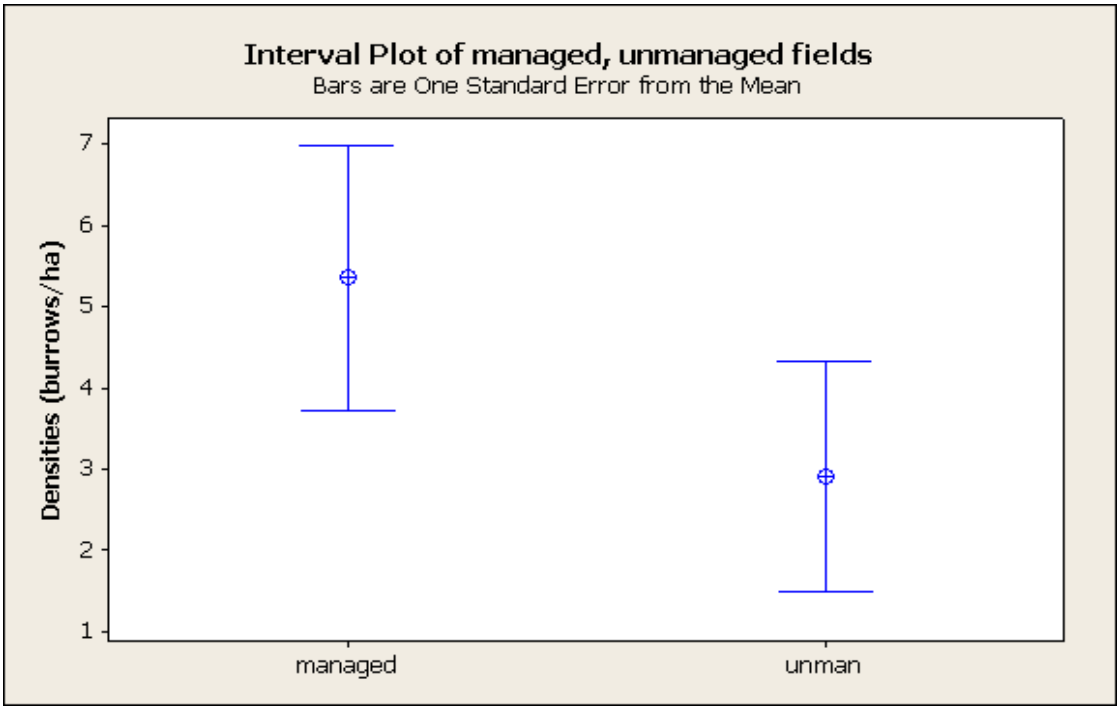


Figure 3: Comparing the mean densities of the managed and unmanaged fields using an interval plot with the center being the mean of the field densities and the bars showing standard error.

I found that the greatest distance a burrow was from a field was within 50 m.

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