THE DISTRIBUTION AND GROWTH OF FISH IN THE RED CEDAR RIVER DRAINAGE IN RELATION TO HABITAT AND VOLUME OF FLOW

Thesis for the Degree of Ph. D.
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William Robert Meehan

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THE DISTRIBUTION AND GROWTH OF FISH IN THE RED CEDAR RIVER DRAINAGE IN RELATION TO HABITAT AND VOLUME OF FLOW

presented by

William Robert Meehan

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E. W. Roelofs
Major professor

Date May 20, 1958

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THE DISTRIBUTION AND GROWTH OF FISH IN THE RED CEDAR RIVER DRAINAGE IN RELATION TO HABITAT AND VOLUME OF FLOW

by

WILLIAM ROBERT MEEHAN

AN ABSTRACT

Submitted to the School for Advanced Graduate Studies of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Fisheries and Wildlife

1958

Approved E. W. Roelofs

William Robert Meehan

Fish populations were sampled throughout the drainage system of the Red Cedar River in the central portion of Michigan's Lower Peninsula. Sampling was done primarily with an A.C. shocker and a drag seine. The A.C. shocking unit was the most effective gear in obtaining numbers of individuals and variety of species.

Over half of the total population of the system in numbers are minnows. Of these, the northern common shiner, bluntnose minnow, and northern creek chub are the most numerous. The most important game fish is the northern pike, while the smallmouth bass and the rock bass are angled for to a lesser extent. The greatest diversity of species was found in the larger section of the river.

Data are presented for some of the more common species concerning length-weight relationships, body-scale length relationships, coefficient of condition, and age and growth. For the most part, growth is as good or better than it is in other midwestern streams.

Differences in growth increment in white suckers and rock bass above and below a source of domestic pollution are not significant, but the differences are greater in the white sucker which is a bottom feeder.

Differences in the average total length of northern common shiners throughout the drainage were found, but could not be correlated with: (1) volume of flow; (2) date of collection; (3) habitat; or (4) gear used to make collections.

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Mr. Joseph B. Hunn and many other of the author's colleagues in the fisheries and wildlife department are gratefully acknowledged for their assistance in much of the field work.

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INTRODUCTION

For many years, one of the major problems confronting aquatic biologists has been the difficulty of investigating stream fish populations on a quantitative basis. Extreme variations in environmental conditions, mobility of these fish populations, and varying efficiencies and selectivities of different types of sampling gear are some of the principal factors which limit the extensiveness of a quantitative study.

Environmental conditions in a lotic situation are much more variable than conditions found in standing waters. Temperature of the water, turbidity, and other physical and chemical characteristics of the water in a stream or river may vary daily with varying weather conditions over the watershed, and certainly seasonal changes are much more extreme than would be the case in a lake or pond. A hard rain for a period of only a few hours may increase the volume flow of a stream by four or five times. The effects of such an occurrence on the various types of habitat found in the stream may be devastating. A small stretch of gravel, perhaps the spawning site of a number of fish, may be completely silted over. This would perhaps be considered as a detrimental effect. On the other hand, some "desirable" conditions may be set up at the same time. The increased discharge and its accompanying debris may undercut a bank on the outside of a meander to a depth which will afford suitable cover for one or more fish in an area where there was previously none. This same hard rain over a lake might affect the surface temperature slightly or cause some roiling near the shores, but no major environmental changes would take place.

The mobility, or at least the potential mobility, of stream fish populations is another factor which presents difficulties in studying them quantitatively. Scott (1949), Gerking (1950), and other investigators agree that certain species native to the stream move about very little. Gerking (1950) and Larimore (1952) further suggest that certain species have definite home ranges. On the other hand, the movements of some species may be quite widespread, as is the case with the white sucker. Funk (1957) divides certain species each into two groups, one a "sedentary" group which remains within a limited area, and the other a "mobile" group which ranges more freely. With respect to the sedentary group, the factors which may determine the stability of the group are a homing instinct, social behavior, and recognition of a home range. Larimore (1952) demonstrates the attachment of smallmouth bass to home pools in Jordan Creek, Illinois. Gerking (1953) shows that the home range of the rock bass, green sunfish, and longear sunfish in streams which he studied is 100 to 200 feet of stream, while the smallmouth bass, golden redhorse, and hog sucker have home ranges of 200 to 400 feet. Barriers of a temporary or permanent nature, such as low water levels and dams, are likewise important factors in limiting fish movements. Mill-dams on tributary streams were found to be effective barriers to upstream movements from impounded waters in Tennessee (Ruhr, 1957).

The efficiency and selectivity of various types of gear used to sample fish populations has long been a subject of discussion among fisheries investigators. While collections made with several types of gear, such as electric shockers, drag seines, and gill nets, will show the diversity of a fish population more effectively than would be shown by the use of any one gear alone, still there remains the problem that each gear will indicate a different species composition. Also, different kinds of gear have different efficiencies when used in various types of habitat. For example, the electric shocker can be used successfully to collect fishes such as centrarchids from brushy areas along the stream bank, while a drag seine would prove to be highly ineffective because of obstructions. A combination of several types of gear has been used successfully by some workers, such as a drag seine used as a block seine in conjunction with a shocking unit. It is generally agreed upon by biologists that electrofishing gear (A.C. and D.C. shockers, electric seines, et cetera) is the most efficient means of capturing most species of fish. There are of course exceptions. Funk (1957) finds the electric seine the most effective of the three kinds of gear used (electric seine, drag seine, hoopnet) for capturing hog suckers, black redhorse, gizzard shad, smallmouth buffalo, river carpsucker, golden redhorse, green sunfish, and bluegills in Missouri streams. The hoopnet was most effective in capturing yellow bullheads and flathead catfish. The electric seine and drag seine were equally effective in taking longnose gar, river carpsucker, northern redhorse, smallmouth bass, and freshwater drum. As a result of his investigations, Funk feels that the electric seine gives the best indication of population makeup of any one gear.

Another of the often-asked questions is the suitability of alternating current units versus those employing direct current. Ruhr (1957) found the D.C. unit to be favorable in its feature of attracting fish to the positive electrodes, but limited in its effectiveness by excessively hard or soft waters. His work on Tennessee streams with an A.C. shocker demonstrated that poor results were obtained when total alkalinities were below 20 p.p.m., and best results were obtained when alkalinities were 75 p.p.m. or somewhat higher. Manipulation of the control button so as to produce a pulsating current was more effective than merely using a steady flow of current. Experience of the crew in operating the shocker and netting the affected fish was another important consideration.

Rotenone has been used as a stream sampling agent with excellent results. It gives the largest sample from a population, but has several drawbacks. Chief among these are the fact that it destroys the fish collected, which is not permissible in many methods of population estimation, and the fact that it is generally restricted to smaller tributaries and isolated sections because of the public resentment to the damage downstream from the sampling area. With respect to the first disadvantage of the use of rotenone as a stream sampling agent, some effort is being made to perfect methods of reviving fishes which have been affected. Furthermore, the use of potassium permanganate as an oxidizing agent to counteract the effect of rotenone below the sampling area has been tried, but at the present time has not been developed sufficiently to warrant its general use.

This study was undertaken with several objectives in mind. Primarily, a survey of the fishes of the Red Cedar River was desired, including information concerning growth, condition, and general ecology wherever this type of data could be obtained. In addition, differences in growth of fishes resulting from pollution by domestic sewage were to be considered, as well as size and species distribution of fishes in relation to the volume of flow of the river at various stations.

DESCRIPTION OF THE STUDY AREA

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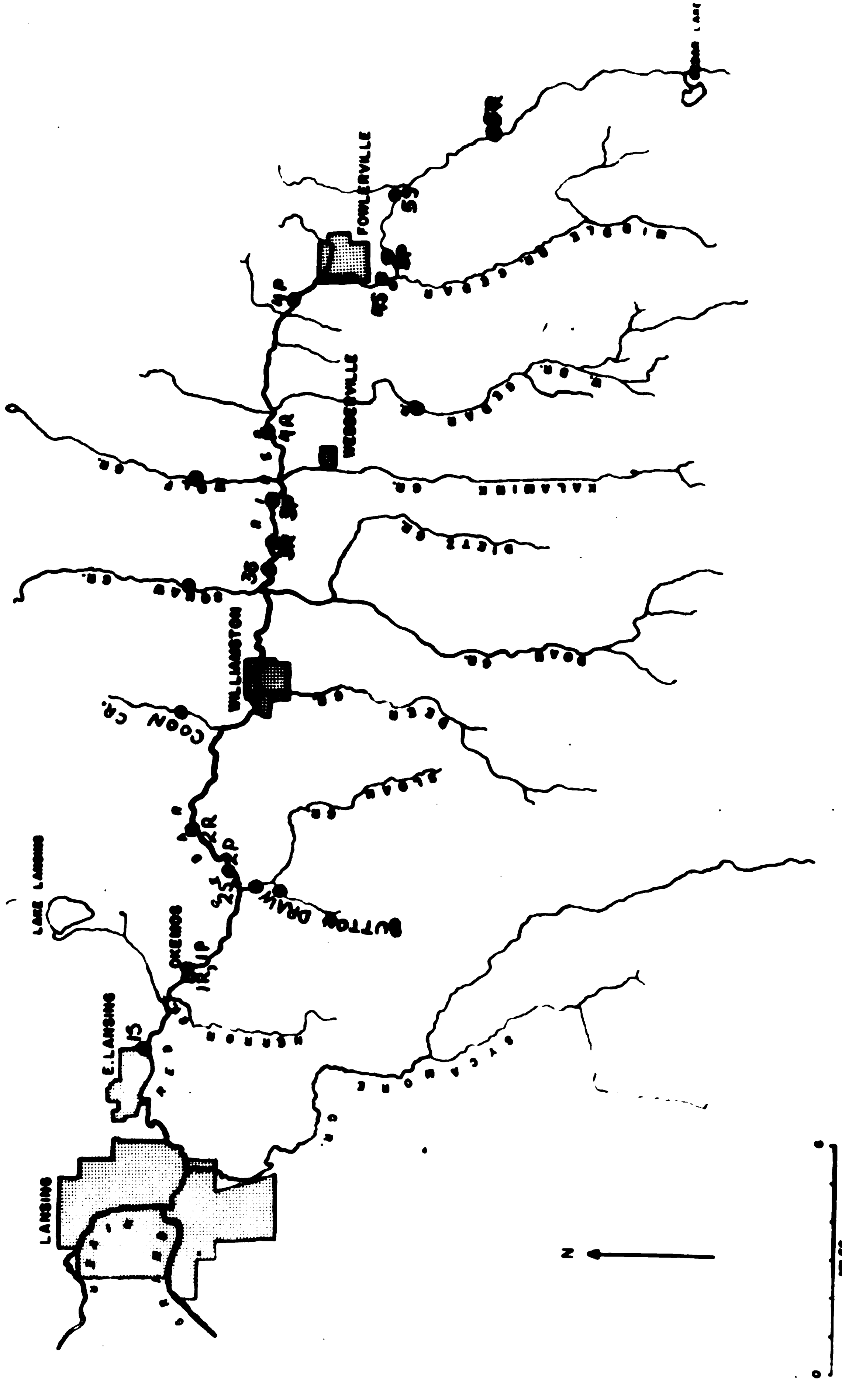
Watershed

The Red Cedar River has its source in Cedar Lake which is located in southwestern Livingston County in Sections 28 and 29, Township 1 North, Range 3 East of the Michigan Meridian. It flows generally northwestward through Livingston County for approximately 18 miles and then continues westward through Ingham County for 28 miles, where it enters the Grand River within the city of Lansing (Figure 1).

The river and its tributaries drain an area of about 475 square miles, one-fourth of which is drained by Sycamore Creek and its feeder streams. The river has an average gradient of 2.51 feet per mile, with about one-half of the fall occurring within the uppermost one-third of the river. Cedar Lake lies at an elevation of 934 feet above sea level, and the confluence of the Red Cedar River with the Grand River lies at 817 feet above sea level. The stream pattern of the river and its tributaries is a combination of trellis and dendritic types of drainage, as is well illustrated by Figure 1.

The flow of the river is usually highest during the late spring, when a combination of melting snow, rather heavy rains, and not yet thawed ground occasionally brings about serious floods. The lowest flows are found in the late fall before the ground has begun to freeze again and prior to

Figure 1. Drainage area of the Red Cedar River and its tributaries. Overlay shows location of sampling stations.


LANSING
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LAKE LANSING
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WEBBERVILLE
FOWLERVILLE
COON CR.
BUTTON DRAIN
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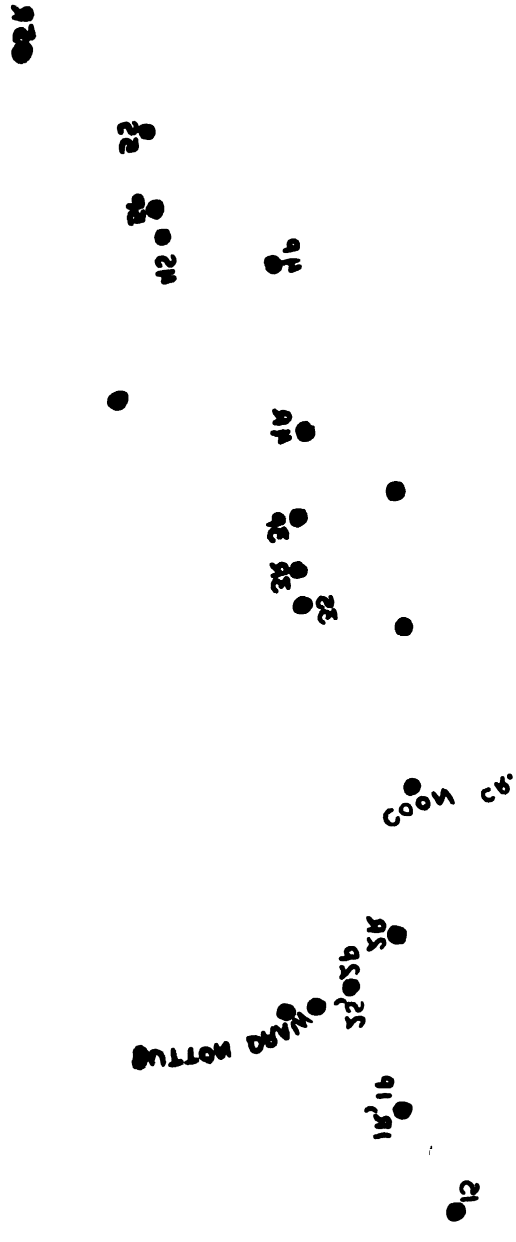
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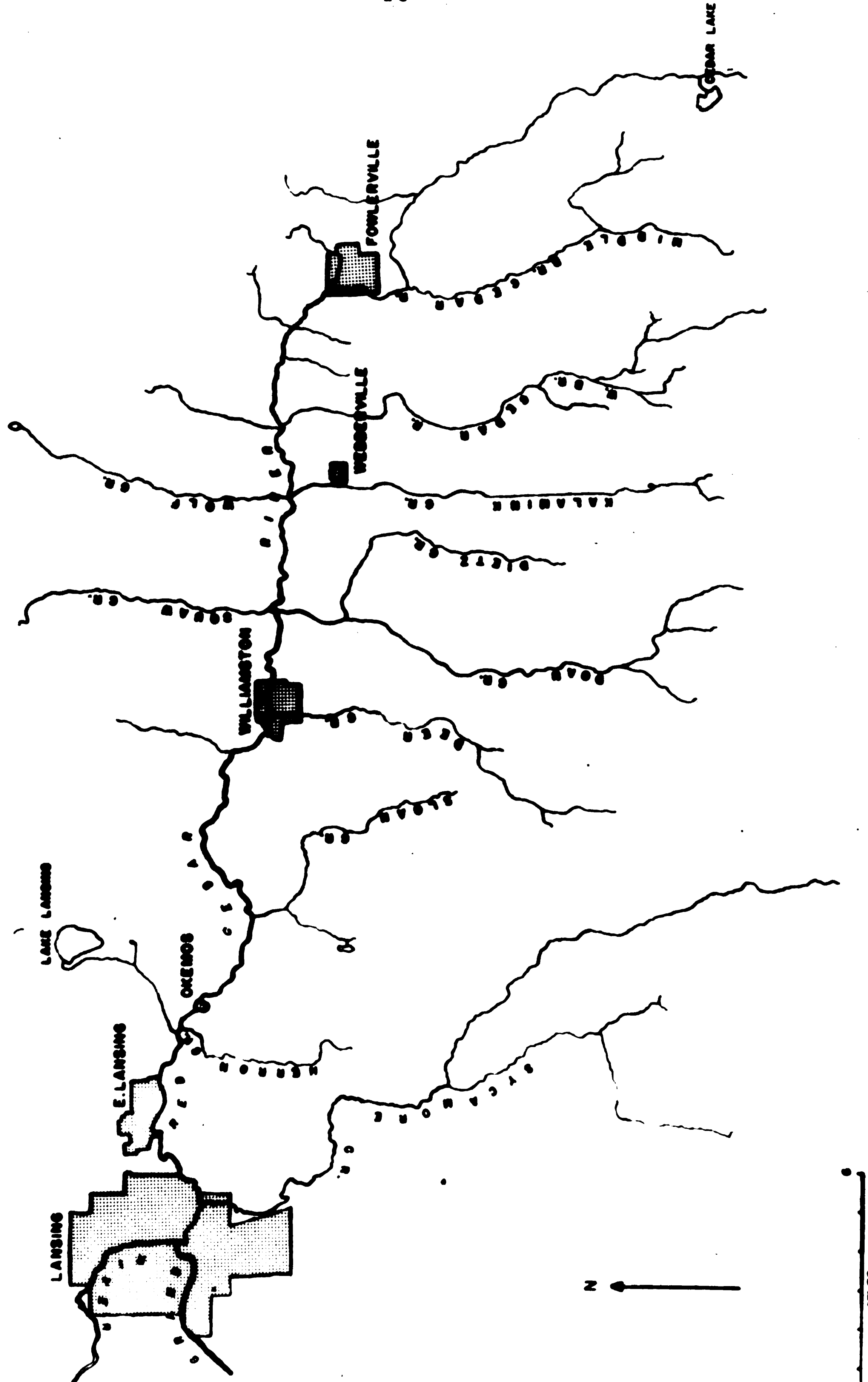
LANSING
E. LANSING
OKEMOS
LAKE LANSING
WILLIAMSTON
WEBBERVILLE
FOWLERVILLE
CEDAR LAKE
N

winter precipitation (Figure 2). The river in its upper reaches is generally quite clear following the initial spring floods, but quite often an apparent reddish-brown color is observed which is caused primarily by reflections from the bottom in the relatively shallow water (Figure 3). The lower stretches of the river, however, usually appear more turbid, largely because the deeper water here accentuates this condition (Figure 4).

There are three artificial permanent impoundments on the Red Cedar River. The most significant of these structures is located at Williamston, and was originally constructed to facilitate the operation of a sawmill. The original dam has since been replaced by one which maintains a 13-foot head and aids in providing power for a private frozen food and refrigeration plant (Brehmer, 1956). The backwaters of this dam extend upstream for about 2 miles, but are contained for the most part within a narrow belt extending a short distance out from the main channel (Figure 5). The other two artificial dams, one of which is located at the picnic ground in Okemos (Figure 8), the other on the Michigan State University campus in East Lansing, serve recreational and aesthetic purposes. The East Lansing reservoir also supplies a campus power plant.

A continuous recording flow gauge is located beneath the Farm Lane Bridge in East Lansing, and is maintained by the Lansing Division of the United States Geological Survey. The data recorded represent the discharge from about 355 square miles of the drainage area. A Taylor continuous recording thermograph is maintained by graduate students at Michigan State University engaged in limnological studies on the river, and has been in operation since the summer of 1957.

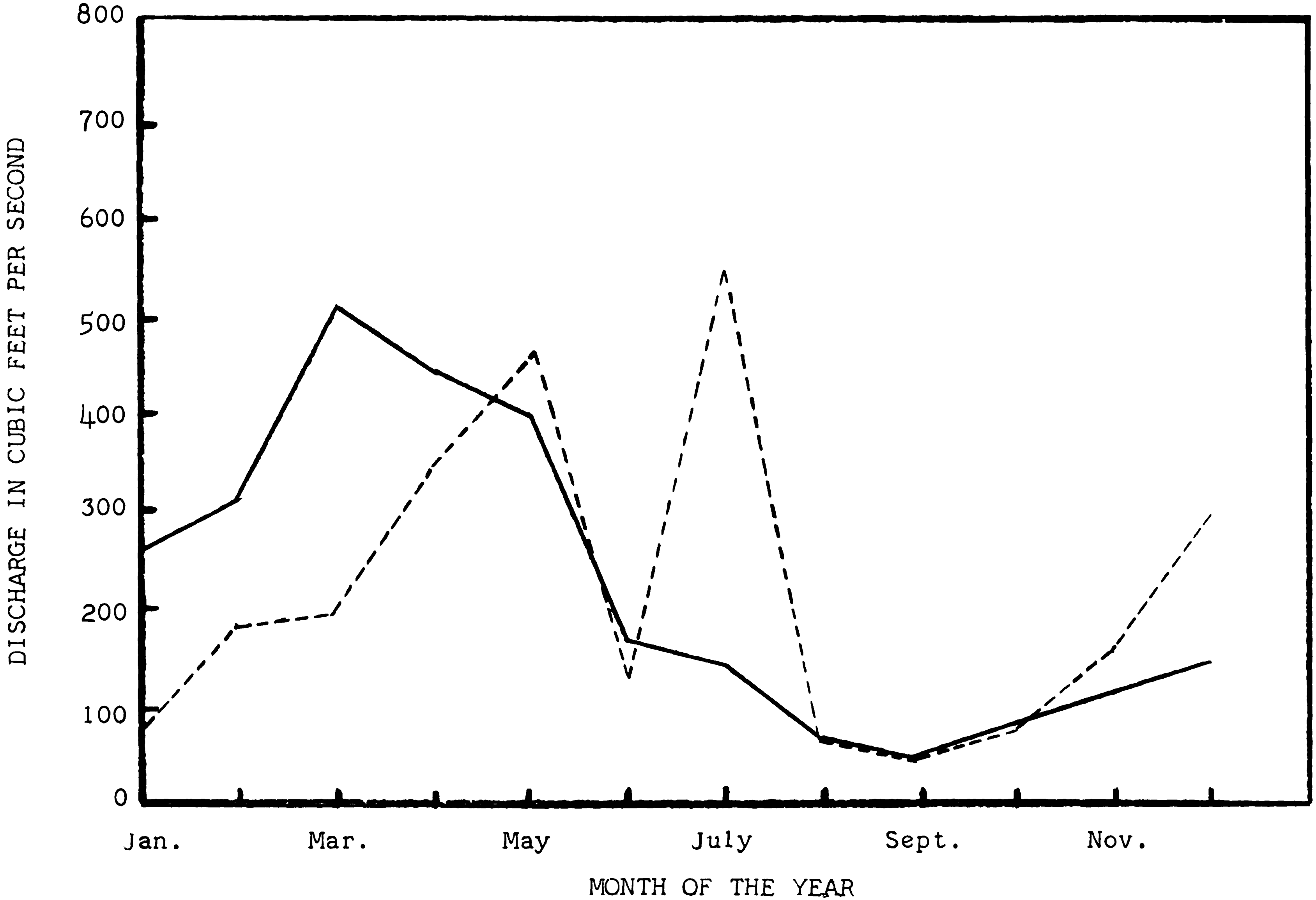

Figure 2. Mean discharge of the Red Cedar River for the years 1951 to 1957 (solid line) and for 1957 (broken line).

Figure 3. Photograph of the Red Cedar River to show the apparent reddish-brown color (somewhat overemphasized).

Figure 4. Photograph of the Red Cedar River to show the turbidity which is more apparent downstream. Gillnet is being lifted.

Figure 5. Photograph of backwater formed by the Williamston dam.

Climate

The study area is located within a climatic type described by Koeppen (Finch et al., 1957) as Dbf. In this system of climatic classification, the symbols Dbf indicate the following conditions:

D - a humid microthermal climate; that is, one in which the mean temperature of the coldest month is less than 32° F. and the mean temperature of the warmest month is more than 50° F. Rather cold winters and large annual temperature ranges are found in this type.

b - the mean temperature of the warmest month is less than 71.6° F.

f - moisture throughout the year. The location of the study area just to the east of Lake Michigan and the prevailing westerly to southwesterly winds bringing moisture from the lake are factors important in determining this condition.

Although precipitation is fairly evenly distributed throughout the year, the period of maximum rainfall is in late spring and early summer. The normal annual precipitation is about 30.5 inches, including melted snow. Snowfall generally averages about 45 inches, and this snow cover is generally of sufficient duration to have a marked effect upon winter temperatures. Sunlight falling upon the snow is reflected to a great extent, so that little of the solar energy is effective in heating the ground or the atmosphere. Also, the low conductivity of snow tends to retard the flow of heat from the ground below to replace that which is being lost. Winter precipitation is largely cyclonic in origin. Maritime tropical air masses from the Gulf of Mexico travel northward up the Mississippi valley, gradually being chilled by the cold ground surface and by colder and denser continental polar air which they override. Summer precipitation is for the most part of a convectional nature, often falling from cumulo-nimbus clouds in the form of sharp showers and accompanied by thunder and lightning. The same maritime tropical Gulf air masses which penetrate the area set up conditions favorable for convection.

The mean annual temperature for the area is 46.8° F., with a winter mean of approximately 24.0° F. and a summer mean of approximately 68.5° F. The frost-free season generally is about 160 days and extends from the first week in May to the first week in October.

Winds rarely attain high velocities in the area, evaporation is generally low, and humidity is moderately high.

Figure 6 is a climatic diagram which was compiled from the records of the United States Weather Bureau station at Howell, Michigan, and contains precipitation and temperature data which characterize the study area.

Seasonal weather is characterized by rapid and nonperiodic changes. During the winter, when the sun (and along with it the storm belt) has retreated south, weather conditions are

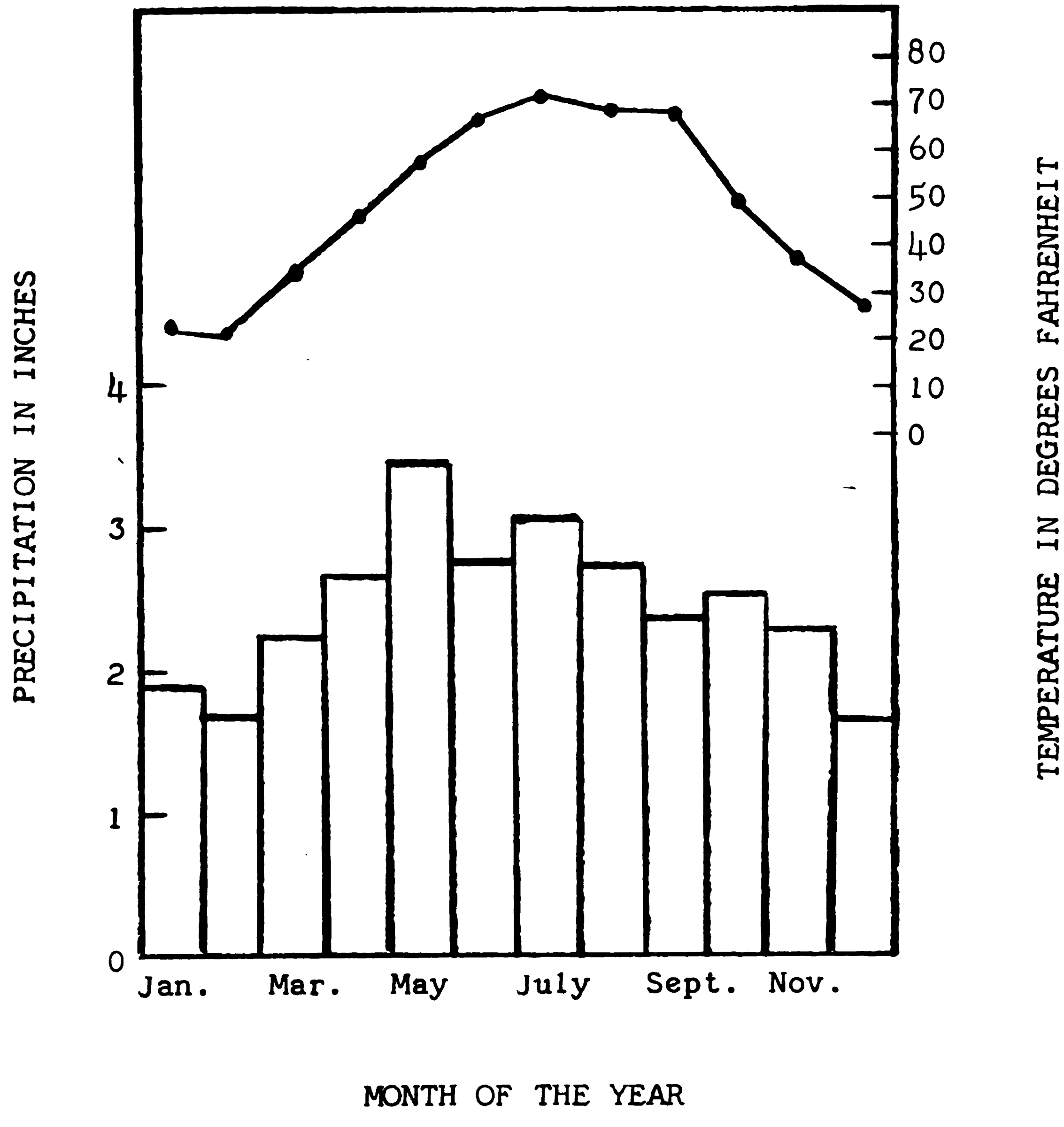

Figure 6. Climatic diagram for Howell, Michigan.

dominated by cyclones and anticyclones associated with shifting polar and tropical air masses, and the fronts which develop along their boundaries. An anticyclone made up of cold polar continental air descending from arctic Canada may produce a bitter "cold wave" over the area for several days or weeks, and then be replaced by warmer maritime tropical air from the south.

Geology

The rock strata which lie immediately beneath the glacial drift in the area in which the study was undertaken are of the Pottsville series of Pennsylvanian age. This series varies in thickness from 0 to 535 feet, and includes shales, coal beds, the Parma sandstone, and a persistent, shaly limebed called the Verne limestone.

The topography of the area is nearly level to rolling, resulting from the Cary phase of the late Wisconsin glaciation. The drift is quite calcareous, containing large quantities of limestone debris. Among the landforms which typify the region are the characteristic deposits of continental glaciation. Between the recessional moraines which run in an east-west direction in the area are found areas of gently undulating ground moraine or till plain. A few eskers are found running in a north-south direction, most of them in the southern portion of the watershed. These mounds of water-sorted materials serve as a source of gravel for road construction and concrete in the area. Numerous depressions, some of them holding water, are found throughout the watershed. These are called pits if they are found in an outwash plain, or kettles when they are found in morainic deposits, but they are formed similarly in either case. Blocks of ice are left buried beneath the drift as the glacier melts away, and as these ice blocks melt the overburden slumps into the vacancies forming the pits or kettles.

In terms of the fluvial cycle, the Red Cedar River is in the mature stage of valley development. Meanders are common in the lower reaches of the river, and one oxbow has been cut off about a mile downstream from Okemos.

Soils

The soils of Ingham and Livingston Counties are derived mainly from limy loam glacial till (Whiteside et al., 1956). The primary soil series in the area are the Miami and the Conover, which are essentially gray-brown podzols of good to intermediate drainage. The unweathered drift underlying the Miami soils is alkaline and contains considerable amounts of limestone debris.

More specifically, the soils in the immediate vicinity of the Red Cedar River can be considered to be of three main types:

1. Genesee fine sandy loam. This well-drained alluvial soil is found along the lower reaches of the river and extends

upstream from the mouth almost to the city of Williamston.

2. Griffin loam. These alluvial deposits are more poorly-drained than the Genesee loam, and range from slightly acid to alkaline in reaction. They are found from the vicinity of Williamston upstream to the vicinity of Fowlerville. Here the soils along the river give way to the Carlisle muck.

3. Carlisle muck. This organic soil type is found from the proximity of Fowlerville upstream to Cedar Lake, the source of the river. This soil is characteristically medium acid to alkaline in reaction. It is generally rich in lime and phosphorus but poor in potash.

Land Use

Dairy and general farming predominate in the area as a whole, with hogs, poultry, and sheep as minor enterprises (Hill and Mawby, 1954). Most of the crops grown are the feed crops of hay, pasture, corn, and oats. The major cash crop is wheat, with sugar beets and field beans important in areas with favorable soil conditions. The major factors influencing the choice of these particular enterprises are: (1) the relatively long growing season; (2) the predominance of sandy loams, silt loams, and loams of medium to high fertility; and (3) the good market for whole milk in the area.

For the most part, land use practices and agricultural techniques in the study area seem to be sound. As a result, excessive run-off during times of the year when the soil is

capable of absorbing water is not a problem. In the upper portions of the watershed, the river and its tributaries have in many places been dredged to straighten and deepen the channel for agricultural purposes. The high incidence of wetlands in the upper portion of the watershed was partially responsible for this work which had marsh and swamp drainage as the objective.

Wood lots, a few of them grazed quite heavily, dominate the use of the land immediately adjacent to the river. A few small fields of corn and other grain crops are found along the river banks, and other fields which have been allowed to lie fallow for various periods are occasionally encountered. In the wooded areas, the main species of trees are the white oak, elm, ash, soft maple, shagbark hickory, and basswood, while the muck soils are dominated by tamarack, aspen, and shrubs of various kinds.

METHODOLOGY

METHODOLOGY

Selection of Sampling Stations

For the purposes of this study, the Red Cedar River was divided into five sections, each approximately 9 miles in length. Three sampling stations were then selected within each of these sections on the basis of general habitat types. The author found three major habitat types in the Red Cedar River and broadly classified them as follows:

1. Riffle areas (R)
2. Pools (P)
3. Sluggish stretches (S)

Although most of the river was described by the third category, at least one area in each of the other two categories was found in each sampling section. Hence 15 mainstream stations were designated, a riffle area, a pool, and a sluggish stretch in each of the five sections. Wherever possible, the stations were selected so as to give the broadest coverage possible. However, in section 1 the riffle and pool stations were in the same general area, and in section 2 the pool and sluggish stretch stations were in close proximity. A description and a photograph of each of the sampling stations is included (Table I; Figures 7 through 19). Also see Figure 1.

TABLE I

DESCRIPTION OF SAMPLING STATIONS ON THE RED CEDAR RIVER

	Location of Station				Characteristics of the River			
Sta. No.	Specific Location	Sec.	Twp.	Range	Width feet	Depth feet	Bottom Material	Remarks
1 S	3/4 mile upstream from Farm Lane Bridge on MSU campus	18	4N	1W	90	4-5	fine sand	many sunken branches
1 R	150 yds upstream from Okemos Rd Bridge at picnic ground	21	4N	1W	80	0.5	sand and silt	riffle formed by small stone dam
1 P	50 yds downstream from station 1 R	21	4N	1W	80	5	coarse gravel and small rocks	
2 S	250 yds upstream from VanAtta Rd Bridge	25	4N	1W	60	2-2.5	coarse sand	
2 P	50 yds upstream from station 2 S	25	4N	1W	60	3-4.5	fine gravel	
2 R	50 yds upstream from U.S. Highway 16 Bridge	29	4N	1E	55	1.7	coarse gravel; few small to medium sized rocks	
3 S	75 yds upstream from Dietz Rd Bridge	4	3N	2E	45	1.5	fine sand and silt	
3 R	50 yds upstream from Michigan Highway 47 Bridge	4	3N	2E	43	1.5	coarse sand; some fine gravel; a few large rocks	

3 P	25 yds upstream from Webberville Rd Bridge	3	3N	2E	39	2.5-3	silt and fine sand	much organic material accumulated in bottom of pool
4 R	200 yds upstream from Gramer Rd Bridge	1	3N	2E	25-35	1.5-2	gravel	25 ft sandbar at midstream caused deeply undercut banks on outsides of current deflections
4 P	50 yds downstream from Gregory Rd Bridge	3	3N	3E	25	1.5-2.5	thick silt	
4 S	100 yds downstream from Van Buren Rd Bridge	15	3N	3E	10-15	1	coarse sand and fine gravel	
5 P	25 yds downstream from Fowlerville Rd Bridge	22	3N	3E	10	1-3	thick silt	thick ooze quite extensive in this area
5 S	25 yds downstream from Bowen Rd Bridge	23	3N	4E	7	1-1.3	silt	considerable organic debris on bottom, forming a thick ooze
5 R	Immediately downstream from Mason Rd Bridge	32	3N	4E	3	.5-.7	coarse sand and fine gravel	

Besides these 15 mainstream stations, 7 tributary streams were sampled periodically throughout the study period. These streams were (Figure 1):

1. Entering the river from the north:
   a. Coon Creek
   b. Squaw Creek
   c. Wolf Creek
2. Entering the river from the south:
   a. Button Drain
   b. Sloan Creek
   c. West Branch of the Red Cedar River
   d. Middle Branch of the Red Cedar River

Collections were made as frequently as possible throughout the summer and fall of 1957.

Sampling Gear and Techniques

Six different types of collecting gear were used in this study, for the purpose of obtaining as diverse a sample as possible as well as for sampling as efficiently as possible in various habitats.

Wherever possible, an A.C. shocker was used to make the collections. Hand-held electrode poles 6½ feet in length with circular copper tubing electrodes were employed. The power source was a Universal 110-120 volt A.C. generator. For the most part, only two persons operated this unit, each one handling an electrode and one retrieving the stunned fish with a dip net. The most successful technique was found to be a manipulation of the electrodes in a pulsating manner. When this technique was used, considerably fewer fish were seen to rush away from the field ahead of the crew. A dip net with a graduated mesh size of 0.50 inch to 0.125 inch at the bottom of the bag was used to retrieve affected fish.

Two collections were made employing a Homelite 230 volt D. C. generator placed in a 7-foot wooden pram with a metal center strip on the bottom. This strip of metal acted as the negative electrode, and fish were attracted to two hand-held positive electrodes similar in design to those used with the alternating current unit described previously. In using this unit, one person guided the boat by means of a rope harness attached to the bow, one person operated each of the two positive electrodes, one person on either side of the boat, and a fourth person dipped stunned fish and transferred them to a container in the boat where they remained until they could be processed.

At stations where bottom conditions permitted, a drag seine 4 x 15 feet and with a 0.25 inch mesh was used at times. A few stations were better suited for seining than for shocking, and here the drag seine was used almost exclusively. The usual procedure was to work upstream toward some natural obstruction, near which one person would pivot while the other circled around him, the two poles then being brought together near shore and the seine lifted.

Two sizes of gillnets were used at station 1S to obtain samples. One was a 1-inch bar mesh net 5 x 100 feet and the other a 2-inch bar mesh net of similar dimensions. They were set by boat (Figure 4) for periods of from 2 to 12 hours.

Several funnel-type glass minnow traps with 1-inch entrances were used to collect minnows at station 1R, where conditions were ideal for their use. The traps were baited with cracker crumbs and set for 10-minute periods.

Several collections were made by hook and line, using spinning tackle and small spoons. Rock bass, smallmouth bass, and northern pike were the species most frequently taken by this method.

Most of the larger fish were fin-clipped in such a manner that the section in which they were taken could be determined upon recapture, and following determinations of total length, weight, and the removal of some scales for age and growth determinations, they were released at their site of capture. Most of the smaller fishes, such as the minnows and the darters, were preserved in 5 percent formalin for further study in the laboratory. Fishes were identified by keys written by Hubbs and Lagler (1949) and Harlan and Speaker (1956). Scales were prepared for study by impressing them on plastic squares using a scale press. They were examined by projecting them at 10 times their size with a Ken-A-Vision micro-projector, and annuli determined.

Measurements of flow were taken using the floating bobber system of Robins and Crawford (Lagler, 1956) in which the time required for a float to traverse a given distance is measured, and the volume of flow is determined from these figures and stream dimensions. These measurements compared favorably with those recorded by a Gurley current meter and by the U. S. Geological Survey continuous recording flow gauge.

The following measurements of volume of flow taken at each section of the river on November 4, 1957, by means of the floating bobber method, indicate the proportion of total flow at each section:

Section 1 - 89.0 cfs (cubic feet per second)
Section 2 - 66.0 cfs
Section 3 - 39.0 cfs
Section 4 - 12.0 cfs
Section 5 - 3.6 cfs

On this day, the U.S. Geological Survey flow gauge recorded a discharge of 84 cfs. If the volume of flow at section 1 is considered as 1, then the proportion of flow at each of the sections would be:

Section 1 - 1.00
Section 2 - 0.74
Section 3 - 0.44
Section 4 - 0.13
Section 5 - 0.04

When this set of measurements was made, stations at or near the center of each section were selected.

Other observations routinely recorded were water temperature, air temperature, and general weather conditions. Temperatures were recorded in degrees Centigrade by means of a small pocket thermometer.

Check List of Fishes Recorded During the Present Study in the Red Cedar River Drainage

Petromyzontidae

Ichthyomyzon castaneus Girard - chestnut lamprey

Catostomidae

Moxostoma erythrurum (Rafinesque) - golden redhorse

Moxostoma aureolum (LeSueur) - northern redhorse

Hypentelium nigricans (LeSueur) - hog sucker

Catostoma commersonnii commersonnii (Lacepede) - common white sucker

Cyprinidae

Cyprinus carpio Linnaeus - carp

Semotilus atromaculatus atromaculatus (Mitchill) - northern creek chub

Hybopsis biguttata (Kirtland) - hornyhead chub

Rhinichthys atratulus meleagris Agassiz - western blacknose dace

Notemigonus crysoleucas auratus (Rafinesque) - western golden shiner

Notropis rubellus (Agassiz) - rosyface shiner

Notropis cornutus frontalis (Agassiz) - northern common shiner

Notropis deliciosus (Cope) - sand shiner

Pimephales notatus (Rafinesque) - bluntnose minnow

Campostoma anomalum pullum (Agassiz) - central stoneroller

Ameiuridae

Ameiurus melas melas (Rafinesque) - northern black bullhead

Ameiurus natalis natalis (LeSueur) - northern yellow bullhead

Schilbeodes mollis (Hermann) - tadpole madtom

Schilbeodes marginatus marginatus (Baird) - common eastern madtom

Umbridae

Umbra limi (Kirtland) - western mudminnow

Esocidae

Esox vermiculatus LeSueur - mud pickerel

Esox lucius Linnaeus - northern pike

Percidae

Hadropterus maculatus (Girard) - blackside darter

Etheostoma nigrum nigrum (Rafinesque) - central Johnny darter

Etheostoma caeruleum caeruleum (Storer) - northern rainbow darter

Centrarchidae

Micropterus dolomieui dolomieui Lacepede - northern smallmouth bass

Lepomis gibbosus (Linnaeus) - pumpkinseed

Lepomis macrochirus macrochirus Rafinesque - common bluegill

Ambloplites rupestris rupestris (Rafinesque) - northern rock bass

Pomoxis nigromaculatus (LeSueur) - black crappie

Atherinidae

Labidesthes sicculus sicculus (Cope) - northern brook silverside

Gasterosteidae

Eucalia inconstans (Kirtland) - brook stickleback

Figure 7. Station 1 S

Figure 8. Stations 1 R and 1 P

Figure 9. Stations 2S and 2P

Figure 10. Station 2R

Figure 11. Station 3S

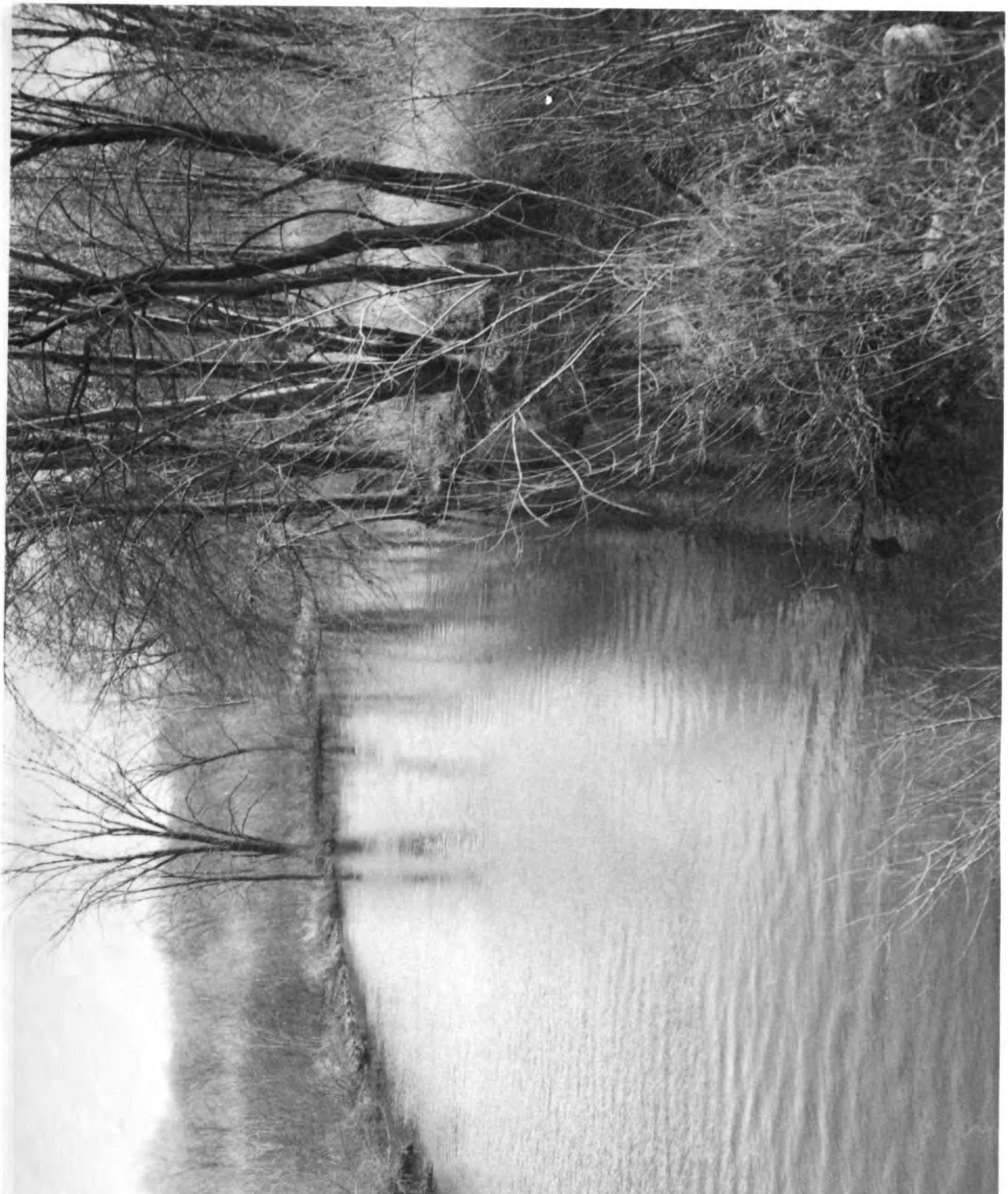

Figure 12. Station 3R

Figure 13. Station 3 P

Figure 14. Station 4R

Figure 15. Station 4P

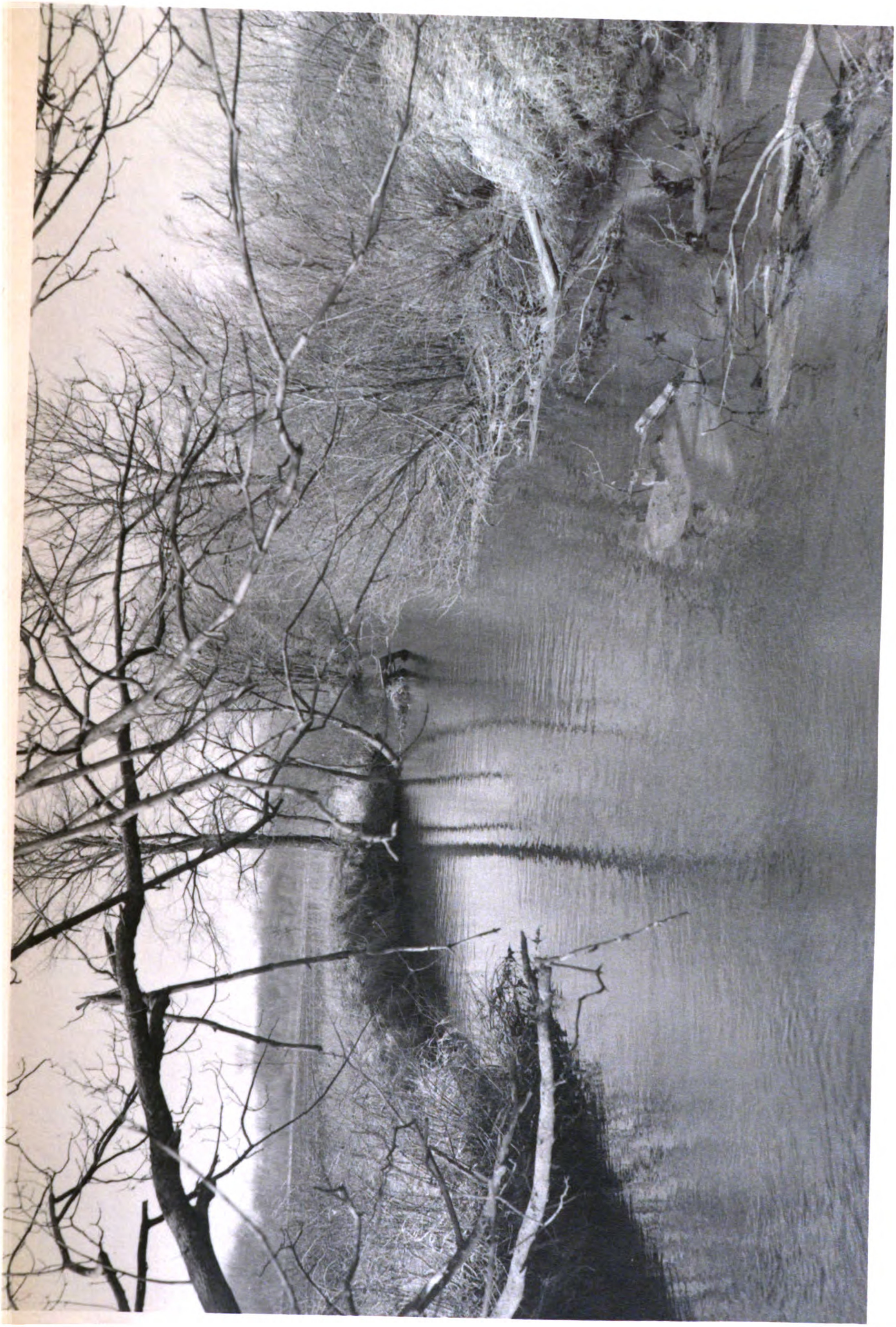

Figure 16. Station 4S

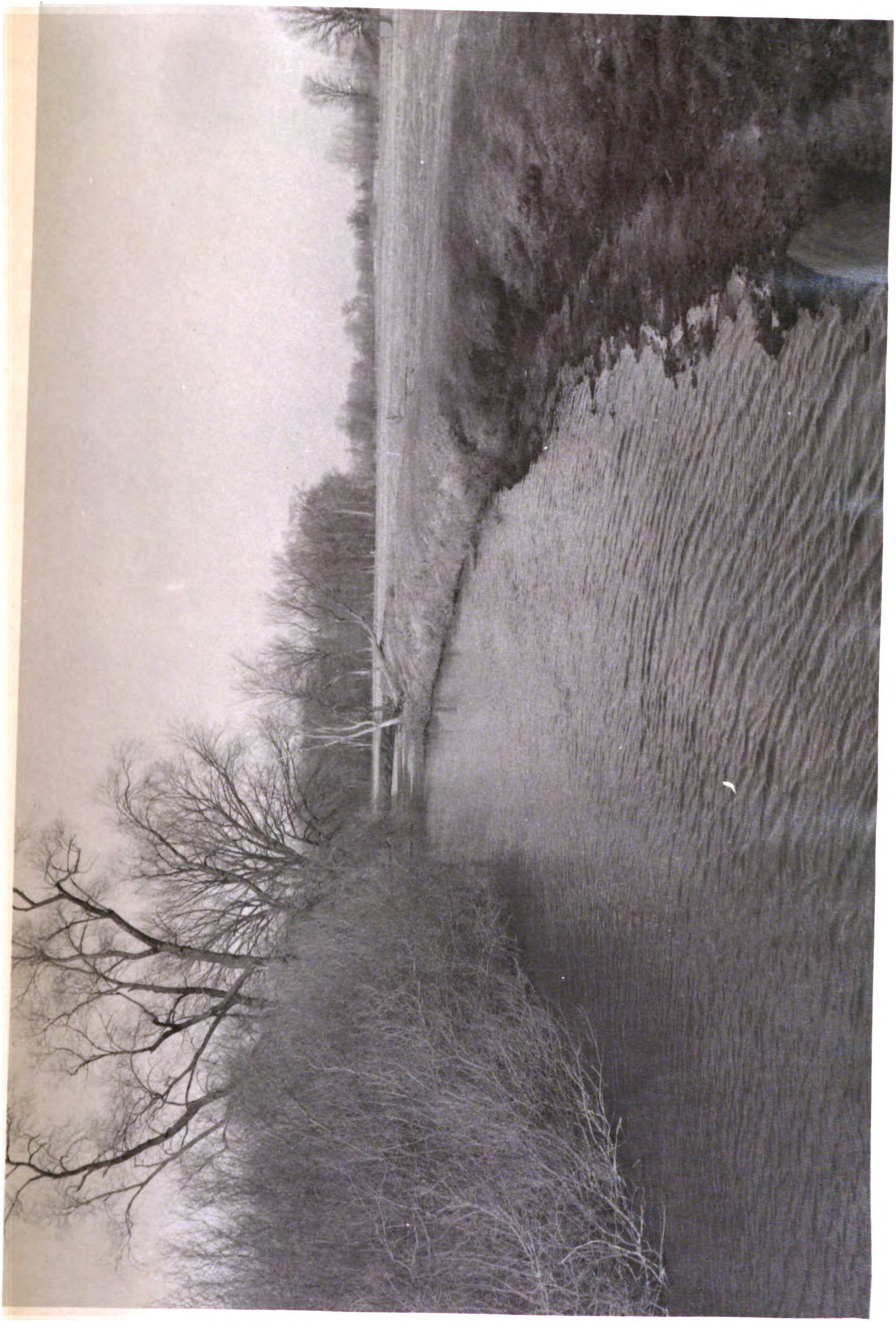

Figure 17. Station 5P

Figure 18. Station 5S

Figure 19. Station 5R

RESULTS

RESULTS

Species Composition and Distribution

During this study, 1131 fish representing 32 species were collected. The species composition and distribution of the fishes collected from the Red Cedar River during the course of the investigation is illustrated in Table II.

Over 87 percent of all the fishes collected during the study period were forage fishes, or those species having rather small adult forms. Of this group, over 60 percent were members of the minnow family, with the northern common shiner as the most abundant species, and the bluntnose minnow and northern creek chub almost twice as numerous as any of the remaining species. These three species of minnows represented almost half (43.7 percent) of the entire collection.

Of the coarse fishes, the common white sucker was by far the most numerous; fish of this species were almost twice as abundant as any other species of coarse fish.

The rock bass was the most common of the game and pan fishes; the northern pike and the smallmouth bass were the only other species of this group which were fairly common.

Riffle areas were the most productive of the three main habitat types sampled. Over half of the fish collected were captured in riffle areas. This result is undoubtedly due to

TABLE II

SPECIES COMPOSITION OF HABITAT TYPES, EXPRESSED IN NUMBERS AND PERCENT

	Species	Riffle Areas		Pools		Sluggish Stretches		Entire River	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Game and Pan Fish	Mud pickerel	-	-	-	-	3	1.5	3	0.3
	Northern pike	8	1.4	1	0.3	8	3.7	17	1.5
	Bluegill	1	0.2	3	0.9	2	0.9	6	0.5
	Pumpkinseed	-	-	-	-	1	0.5	1	0.1
	Northern rock bass	22	3.8	9	2.7	8	3.7	39	3.4
	Black crappie	-	-	1	0.3	-	-	1	0.1
	Northern smallmouth bass	4	0.7	4	1.2	5	2.3	13	1.1
	Total	35	6.3	18	5.4	27	12.0	80	7.0
Coarse Fish	Chestnut lamprey	1	0.2	-	-	-	-	1	0.1
	Golden redhorse	-	-	-	-	2	0.9	2	0.2
	Northern redhorse	-	-	-	-	3	1.5	3	0.3
	Hog sucker	1	0.2	-	-	1	0.5	2	0.2
	Common white sucker	14	2.4	6	1.8	12	5.6	32	2.8
	Black bullhead	-	-	-	-	1	0.5	1	0.1
	Yellow bullhead	10	1.7	3	0.9	4	1.9	17	1.5
	Carp	-	-	-	-	8	3.8	8	0.7

	Total	26	4.5	9	2.7	31	14.7	66	5.9
Forage Fish	Mudminnow	25	4.3	1	0.3	30	13.9	56	4.9
	Common eastern madtom	3	0.5	-	-	-	-	3	0.3
	Tadpole madtom	-	-	1	0.3	3	1.4	4	0.4
	Central stoneroller	-	-	11	3.3	-	-	11	1.0
	Bluntnose minnow	113	19.6	11	3.3	6	2.8	130	11.4
	Sand shiner	2	0.3	1	0.3	1	0.5	4	0.4
	Northern common shiner	125	21.7	84	24.9	28	13.0	237	20.9
	Rosyface shiner	40	6.9	-	-	-	-	40	3.5
	Golden shiner	-	-	2	0.6	-	-	2	0.2
	Western blacknose dace	69	11.9	10	3.0	33	15.3	112	9.9
	Hornyhead chub	9	1.6	4	1.2	7	3.2	20	1.8
	Northern creek chub	46	8.0	47	13.9	32	14.8	125	11.1
	Rainbow darter	37	6.4	1	0.3	2	0.9	40	3.5
	Central Johnny darter	18	3.1	17	5.0	6	1.9	41	3.6
	Blackside darter	26	4.5	40	11.8	12	5.6	78	6.9
	Brook silverside	1	0.2	-	-	-	-	1	0.1
	Brook stickleback	1	0.2	80	23.7	-	-	81	7.2
	Total	515	89.2	310	91.9	160	73.3	985	87.1
	Grand Total	576	100.0	337	100.0	218	100.0	1131	100.0

the fact that riffle areas are a favored habitat for many of the minnows, and minnows represented a large proportion of the total collection.

Table III represents the species composition and distribution of fishes collected in each of the five sections of the main stream. Due to the small sample sizes of certain species, some of the figures are misleading when the river as a whole is considered. For example, only one carp was taken from the main river during the study period. Hence, the section in which it was taken (section 1) contained 100 percent of all carp taken. However, the author has observed carp in at least two other sections, and this species may possibly be more numerous in some other section.

More species were taken in section 1 than in any of the other four sections. This observation substantiates the findings of other investigators who have correlated diversity of species with increased size of the river (Starrett, 1950). The lack of sufficient data from section 3 is due to the fact that hook and line samples were the only ones taken from the mainstream in that section.

Sections 2 and 4 were selected to present data comparing fish populations of the mainstream and adjacent tributaries (Table IV). The absence of the larger fishes in the tributaries would be expected. Smallmouth bass were restricted to the lower portions of the river, and large northern pike were not taken in the headwaters. The western mudminnow was taken only in the upper reaches of the drainage system.

TABLE III

DISTRIBUTION OF FISHES COLLECTED IN THE RED CEDAR RIVER, BY SPECIES AND MAINSTREAM SECTIONS. FIGURES REPRESENT THE PERCENTAGE OF EACH SPECIES OCCURRING IN EACH OF THE FIVE SECTIONS

	Species	Number	Section 1	2	3	4	5	Percent of Total
	Mud pickerel	2	-	-	-	-	100.0	0.4
Game and Pan Fish	Northern pike	17	-	29.4	23.5	47.1	-	3.1
	Bluegill	4	50.0	-	-	25.0	25.0	0.7
	Pumpkinseed	1	100.0	-	-	-	-	0.2
	Northern rock bass	37	29.7	24.3	-	29.7	16.3	6.7
	Black crappie	1	-	-	-	-	100.0	0.2
	Northern smallmouth bass	13	23.0	69.2	7.8	-	-	2.3
	Chestnut lamprey	1	-	-	-	100.0	-	0.2
	Golden redhorse	2	100.0	-	-	-	-	0.4
Fish	Northern redhorse	3	100.0	-	-	-	-	0.5
	Hog sucker	2	50.0	-	-	50.0	-	0.4
	Common white sucker	20	40.0	5.0	-	55.0	-	3.6

Coarse	Black bullhead	1	100.0	-	-	-	-	0.2
	Yellow bullhead	17	23.5	-	-	58.8	17.7	3.1
	Carp	1	100.0	-	-	-	-	0.2
Forage Fish	Mudminnow	26	-	-	-	100.0	-	4.6
	Common eastern madtom	3	-	-	-	100.0	-	0.5
	Bluntnose minnow	98	90.8	6.2	-	2.0	1.0	17.5
	Sand shiner	3	67.0	33.0	-	-	-	0.5
	Northern common shiner	145	70.3	5.5	-	5.5	18.7	26.1
	Rosyface shiner	40	82.5	12.5	-	5.0	-	7.2
	Western blacknose dace	3	67.0	33.0	-	-	-	0.5
	Hornyhead chub	11	45.5	27.3	-	27.2	-	2.0
	Northern creek chub	21	61.9	-	-	-	38.1	3.8
	Rainbow darter	3	-	67.0	-	33.0	-	0.5
	Central Johnny darter	19	-	5.3	-	57.9	36.8	3.4
	Blackside darter	61	1.6	8.2	-	34.4	55.8	11.0
	Brook silverside	1	100.0	-	-	-	-	0.2
	Total	556						

TABLE IV

SPECIES PRESENT IN MAINSTREAM SECTIONS
2 AND 4 AND THEIR TRIBUTARIES

	Species	Section 2		Section 4	
		Main Stream	Tribu-taries	Main Stream	Tribu-taries
Game and Pan Fish	Mud pickerel			x	x
	Northern pike	x		x	
	Bluegill			x	
	Northern rock bass	x		x	
	Northern smallmouth bass	x			
Coarse Fish	Chestnut lamprey			x	
	Hog sucker			x	
	Common white sucker	x	x	x	x
	Yellow bullhead			x	
Forage Fish	Mudminnow			x	x
	Common eastern madtom			x	
	Bluntnose minnow	x	x	x	x
	Sand shiner	x			
	Northern common shiner	x	x	x	x
	Rosyface shiner	x		x	
	Western blacknose dace	x	x		x
	Hornyhead chub	x	x	x	x
	Northern creek chub		x		x
	Rainbow darter	x	x	x	
	Central Johnny darter	x	x	x	x
	Blackside darter	x	x	x	x
	Brook stickleback		x		

Efficiency and Selectivity of Gear

Several samples were compared to give an indication of the efficiency and selectivity of the three main types of gear used to sample fish populations in the Red Cedar River Drainage. These were the drag seine, A.C. shocker, and D.C. shocker described earlier.

Samples 2 (seine) and 3 (A.C.) were taken on two consecutive days, July 2 and July 3 respectively (Table V). They were taken at the same location in a long pool in Button Drain, a tributary to the mainstream at section 2 (Figure 1). The A.C. shocking unit was definitely more effective than the seine at this station; almost five times as many fish were captured with the shocker as were taken with the seine. The absence of the western blacknose dace in the seine sample is characteristic of this study. In most cases, the average size of each species was larger in the A.C. samples.

Another comparison of seine and A.C. shocker samples (Table VI) shows somewhat similar results to those illustrated by Table V. Samples 6, 7, and 8 were taken on the same day (July 5) in three tributary streams with similar habitat types (Coon Creek, Squaw Creek, and Wolf Creek; see Figure 1). Again the A.C. unit was more effective in taking the western blacknose dace. The central stoneroller was never found in Squaw Creek or in Wolf Creek, and its presence in Coon Creek when this sample was taken may be indicative of a preference for conditions at that station rather than a selective effect of

TABLE V

COMPARISON OF SEINE AND A.C. SHOCKER CATCHES TAKEN FROM THE SAME LOCATION IN BUTTON DRAIN ON SUCCESSIVE DAYS

Species	Sample Number 2 (seine)			Sample Number 3 (A.C. shocker)		
	Number	Percent of Sample	Average Total Length in Centimeters	Number	Percent of Sample	Average Total Length in Centimeters
Common white sucker	1	7.1	9.4	-	-	-
Bluntnose minnow	1	7.1	3.7	15	15.5	5.4
Northern common shiner	4	28.6	5.6	6	6.2	6.8
Western blacknose dace	-	-	-	47	48.5	5.5
Northern creek chub	2	14.3	6.7	7	7.2	10.1
Rainbow darter	2	14.3	5.5	18	18.5	5.1
Central Johnny darter	4	28.6	4.7	4	4.1	5.6
Total Number in Samples	14			97		

TABLE VI

COMPARISON OF THREE SAMPLES TAKEN UNDER SIMILAR CONDITIONS ON JULY 5, 1957, USING TWO DIFFERENT KINDS OF GEAR

Species	Sample Number 6 (seine) Coon Creek			Sample Number 7 (seine) Squaw Creek			Sample Number 8 (A.C.) Wolf Creek		
	Number	Percent in Sample	Average Total Length in Centimeters	Number	Percent in Sample	Average Total Length in Centimeters	Number	Percent in Sample	Average Total Length in Centimeters
Mud pickerel	-	-	-	-	-	-	1	0.9	17.2
Bluegill	2	1.3	4.5	-	-	-	-	-	-
Common white sucker	5	3.2	9.3	1	5.6	16.6	5	4.3	11.6
Mudminnow	-	-	-	1	5.6	3.4	21	18.3	8.3
Central stoneroller	11	7.1	8.0	-	-	-	-	-	-
Bluntnose minnow	2	1.3	5.3	-	-	-	6	5.3	7.1
Northern common shiner	4	2.6	8.5	14	77.8	4.9	12	10.4	7.5
Golden shiner	-	-	-	2	11.0	5.0	-	-	-
Western blacknose dace	10	6.4	4.4	-	-	-	33	28.7	6.2
Hornyhead chub	-	-	-	-	-	-	1	0.9	5.2
Northern creek chub	36	23.0	5.9	-	-	-	32	27.8	9.0
Central Johnny darter	6	3.8	4.4	-	-	-	2	1.7	5.9
Blackside darter	-	-	-	-	-	-	2	1.7	7.1
Brook stickleback	80	51.3	3.5	-	-	-	-	-	-
Total Number in Samples	156			18			115		

the gear. The average size of fishes of most species was larger in the A.C. samples than in samples taken with the drag seine.

Table VII illustrates collections made with all three of the principal kinds of gear used in the study. The three collections were made within a 9-day period (July 24 to August 1) and were made in sections 2, 4, and 5. As before, the A.C. unit was the most effective gear for taking western blacknose dace. However, the D.C. unit accounted for larger numbers and more species than either the A.C. shocker or the drag seine. This increased efficiency was possibly due in large part to a larger crew operating this unit.

Tables VIII and IX illustrate the variation in size and species composition of fishes taken from the same location at different times during the study period. Samples 3 and 19 (Table VIII) were taken from Button Drain using the A.C. shocker. While the variation in species composition may be due partly to instantaneous factors (those factors which may cause a group of fish to be at a location which is not a part of their everyday habitat, such as migration), the increased average size in fishes in the same sample taken at the later date is probably a real value representing growth. The same conditions apply to the data represented in Table IX.

A chi-square test applied to the data presented in each of the Tables (VIII and IX) shows a highly significant difference between the species composition (numbers) between sampling

TABLE VII

SPECIES DISTRIBUTION AND AVERAGE TOTAL LENGTH OF FISH TAKEN FROM RIFFLE AREAS IN THREE SECTIONS OF THE MAIN STREAM, USING THREE DIFFERENT TYPES OF GEAR

Species	Sample Number 12 (seine) Section 2 (July 24)			Sample Number 15 (D.C.) Section 4 (July 29)			Sample Number 19 (A.C.) Section 5 (Aug. 1)		
	Number	Percent in Sample	Average Total Length in Centimeters	Number	Percent in Sample	Average Total Length in Centimeters	Number	Percent in Sample	Average Total Length in Centimeters
Mud pickerel	-	-	-	1	0.9	14.2	-	-	-
Northern pike	-	-	-	8	7.2	19.6	-	-	-
Northern rock bass	2	11.8	2.3	9	8.1	13.5	-	-	-
Northern smallmouth bass	1	5.9	2.9	-	-	-	-	-	-
Chestnut lamprey	-	-	-	1	0.9	4.1	-	-	-
Hog sucker	-	-	-	1	0.9	25.1	-	-	-
Common white sucker	1	5.9	6.3	11	9.9	24.2	-	-	-
Yellow bullhead	-	-	-	10	9.0	14.2	-	-	-
Mudminnow	-	-	-	24	21.6	6.5	-	-	-
Common eastern madtom	-	-	-	3	2.8	9.7	-	-	-
Bluntnose minnow	4	23.5	5.4	2	1.8	4.2	1	1.3	6.7
Northern common shiner	5	29.4	7.4	5	4.5	6.0	28	35.0	7.9
Rosyface shiner	4	23.5	5.8	2	1.8	6.0	-	-	-
Western blacknose dace	-	-	-	-	-	-	19	23.6	5.8
Hornyhead chub	-	-	-	2	1.8	12.9	-	-	-
Northern creek chub	-	-	-	-	-	-	24	30.0	8.9
Rainbow darter	-	-	-	1	0.9	6.4	7	8.8	5.4
Central Johnny darter	-	-	-	10	9.0	5.0	-	-	-
Blackside darter	-	-	-	21	18.9	7.1	1	1.3	6.6
Total Number in Samples	17			111			80		

TABLE VIII

SPECIES DISTRIBUTION AND AVERAGE TOTAL LENGTH OF FISH TAKEN WITH A.C. SHOCKER FROM THE SAME LOCATION IN BUTTON DRAIN AT DIFFERENT TIMES DURING THE STUDY PERIOD

Species	Sample Number 3 (3 July)			Sample Number 19 (6 August)		
	Number	Percent of Sample	Average Total Length in Centimeters	Number	Percent of Sample	Average Total Length in Centimeters
Bluntnose minnow	15	15.5	5.4	1	1.3	6.7
Northern common shiner	6	6.2	6.8	28	35.0	7.9
Western blacknose dace	47	48.5	5.5	19	23.6	5.8
Northern Creek chub	7	7.2	10.1	24	30.0	8.9
Rainbow darter	18	18.5	5.1	7	8.8	5.4
Central Johnny darter	4	4.1	5.6	-	-	-
Blackside darter	-	-	-	1	1.3	6.6
Total Number in Samples	97			80		

TABLE IX

SPECIES DISTRIBUTION AND AVERAGE TOTAL LENGTH OF FISH TAKEN AT STATION 1 R WITH THE A.C. SHOCKER AT DIFFERENT TIMES DURING THE STUDY PERIOD

Species	Sample Number 1 (2 July)			Sample Number 35 (9 October)		
	Number	Percent of Sample	Average Total Length in Centimeters	Number	Percent of Sample	Average Total Length in Centimeters
Bluegill	-	-	-	1	3.7	5.3
Bluntnose minnow	71	68.3	5.0	3	11.1	7.6
Sand shiner	-	-	-	2	7.4	5.0
Northern common shiner	23	22.1	5.4	16	59.3	5.7
Rosyface shiner	1	1.0	5.4	3	11.1	5.2
Western blacknose dace	1	1.0	5.0	1	3.7	5.8
Hornyhead chub	3	2.8	7.1	-	-	-
Northern creek chub	5	4.8	6.6	-	-	-
Brook silverside	-	-	-	1	3.7	7.8
Total Number in Samples	104			27		

dates at each of the stations considered; that is, these differences are greater than would be expected by chance of sampling alone.

Length-Weight Relationship

The equation used in this study to express the length-weight relationship of the several species considered is $W = aL^n$, where W = weight in grams, L = total length in centimeters, and a and n are constants. When expressed in logarithmic form, the equation becomes a straight line: $\log W = \log a + n \log L$.

The values of log a and n are found as follows (Lagler, 1956):

$$\log a = \frac{\Sigma \log W \times \Sigma (\log L)^2 - \Sigma \log L \times \Sigma (\log L \times \log W)}{N \times \Sigma (\log L)^2 - (\Sigma \log L)^2}$$

where N is the number of individuals and Σ is the sum

and:

$$n = \frac{\Sigma \log W - (N \times \log a)}{\Sigma \log L}$$

Calculated weights were determined by use of the formula: $\log W = \log a + n \log L$, and the antilog of this figure is the value of the calculated weight.

The method of tabulation used in this study follows that used by Beckman (1948) and Lagler (1956) and is illustrated by Table X, which represents a small portion of the information gathered concerning the northern rock bass.

TABLE X

A SMALL PORTION OF THE LENGTH AND WEIGHT DATA COLLECTED ON THE NORTHERN ROCK BASS TO DEMONSTRATE THE METHOD USED TO TABULATE LENGTH-WEIGHT RELATIONSHIP FIGURES

Total Length (cm.)	Log L	Weight (gms.)	Log Weight	Log L x Log W	Log L^2	Calculated Log W	Calculated W
5.4	0.732	4	0.602	0.441	0.536	0.633	4.3
9.4	0.973	20	1.301	1.266	0.947	1.271	18.7
11.4	1.057	32	1.505	1.591	1.117	1.493	31.1
12.8	1.107	40	1.602	1.773	1.225	1.625	42.2
13.1	1.117	42	1.623	1.813	1.248	1.651	44.8
13.4	1.127	52	1.716	1.934	1.270	1.677	47.5
15.8	1.199	68	1.833	2.197	1.438	1.868	73.8
18.4	1.265	113	2.053	2.597	1.600	2.043	110.4
19.4	1.288	128	2.107	2.714	1.659	2.104	127.1

Figures 20 through 31 show the length-weight relationships for the species of fish in the Red Cedar River for which sufficient data were gathered to express the relationship satisfactorily. The logarithmic as well as the arithmetic relationship is shown on each graph, as is the equation which expresses this relationship. The length-weight relationship is illustrated for the following species of fish found in the Red Cedar River: northern pike (Figure 20), northern rock bass (Figure 21), northern smallmouth bass (Figure 22), common white sucker (Figure 23), western mudminnow (Figure 24), bluntnose minnow (Figure 25), northern common shiner (Figure 26), western blacknose dace (Figure 27), hornyhead chub (Figure 28), northern creek chub (Figure 29), northern rainbow darter (Figure 30) and blackside darter (Figure 31).

The total lengths of rock bass and smallmouth bass were converted to standard lengths by conversion factors presented by Beckman (1948), and the length-weight relationships for these two species were compared with the statewide averages determined by Beckman. The agreement was very close with the exception of two and three of the larger individuals. Comparisons could not be made for some of the other species, such as the darters and minnows, because of the lack of comparable data.

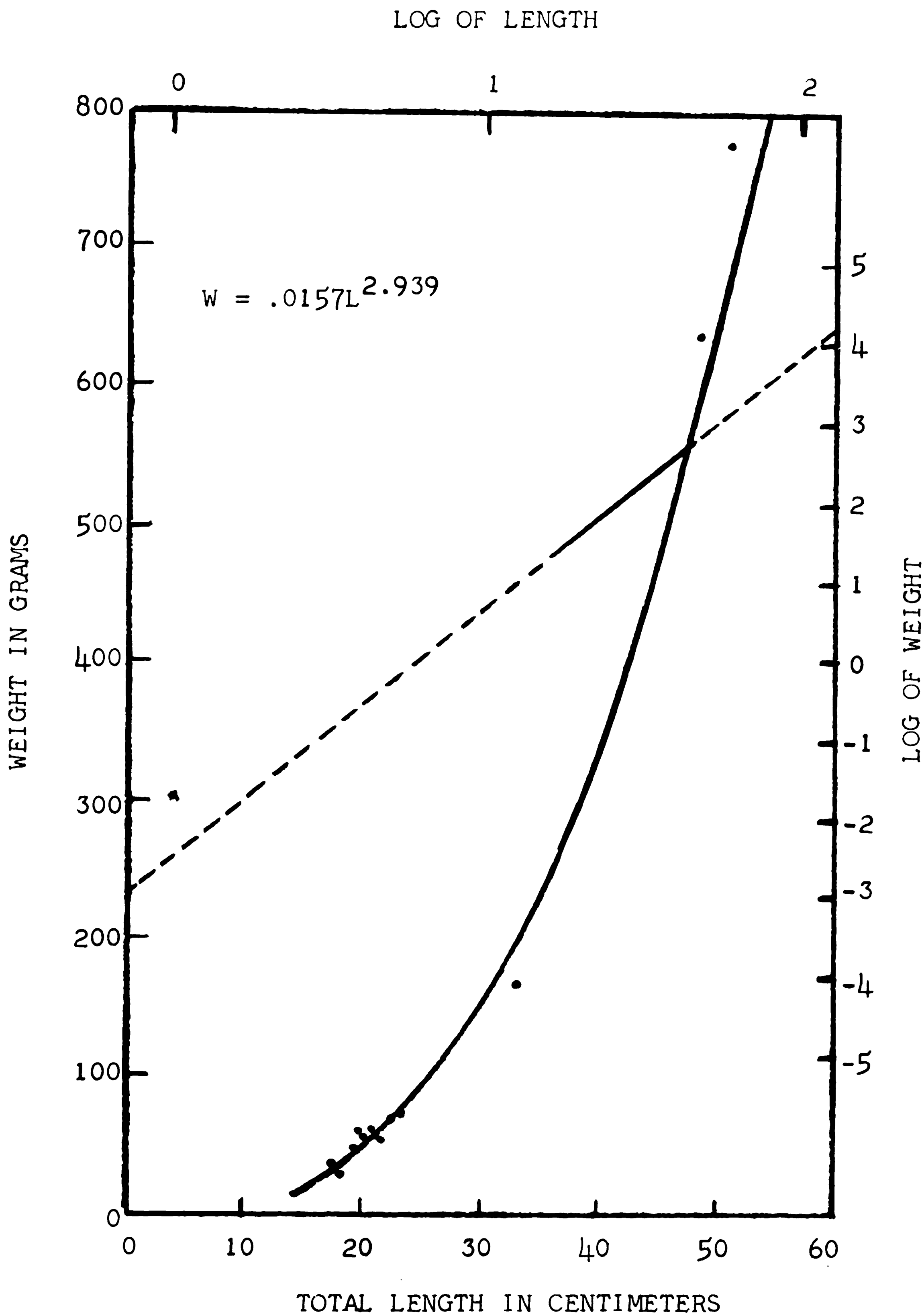

Figure 20. Length-weight relationship of the northern pike in the Red Cedar River.

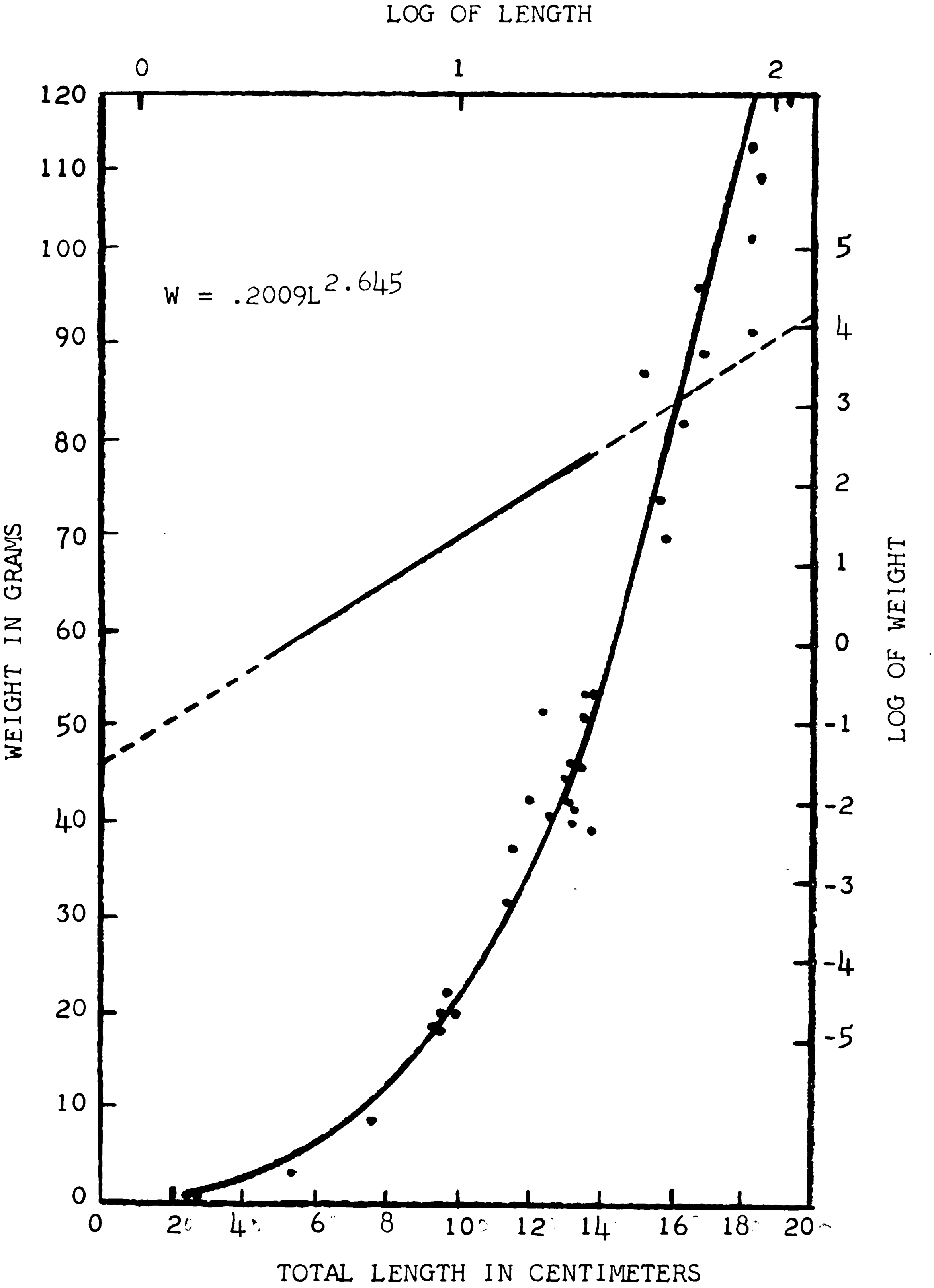

Figure 21. Length-weight relationship of the northern rock bass in the Red Cedar River.

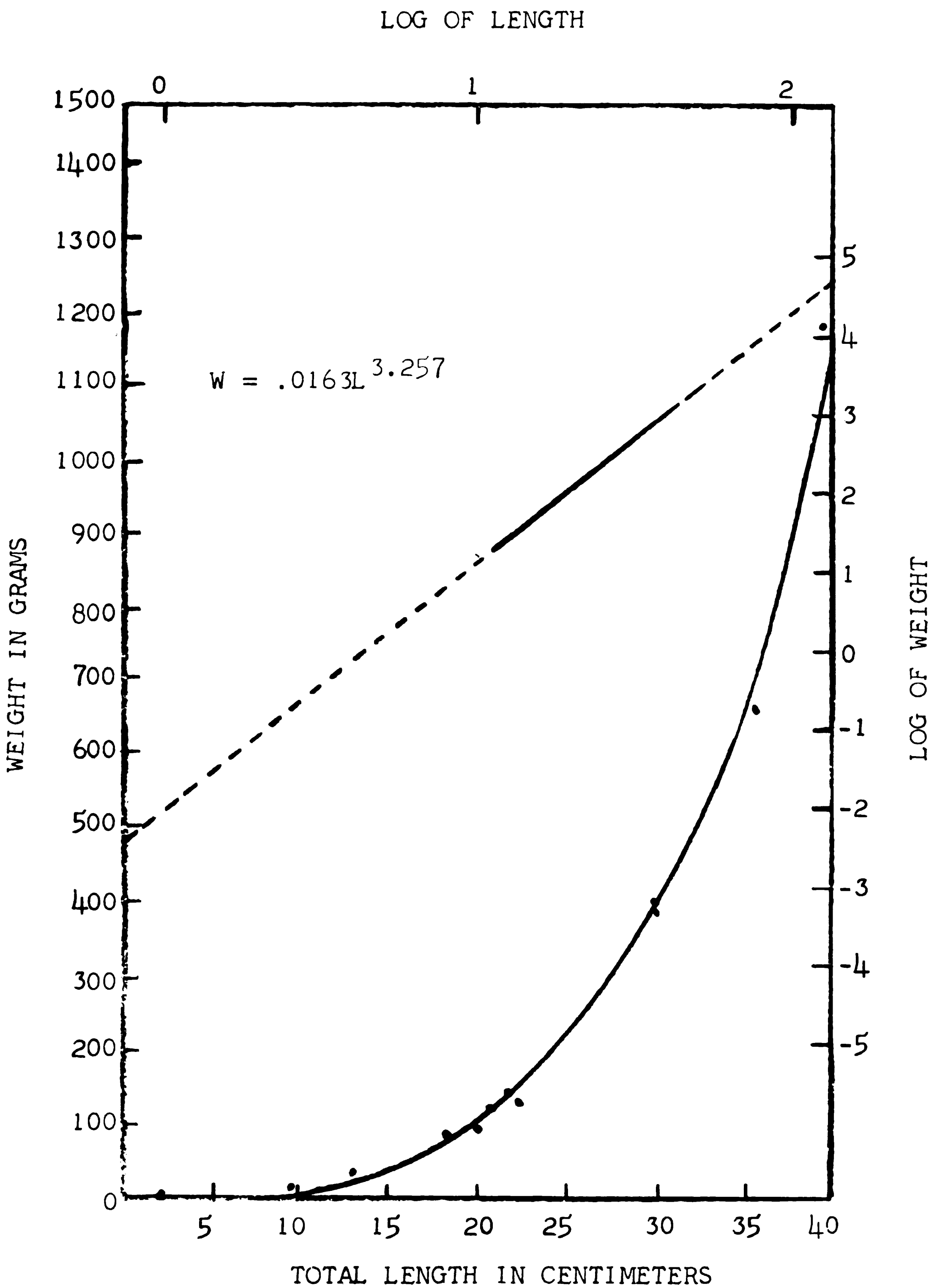

Figure 22. Length-weight relationship of the northern small-mouth bass in the Red Cedar River.

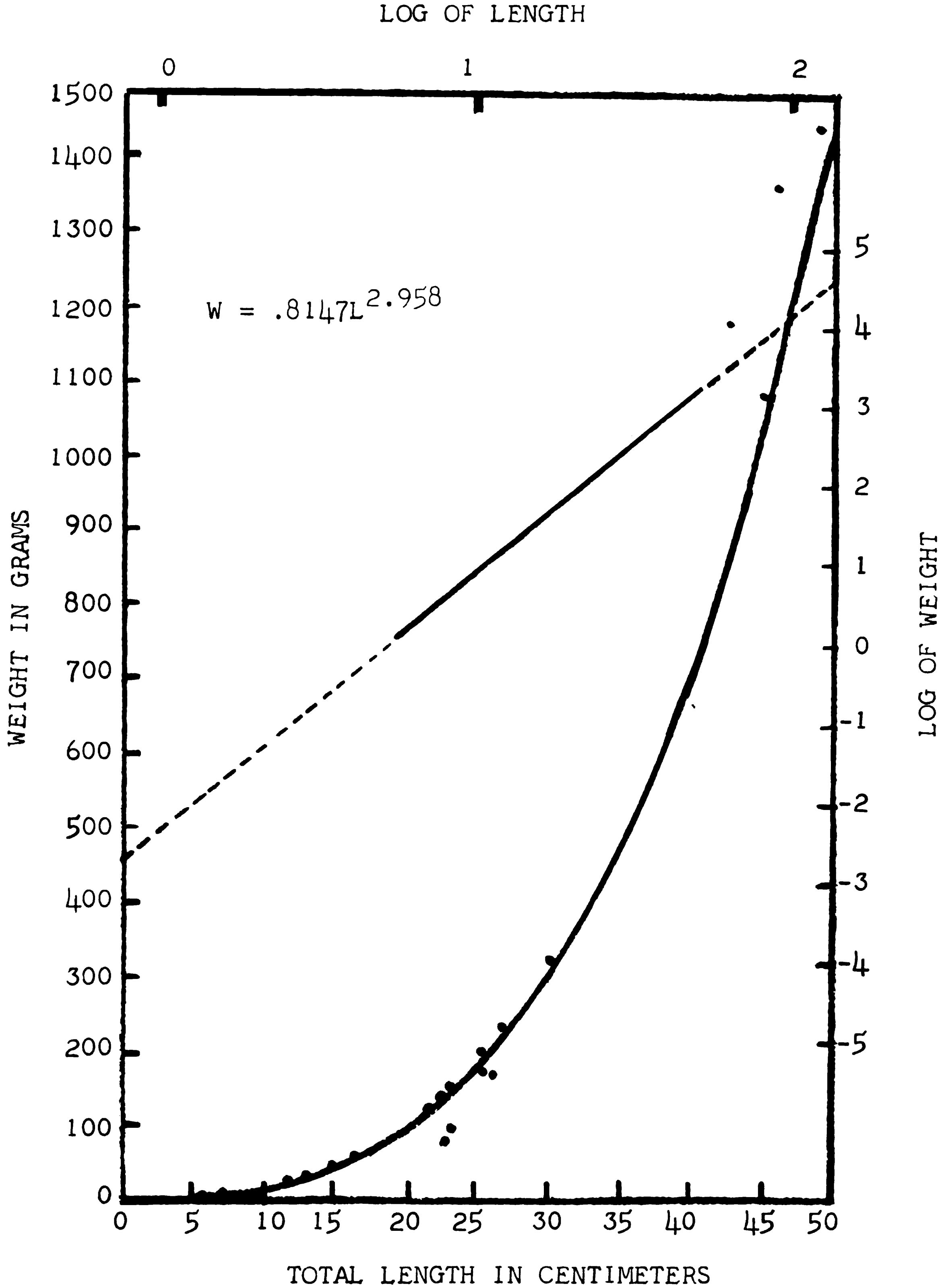

Figure 23. Length-weight relationship of the common white sucker in the Red Cedar River.

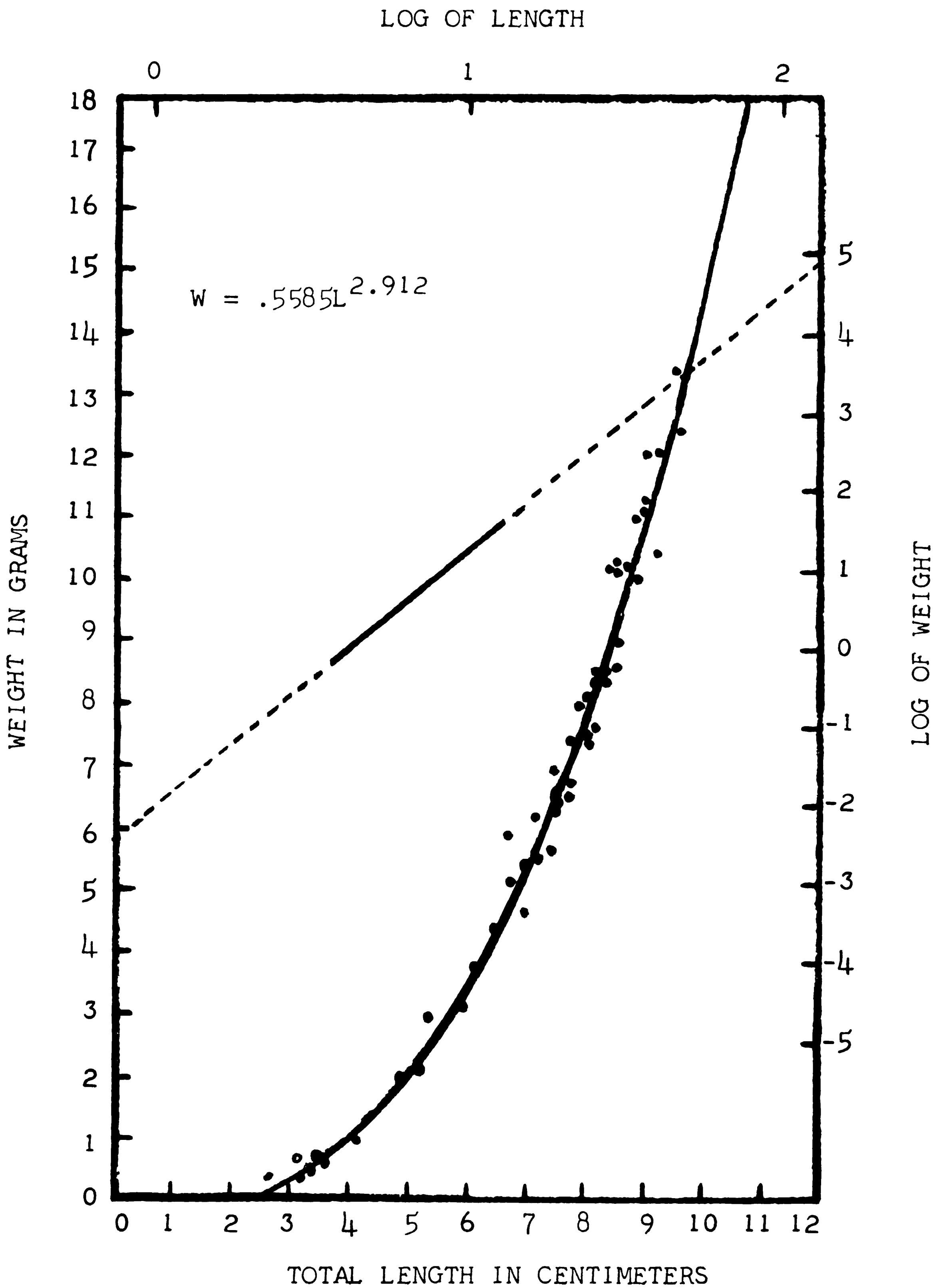

Figure 24. Length-weight relationship of the western mudminnow in the Red Cedar River.

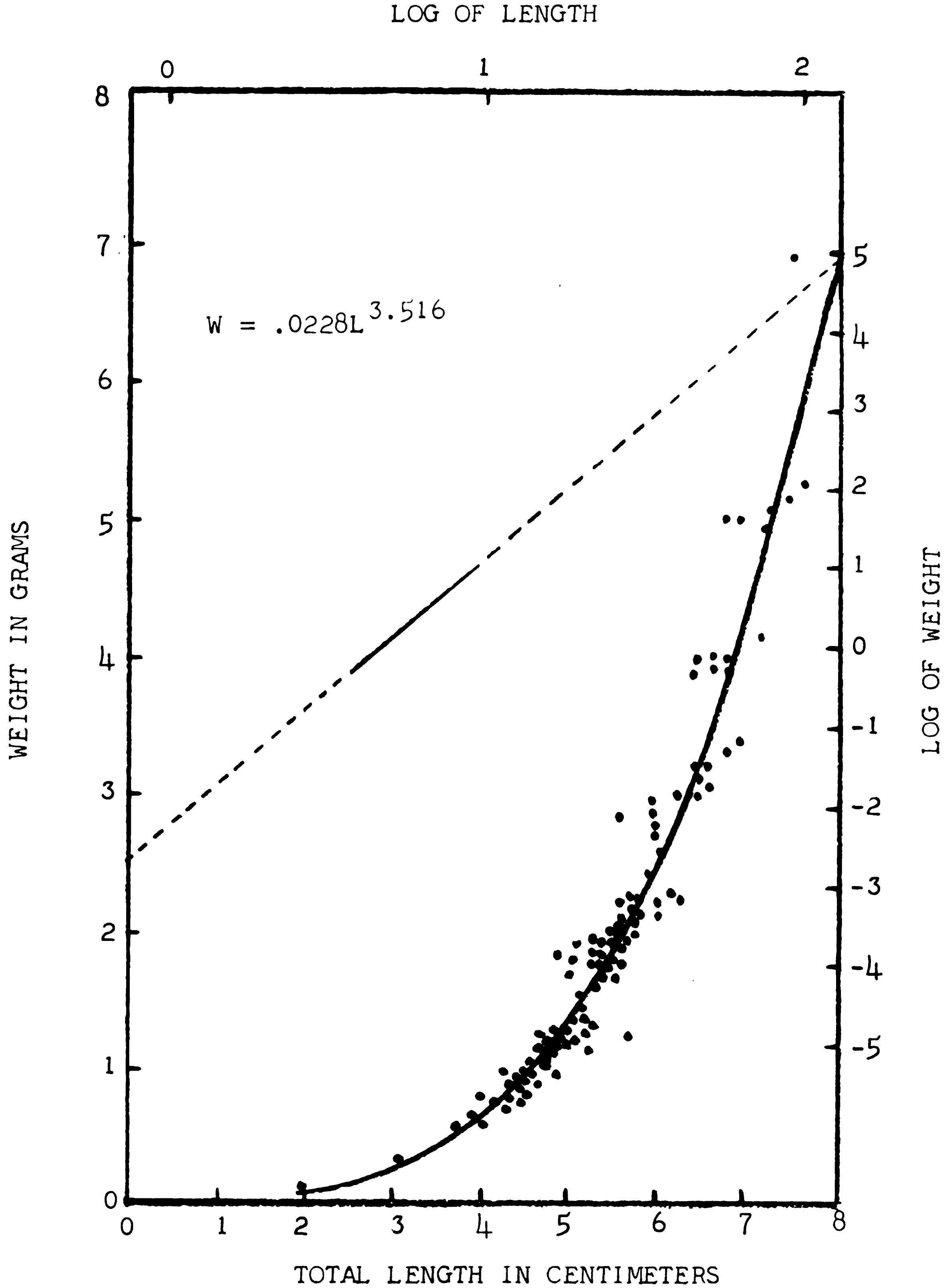

Figure 25. Length-weight relationship of the bluntnose minnow in the Red Cedar River.

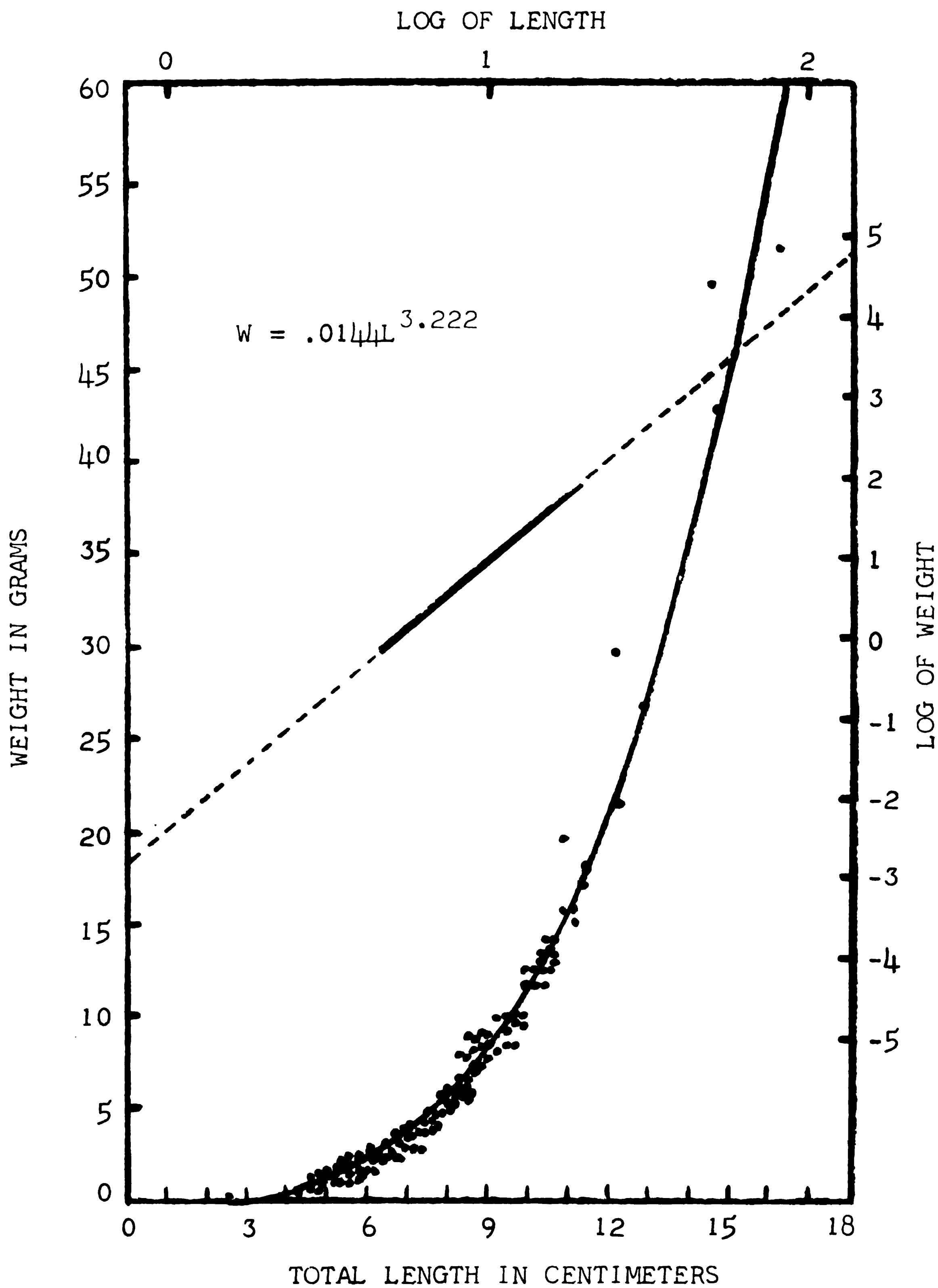

Figure 26. Length-weight relationship of the northern common shiner in the Red Cedar River.

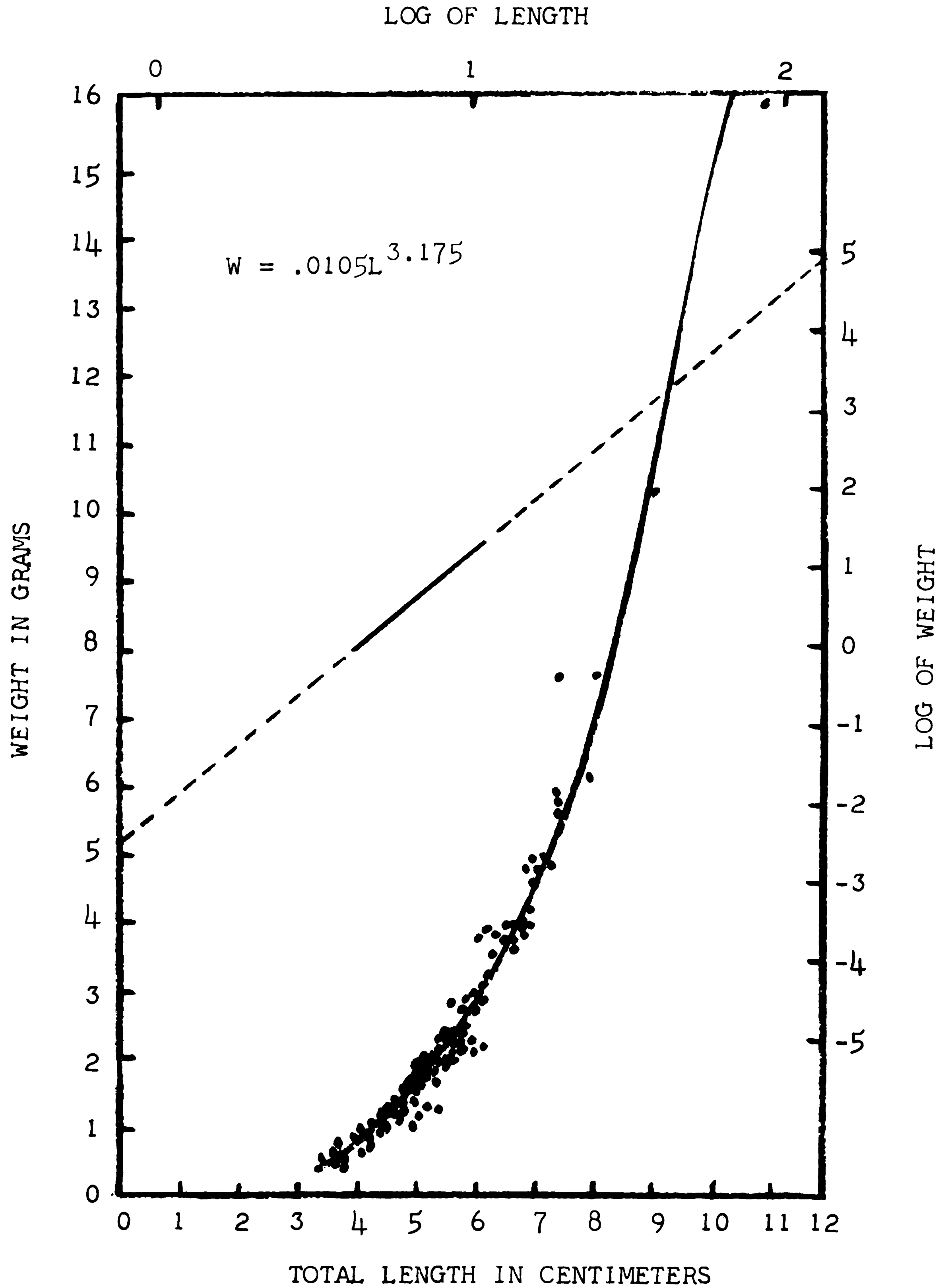

Figure 27. Length-weight relationship of the western blacknose dace in the Red Cedar River.

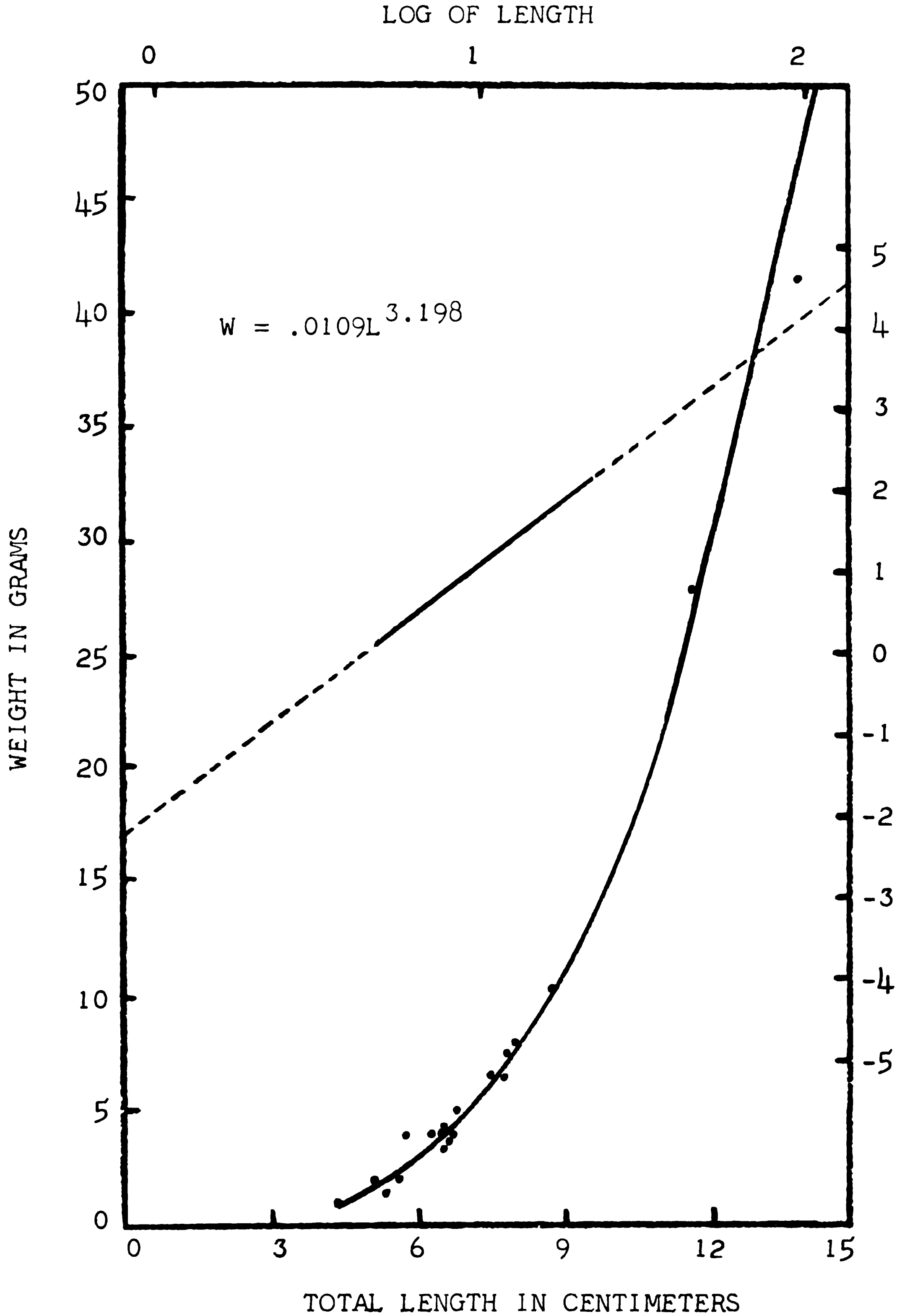

Figure 28. Length-weight relationship of the hornyhead chub in the Red Cedar River.

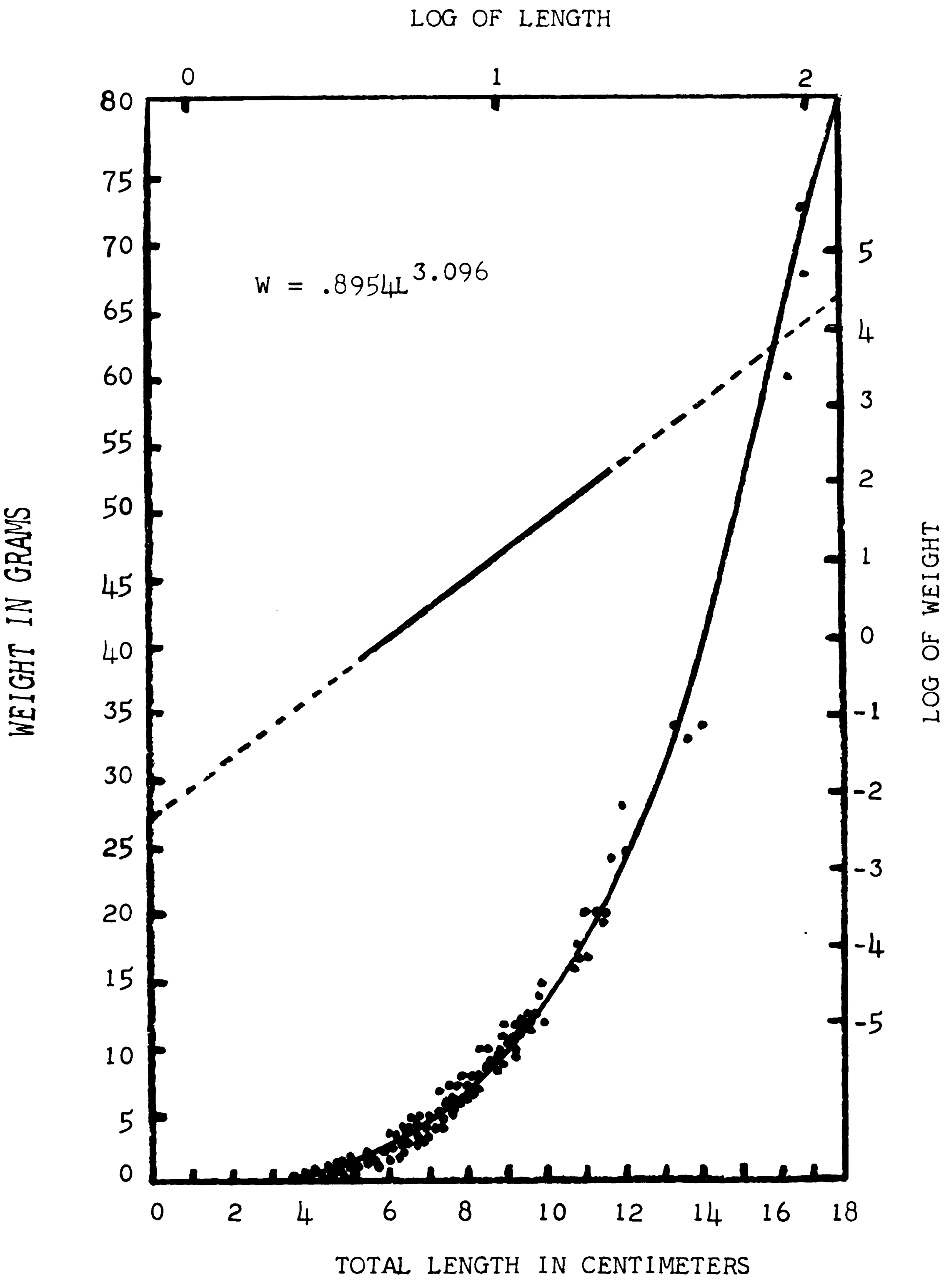

Figure 29. Length-weight relationship of the northern creek chub in the Red Cedar River.

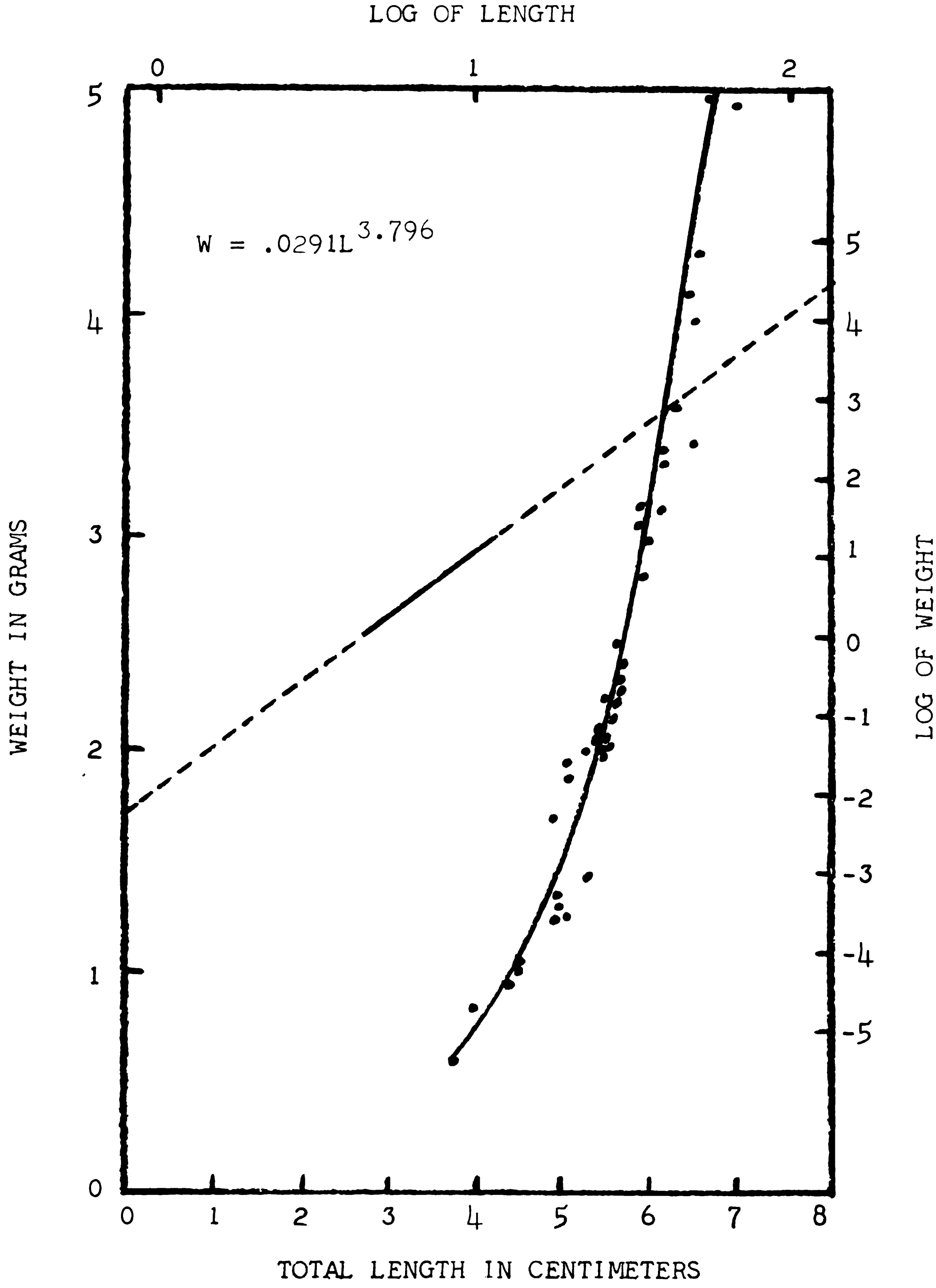

Figure 30. Length-weight relationship of the northern rainbow darter in the Red Cedar River.

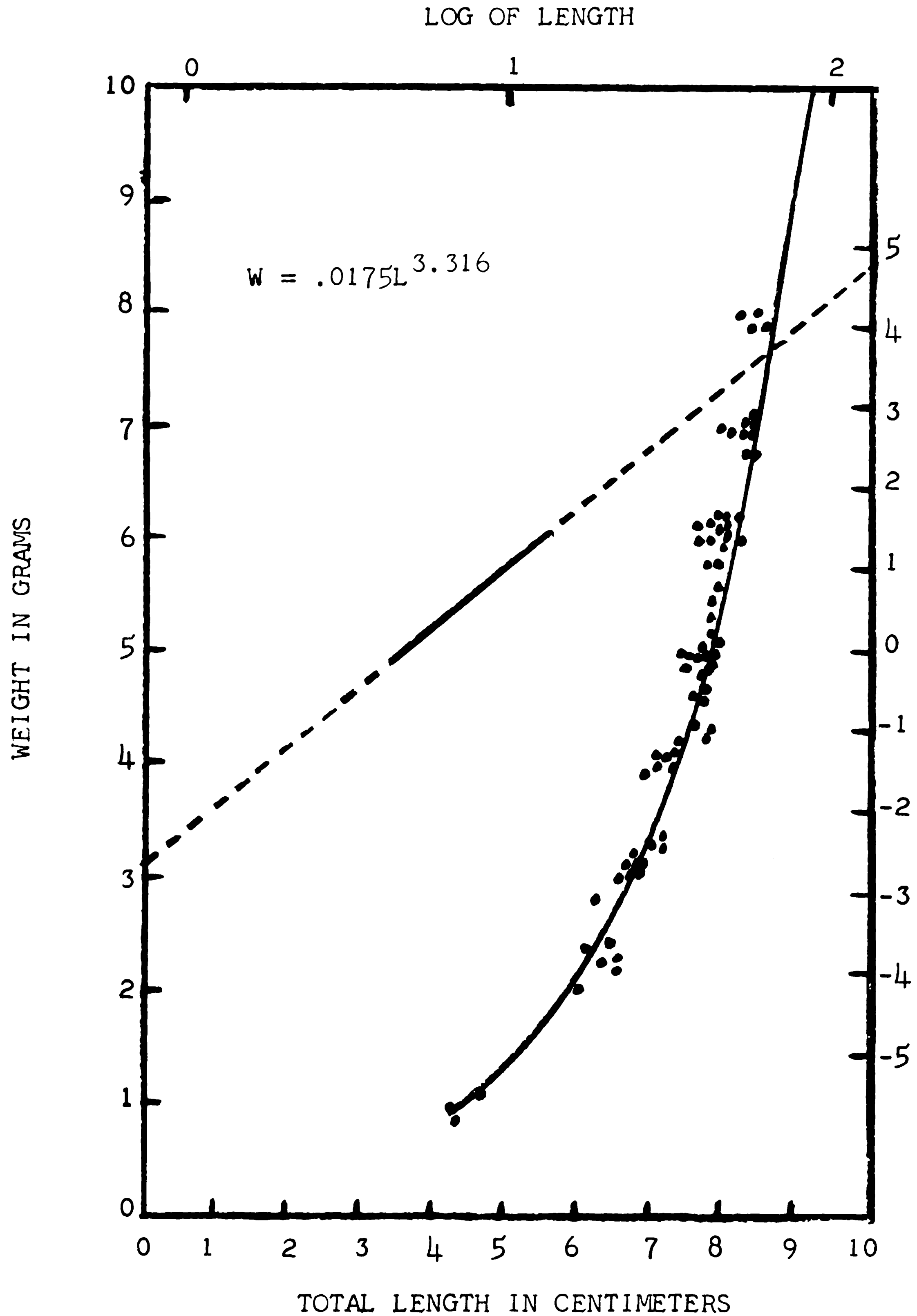

Figure 31. Length-weight relationship of the blackside darter in the Red Cedar River.

Body-scale Length Relationship

The relationship existing between the magnified scale radius and the total length of three species of fish in the Red Cedar River was determined (scales were taken from the left side of fish, above the lateral line in the case of soft-rayed fishes, below in the case of spiny-rayed fishes). This relationship may be expressed by the equation: L = a + c S, where L = the total length of the fish in centimeters, S = the length of the scale radius x 10 in centimeters, and a and c are constants. In this relationship, a is the intercept of the ordinate and c is the regression coefficient which gives the slope of the regression. The slope c may be found by using the formula: $\frac{\sum xy}{\sum x^2}$ where $\sum$ is the sum and x and y are deviations from the means $\bar{S}$ and $\bar{L}$, respectively.

Sufficient specimens of early age were not obtained, so that the body-scale length relationship was determined as one regression rather than as two, with a separate regression for earlier ages as shown by Patriarche and Lowry, 1953.

The body-scale length relationship for the common white sucker, northern smallmouth bass and northern rock bass in the Red Cedar River were described as linear regressions expressed in centimeters by the following equations:

1. Common white sucker: L = 1.88 + 3.07 S (Figure 32)
2. Northern smallmouth bass: L = 2.24 + 2.69 S (Figure 33)
3. Northern rock bass: L = 2.67 + 1.12 S (Figure 34)

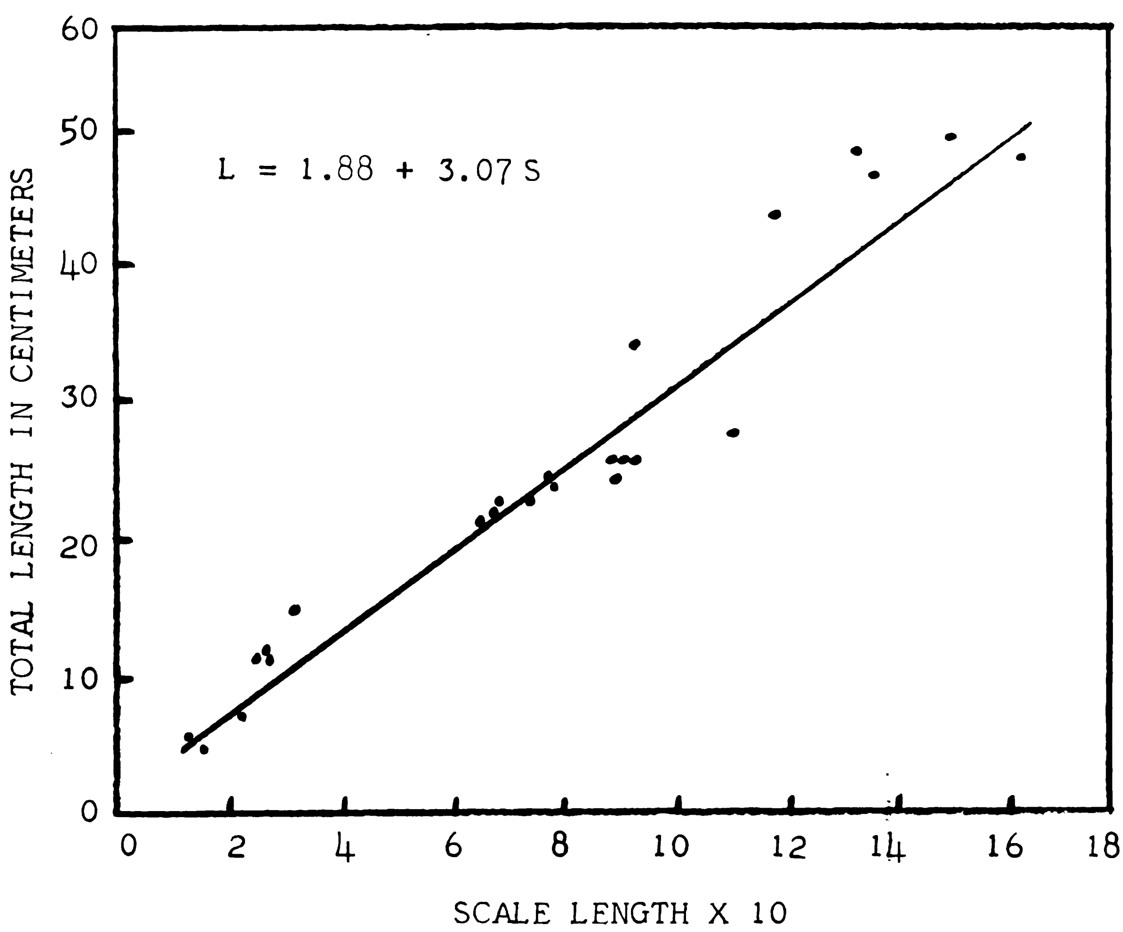

Figure 32. Body-scale length relationship of the common white sucker in the Red Cedar River.

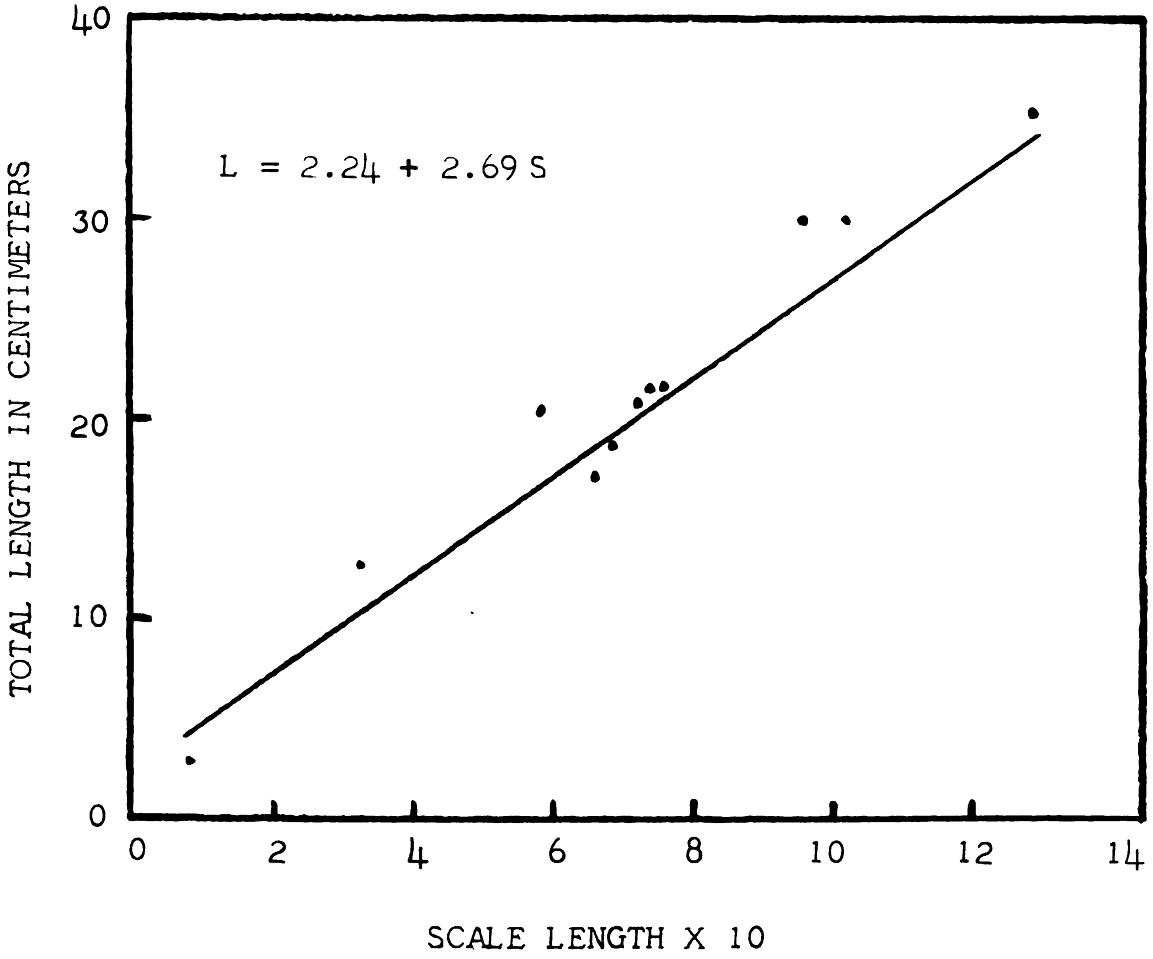

Figure 33. Body-scale length relationship of the northern smallmouth bass in the Red Cedar River.

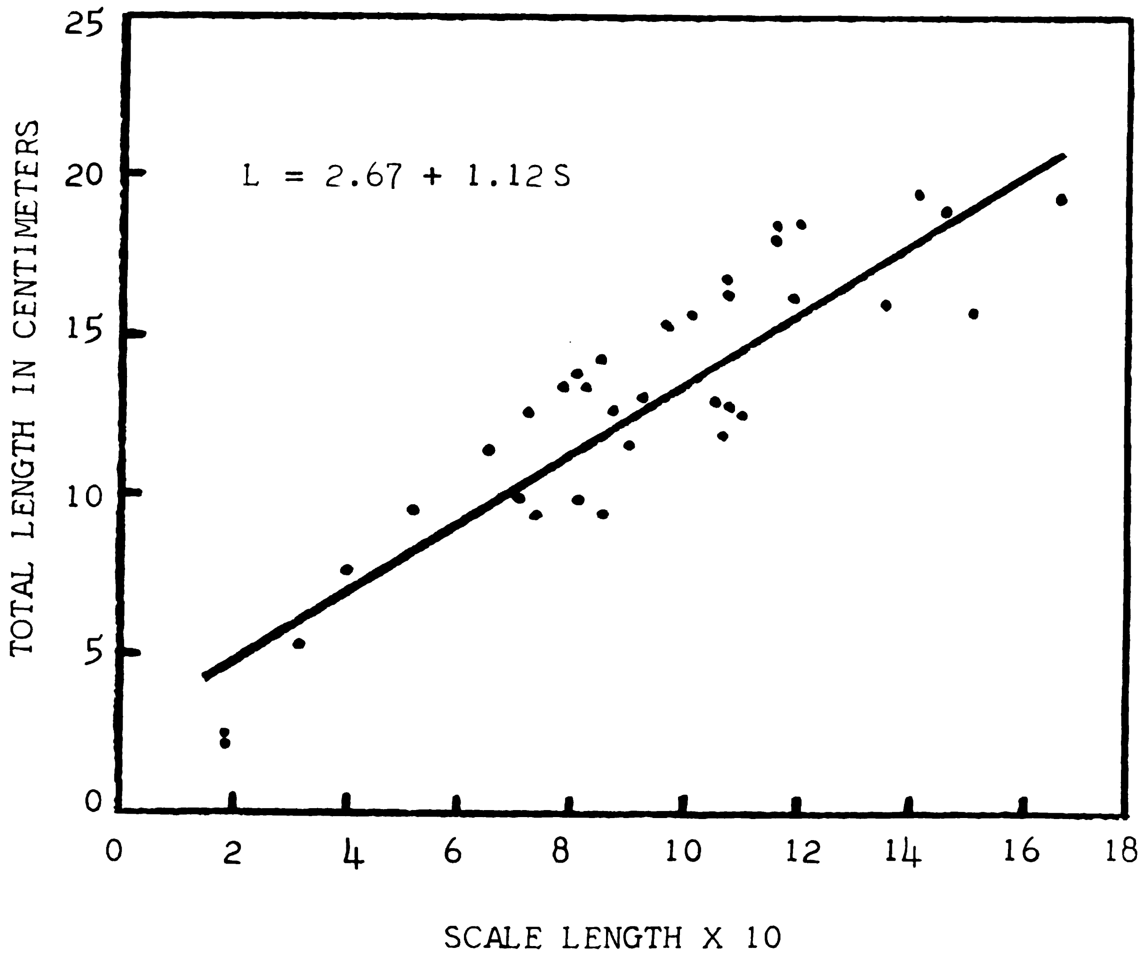

Figure 34. Body-scale length relationship of the northern rock bass in the Red Cedar River.

Differences in Coefficient of Condition

The coefficient of condition, K, was determined for the northern creek chub and the northern rock bass, using the following formula:

$$K = \frac{W \times 100}{L^3}$$

where W = weight in grams and L = total length in centimeters. When expressed logarithmically, the formula becomes:

$$\log K = \log W + 2 - 3 \log L$$

The coefficients of conditions were then analyzed statistically to determine whether differences existed in the condition of each of the two species in various sections of the river. To remove the error which might be produced by fish of different sizes having different condition factors, fish of one size class in each species were selected for the determinations. Northern creek chubs between the total lengths of 6.1 and 10.0 centimeters, and rock bass of 11.0 to 16.0 centimeters total length were used.

Table XI shows the results of an analysis of variance (Snedecor, 1956) of coefficients of condition for the northern creek chub. After this highly significant "F" value was calculated, a further test was run to ascertain exactly where the differences were to be found. A multiple range test for correlated and heteroscedastic means, described by Duncan (1955 and 1957), was performed with the following results:

(DBEA) (C) at the 1% level of significance.

TABLE XI

RESULTS OF ANALYSIS OF VARIANCE OF COEFFICIENTS OF CONDITION OF NORTHERN CREEK CHUBS THROUGHOUT THE RED CEDAR RIVER DRAINAGE, SHOWING HETEROGENEITY OF THE DATA

Source of Variability	Degrees of Freedom	Sum of Squares	Mean Square
Total	66	1.96	-
Within Samples	62	1.12	0.018
Between Samples	4	0.84	0.210

$$F = \frac{.210}{.018} = 11.67^{**}$$

The letters designate samples from the following stations:

D - station at Button Drain

B - station 5 P

E - station 1 R

A - station at Wolf Creek

C - station at Coon creek

All samples appearing within the same parenthesis are homogeneous. Hence, the average coefficient of condition of northern creek chubs in Coon Creek differs significantly from that of all other samples. The average K factor for the Coon Creek sample was higher (1.61; that is, the creek chubs were in a better condition) than at other stations in the drainage (1.29 to 1.41). The reason for this greater K is at present not known, but very high fertility of the lands which Coon Creek drains may possibly increase production to the extent that the greater food supplies allow the fishes to attain greater plumpness or robustness, the measure of K.

Only three rock bass samples were tested; one from station 1 R, one from station 5 P, and one from station 4 R. The results of an analysis of variance of the coefficients of condition of these rock bass is shown in Table XII. In order to determine where the differences actually were, the multiple range test described above was employed. The results at the 1 percent level of significance were:

(AB) (BC). The letters designate samples from the following stations:

TABLE XII

RESULTS OF ANALYSIS OF VARIANCE OF COEFFICIENTS OF CONDITION OF NORTHERN ROCK BASS AT THREE STATIONS ON THE RED CEDAR RIVER, SHOWING HETEROGENEITY OF THE DATA

Source of Variability	Degrees of Freedom	Sum of Squares	Mean Square
Total	14	0.83	-
Within Samples	12	0.45	0.038
Between Samples	2	0.38	0.190

$$F = \frac{.190}{.038} = 5.0^{*}$$

A - Station 1 R

B - Station 5 P

C - Station 4 R

Hence, the K at station 4 R differs significantly from the K at station 1 R. In this comparison, the highest average K was found at station 4 R (2.22), the lowest at station 1 R (1.85), and the value at station 5 P was 2.01.

Age and Growth

Very little work has been published on the growth of stream fishes, and since this phase of fisheries biology is extremely important, particularly in the recognition of suitable or unsuitable environmental conditions for sport and food fishes, a brief study of the age and growth of three species, the northern smallmouth bass, the northern rock bass, and the common white sucker, has been included in this study. In Tables XIII-XV, the average growth increments were determined by averaging the increments of each age group for a given year.

Patriarche and Lowry (1953) found that the growth rate of smallmouth bass in the Black River, Missouri, began to decrease after the third year of life. Stroud (1949) found a similar situation in several TVA storage reservoirs in Tennessee and North Carolina. The growth rate of northern smallmouth bass in the Red Cedar River increased slightly each year up to and including the fourth year of life (Table XIII and Figure 35). Unfortunately, no fish of age group V were taken.

TABLE XIII

AVERAGE CALCULATED LENGTH AT END OF EACH YEAR OF LIFE AND AVERAGE GROWTH INCREMENT OF NORTHERN SMALLMOUTH BASS IN THE RED CEDAR RIVER

Age Group	Number of Fish	Total Length in Centimeters at Capture	Calculated Total Length in Centimeters at End of Year 1	2	3	4
I	3	13.2	6.2			
II	5	20.7	6.4	12.7		
III	2	30.0	5.8	14.3	23.3	
IV	2	37.6	6.0	14.5	22.5	32.3
Grand Average			6.1	13.8	22.9	32.3
Average Increment			6.1	7.8	8.5	9.8
Number of Fish			12	9	4	2

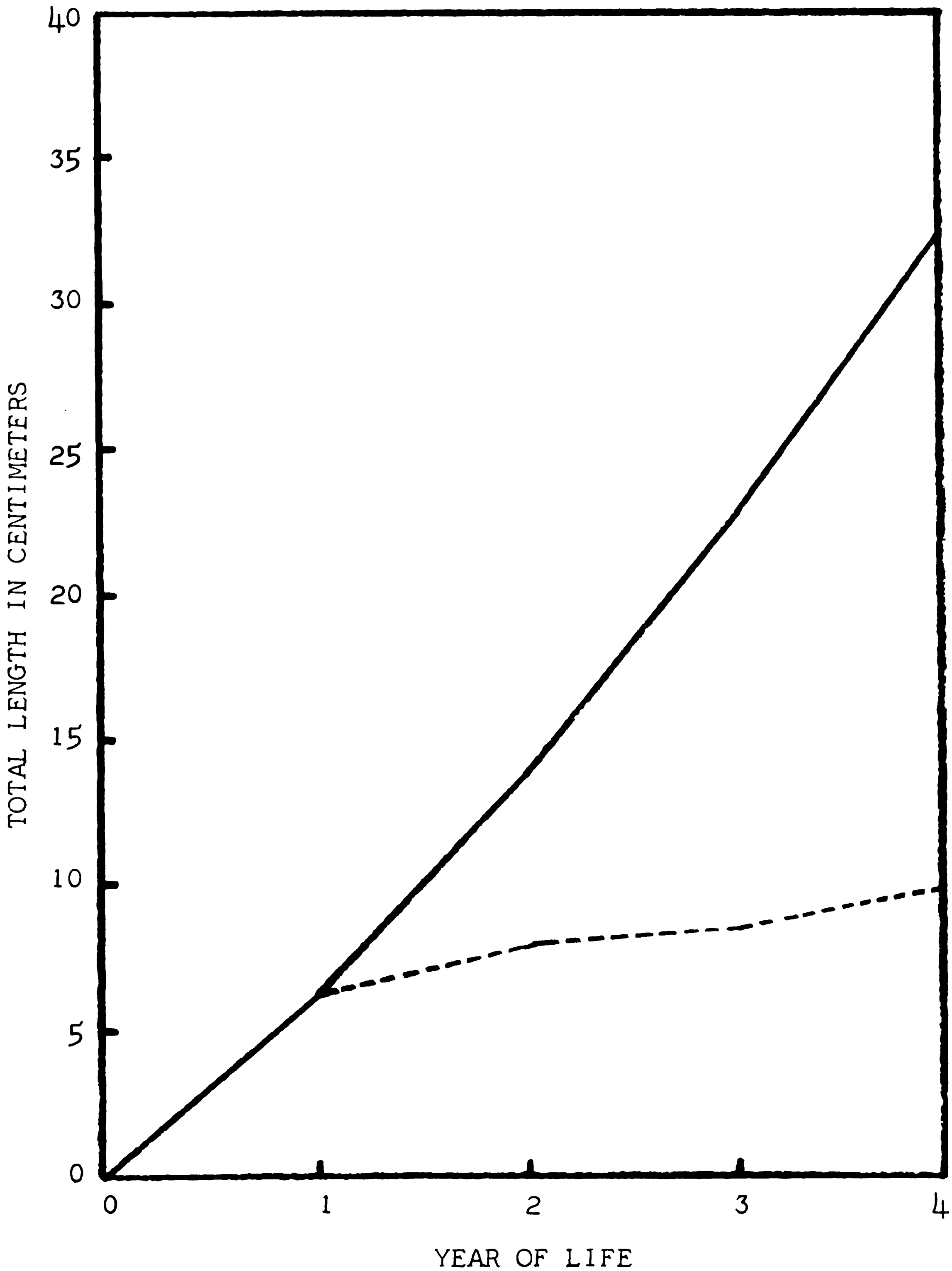

Figure 35. Calculated total length attained by northern smallmouth bass at the end of each year of life (solid line) and average annual growth increment (broken line).

The growth rate of the northern rock bass in the Red Cedar River (Table XIV and Figure 36) agreed very closely with those obtained by Patriarche and Lowry (1953) in Missouri and by Scott (1949) in his study of a rock bass population in the Tippecanoe River in Indiana.

The growth rate of the common white sucker in the Red Cedar River (Table XV and Figure 37) begins to decrease at the end of the fourth year of life, after a fairly uniform annual increase up to that time.

In order that some idea might be gained of the effects of the addition of domestic sewage treatment effluents to the river at Williamston upon the growth of fishes in the river, an analysis of variance was performed on the average growth increment between ages 0 and I, and between ages I and II of the common white sucker and the northern rock bass. The effects on sucker growth were of particular interest since this group feeds close to the base of the food chain, and would be the most likely group to be affected. Each species was lumped into two groups, those taken above the Williamston sewage treatment plant, and those taken below it. Only fish taken from the main river were used. The results of "F" tests on these data are shown in Table XVI, and it is seen that no statistically significant differences in growth increment can be detected. It is of interest, however, to note that the differences are greater in both cases in the white sucker than in the rock bass.

TABLE XIV

AVERAGE CALCULATED LENGTH AT END OF EACH YEAR OF LIFE AND AVERAGE GROWTH INCREMENT OF NORTHERN ROCK BASS IN THE RED CEDAR RIVER

Age Group	Number of Fish	Total Length in Centimeters at Capture	Calculated Total Length in Centimeters at End of Year 1	2	3	4	5
I	2	6.6	3.3				
II	16	11.9	5.3	7.2			
III	7	15.1	4.5	7.9	11.8		
IV	3	16.0	3.0	6.7	10.0	14.0	
V	6	18.5	2.6	5.8	9.7	13.0	16.0
Grand Average			3.7	6.9	10.5	13.5	16.0
Average Increment			3.7	3.1	3.7	3.7	3.0
Number of Fish			34	32	16	9	6

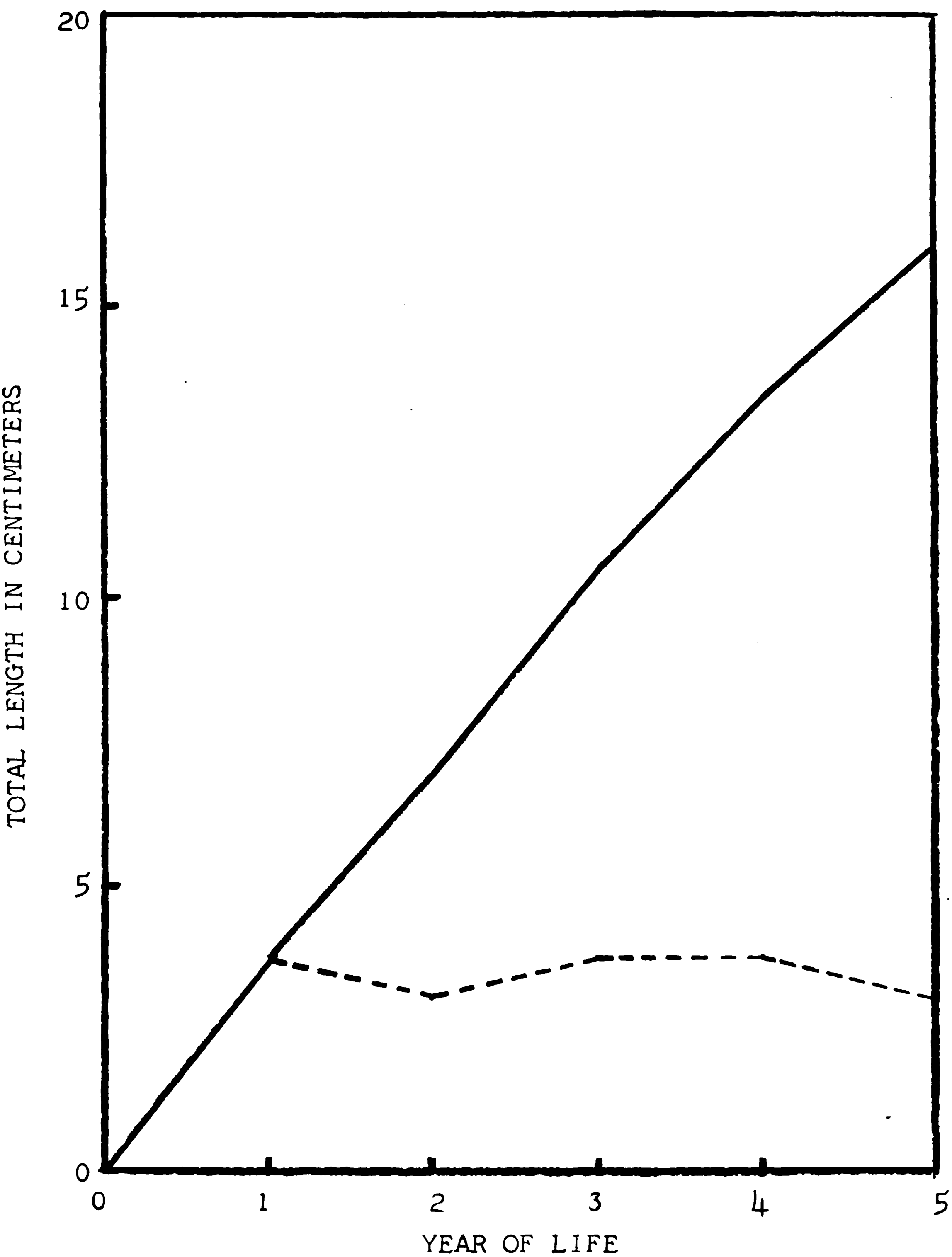

Figure 36. Calculated total length attained by northern rock bass at the end of each year of life (solid line) and average annual growth increment (broken line).

TABLE XV

AVERAGE CALCULATED LENGTH AT END OF EACH YEAR OF LIFE AND AVERAGE GROWTH INCREMENT OF COMMON WHITE SUCKERS IN THE RED CEDAR RIVER

Age Group	Number of Fish	Total Length in Centimeters at Capture	Calculated Total Length in Centimeters at End of Year 1	2	3	4	5	6
I	5	10.5	5.7					
II	15	21.7	5.7	13.9				
III	1	26.0	3.0	7.0	16.5			
IV	3	41.0	6.3	15.3	25.8	35.3		
V	1	45.4	4.5	15.5	26.0	37.0	44.0	
VI	2	47.3	7.8	14.0	22.5	31.3	37.5	43.0
Grand Average			5.5	13.1	22.7	34.5	40.8	43.0
Average Increment			5.5	7.7	9.8	9.8	6.6	5.5
Number of Fish			27	22	7	6	3	2

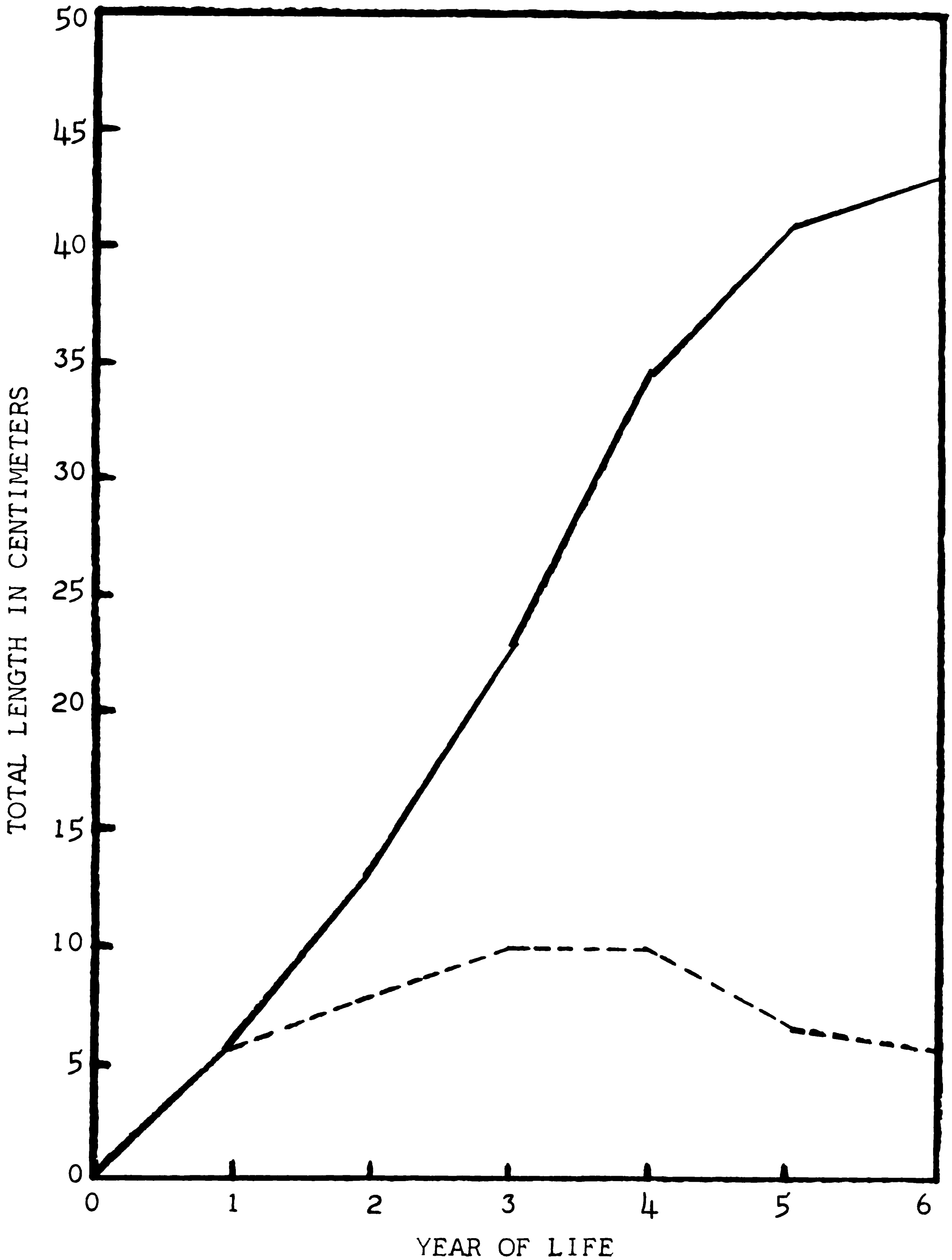

Figure 37. Calculated total length attained by common white sucker at end of each year of life (solid line) and average annual growth increment (broken line).

TABLE XVI

RESULTS OF ANALYSIS OF VARIANCE OF LENGTHS OF COMMON WHITE SUCKERS AND NORTHERN ROCK BASS FROM ABOVE AND BELOW THE WILLIAMSTON SEWAGE TREATMENT PLANT

Species		Average Increment of Growth in Centimeters Between Years 0-I	I-II
Common White Sucker	Above Plant	5.6	7.8
	Below Plant	6.3	8.1
	"F" Value	0.920	0.073
Northern Rock Bass	Above Plant	3.3	3.8
	Below Plant	3.2	3.7
	"F" Value	0.108	0.038

Size Differences Compared With Volume of Flow

In order to ascertain whether volume of flow had any bearing on the average size of a given species of fish present in various sections of the river, several statistical tests were made on the average lengths of northern common shiners taken at various stations throughout the Red Cedar River Drainage. An analysis of variance showed that highly significant differences did exist (Table XVII).

In order to determine where these differences actually were, the multiple range test described in the section concerning coefficient of condition was employed. The results of this test at the 5 percent level of significance were as follows:

(CALF) (ALFBJ) (LFBJKE) (FBJKEIDG) (BJKEIDGH).

The letters designate samples from the following stations:

C - station at Squaw Creek

A - station 1 R

L - station 1 P

F - station 4 R

B - station at Button Drain

J - station at West Branch of the river

K - station 1 R

E - station 2 R

I - station at West Branch of the river

D - station at Wolf Creek

G - station 5 P

H - station at Button Drain

TABLE XVII

RESULTS OF ANALYSIS OF VARIANCE OF LENGTHS OF NORTHERN COMMON SHINERS THROUGHOUT THE RED CEDAR RIVER DRAINAGE

Source of Variability	Degrees of Freedom	Sum of Squares	Mean Square
Total	215	826.32	-
Within Samples	204	623.11	3.05
Between Samples	11	203.21	18.47

$$F = \frac{18.47}{3.05} = 3.06^{**}$$

Since samples occurring within the same parenthesis are homogeneous, another way of stating the results is:

H differs significantly from C, A, L, F

G differs significantly from C, A, L.

D differs significantly from C, A, L.

I differs significantly from C, A, L

E differs significantly from C, A

K differs significantly from C, A

J differs significantly from C

B differs significantly from C

The reasons for these differences in average length of northern common shiners could not be determined. Individual tests showed no correlation between size differences and any of the following factors: (1) volume of flow; (2) date of capture; (3) habitat (riffle, pool, or sluggish stretch); or (4) gear used to make the collection.

DISCUSSION

DISCUSSION

Since the chief aim of the Red Cedar River investigation was to obtain a knowledge of the species present and their distribution throughout the drainage system, different types of sampling gear were used to make the collections. As a result, accurate comparisons of the species composition between the various sections of the river are not feasible. With this limitation in mind, however, the general pattern of distribution and abundance may be seen.

Because of the large proportion of minnows in the Red Cedar River, it might well be classed as a minnow stream. Several commercial bait dealers in the area recognize this fact and obtain large quantities of minnows for sale to sport fishermen in the area.

The game fish which are sought (although the fishery seems to be quite under-exploited) are the northern pike, smallmouth bass and rock bass, the latter being a favorite fish of many youngsters in the vicinity of the river. A few people also fish occasionally for coarse fish, with the white sucker and the carp as the usual goals.

Riffle areas were found to have the largest numbers of fish and the widest diversity of species of the three major habitat types sampled. This type of habitat may be more of a feeding ground than a home site for many of the fishes, such as the minnows. Since there is generally a pool connected with a riffle, it would seem quite likely that a group of fish might actually reside in the pool but make forays to the riffle to feed.

In sampling the Red Cedar River Drainage, the A.C. shocker is the most effective gear. The conditions encountered on the river are for the most part prohibitive to the use of drag seines. Snags in the form of branches, jagged rocks, and litter from man's activities are common. In the upper reaches of the river in the few sections which have not been dredged, and in most of the tributaries, overhanging shrubs and thick vegetation along the banks and sometimes in the stream itself make seining impractical. A portable back-pack fish shocker such as those described by Haskell et al. (1954) would seem to be a very suitable device for collecting fishes in these areas, and could be operated quite efficiently by a crew of two. An electric seine such as that described by Funk (1947) might prove very effective in sampling the lower reaches of the river. In the wider and slower section of the river (section 1), gill nets are a good means of obtaining samples of the larger fish. This method along with the electric seine should yield a quite complete representative sample.

In riffles, the use of glass minnow traps such as those described in the chapter on methods is a fine way to obtain samples of many of the smaller fishes. Another fact in the favor of this gear is that it can be fished by one person.

In general, the growth of the three fishes considered in this study is as good or somewhat better in some cases (smallmouth bass, for example) than the growth of the same species in other midwestern streams (refer to section on age and growth). The species composition could certainly be more favorable than it is at present from the sport fisherman's point of view. Either a greater variety of game fishes or a larger number of those already established would please the angler. The effects which pollution may have on the species composition in the Red Cedar River were not studied, but they may be of considerable importance.

All of the larger fish which were taken alive were fin-clipped and returned to the site of capture. They were marked in a manner which would reveal the section of their original capture upon subsequent capture. The major stations at which fish were marked were as follows:

Station 1 R	- 1 smallmouth bass
	6 rock bass
Station 2 R	- 3 smallmouth bass
	7 rock bass
Station 4 R	- 9 rock bass
	8 northern pike
	16 common white suckers

Throughout the study, no fin-clipped fish were recaptured. Although the proportion of larger fish was quite small, this observation may still indicate that either the populations of the species tagged are quite large, or the movement of these fish is rather widespread.

Finally, the concept of "instantaneous conditions" is of major importance in evaluating the information gathered in a survey such as the Red Cedar River study. A population of minnows may be congregated in or passing through a small portion of the stream at the time when a sample is taken, giving an erroneous picture of the "normal" situation. The true condition can be determined only by taking the whole system into consideration.

SUMMARY

SUMMARY

1. The fishes of the Red Cedar River Drainage area were studied to determine their distribution and composition, and to establish a foundation of age and growth material upon which further investigation could be based and expanded.

2. The Red Cedar River was divided into 5 sections, and 3 sampling stations were designated in each section. The selection of these sampling stations was based on 3 major habitat types.

3. Collections were made using primarily an A. C. shocker and a drag seine. Other gear employed in the study included a D. C. shocker, gill nets, glass minnow traps, and hook and line.

4. Thirty-two species of fish comprised the total population. The minnows made up over 60 percent of the total number of all fishes. The northern common shiner was the most abundant species.

5. The length-weight relationship is presented for 12 species.

6. The body-scale length relationship is presented for the smallmouth bass, rock bass, and white sucker.

7. The coefficient of condition of the northern creek chub and the rock bass is compared throughout the drainage system. There are differences in condition between one tributary

and the rest of the system, but at present the reason is not definitely known.

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LITERATURE CITED

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