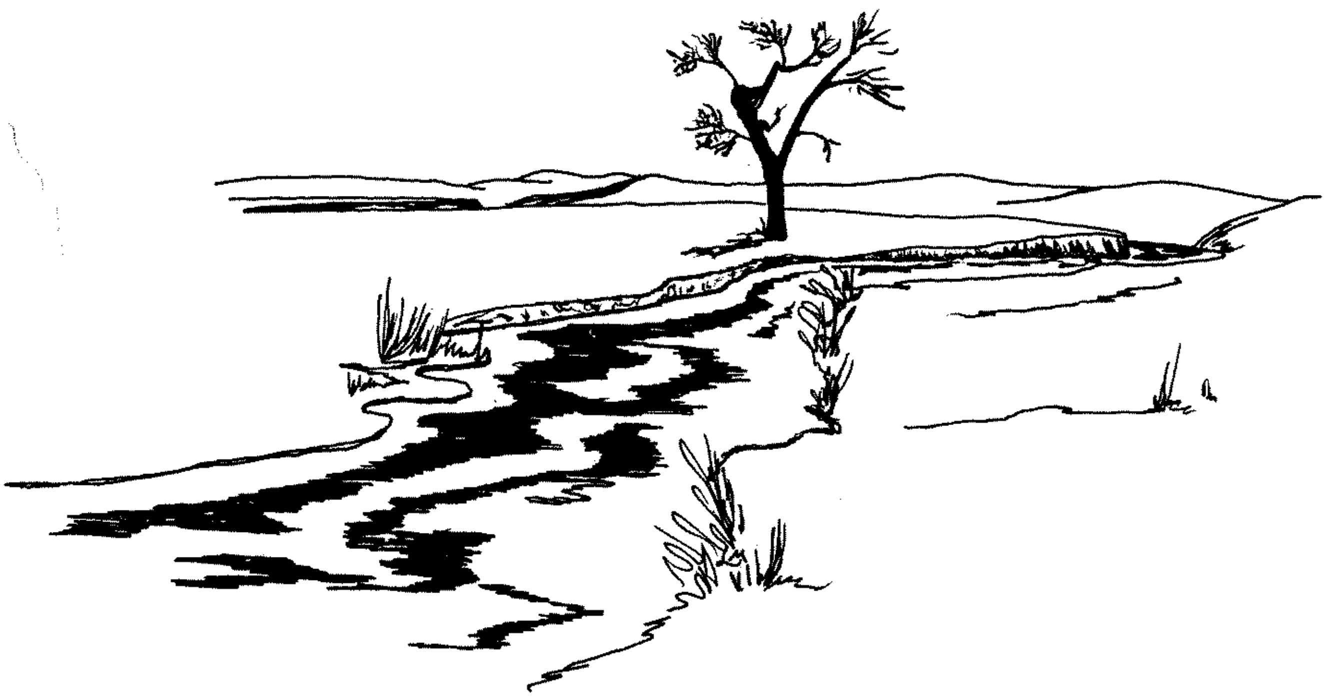
Montana Department of Fish, Wildlife and Parks

An Aquatic Resources Assessment of Selected Streams in the Lower Yellowstone River Basin

Final Report



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by

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INTRODUCTION

Increased energy development in southeastern Montana appears imminent. The developments will consume vast amounts of water which is present in limited amounts. In the interest of collecting information prior to these developments, the Bureau of Land Management (BLM) contracted with the Montana Department of Fish, Wildlife and Parks to inventory the aquatic resources of selected prairie streams in the area. The overall study area extended from the Montana-North Dakota border to Kinsey, Montana (Figure 1). This area is included in the Richland-Glendive, Wibaux, Baker, Kinsey, Custer and Prairie Planning Units of the Miles City District of the BLM. A complete listing of the study streams and their legal descriptions is presented in Table 1.

The specific objectives of this study were to inventory the aquatic resources and collect baseline information on the streams listed. Species composition, diversity, distribution and relative abundance were determined for fish and aquatic macroinvertebrates. In addition, morphological characteristics and basic water chemistry were measured for all streams.

Prior to this survey, information on fish and macroinvertebrates in this area was virtually nonexistent. The information gathered in this and related studies will be used to predict impacts of future energy developments in the lower Yellowstone River basin. Data obtained for this report was collected during the field seasons of mid-March to November 1, 1979 and April 2 through August 28, 1980.

STUDY AREA

Drainage and Topography

The study area encompasses the final 273 river kilometers of the Yellowstone River as it flows northeasterly to it's confluence with the Missouri River in North Dakota. From the mouth of Fourmile Creek to the mouth of Muster Creek, the furthest east and west points, respectively, there is an approximately 122 meters difference in elevation (Figure 2). The gradient between these two point averages 0.47 mkm-1. With the exception of one stream, Fourmile, all streams and drainage basins lie entirely within Montana.

The general topography of the study area can be described as gently rolling to rolling hills broken by rough, hilly badlands. As the river flows toward North Dakota, the hills become more strongly rolling on the north side of the river with rough badlands and scoria buttes predominate in the south. The river bottom is terraced and generally flat with some undulating hills. Soils of the prairie and badlands region are mostly loams and heavy, shaley clays. The river bottom soils are rich alluvium with sands and sandy loams present. Soils of this rolling and hilly topography range from rock and stone to loams and alluvium.

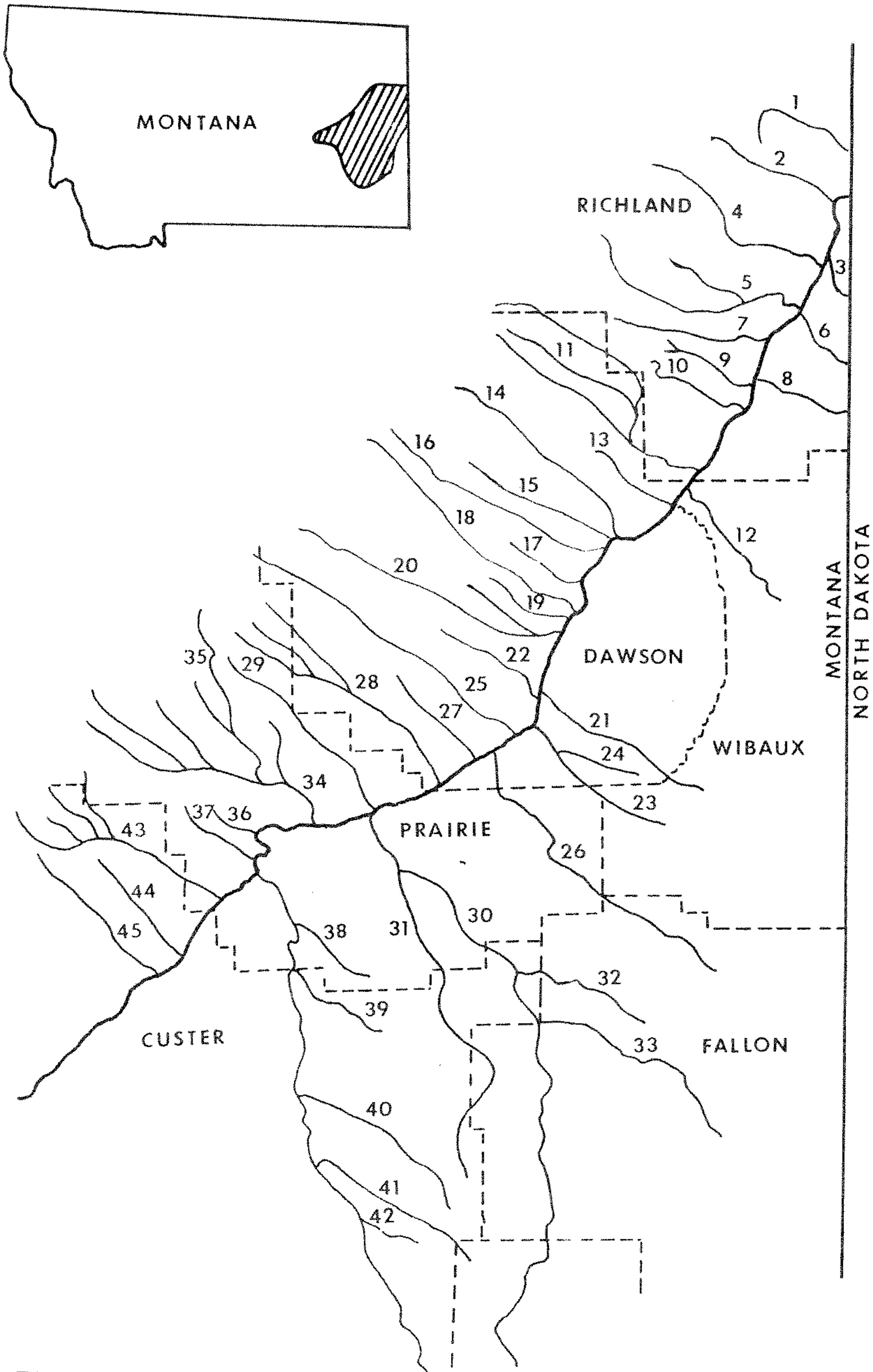


Figure 1. Map showing location of study area and streams included in the investigation.

Table 1. A listing of all streams and sample sites investigated in consecutive order starting with the stream furthest downstream.

Stream Number[1]	Stream	Site	Legal Description
1	Fourmile (L)[2]	1	T25N R59E S23 DC
		2	T25N R58E S11 AA
2	First Hay (L)	1	T24N R60E S31 BA
		2	T24N R59E S32 AD
		3	T24N R58E S16 BD
3	Bennie Peer (R)[3]	1	T22N R59E S1 BD
		2	T22N R57E S25 BD
4	Lone Tree (L)	1	T22N R59E S10 AB
		2	T23N R58E S36 AB
		3	T23N R58E S19 DC
5	Fox (L)	1	T22N R59E S19 DC
	(N.Fk)	2	T22N R58E S20 DB
	(N.Fk)	3	T22N R57E S14 CB
	(S.Fk)	4	T22N R56E S17 BB
6	O'Brien (R)	1	T21N R59E S10 AC
		2	T21N R59E S25 BD
7	Crane (L)	1	T21N R58E S14 CD
		2	T21N R58E S22 AB
8	Shadwell (R)	1	T20N R59E S 7 BA
		2	T20N R59E S24 DB
9	Sears (L)	1	T21N R58E S27 CA
10	Dunlap (L)	1	T20N R58E S27 CA
11	Burns (L)	1	T19N R57E S25 CC
		2	T19N R57E S32 AC
		3	T19N R56E S10 DD
	(N.Fk)	4	T20N R56E S26 DD
12	Cottonwood (R)	1	T18N R57E S11 BC
		2	T17N R58E S6 AB
13	War Dance (L)	1	T18N R57E S2 BA
14	Thirteenmile (L)	1	T18N R56E S35 BC
		2	T18N R56E S7 AC
		3	T19N R55E S20 DB
15	Morgan (L)	1	T17N R56E S5 BD
		2	T18N R55E S35 BC
16	Lower Sevenmile (L)	1	T17N R56E S18 BB
		2	T17N R55E S4 CA
17	Threemile (L)	1	T17N R55E S35 AC
18	Deer (L)	1	T16N R56E S5 CA
		2	T16N R55E S12 BD
		3	T16N R55E S6 AC
		4	T17N R53E S10 DA
19	Dry (L)	1	T16N R55E S34 BD
		2	T16N R55E S29 BD
20	Upper Sevenmile (L)	1	T16N R55E S34 AA
		2	T16N R54E S36 DD
		3	T16N R53E S10 BB
21	Sand (R)	1	T15N R55E S28 AA
		2	T14N R56E S6 AA
22	Sand (L)	1	T15N R55E S29 DB
23	Cedar (R)	1	T14N R55E S20 AB

Table 1. Continued

Stream Number	Stream	Site	Legal Description
23	Cedar	2	T13N R55E S2 DB
		3	T13N R56E S20 AA
24	Magpie (R)	1	T14N R55E S34 AC
25	Clear (L)	1	T14N R55E S19 AC
		2	T15N R53E S35 AC
26	Cabin	1	T14N R54E S34 CD
		2	T12N R54E S3 BB
27	Crackerbox (L)	1	T13N R54E S6 AD
28	Bad Route (L)	1	T13N R53E S16 AA
		2	T14N R52E S24 AD
		3	T15N R51E S36 DB
29	Hatchet (L)	1	T13N R53E S29 AD
30	O'Fallon	1	T13N R52E S33 CD
		2	T11N R54E S30 DD
		3	T9N R55E S17 DB
		4	T8N R56E S30 DA
		5	T5N R56E S17 CA
31	Whitney (L)	1	T12N R53E S31 CD
		2	T10N R53E S9 AD
32	Pennel (R)	1	T9N R55E S6 BD
		2	T10N R55E S34 AC
33	Sandstone (R)	1	T8N R56E S6 DB
		2	T8N R57E S26 BA
34	Cherry (L)	1	T12N R51E S12 DB
		2	T13N R48E S12 DB
		3	T13N R49E S9 CC
		4	T14N R47E S26 CC
35	Brakett (L)	1	T13N R50E S23 CC
		2	T14N R50E S34 AD
36	Lost Man's (L)	1	T12N R51E S15 AC
37	Crooked (L)	1	T12N R51E S33 DB
38	Tenmile (R)	1	T11N R51E S32 CB
		2	T10N R51E S3 BA
39	Coal (R)	1	T10N R51E S29 CD
		2	T9N R51E S3 BD
40	Locate (R)	1	T8N R51E S2 CC
		2	T8N R52E S22 DB
41	Sheep (R)	1	T7N R51E S36 CA
42	Trail (R)	1	T5N R52E S25 DD
43	Custer (L)	1	T11N R50E S18 DB
		2	T11N R49E S9 CD
		3	T12N R48E S35 CA
44	Harris (L)	1	T10N R49E S30 AD
45	Muster (L)	1	T9N R48E S10 AA

1/ Stream number is determined by upstream distance from Missouri - Yellowstone confluence (See Figure 1).
2/ (L) Left - indicates which side of the Yellowstone each stream enters when facing downstream.
3/ (R) Right - Indicates which side of the Yellowstone each stream enters when facing downstream.

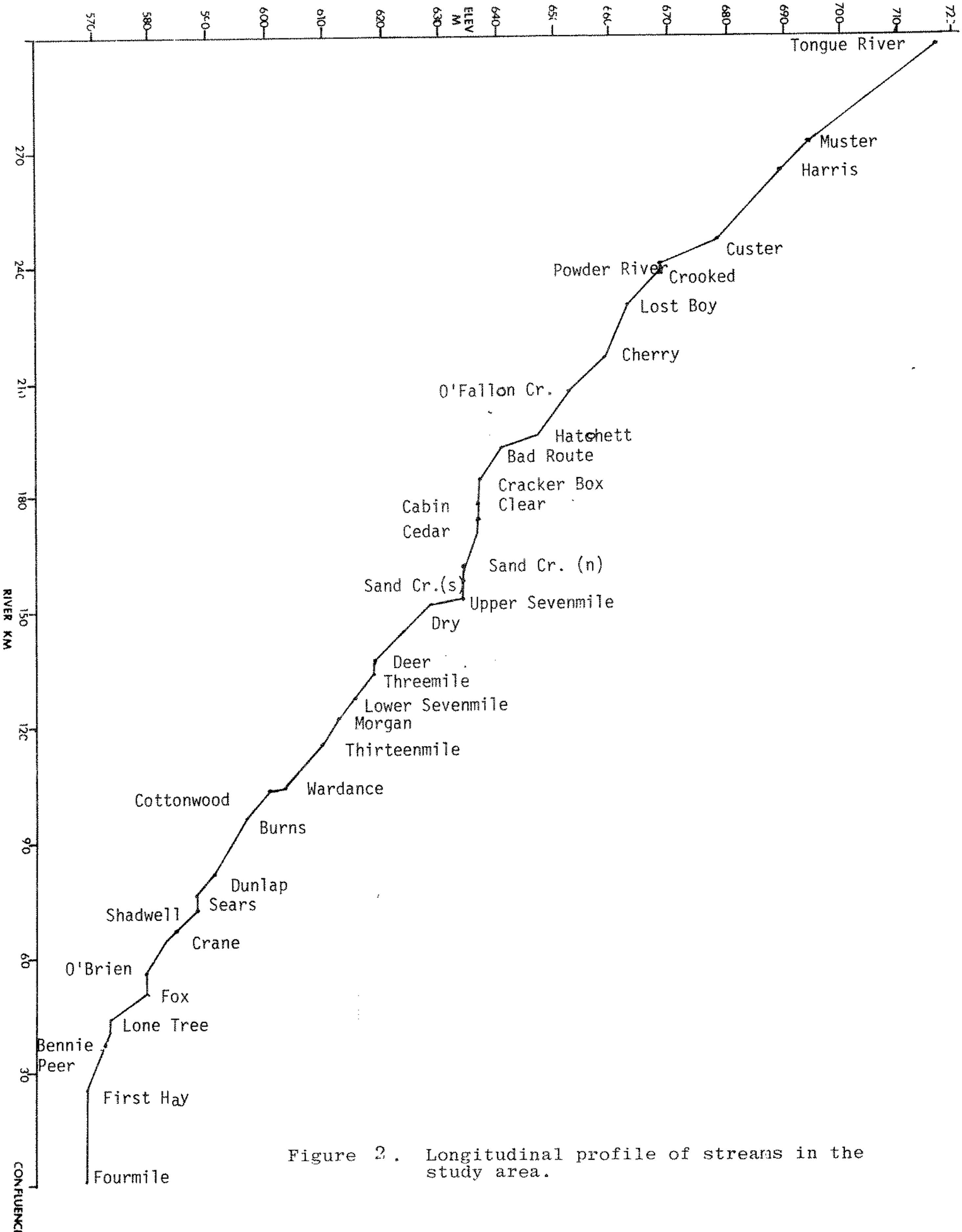


Figure 2. Longitudinal profile of streams in the study area.

Grasslands predominate the drainage basins. Cottonwoods dot the lengths of the drainages and in some isolated instances as O'Fallon Creek, ponderosa pine savannahs are a prominent feature. These rangelands can be classified as prairie and badland grasslands.

Agriculture, at present, is the dominant industry. Most rangeland is used for grazing with uplands and plains areas utilized for dryland farming. For these reasons, small reservoirs, stockponds, and other small impoundments were of common occurrence throughout the study area. Three major water projects influence several streams in the study area. Numerous small irrigation diversions and pumps are common all along the Yellowstone River bottomland. The major projects, and most of the smaller ones, parallel the Yellowstone River on the north bank. Kinsey Water Project starts at Sunday Creek and empties into Harris Creek. Buffalo Rapids begins upstream of the Powder River and more or less terminates at Hollecker Lake near Glendive. The largest canal, Intake, starts at the Intake diversion and eventually flows into the Missouri River in North Dakota. These canals have been designed with built-in siphons to allow stream water to bypass the canal water at points where the canals bisect stream channels. The canal water level is regulated by a system of flumes which discharge water sporadically into the lower reaches of stream channels intersected. In fact, several streams maintain a flow in their lower reaches as a result of "spill" water from the canals.

Streams in the study area illustrate characteristics typical of a prairie environment. The prairie is a region of relatively low precipitation and high evaporation. Typically, soils of the prairie have little capacity to hold water. During severe rainstorms a creek may swell and overflow its banks, only to return to its channel almost immediately after the rain ceases. Streams may be reduced to a series of pools by late summer. A bimodal discharge pattern is also typical of prairie streams. Peak flows occur during spring runoff, coincidentally with lowland snow melt, usually in late March or early April. This is followed by a smaller peak discharge in June, historically the wettest month. Many of the streams drain relatively small basins, and in a hierarchy, consist of low order streams. Several others, such as O'Fallon Creek, have large drainage basins with many smaller tributaries. Water from these prairie streams, while important, probably do not contribute much to the Yellowstone River. Due to their nature, peak runoff for prairie streams occurs when the Yellowstone River is in a low flow period.

GEOLOGY

General Geology

The area (Figure 3), covered in this report, is underlain by cretaceous and paleocene sedimentary rocks consisting dominantly of sandstones and shales. The rocks are generally horizontal except where interrupted by structural uplift of the Cedar Creek anticline and the northern section of the Bighorn Mountain uplift. The northern most area has been glaciated most recently during the Wisconsin advance and perhaps, by the older Illionian advance. The drainage divides in the north central section of the geological map are capped by varying thicknesses of Tertiary age, Flaxville gravels.

The area can be subdivided, on the basis of landform types, into two geologic provinces. The northern province referred to, in this paper, as the glaciated plains and the remaining area as the sedimentary plains.

Drainage

The master stream draining the region is the Yellowstone River. Two major tributaries join the Yellowstone in the area covered, these are the Powder River and O'Fallon Creek. The drainage along these rivers is in a mature state having well defined flood plains and flood plain features. The rivers are flanked by terrace levels of Tertiary and Quaternary age. The flood plains and terraces are composed primarily of sands, silts, and gravels.

Structure

The area is dominated by two major structural features, the Cedar Creek anticline and the north end of the Bighorn Mountain uplift.

The Cedar Creek anticline is lineated in a southeast to northwest direction and centered between the cities of Baker and Glendive. The Cedar Creek anticline has brought rocks of late Cretaceous age to the surface in this region. These rocks consist of the Hell Creek Formation, Fox Hills Sandstone and the upper Pierre shale. The Hell Creek Formation and the Fox Hills are predominately sandstones, while the Pierre is predominately a shale. The differential erosion of these rocks has resulted in a badlands topography which has an aesthetic value and has been somewhat presented as Makoshika State Park. The Cedar Creek anticline is presently being exploited for its potential as a reservoir and petroleum trap.

The northern end of the Bighorn Mountain uplift enters the area in the southwestern portion of the map (Figure 3). The Powder River is flowing along the axis of the uplift. Upper cretaceous

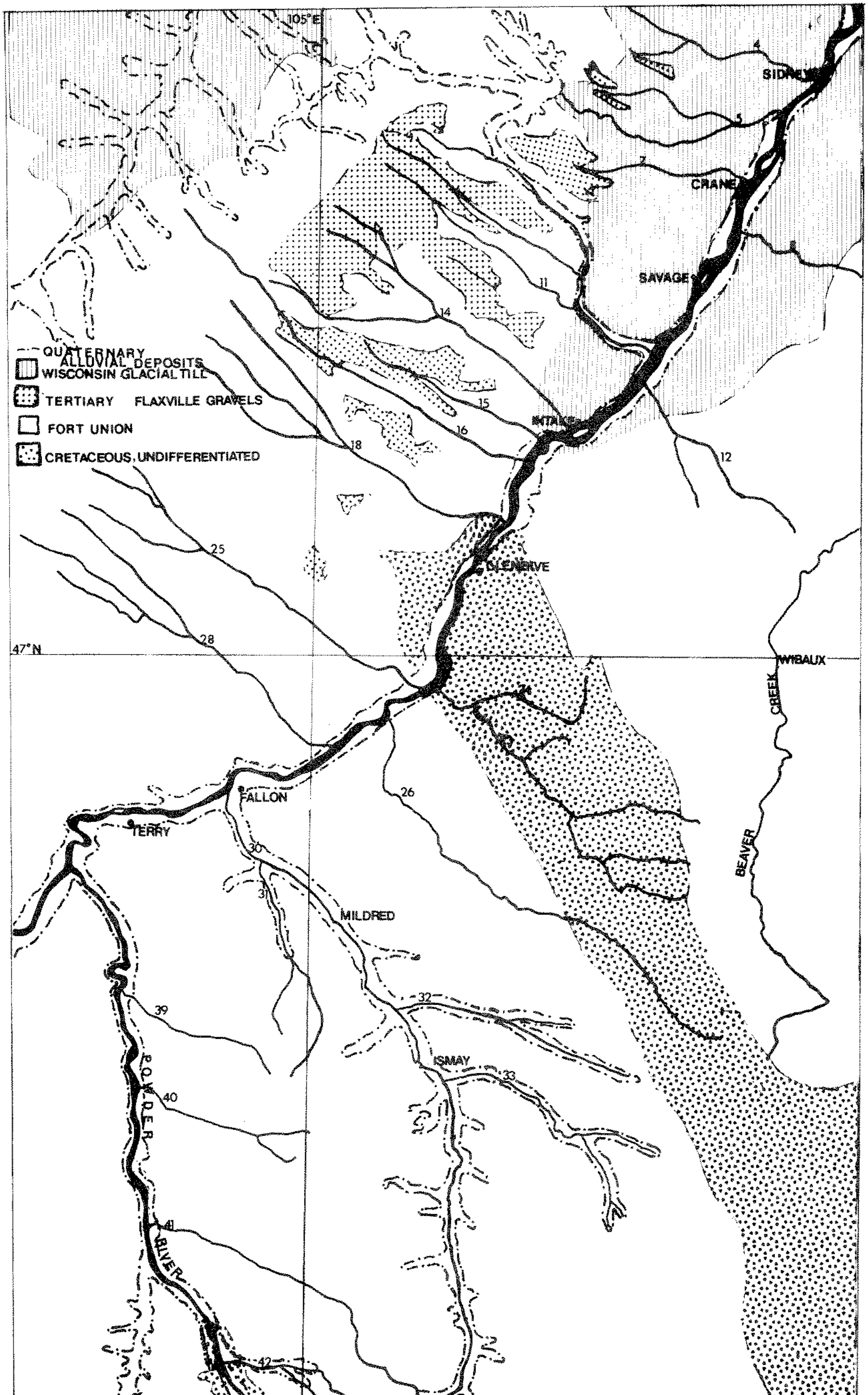


Figure 3. Geological features in the study area.

rocks of the Formation are brought to the surface. These are predominantly sandstones and mudstones but do contain some thin lignite and sub-bituminous coal beds.

A third structure which enters the area but has no topographic significance is the southwestern tip of the Williston Basin. This structure is centered around Williston, North Dakota and extends into Montana to the area around Sidney and Savage. The Williston Basin is one of the major petroleum producers in the western plains area.

The Glaciated Plains

The Glaciated Plains, in the northern portion of the geologic map (Figure 3) are the remnant deposits of continental glaciation. Ice, originating in the Canadian Kewatin Center, moved southward into Montana. This movement of ice took place during the Wisconsin Glacial Advance which terminated some 10,500 to 11,000 Before Present (BP). As the ice moved southward, it disrupted and displaced major drainage systems which flowed northward to Hudson Bay. The most important of these drainages in eastern Montana are the Missouri and Yellowstone Rivers which were forced to join and flow eastward.

When the ice reached its southern most extent, it made a standstill for some period of time. This resulted in a damming up of the Yellowstone's waters into a large glacial lake called Glacial Lake Glendive. This lake was centered around the town of Glendive and extended into the tributary valleys of streams joining the Yellowstone. The highest shoreline level of Glacial Lake Glendive stood at approximately 2,500 feet above sea level. Remnant silt deposits of Glacial Lake Glendive may be observed in these tributary valleys.

A smaller glacial lake was centered around the town of Lambert. A standstill of the ice at this point allowed meltwater flowing off the glacier to flow parallel to the ice front cutting a meltwater channel. This channel is presently occupied by the North Fork of Burns Creek and Fox Creek. Redwater Creek was dammed to form Glacial Lake Circle which stood about 2,600 feet above sea level at its highest stage.

Deposits along these stream channels are dominantly sands and gravels and are termed glacial-fluvial or glacial outwash deposits. The word fluvial indicating that the deposit originated as a stream transported and deposited sediment. Glacial-fluvial indicating the source of water was the meltwater flowing off the glacier.

Other glacial deposits in the area are the till plain deposits. These deposits consist of all material transported by the ice during glaciation. Till plains cover the greater portion of the glaciated plains region. Till plain deposits are found in the northern portion of the map.

Sedimentary Plains

This area consists of a maturally dissected topography. Numerous streams have cut into and dissected soft sedimentary rocks. The area is underlain by the Fort Union and upper cretaceous formations.

The Fort Union is characterized by three members, they are in ascending order: the Tullock, Lebo Shale, and the Tongue River members. The Tullock member consists of a series of interbedded sandstones, siltstones, and shales. The Lebo member is a dark gray shale ranging to a thickness of 200 feet. The Tongue River member consists of a massive sandstone unit interbedded with seams of shale and coal. The coal grades from lignite into sub-bituminous to bituminous and is easily strippable. Generally, the grade of coal becomes better in a southerly direction. This is probably a result of compression and perhaps a low grade metamorphism driving out the volatiles during the Bighorn uplift and tectonic activity of the Cedar Creek anticline.

Clinker beds can be found throughout the aerial distribution of the Fort Union Formation. The clinkers are red in color and are the slag produced by underground burning of coal seams. The red color is a result of the oxidation of iron compounds in the rocks, during the burning process.

The Fort Union Formation is a paleocene age (60-70 million years old) unit and was capped by tertiary age stream gravels during a period of erosion and deposition. Remnants of these gravels can be found on some of the drainage divides in the northern portion of Figure 3. These tertiary age gravels are known as the Flaxville Gravels.

Other areas of the Sedimentary Plains are underlain by late or upper cretaceous sedimentary rocks. These exposures are located in areas where tectonic uplift has occurred. Subsequent erosion of the overlying Fort Union Formation in these areas has exposed the upper cretaceous units. The cretaceous formations are predominantly sandstones and shales.

Eastern Montana's wealth can be intimately associated with it's geologic past. Undoubtedly, the future will see further exploration, expansion and utilization of these resources.

CLIMATE

Eastern Montana climate is semiarid continental. Large temperature fluctuations, both daily and annual, are characteristic of the climate. Annual precipitation ranges from 30.5 cm to 40.6 cm with 33 cm an average. Maximum precipitation occurs in late spring to early summer, historically peaking in June, with minimum amounts occurring in the winter months. From 65-85 percent of the annual precipitation occurs between April and September. Seasonal snowfall seldom accumulates because of thaws.

Normally, January is the coldest month and July is the warmest month of the year. During January, in Miles City, the average maximum temperature is -2.9°C (26.7°F) and average minimum temperatures is -14.3°C (6.2°F). For the warmest month, July, these figures are 31.1°C (88.0°F) and 14.5°C (58.1°F), respectively. For an average year, eastern Montana has about 4 months without a killing frost. The Yellowstone River bottomland may have 130-140 frost free days.

The year 1980 will be remembered as a drought year. Spring was exceptionally warm in addition to being dry. For example, beginning in May 1979 and ending in August 1980, precipitation was 62% of normal for this sixteen month period. This data is for the Miles City area (U.S. Dept. Trans. personal communication), but serves to illustrate the conditions encountered throughout the study area. Crop failure and damage was widespread throughout eastern Montana. In addition, an extremely large range fire swept through the study area in the Glendive region. The 1980 field season was one of severe conditions throughout the prairie.

METHODS

Possible sample sites were located on base maps (BLM Surface Management Quads 1=126,720). Locations were based on relative stream position, i.e. mouth, midreach, and headwater reaches. As worked progressed, it became apparent that most streams were either emphemeral or intermittent and locations were then chosen where there was water and where access was possible. Each reach was consecutively numbered, beginning with the mouth. All streams of the study were checked for possible sampling.

In 1979, stream survey forms were completed for each sample site according to the methods outlined on BLM form 6670.1. Field data was recorded in the field book, and a permanent copy later transcribed to form 6670.2. In 1980, a revised stream survey form, which included a more extensive compilation of morphological information, was completed for each site. Input forms also were completed for each stream for entry into the Interagency Stream Fishery Data Base located in Helena. From this data base, a rating procedure developed by Montana Fish, Wildlife and Parks (MFWP) (1979), assigned each stream a fish resource value which included a species and habitat value and a sport fishing potential value.

At every sample site, conductivity, dissolved oxygen, temperature, and limited chemical analyses were conducted. Conductivity was recorded with a YSI Model 33 S-C-T meter and dissolved oxygen with a YSI Model 57 oxygen meter. Hach DR-EL2 and Hach Model Al-36-P kits were used to determine total (methyl orange) alkalinity, pH (wide range) and turbidity. A Taylor thermometer was used to record temperature. In addition, thermographs were placed at three sites on O'Fallon Creek. Temperatures were recorded with Taylor 30-day recording thermographs on reaches 1 and 2, and a Partlow 31-day recording thermograph on reach 3 in 1979. Taylor thermographs were used at all three sites in 1980. All temperatures were recorded in ^{o}F and converted to ^{o}C. All thermograph data collected in 1979 was analyzed through a computer program (Bob McFarland, personal communication).

Aquatic invertebrates were sampled during both field seasons on all creeks containing water. In 1979, 32 streams were sampled at 40 sites. Thirty-one samples were taken at the mouth sections and nine at upper reaches. In 1980, 38 streams were sampled with 31 collections taken from the mouth section and 8 from upper sites. The mouth section was chosen in most instances to insure adequate flowing water. Most samples were modified kick samples, but many samples were taken by digging and otherwise disturbing the stream bottom with a dip net.

In addition, 30-day basket samples (Clancy 1978) were collected on two reaches of O'Fallon Creek in 1979. Four of these samplers were set in the mouth reach on March 28, 1979, and collected May 2. Two of these samplers were reset at this time, and collected May 31. On reach 3, four samplers were set March 29, collected and reset May 7, with final collections on June 1.

All invertebrate samples were fixed in the field with a 10% formalin solution. In the lab, the samples were washed through a 30 mesh screen, picked, and specimens preserved in a 50% ETOH solution.

Collecting and sampling of fish populations was accomplished primarily with seines. Either a 9.0 x 1.2 meter, 6 mm bag seine or a 4.5 x 1.2 meter, 6 mm bag seine, as dictated by stream conditions, was used. Usual sampling procedures consisted of three sweeps through the reach, usually followed by subsequent hauls to confirm that all species present in the reach had been sampled. During the second year, the final sampling effort of the season was directed exclusively towards locating new species. Electrofishing was used during the early high water period. Electrofishing gear, employing a boom operation, was mounted aboard a 4.1 meter Boston Whaler boat. Occasionally, in periods of lower flow, a bank shocker with a mobile positive was utilized. Power was supplied by a 3000 watt, 115 volt, 60 cycle generator. A Fisher Shocker control box varied the current and pulse frequency as dictated by water conditions. If sufficient water was present, experimental gill nets, approximately 38 meters in length, were dead set. Gill nets were set as late as possible in the evening and pulled as early as possible the following morning. Traps, constructed of reinforcing bar and chicken wire as well as hoop nets were baited and fished for catfish in O'Fallon Creek.

Sauger, walleye and northern pike were weighed, measured, and when sufficient size marked with a color-coded Anchor tag. Channel catfish were also weighed and measured but tagged with numbered yellow cinch tags. A list of tag colors and numbers used is provided in the Appendix , Tables 7, 8, and 9. Scale samples were taken beneath the dorsal fin on the left side and age class assigned in the lab. Counts were made of all fish species captured at each sample site. Fishes of Montana (Brown 1971) facilitated identification of species in the field. If identification was questionable, specimens were preserved in formalin and later identified in the lab. In cases where further verification was necessary, specimens were sent to Dr. Gould at Montana State University for positive identification.

A portfolio of slides was assembled of each creek and associated sample sites in the study in 1980. At least two pictures giving an upstream and downstream view were taken at each site. Each slide was labelled with the creek name, its number (from Table 1), site number, date, and view.

Throughout the study, casual wildlife observations were noted and recorded. A listing of the observations is included in the Appendix , Tables 10 and 11.

STREAM CHARACTERISTICS

Streams within the study area cover the entire spectrum of prairie streams - from temporary drainages containing large volumes of water after a heavy rain but drying up soon after, to those that flow in early spring and then are reduced to a series of pools by late summer, to small perennial streams, fed by springs or ground water. Rapid changes in stream conditions which alter the characteristics of the streams and organisms found, typify the area. A summary of the study stream descriptions is presented in Table 2.

In early spring when these smaller streams generally flow or after a wet spell, fish tend to move upstream and repopulate areas swiftly (McAda et al. 1980). As the stream dries up and becomes in some cases a series of isolated pools, fish either move downstream to more permanent waters or become stranded. In the later case, a low dissolved oxygen level will be the critical factor in the decimation of the crowded fish. This exact phenomena was witnessed in the study area over both years but was exceptionally noticeable in 1980. In some cases, the fish kill would be due not only to low DO levels but also to lack of sufficient water. Reintroduction of fish again occurs with the next wet period. The productivity of these streams is dependent on and affected by velocity, extreme fluctuations in the water level, turbidity, high summer temperatures, and the character of the bottom (Jewell 1925). As a result, species distribution and abundance will vary seasonally (Merriner et. al. 1971). Jewell (1925) indicates that the most abundant life is found during early summer when the creeks are reduced to pools connected by shallow riffles.

Stream modifications, including diversions, rechannalization and water addition and withdrawal common in the study area, have a major affect on water quality, substrate diversity and thus species productivity. McAda et al. (1980) found in the San Rafael river system (upper Colorado river basin) that diversion of water for irrigation was probably a major cause of the differences in habitat between the upper and lower sections of river. A minimum of seventeen streams in the study area are bisected by any one of the three large irrigation canals. Several stream channels were completely dry on the upward side of the canal, but maintained a flow on the lower side. Spill water appears to account for most, if not all of the existence of several streams. The presence of this water in the mouth reaches may provide additional habitat for use by Yellowstone fish species, particularly for feeding, spawning and rearing areas. In some instances, the streams maintain a flow or at least contain water above the canal. The siphoning system constructed on the canal may be a permanent barrier to upstream movement of fish, particularly the larger species, although, actual documentation has not yet been made.

It is readily apparent that irrigation or spill water modifies flow regime, and also, to some degree, chemical parameters of the stream. For example, irrigation water is subject to surface runoff, a source of salt and sediment. Salt pick up is primarily related to deep percolatum and seepage from various irrigation canals, whereas sediment pickup is influenced by volume and velocity of surface runoff. The specifics of irrigation water modifying streamflow and chemical parameters, however, are beyond the scope of this project.

Stream survey forms were completed for each sample site in the study. Each reach was rated as to the proportion of the section comprising pool, run and riffle areas. Each of these items was then rated for substrate particle size using a 100% total. The five categories were hardpan or bedrock, boulders (over 26 cm), rubble (6.4-26 cm), gravel (2 mm-6.4 cm) and fines (under 2 mm). The character of the bottom in part, determines productivity. On one extreme, the rock bottom, which is rather uncommon to the prairie stream is most productive, while on the other extreme, clay substrates are almost barren (Jewell 1925). The substrate of many of the streams included from one to all five categories at varying points along the length of their drainages. The characteristics of the bottom appeared to be dependent in part on the surrounding habitat, bank stability, soil composition and whether water was standing or flowing. A summary of study stream substrates and other features is presented in Table 2 .

Silt and muck bottoms were the most common substrates encountered. It also appeared that the percent of fines comprising the pools generally increased with consecutive upstream sites. Many pools and areas of standing water seemed to be characterized by muck-ooze bottoms. Exceptions to these included portions of Cherry, Cottonwood, Custer (site 1), Fox (site 3) and Upper Sevenmile (site 1) creeks. Occasionally the mouth reaches of some streams also exhibited a silt type bottom, a condition resulting from and influenced by Yellowstone River backwater.

Table 2. Descriptive notes on creeks in study area.

Creek	(m) Elevation	(km) Rivermile	Substrate	Major Features
Muster	695.4	272.6	Gravel, rocks some boulders	Cutbanks show some erosion but veg. growing to water's edge. No water in upper reaches.
Harris	689.3	264.5	Sand, gravel	Irrigation water channeled into stream about 95 m from the mouth. Upper reaches of creek dry.
Custer	677.1	246.5	Mud,muck, interspersed with gravel bars. Large rocks scattered along the mouth sec.	Some portions of creek with standing water in form of interconnecting pools. Reservoirs dot length of drainage. Surroundings are a sagebrush flatland.
(Powder River tributaries)				
Tenmile	671	11.7	Muck, debris, thick.	Water present in scattered pools. Streambanks erosion prone. Upper reaches dry.
Coal		24.5	Silt, muck.	Steep cutbanks characterize drainage. Stream dries up except for small scattered pools. At site 2, one pool appears to be spring-fed. Sagebrush grassland extensively used by cattle.
Locate		41.2	Gravel,rocks at mouth silt to muck above.	Stream runs underground in much of valley occasionally surfacing. Most of year-standing water only.

Table 2. Continued

Creek	(m) Elevation	(km) Rivermile	Substrate	Major Features
Sheep	-	64.8	.3-.6 m deep muck	Long drainage containing water in early spring & then drying up. A chain of several stock watering ponds near mouth contained N.P. in early summer but went dry by late summer.
Trail		91	Muck	Creek contains water only during spring runoff & heavy rainstorms.
Crooked	671.0	239.6	Silt & muck in parts of drainage intermixed with large sandstone rocks.	Surroundings are badlands. Drainage characterized by steep cutbanks, meandering channel, appears to hold a large volume of water during spring runoff.
Lost Boy	664.9	230.9	Sand, silt.	Rugged badlands surroundings. Water present for approx. 50 m. up from the mouth. Harsh aquatic environment.
Cherry	658.8	217.4	Gravel changing to mud upstream.	Creek flows early spring then dries to isolated pools. Surroundings grazed by cattle. Forms a large drainage area with Cedar Creek & Brackett Creek.
Cedar (Trib. of Cherry)		14.3	At lowest section consists of silt-clay bottom interspersed w/gravel.	Streambed wide and shallow at sites 1 & 2, narrowing at site 3. Surroundings are sagebrush grassland. By late summer, creek is dry with exception of small isolated pools. A major portion of drainage is located on public land.

Table 2. Continued

Creek	(m) Elevation	(km) River Mile	Substrate	Major Features
Brakett		17.5	Gravel, rock	Grassland. Dry sections with small scattered pools. Cattle grazing in area.
O'Fallon	652.7	208.4	Mainly silt, gravel; mud esp. in pools. Some rocks and boulders.	Largest tributary in study area. Cottonwoods along much of drainage. Creek flowed in 1979 but reduced to pools in 1980.
Whitney (Tributary of O'Fallon)	-	17.1	Mainly mud & muck. Sand & gravel at mouth.	Portions of drainage dry. Sagebrush, grassy creek banks; at site 2 area severely overgrazed by cattle & sheep.
Pennel (Tributary of O'Fallon)	-	64.2	Mud with scattered gravel bars.	Channel narrow with steep rounded banks vegetation overhanging and covering banks. Surroundings are alfalfa fields. Channel contained water throughout both summers.
Sandstone (Tributary of O'Fallon)	-	81.4	Silt underlain with gravel.	All reaches observed contain water, channel wide. Deep pools in some areas provide potential habitat for larger fish.
Hatchet	646.6	196.6	-	Grasses have grown in the channel. Water present only during heavy rainstorms.
Bad Route	640.5	120.4	Site 1-good rocky bottom, above - clay, muck.	Shallow flowing water. A flume above site 1 influences flow; upper reaches-dry with scattered pools; bank encroachment by agriculture and roads.

Table 2. Continued

Creek	(m) Elevation	(km) Rivermile	Substrate	Major Features
Crackerbox	637.5	115.4	Stable gravel	Flow at lower sections exist due to water released from Buffalo rapids. Water shallow. Upper reaches dry after spring runoff. Wide channel contains large volume of water during early spring runoff.
Cabin	637.5	112.9	Sand, silt	Water shallow, limited flow. Catfish sampled were fingerling size. At site 2 channel holds fair vol. water, mainly in pools. Small tributary enters above here. Heavy vegetation overhangs banks. Water drawn off for irrigation.
Sand (right bank)	634.4	99.8	Sand, silt	Badlands surroundings. No fish or aquatic insects. High flow during spring runoff, otherwise creek dry with the exception of several springs. Extensive erosion.
Clear	637.5	107.6	Sand, silt	Grassy lowland surrounding the creek. Water released from Buffalo Rapids was evidenced to significantly alter volume and flow at mouth. Stream runs subsurface over portions of this upper drainage. Entire drainage has flowing water during spring runoff.
Cedar	637.5	106.6	Silt-clay interspersed with gravel.	Streambed wide and shallow at sites 1 & 2 and narrowing at site 3. Stream surrounded by sagebrush grassland.
Sand	634.4	101.2	Gravel, rocks, some boulders.	Fast flowing, water clear, lush vegetation, "Babbling Brook", at mouth section. Above dry.

Table 2. Continued.

Creek	(m) Elevation	(km) River Mile	Substrate	Major Features
Upper 7 Mile	634.4	154.3	Gravel at lower section. Changing to mud above.	Large reservoir above site 3, contained northern pike at one time. they have since been found in the creek.
Dry	628.3	152.7	Mud to sand to stable gravel.	Lower portions of creek flow through Glendive. Standing water, mainly in small shallow pools over some portions of creek. Sampling efforts produced no fish.
Deer	619.2	137.8	Silt to clay.	Drainage consists of interconnecting pools with stretches of lower reaches dry by mid-summer. Game fish sampled at the lower sections include northern pike, channel catfish and burbot. These were all sampled in a pool under the bridge on Hwy 16 just prior to channel alteration/re-establishment work conducted by the Highway Dept. N.P. were also found in pools in upper portion of drainage.
Threemile	619.2	134.4	Mud	Contains water only during spring runoff or heavy rainstorms.
Lower 7 Mile	616.1	128.7	Gravel, rocks	Creek dry along most of drainage with some areas consisting of small interconnecting pools; wide channel.
Morgan	613.1	122.8	Gravel, rocks	At mouth, creek is dry with the exception of pool behind small beaver dam. At site 2 stream is spring fed. 1979 stream consisted of interconnected pools but almost totally dry in 1980.

Table 2. Continued

Creek	(m) Elevation	(km) Rivermile	Substrate	Major Features
Thirteenmile	610.0	116.0	Sand, gravel, rocks	Lush streambank vegetation. Creek contains water at lower sections in form of interconnecting pools. At site 3 creek dry with scattered pools. Large conc. of minnows in these pools. Clear, calm water. Surroundings -hay meadows in lower reaches, wheat field above.
War Dance	603.9	105.0	Muck	Below Intake canal this creek has been diverted and rechanneled for irrigation. Dense riparian vegetation, and alfalfa fields.
Cottonwood	600.9	104	10-20 cm, silt over solid bottom.	Creek dries up after spring runoff except for scattered pools. Some pools spring fed. Badlands setting with extensive cattle grazing.
Burns	597.8	97.8	Gravel, rocks in lower section, muddy above.	Creek flows through heavily vegetated river bottom before entering Yellowstone. Four beaver dams are located along Sec. 1. Upstream forks flow primarily during spring runoff. Some portions of drainage contain deep pools with abundant vegetation, other portions dry.
Dunlap	591.7	83.0	Silt to muck.	Creek flows through Elk Island Recreation area. Flow of lower section maintained by Intake canal. Volume and velocity of water change is erratic.
Sears	588.0	77.7	Sand, gravel	Creek runs into side channel of braided portion of Yellowstone River. Irrigated fields along portion of creek.

Table 2 . Continued

Creek	(m) Elevation	(km) River Mile	Substrate	Major Features
Shadwell	588.7	77.7	Red shale, with some silt in pools	Upper reaches large pools in late summer. Vegetation cover good at upper site. Reeds, cattails present in fall at upper site. Mouth reach, extensively shallow pools and reeds present. Upper portion of stream rolling hills, mouth is steep banks.
Crane	582.6	65.6	Several centimeters of silt on gravel	Gartside Res. headwater, as stream dry up above. Intake spill water probably contribute to flow. From Hwy 16 to mouth, cuts through agricultural fields, and these fields farmed fairly close to stream channel. At Seven Sisters recreation area, stream bordered by a good riparian environment, i.e cottonwoods, dogwood, rosebush & grasses.
O'Brien	579.5	57.0	Mud & silt, deep	Upper site had high, steep banks. Stream did not flow. Extensive vegetation in stream channel & stream. Grasses & trees abundant. Hay fields border stream channels. Only one species brook stickle-back, found. Almost bog like. Stock watering ponds present on stream.
Fox	579.5	52.1	Bedrock at mouth, Gravel in middle reaches. Below Fox Lake, extreme-ly silty & mucky.	Lower portion has heavy agricult-ure use, channel lined with trees & grasses. Middle section, cattle & pasture utilization, with juniper & Russian olive present. Upper reaches bordered by wheat fields and stream is shallow, very mucky, and cattails & reeds present. Grasses & some trees present.

Table 2. Continued.

Creek	Elevation (m)	River Mile (km)	Substrate	Major Features
Lone Tree	573.4	27.5	Extremely silty at mouth, upper portion gravel.	At mouth, rechanneled, & very silty. Heavy vegetation, trees, rosa sp. and grasses in channel. Further up gravel, some trees & good grass. Oil & gas wells present. One within 200 m of stream. Extensive cattle use. Reservoirs present on stream.
Bennie Peer	573.4	41.2	Mud & silt at lower reaches	High, sandy, clay banks, some trees, pasture and hay use bordering stream. As approach N.D. border stream is in area of intense oil and gas drilling. Stream largely in pools in later part of year, & appears large in upper reaches.
Firt Hay	567.3	26.4	Gravel in mouth reach. Upper reaches have gravel with some silt.	Mouth reach bordered by thick trees & grass, and bordered by hay fields. Appears Intake spills into stream. Upper two reaches bordered by agricultural use, mainly hay & wheat, and is mainly pools, with the channel bordered by grass, and a few trees. Uppermost reach is intermittent pools, some fairly large
Fourmile	567.3	1.6	Largely silt & sand, with some gravel	Area surrounded by hay & wheat field. Channel at first site, pool like due to beaver dams. Trees & grasses cover good. At upper site, grass up to stream bank, few trees. Site was immediately below a culvert and appears to go underground.

A ratio of the five bottom types (hardpan, boulders, rubble, gravel, and fines) using information collected at all sites and combining pool, run and riffle areas, was determined to be 3:1:12:33:35. Clearly, fines and gravel compose a high degree of the substrate material in these streams. In a breakdown of these categories into pool, run, and riffle areas, it appears that fines and gravel dominate the pool substrates with fines ahead of gravel by a two to one margin. The run areas are composed almost equally with gravel and fines and to a lesser extent rubble with a ratio of 2:2:1, respectively. The riffle areas are characterized by rubble, gravel and fines in a ratio of 1:3:1, respectively.

In summarizing the results of the percentages of pool, run, and riffle areas for each reach analyzed, 62 out of 90 sites were composed of 50% or more of pools. In 24% of the sites, pools composed 100% of the reach. Runs were present at 71% of the sites but only 22% of the time did they comprise 50% or more of the reach. Riffle areas were proportionately less abundant. The ratio of pool to run to riffle combining all site analyses, was determined to be 10:4:1, respectively.

Also included with each stream surveyed was an esthetics rating. The rating was coded 1 (low) to 5 (high). Features that were considered to detract from esthetics included pollution, dewatering, channelization, riprap (particularly car bodies and discarded building materials), mine tailings, a busy highway along stream and severe land use. The guidelines for each number included the following:

1. A stream with <u>low</u> esthetic qualities.

2. A stream and area with fair esthetic qualities.

3. A water with natural beauty but of a more common type than listed under 4 and 5. A clean stream in an attractive setting.

4. A water comparable to 5 except that it may lack pristine characteristics. Presence of human development such as roads, farms, etc. usually comprise the difference between 4 and 5.

5. A water of outstanding beauty in a pristine setting.

Of the 91 sites rated, 46 were given a rating of 2, 43 were rated 3 and 2 sites were given a rating of 4. No particluar patterns emerged in regards to the ratings of 2 and 3, other than that almost all sites rated were equally divided between the two. The study area could be generally considered of fair esthetic value and tending to have a common sort of natural beauty. The two reaches rated as 4 were Crane Creek, site 1 , and Morgan Creek, site 1. The reach on Crane Creek was rated high for obvious reasons. It flows through the Seven Sisters state recreation area. Although the Morgan Creek reach flows through hay meadows, marring it's naturalness with human influence, the area is a rather pleasing panorama of Yellowstone River bottomland and thus was given a higher rating.

One comment that should be made here in regards to esthetics, especially when dealing with prairie streams, is that "natural beauty" takes on an entirely different image. Comparisons cannot be made with other aquatic environments, in particular mountain stream settings, as the prairie has an esthetic beauty of it's own.

RESULTS

Water Quality Characteristics

Results from field tests over the two year period exhibited a wide variation. In part, this may be due to the characteristically less precise testing methods used under field conditions and at times the questionable accuracy of equipment used. Even so, a number of generalizations can be made. Alkalinity, a reflection of regional geology, was high, with 87% of the readings in the 200-800 mg/l range. These are comparable to readings determined on Beaver Creek and its tributaries (Elser et al. 1978). The two highest values recorded were 2490 mg/l in 1979 and 1463 mg/l in 1980, both recorded on Shadwell Creek. pH varied from 7.0 to 10.0 with a pH value of at least 8.5 in over 80% of the samples in 1979 and over 94% of the samples in 1980. The readings greater than 8.5 generally occurred in late July and August. Specific conductance, a measure of soluble salts, ranged between 30-5000 umhos/cm with 90% of readings between 30-2400 umhos/cm in 1979. The range for 1980 was 70-24,000 umhos/cm. The low reading of 70 umhos/cm was found on Morgan Creek site 2. The next lowest reading jumped to 350 umhos/cm on Harris Creek, site 1. Eighty-one percent of the readings were in the 70-3800 umhos/cm range. Eight readings were in the 6,800-16,000 umhos/cm range which is higher than the highest readings in 1979. These readings, which were taken at upstream sample sites and mainly recorded in July, may have been exceptionally high due to the lack of flushing of salts with no precipitation in the spring of 1980. Turbidities ranged from the minimum of 0 JTU to the maximum 500 JTU capable of being measured on the equipment used. Over the two years, 95% of the recordings were between 0 and 150 JTU, with 5 in the 500 and greater range. The only safe conclusion to be drawn about dissolved oxygen levels is that they are apparently adequate. The validity of actual recorded results was questionable as the D.O. meter was not functioning properly at all times. Tables 12 and 13, Appendix, summarize all chemical data obtained.

Thermograph information entered in the Bozeman computer program in 1979 provided a precise and detailed analysis of the water temperature profile of O'Fallon Creek. Results related here will focus more heavily on that first year information, with added comparisons with the 1980 information. Seven day average maximum and seven day minimum water temperatures for the three reaches of O'Fallon Creek in 1979 are summarized in Figures 44, 45, and 46, Appendix. The seven day average water temperatures for 1979 and 1980 on the three reaches are illustrated in Figures 4 and 5. In 1979, water temperatures showed a typical increase to a high in July, and dropping off at the end of July, first part of August.

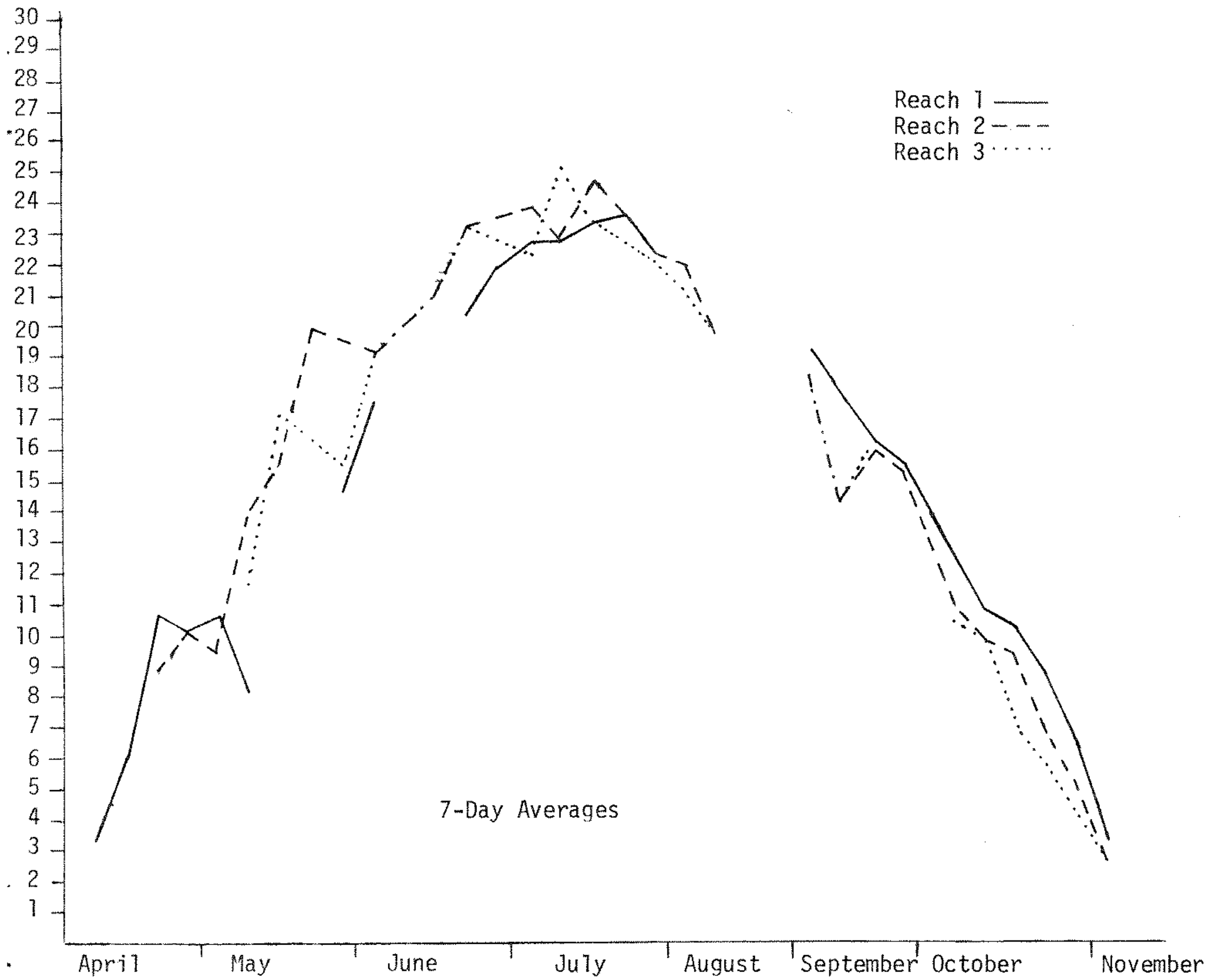
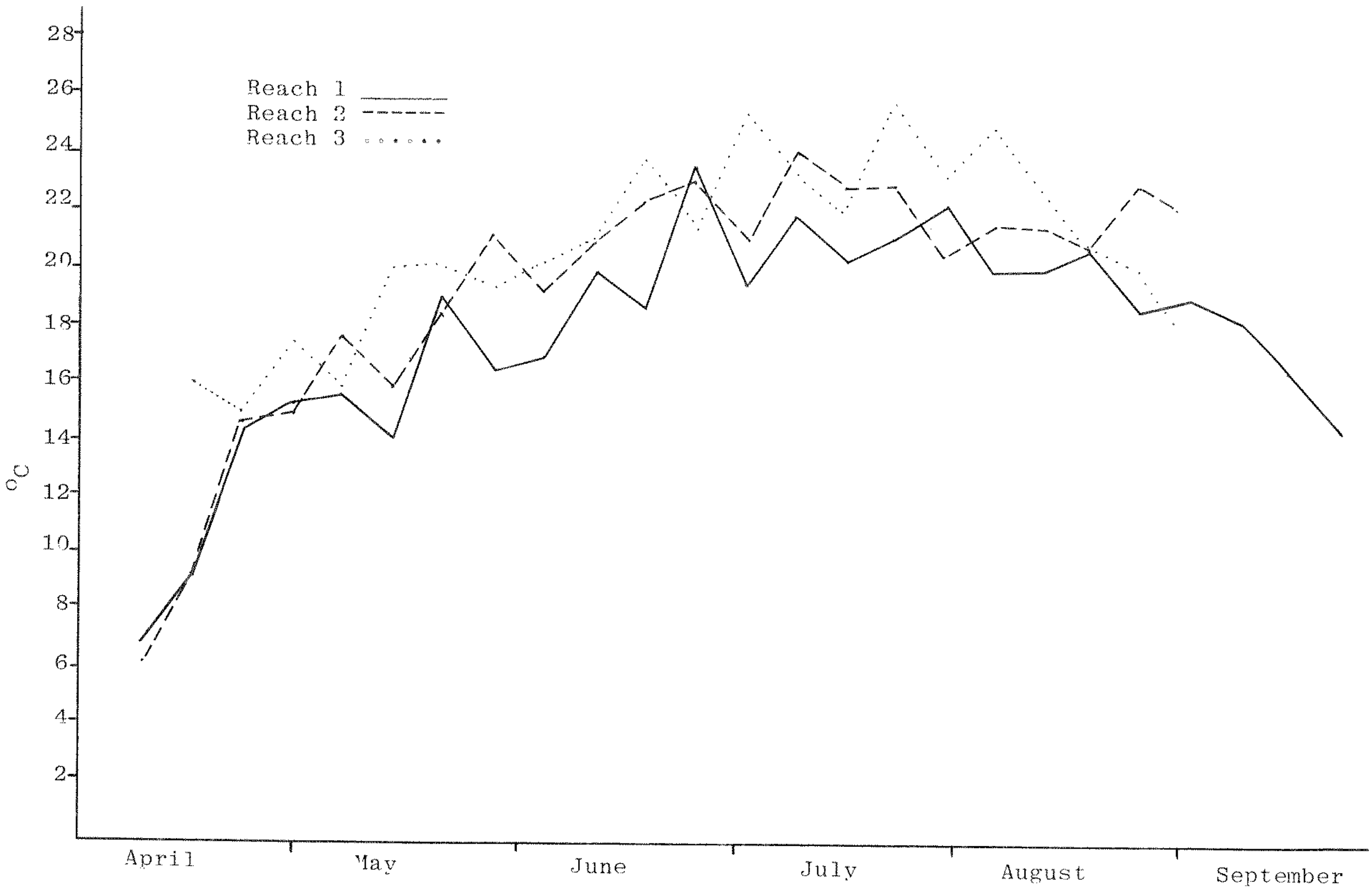


Figure 4 . The 7-day average temperatures of three sites on O'Fallon Creek, 1979.

Figure 5. The seven day average temperatures on three reaches of O'Fallon Creek, 1980.



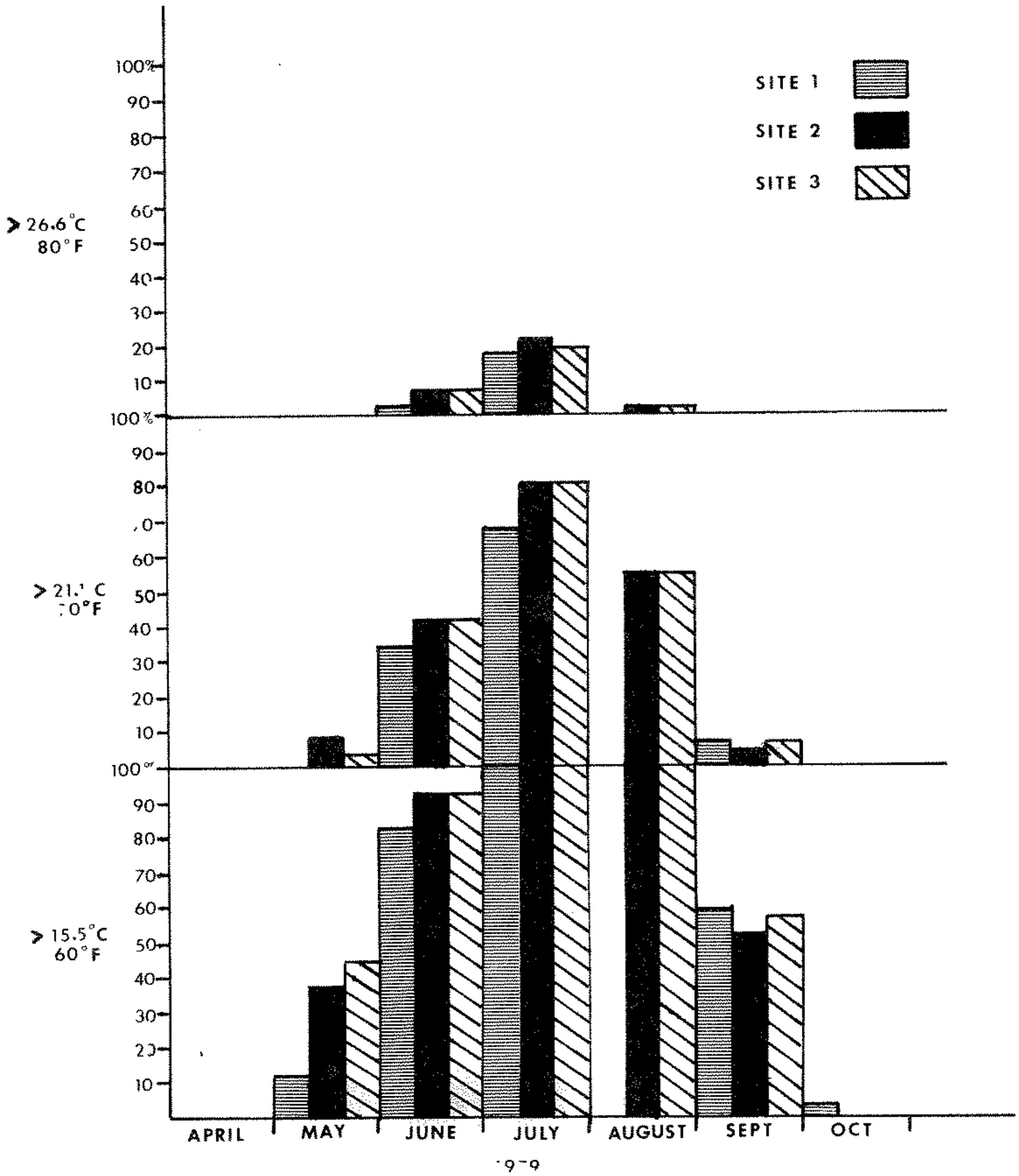


Figure 6 . A graph showing the percentage of the time that temperatures were over 15.5°C, 21.1°C, and 26.6°C at the three thermograph locations on O'Fallon Creek, 1979.

In 1980, water temperatures increased in a similar fashion. Temperatures at each of the reaches compared closely for both years with the exception of the warmer temperatures in early April 1980. Although in Figure 4 time is measured in Julian days whereas in Figure 5 time is measured using calendar days, this general comparison between the two years can be made. At all three sites on O'Fallon Creek, 1979 temperatures peaked in July, with temperatures over 26.6°C (80°F) approximately 20% of the month, and at no time falling below 21.1°C (70°F) (Figure 6). The maximum temperatures in 1979 for reach 1 was 30.9°C (87.0°F), reach 2, 31.1°C (88°F) and reach 3, 28.8°C (83.8°F), with 31.1°C the highest recording of the summer. The highs in 1980 for reaches 1, 2, and 3, respectively, were 31.1°C (88°F) on June 20 and 21, 30.0°C (86°F) on July 6 and 22 and 30.6°C (87°F) on July 28.

The range in individual stream temperatures (Appendix , Tables 12 and 13) were found to correlate closely with thermograph recordings on O'Fallon Creek. These regimes illustrate the typical rise and fall of the stream water temperatures over the summer months.

Aquatic Invertebrates

The aquatic fauna of streams varies tremendously in distribution and abundance both annually and seasonally (Needham 1962, Stehr and Branson 1933). Due to the number of streams sampled in this study, the limited sampling efforts and the fact that the composition of aquatic organisms changes as a result of variations in the stream environment, particularly changes in water temperature, chemistry and flow (Newell 1977), only general conclusions can be drawn from these results. The information gathered provides a representative distribution of aquatic invertebrates in the study area, provides a diversity of organisms in each stream sampled and recognizes predominent forms. This information may also provide an indication of the "health" of these streams. The stressed aquatic systems will have a lower diversity and in cases when composition consisted of a few hardy species, it may be an indication of extremely poor water quality (Klarich 1979). Table 3 shows invertebrate distribution on each stream sampled. Organisms were identified when possible to species.

On the whole, samples did not contain extremely large numbers of individuals, but diversity per sample was great. Streams particularly high in diversity included O'Fallon, Fox, Upper Sevenmile, and Crane Creeks. The richest samples in terms of invertebrate numbers were again Fox, Upper Sevenmile and O'Fallon Creeks. All of these streams were characterized by a gravelly substrate and clear flowing water.

Five phyla are represented in the study area. The class Insecta comprised the greatest portion of aquatic invertebrates. The three most common orders were Diptera, Ephemeroptera, and Hemiptera, occurring in 95%, 92% and 82% of the streams sampled, respectively.

Accordingly, Diptera was found to be the most common group in Beaver Creek (Elser et al. 1978). Species diversity among the orders of Insecta was also highest for Diptera, represented by 48 genera and 13 families. The most widely distributed family was Chironomidae, a group characterized by slower waters and tolerant of low oxygen stress. In Beaver Creek, a stream in this area which has been intensively studied and thus used as a comparison here, Chironominae and Tanipodinae were widely distributed (Elser et al. 1978).

The diversity of Ephemeroptera was represented by 6 families and 14 genera. Of these, *Caenis* sp., associated with running water (Stehr and Branson 1933) outranked other genera , occurring in 87% of the streams sampled. This mayfly was found to be widely distributed in Beaver Creek (Elser et al. 1978) and was also considered a dominant form in Sarpy Creek (Clancey 1978). As a group, Ephemeroptera exhibits a broad tolerance to varying stream habitats (Bell 1969, Schwehr 1977). Of special interest concerning mayfly collections, was the identification of *Cloeon* sp. According to Oswald (personal communication), this is the first record of this genera in Montana.

In this study, Odonata was present on 59% of the streams sampled. In Beaver Creek, this group was also found to be abundant (Elser et al. 1978). In these results, *Ishnura* sp. was determined to be the most widely distributed genus.. Sampling efforts produced an interesting find, the dragonfly *Macromia* sp. According to Oswald (personal communication), this was the first find of this organism in Montana. At about this same time *Macromia* sp. was identified by Mark Gorges (personal communication) on Box Elder Creek in the Little Missouri River drainage.

Plecoptera were not common in the study area. In 1979 only one genus of stoneflies, *Isoperla* sp. was identified, on Custer Creek. The distribution of this order increased in 1980 to include 2 additional streams. The greatest number of individuals in this taxa were identified on Thirteenmile Creek. Schwehr (1977) indicated that Plecoptera are more well adapted to a cold water environment. Newell (1977) stated that few adult Plecoptera were identified in the lower Yellowstone River. The limited distribution of stoneflies in the study then may be due to lack of suitable habitat.

Trichoptera were not abundant in the study area. The most common caddisflies were *Cheumatopsyche* spp. and *Hydropsyche* spp. These two genera were found to be the only two major caddisfly groups below Miles City during research conducted on the Yellowstone River (Schwehr 1977).

Hyalella azteca was a common amphipod found to occur in 28 of the 39 streams sampled. According to Pennak (1978), this species is common to unpolluted, clear waters including springs, streams, ponds and pools. Over the study area, this organism appeared in streams

Table 3. Distribution of aquatic invertebrates by stream in the study area; x indicates 1979, + indicates 1980, o indicates both 1979 and 1980.

Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	22	23	24	25	26	27	28	30	31	32	33	34	35	36	37	38	39	40	43	44	45
PLATYHELMINTHES																																								
Turbellaria							x								x												x													
NEMATODA	x				o				x				+	x	+				o	x							x		x			+						x		
ANNELIDA																																								
Oligochaeta																																								
Tubificidae																																								
Inmatures with capilliform chaetae				x									x													x	x			x										
Inmatures without capilliform chaetae				x	x		x		x	x			x				x		x	x			x				x					x				x	x	x		
Limnodrilus claparedianus									x																															
Limnodrilus hoffmeisteri					x		x		x				x				x										x					x				x		x		
Limnodrilus udekemianus																	x										x									x		x		
Naididae																																								
Nais c.f. *barbata*							x																x																	
Nais c.f. *communis*																														x										
Ophidonais serpentina				x	x														x							x	x													
Hirudinea				+		+							+																											
Glossiphoniidae					x		x																																	
Erpobdellidae	x				x								x														x													
MOLLUSCA																																								
Gastrapoda																														+										
Pulmonata																																								
Physidae																																								
Physa spp.	x			+	o	o	o			+		x	o			x		x	o	x					+	+	x	+				+				x	+		+	
Lymnaeidae																																								
Lymnaea spp.					x	x	o						x						x							+						x							+	
Planorbidae																																								
Gyraulus spp.					x	+	x												x				+			+														
Ancylidae																																								
Ferrissia sp.							x																																	
Bivalvia																																								
Heterodonata																																								
Sphaeriidae																																								
Pisidium sp.					x																																			

Table 3. Continued.

Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	43	44	45
ARTHROPODA																																									
Insecta																																									
Ephemeroptera						+																												+							
Baetidae																																									
Baetis spp.		x		o	x			+			x			x	x	x	x		o	o					+	x		x				+			+					+	+
Callibaetis sp.					x		x	+			x	+		x	x	x	x	x	o											o	x	+		+					+		
Centroptilum sp.	x			x								x														x															
Cloeon sp.											x																														
Pseudocloeon sp.					x											x	x			x						x													x		
Heptageniidae																																									
Heptagenia sp.		x									x																	x													
Rhithrogena undulata					x				+																																
Stenonema sp.																												x													
Leptophlebiidae																																									
Choroterpes albiannulata											x			x	x	x				x					+	x						+									
Leptophlebia gravastella															x																										
Paraleptphlebia c.f. debilis							x																																		
Tricorythidae																																									
Tricorythodes minutus				+	x		+	+						x		x			x	+					+	x		x		+		+								+	+
Ephemeridae																																									
Hexagenia sp.											+																			+	x										
Caenidae																																									
Caenis sp.	o	x	+	o	x	x	o	+	x		o	x	x	x	o	x	x	x	x	x	x		+	x			x	o	+	o	x	o	o	+			o	x	+		+
Odonata	+																															+									
Gomphidae																																									
Gomphus sp.				x							+																	+											+		
Ophiogomphus sp.					x																							x									x				
Aeshnidae																																							+		
Aeshna sp.	x			+		x												x																				+	+		
Macromiidae																																									
Macromia sp.																																x									
Libellulidae																																							+		
Libellula sp.						x	x											x												+											
Sympetrum sp.																			x																						
Lestidae																																									
Lestes sp.					x		x											x	x		+																+				

Table 3. Continued

Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	22	23	25	26	27	28	30	31	32	33	34	35	36	37	38	39	40	43	44	45
Coenagrionidae																										+													
Ishnura sp.				x	x	+	x	+			x	+	x			x	x		o		x						+	+		+					x	+	+		
Plecoptera														+																									
Perlodidae																																							
Isoperla sp.																	+																				x		
Hemiptera																																							
Gerridae																												+	+								+	+	
Gerris sp.																		x																					
Naucoridae																																							
Ambrysus mormon				x	x		x		+										+							x		+											
Corixidae	o		o	x		+	+	+	o			+			+	x	+		x		+		o			x	+		+	+	x	o	+	+	+	+	+		+
Hesperocorixa laevigata							x				x	x							x				x			x													
Palmacorixa gilletti			x																																				
Sigara	x		x	x								x	x		x		x	x	x													x			x				
Trichocorixa verticalis interiores																					x																		
Notonectidae																																							
Notonecta sp.					x	+													x		x												+				+		
Megaloptera																																							
Sialidae																																				+	+		
Sialis sp.				o	x		+										+									x		+	+					+		+	+		
Trichoptera																																							
Polycentropidae																																							
Polycentropus sp.																										x													
Hydropsychidae	x														x					x																			
Cheumatopsyche spp.		x	+	+	o		x		+	+	x			x		x	o		+					+		o		x								o			
Hydropsyche spp.									+		x			x		x	x		o	+				+		o												+	+
Hydroptilidae																																							
Hydroptila sp.														x		x										x													
Ithytrichia sp.					x												x																						
Ochrotrichia sp.																																					x		
Oxyethira sp.					x													x																					
Phryganeidae																																							
Phryganea sp.	x																																						
Limnephilidae																																							
Anabolia sp.					x																														x				
Limnephilus sp.					x		x												x																				

Table 3. Continued

Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	22	23	25	26	27	28	30	31	32	33	34	35	36	37	38	39	40	43	44	45
Leptoceridae																																							
Oecetis sp.	x											x														x													
Coleoptera	+											+															+			+		+		+	+				
Haliphidae																																							
Haliplus sp.																			x															+					
Dytiscidae																					+																		
Agabus sp.							x																																
Colymbetes sp.				x		x																																	
Coptotomus sp.							x										x									x													
Dytiscus sp.							x																																
Graphoderus sp.							x																																
Laccophilus sp.					x		x				x								x																x				
Oreodytes Deronectes sp.							x												x																				
Rhantus sp.																			x																				
Gyrinidae																																		+					
Gyrinus sp.							x																																
Hydrophilidae									+			+																				+		+	+				
Berosus sp.							x												x		x														x		x		
Hydrobius sp.							x																																
Tropisternus sp.																										x													
Carabidae																	x																						
Elmidae																																+							
Dubiraphia sp.				+	o												+		+										x										
Diptera		+							+				+				+							+			+			+	+				+				
Tipulidae				+										+		+				+				+												+			+
Dicranota sp.																x			x	x																			
Erioptera sp.																																					x		
Hexatoma sp.																x																							
Ormosia sp.																																					x		
Ceratopogonidae																																							
Tribe Stilobezziini					x								x	x	x			x							x				x		x								
Simuliidae																																							
Simulium sp.	x											x		x	x	x	o		o	o					o	x										o	x		+

Table 3. Continued.

Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	22	23	25	26	27	28	30	31	32	33	34	35	36	37	38	39	40	43	44	45
Chironomidae	x	+		o	o		o		o	+	+	+	o	o	x	o	o	x	o	o	+	+	o	+	o	o	+		o	+	+	+	+	+	+	o	o	+	+
Tanypodidae																																							
Ablabesmyia sp.					x								x				x									x				x									
Larsia sp.													x			x										x													
Nilotanypus sp.																										x													
Paramerina sp.							x																																
Pentaneura sp.														x																									
Procladius sp.				x	x								x			x	x				x		x																
Psectrotanypus sp.							x																																
Tanypus sp.																							x						x										
Thienemannimyia 1/					x						x			x		x	x								x	x										x	x		
Diamesinae																																							
Diamesa sp.																																				x			
Chironominae																																							
Chironomus sp.			x	x			x								x	x	x	x			x		x		x			x		x		x			x		x		
Cryptochironomus sp.			x									x					x	x				x	x			x		x		x									
Cryptotendipes sp.																													x										
Cyphomella sp.																									x														
Dicrotendipes sp.	x						x						x	x	x	x	x	x	x						x	x			x	x	x								
Endochironomus sp.													x				x									x													
Harnischia sp.									x																														
Paratendipes sp.									x																	x													
Phaenopsectra sp.					x		x								x	x			x	x					x			x		x							x		
Polypedilum s. s. tripodura gr.									x														x		x	x										x			
Pseudochironomus c.f. *fulviventris*				x																						x		x								x			
Pseudochironomus sp. B.																										x													
Stictochironomus sp.															x										x														
Cladotanytarsus sp.																	x									x			x										
Micropsectra spp.				x	x									x		x	x		x						x	x				x	x								
Paratanytarsus sp.	x				x																				x														
Rheotanytarsus sp.				x	x									x		x	x		x	x						x													
Tanytarsus sp.			x		x		x					x	x	x	x	x		x	x			x	x		x			x	x						x				
Orthocladiinae																																							
Acricotopus sp.							x																																
Corynoneura sp.														x																									
Cricotopus bicinctus sp.				x	x							x		x	x	x	x		x						x	x		x	x									x	

Table 3. Continued.

Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	22	23	25	26	27	28	30	31	32	33	34	35	36	37	38	39	40	43	44	45
Cricotopus sp. A.															x	x																					x		
Cricotopus (*Isocladius*) *sylvestris gr.*													x			x			x							x			x						x				
Eukiefferiella sp.														x	x		x		x						x														
Hydrobaenus sp.																										x									x				
Orthocladius (*Euorth.*) *Thien. Type I or III*																																				x			
Orthocladius (*Orth.*) *oliveri*									x																											x			
Orthocladius (*Orth.*) *Cricotopus* (*Cric.*) sp.												x		x	x	x	x		x	x					x	x				x						x	x		
Paracladius c.f. quadrinodosa gr.																									x														
Parametriocnemus sp.																x																							
Psectrocladius (*Allopsect.*) *nr. flavus*																x															x								
Psectrocladius sp. B														x																									
Stratiomyidae																																							
Euparyphus sp.					x																																		
Stratiomyia sp.																												x											
Tabanidae																																							
Chrysops sp.				x	x																																		
Dolichopodidae																										x													
Empididae																																							
Hemerodromia sp.				x																																			
Anthomyiidae																																							
Limnophora sp.	x				x									x		x						x			x			x											
Arachnida																																							
Acari	x					+											x		x																				
Crustacea																																							
Ostracoda																																							
Cypridae																																							
Cypris							x																																
Malacostraca																																							
Amphipoda																																							
Talitridae																																							
Hyalella azteca	x		x	x	x	o	x			+	x	+	o	x	x	x	o	x	o	+	x	x		+	x	x	+	o		o	x				x	o			
Gammaridae				+																																			
Ammarus lacustris					x									x					x																				
Decapoda																																							
Astacidae																																							
Pacifastacus leniusculus	x																																						

1/ Group of four genera; *Thienemannimyia*, *Conchapelopia*, *Arctopelopia*, and *Rheopelopia* which are not separable in larval stage. Pupae examined from Thirteenmile and Sevenmile creeks revealed the presence of *Conchapelopia* and *Thienemannimyia* in these samples.

consisting of standing water or pools with a silt to muck bottom, and streams with gravelly bottoms both with flowing and standing water.

Stream conditions throughout the study area are dictated by weather and seasonal changes. The resulting responses of aquatic organisms will be dependent on these environmental variations. The results of this study in terms of species composition are similar with other studies in this area. The most abundant organisms found are typical of prairie stream environments.

Fish

Qualitative sampling of fish populations produced 43 species representing 30 genera and eleven families. The taxonomic status for these species is presented in Table 4. All names used are in accordance with American Fisheries Society (1960) standard nomenclature. Catostomid and cyprinid populations had widespread distribution throughout the study area (Figure 7). The white sucker (*Catostomus commersoni*), fathead minnow (*Pimiphales promelas*), and creek chub (*Semotilus atromaculatus*) were the dominant species with percent occurrences of 80%, 77.8% and 77.8%, respectively. This is in agreement with Elser, et al. (1978) who found the same three species to be widely distributed in the Beaver Creek drainage, and Clancey (1978) who concluded that the white sucker and fathead minnow were dominant in Sarpy Creek. Other common cyprinids with widespread distribution within the study area include flathead chub (*Hybopsis gracilis*), lake chub (*Couesius plumbeus*) and longnose dace (*Rhinichthys cataractae*). Swaidner and Berra (1978) found that low flow and a lack of predators, conditions found in many of the study streams provides a nursery area for catostomid and cyprinid populations. These smaller fish species are also characteristically tolerant of fluctuating conditions and capable of reinvading an area after a dry spell. The large carnivores, on the other hand, are adapted to more stable habitats. Furthermore, small fish show a size-dependent ability to survive critically low-water conditions. The larger species tend to be more susceptible to the stresses associated with dry periods (Kushan 1976).

Eight species of game fish were represented, with northern pike (*Esox lucius*) and channel catfish (*Ictalurus punctatus*) occurring in 27% and 22% of the streams, respectively. Gill nets, set in periods of high water, indicate several species utilize lower stream reaches for feeding, resting and possibly spawning. Walleye (*Stizostedion vitreum*) and sauger (*Stizostedion canadense*) were almost exclusively located in the lowest reaches of streams when found. Young-of-the-year yellow perch (*Perca flavescens*) were identified in the mouth reach of O'Fallon Creek. The only population of smallmouth bass (*Micropterus dolomieui*) located within the study area were found to comprise 22% of the population of fish at site 2 on Lone Tree Creek in 1979. Two populations of trout, an uncommon game fish in eastern Montana, were also found in the Sidney area. Apparently these populations of brook trout

Table 4. Taxonomic status, scientific and common names of fish sampled in the study area.

Family	Scientific Name	Common Name
HIODONTIDAE	*Hiodon alosoides*	Goldeye
SALMONIDAE	*Salmo trutta*	Brown trout
	Saluelinus fontinalis	Brook trout
ESOCIDAE	*Esox lucius*	Northern pike
CYPRINIDAE	*Cyprinus carpio*	Carp
	Notemigonus crysoleucas	Golden shiner
	Semotilus atromaculatus	Creek chub
	Phoxinus eos	Northern redbelly dace
	Hybopsis gracilis	Flathead chub
	Hybopsis gelida	Sturgeon chub
	Couesius plumbeus	Lake chub
	Notropis atherinoides	Emerald shiner
	Notropis stramineus	Sand shiner
	Hybognathus hankinsoni	Brassy minnow
	Hybognathus placitus/nuchalis	Plains/silvery
	Pimephales promelas	Fathead minnow
	Rhinichthys cataractae	Longnose dace
CATOSTOMIDAE	*Carpiods carpio*	River carpsucker
	Cycleptus elongatus	Blue sucker
	Ictiobus bubalus	Smallmouth buffalo
	Ictiobus cyprinellus	Bigmouth buffalo
	Moxostoma macrolepidotum	Shorthead redhorse
	Catostomus catostomus	Longnose sucker
	Catostomus commersoni	White sucker
	Catostomus platyrhynchus	Mountain sucker
ICTALURIDAE	*Ictalurus melas*	Black bullhead
	Ictalurus natalis	Yellow bullhead
	Ictalurus punctatus	Channel catfish
	Noturus flavus	Stonecat
GADIDAE	*Lota lota*	Burbot
CYPRINODONTIDAE	*Fundulus kansae*	Plains killifish
GASTEROSTEIDAE	*Culaea inconstans*	Brook stickleback
CENTRARCHIDAE	*Leopomis cyanellus*	Green sunfish
	Lepomis gibbosus	Pumpkinseed
	Lepomis macrochirus	Bluegill
	Micropterus dolomieui	Smallmouth bass
	Pomoxis annularis	White crappie
	Pomoxis nigromaculatus	Black crappie
PERCIDAE	*Perca flavescens*	Yellow perch
	Stizostedion canadense	Sauger
	Stizostedion vitreum	Walleye
	Etheostoma exile	Iowa darter

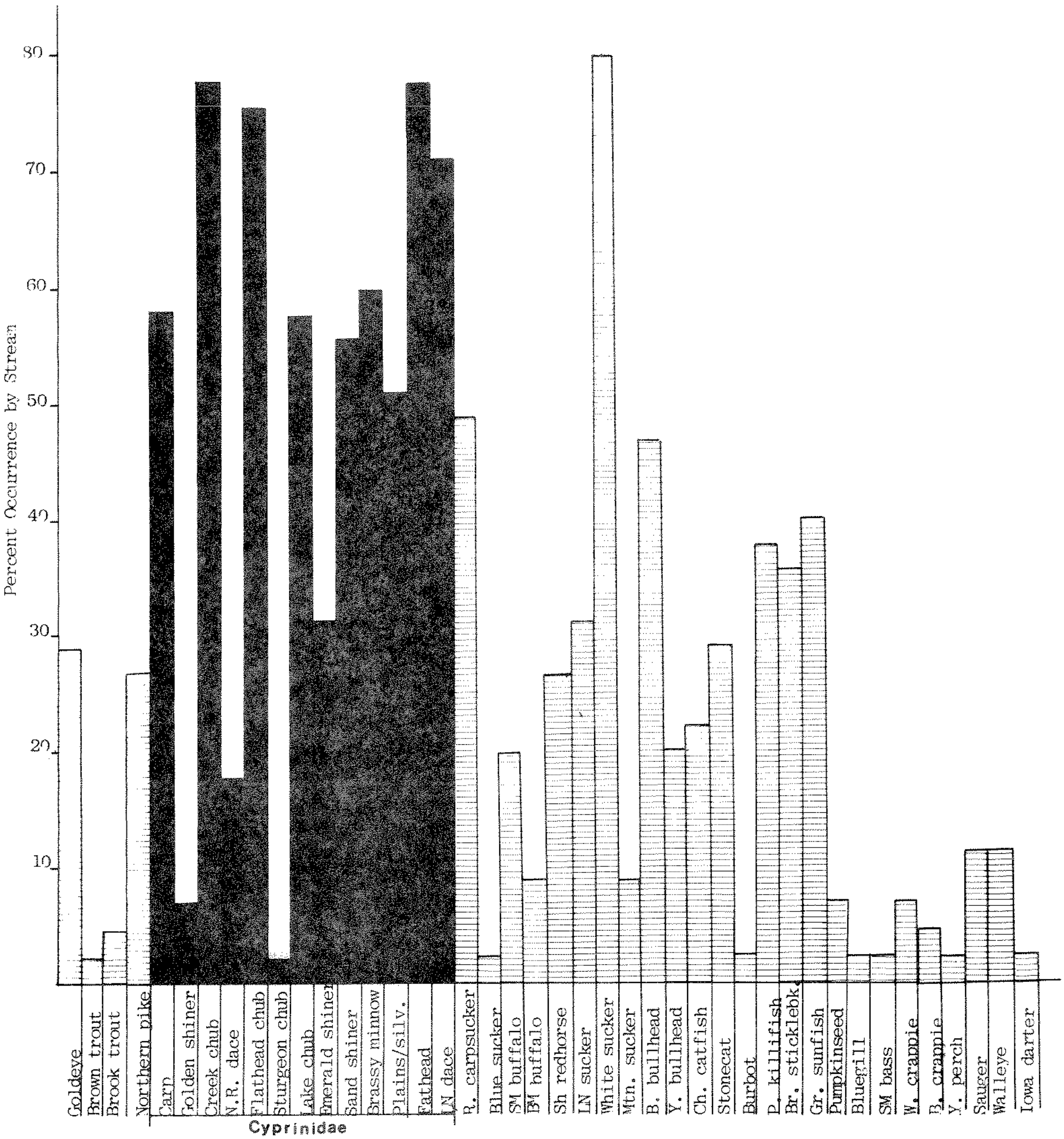


Figure 7 . A presentation of all species identified and their percent occurrence for the entire study area.

(*Salvelinus fontinalis*) are self sustaining, as both are located above the Intake Canal. In addition, two small burbot (*Lota lota*) were found about 6.5 km upstream from the mouth of Deer Creek (near Glendive) suggesting they may have migrated from the river. Lack of sufficient water is probably a major factor limiting game fish populations in these drainages.

Two fish, formerly classified as species of special concern were found throughout the study area. The creek chub and the plains killifish (*Fundulus kansae*) were found in 35 and 17 streams, respectively.

Eight populations of northern redbelly dace (*Phoxinus eos*) were found in the Glendive-Sidney vicinity. Previously, these fish had been documented by Brown (1971) only in the Missouri River drainage. The Iowa darter (*Etheostoma exile*), another recent addition to the Yellowstone River drainage, was found in Lone Tree Creek. Other fish found in only a few streams include the sturgeon chub (*Hybopsis gelida*), blue sucker (*Cycleptus elongatus*), bigmouth buffalo (*Ictiobus cyprinellus*), mountain sucker (*Catostomus platyrhynchus*), pumpkinseed (*Lepomis gibbosus*) and bluegill (*Lepomis macrochirus*). A distribution listing of fish species by study stream is compiled and presented in Table 5.

O'Fallon Creek

O'Fallon Creek is the largest tributary of the Yellowstone River included in the study. Paralleling recent energy exploration, Intake Water Company has contracted a consulting firm to collect information on various streams in the area. Flow data, believed to be typical of a prairie stream and it's drainage is being gathered in a continuous recording flow gaging station on O'Fallon Creek near Ismay, Montana. The following information is included to accompany sampling emphasis of this stream during the field seasons.

O'Fallon Creek drains a basin of approximately 4022 km^2 and flows generally northward. Sandstone and Pennel creeks have the largest drainage areas of the O'Fallon tributaries, with Sandstone the largest main tributary. Both of these streams and Whitney Creek, which comprise the O'Fallon tributaries sampled during this study, are intermittent. At it's mouth, O'Fallon appears to be perennial, but may become intermittent at the upper reaches. The stream does not have large flows except during periods of major runoff. Any significant contributions to the Yellowstone River would be expected between late February to early April when the river is in a low flow period. The water of O'Fallon Creek is of poor quality, being of the sodium-sulfate type. Water quality improves downstream from Ismay to Fallon, but is best during high flow (Karp et al. 1975).

Table 5. Fish species distribution by drainage.

	Goldeye	Brown Trout	Brook Trout	Northern Pike	Carp	Golden Shiner	Creek Chub	Northern Redbelly Dace	Flathead Chub	Sturgeon Chub	Lake Chub
1 Fourmile							x	x			
2 First Hay				x	x		x		x		
3 Bennie Peer	x			x	x	x	x		x		x
4 Lone Tree			x				x		x		x
5 Fox	x		x	x	x		x	x	x		x
6 O'Brien											
7 Crane	x			x	x		x		x		x
8 Shadwell					x		x				x
9 Sears					x		x		x	x	
10 Dunlap	x			x	x		x		x		
11 Burns	x				x		x		x		x
12 Cottonwood	x				x	x	x	x			x
13 War Dance							x	x	x		x
14 Thirteenmile	x			x	x		x	x	x		x
15 Morgan					x		x	x	x		x
16 Lower Sevenmile					x		x	x	x		x
17 Threemile											
18 Deer	x			x	x		x	x	x		x
19 Dry											
20 Upper Sevenmile				x	x		x		x		
21 Sand (R)											
22 Sand (L)		x			x		x		x		
23 Cedar							x		x		x
24 Magpie											
25 Clear	x				x		x		x		x
26 Cabin	x			x	x		x		x		x
27 Timber							x		x		x
28 Bad Route	x						x		x		x
29 Hatchet											
30 O'Fallon	x			x	x	x	x		x		
31 Whitney							x		x		x
32 Pennel					x		x		x		x
33 Sandstone	x			x	x		x		x		x
34 Cherry					x		x		x		x
35 Brakett							x				x
36 Lost Man's									x		
37 Crooked									x		
38 Tenmile							x		x		x
39 Coal					x		x		x		x
40 Locate					x		x		x		x
41 Sheep				x	x		x		x		
42 Trail											
43 Custer					x		x		x		x
44 Harris					x	x	x		x		
45 Muster									x		
No. Streams	13	1	2	12	26	3	35	8	34	1	26
% Occurrence	28.9	2.2	4.4	26.7	57.8	6.7	77.8	17.8	75.6	2.2	57.8

Table 5 Continued.

	Emerald shiner	Sand Shiner	Brassy minnow	Plains/we-st. silver minnow	Fathead minnow	Longnose dace	River carpsucker	Blue sucker	Smallmouth buffalo	Bigmouth buffalo	Shorthead Redhorse
1 Fourmile			x		x						
2 First Hay			x		x	x					
3 Bennie Peer	x	x	x	x	x		x				
4 Lone Tree	x	x	x		x	x					
5 Fox	x	x	x	x	x	x	x		x		
6 O'Brien											
7 Crane			x	x	x	x			x		x
8 Shadwell		x	x		x		x			x	x
9 Sears	x	x		x	x	x	x				
10 Dunlap	x		x	x			x				
11 Burns	x	x	x	x	x	x	x				x
12 Cottonwood		x	x	x	x	x	x		x	x	x
13 War Dance	x				x	x					
14 Thirteenmile		x	x		x	x	x		x	x	x
15 Morgan					x	x	x				
16 Lower Sevenmile	x	x		x	x	x	x				
17 Threemile											
18 Deer		x	x		x	x			x		x
19 Dry											
20 Upper Sevenmile		x	x		x	x	x		x		x
21 Sand (R)(S)											
22 Sand (L) (N)		x		x	x	x					
23 Cedar	x	x	x	x	x	x	x				
24 Magpie											
25 Clear	x	x	x	x	x	x	x				x
26 Cabin	x	x	x	x	x	x	x				x
27 Timber						x					
28 Bad Route		x	x		x	x					
29 Hatchet											
30 O'Fallon	x	x	x	x	x	x	x	x	x	x	x
31 Whitney		x	x	x	x	x					
32 Pennel		x	x		x	x					
33 Sandstone	x	x		x	x	x	x				x
34 Cherry		x	x		x	x	x				x
35 Brakett			x	x	x						
36 Lost Man's						x			x		
37 Crooked				x	x						
38 Tenmile			x	x	x	x	x				
39 Coal			x	x	x	x	x		x		
40 Locate				x	x	x	x				
41 Sheep		x			x	x					
42 Trail											
43 Custer	x	x	x	x	x	x	x				
44 Harris		x	x	x	x	x	x				
45 Muster			x		x	x					
No. Streams	14	25	27	23	35	32	22	1	9	4	12
% Occurrence	31.1	55.6	60.0	51.1	77.8	71.1	48.9	2.2	20	8.9	26.7

Table 5 . Continued

	Longnose sucker	White Sucker	Mountain sucker	Black Bullhead	Yellow Bullhead	Channel catfish	Stonecat	Burbot	Plains Killifish	Brook Stickle-back	Green Sunfish
1 Fourmile		x		x						x	
2 First Hay	x	x		x		x				x	
3 Bennie Peer		x		x	x						
4 Lone Tree		x		x						x	
5 Fox	x	x		x		x	x			x	
6 O'Brien										x	
7 Crane	x	x				x					
8 Shadwell		x		x	x				x	x	
9 Sears		x									
10 Dunlap		x									
11 Burns	x	x		x	x					x	x
12 Cottonwood		x		x	x	x	x		x	x	x
13 War Dance	x	x		x						x	
14 Thirteenmile	x	x	x	x		x	x		x	x	x
15 Morgan	x	x							x	x	
16 Lower Sevenmile	x	x							x		
17 Threemile											
18 Deer		x		x	x	x	x	x	x	x	x
19 Dry											
20 Upper Sevenmile	x	x		x		x	x		x	x	x
21 Sand (R) (S)											
22 Sand (L) (N)		x					x				
23 Cedar		x							x		
24 Magpie											
25 Clear		x	x				x			x	x
26 Cabin	x	x		x		x			x		x
27 Timber		x							x		
28 Bad Route	x	x							x	x	x
29 Hatchet											
30 O'Fallon	x	x	x	x		x	x		x		x
31 Whitney		x		x	x				x		x
32 Pennel		x					x				x
33 Sandstone		x		x		x	x				x
34 Cherry		x	x	x					x		x
35 Brakett		x									x
36 Lost Man's											
37 Crooked									x		
38 Tenmile	x	x		x			x				x
39 Coal		x		x	x						x
40 Locate		x		x						x	x
41 Sheep		x		x	x						
42 Trail											
43 Custer		x							x		x
44 Harris		x					x				
45 Muster		x							x		
No. Streams	14	36	4	21	9	10	13	1	17	16	18
% Occurrence	31.1	80	8.9	46.7	20	22.2	28.9	2.2	37.3	35.6	40

Table 5 . Continued

	Pumpkin-seed	Bluegill	Smallmouth bass	White crappie	Black crappie	Yellow Perch	Sauger	Walleye	Iowa Darter	Species Number
1 Fourmile										7
2 First Hay										12
3 Bennie Peer				x						17
4 Lone Tree		x	x						x	15
5 Fox							x	x		24
6 O'Brien										1
7 Crane							x			16
8 Shadwell										14
9 Sears										11
10 Dunlap								x		11
11 Burns										19
12 Cottonwood	x			x	x			x		27
13 War Dance										11
14 Thirteenmile	x						x			26
15 Morgan										12
16 Lower Sevenmile										14
17 Threemile										
18 Deer							x			23
19 Dry										
20 Upper Sevenmile	x									21
21 Sand (R) (S)										
22 Sand (L) (N)										10
23 Cedar										12
24 Magpie										
25 Clear					x					19
26 Cabin								x		21
27 Timber										6
28 Bad Route				x						14
29 Hatchet										
30 O'Fallon						x	x	x		29
31 Whitney										13
32 Pennel										11
33 Sandstone										18
34 Cherry										15
35 Brakett										7
36 Lost Man's										3
37 Crooked										4
38 Tenmile										13
39 Coal										14
40 Locate										12
41 Sheep										10
42 Trail										
43 Custer										16
44 Harris										12
45 Muster										6
No. Streams	3	1	1	3	2	1	5	5	1	
% Occurrence	6.7	2.2	2.2	6.7	4.4	2.2	11.1	11.1	2.2	

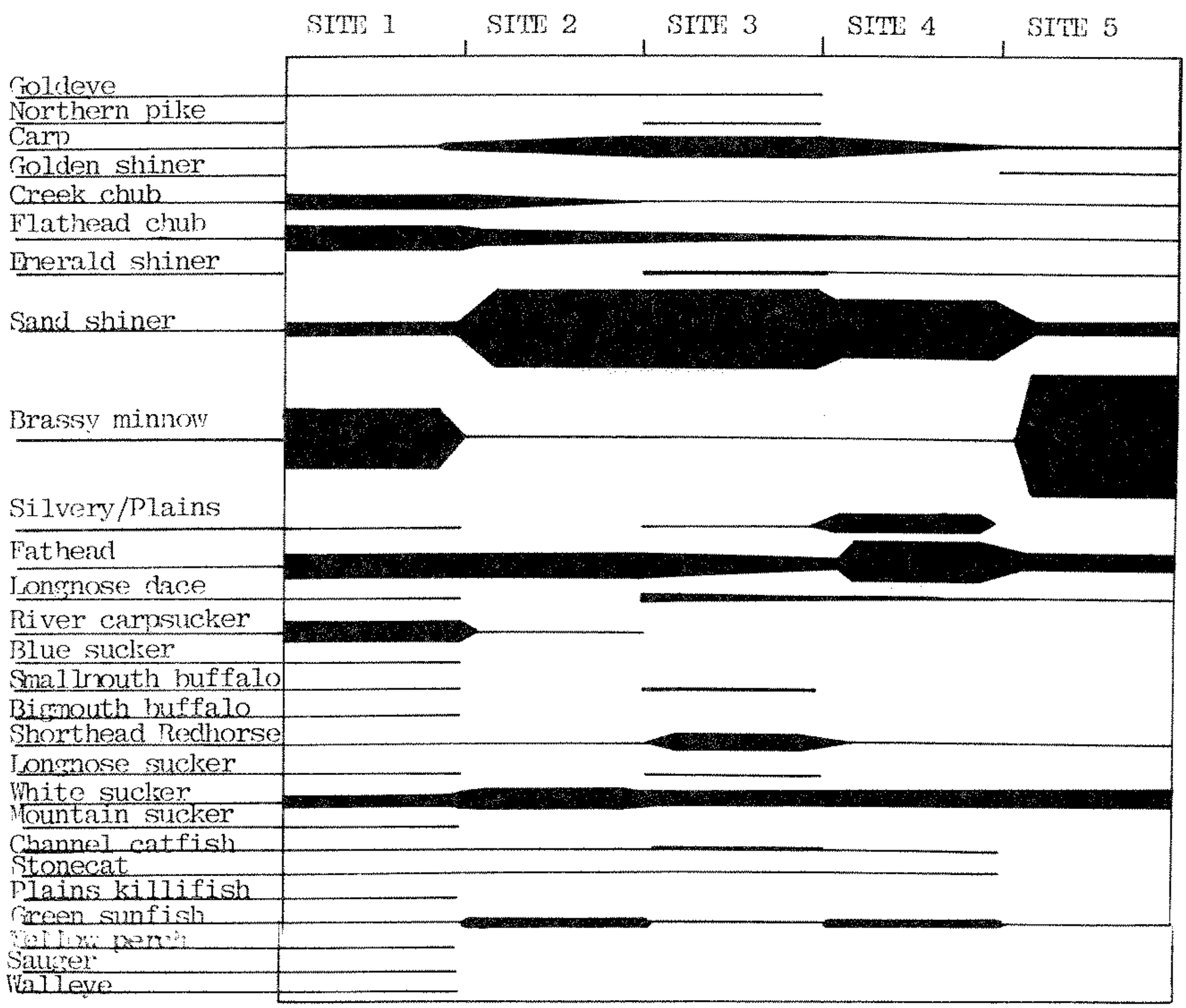


Figure 8. Kite diagram showing the relative abundance and distribution of fish species on all reaches of O'Fallon Creek, 1979-1980.

Twenty-nine species of fish utilized O'Fallon Creek, thirty-one including the three tributaries. The diversity of species generally increases at successive downstream sites with species additions rather than replacements. Four game fish were identified with channel catfish most widely distributed throughout reaches 1 to 4. Channel catfish were also found in the mouth section of Sandstone Creek. Catfish fry were observed in all reaches, where the species was reported. Northern pike were found in reach 3 of O'Fallon Creek as well as both sites on Sandstone Creek. Reach 3, the site with northern pike is approximately eleven kilometers downstream of the Sandstone-O'Fallon Creek confluence. Sauger (*Stizostedion canadense*) and walleye (*S. vitreum*) were only found in the mouth of O'Fallon, presumably migrants from the Yellowstone River. Yellow perch fry were sampled at the mouth section only. Their presence provides evidence that O'Fallon is utilized for rearing purposes. Reach 1 had the highest diversity and included seven exclusive species. Included are the blue sucker, bigmouth buffalo, mountain sucker, and plains killifish. Plains killifish were only found at one other site in the drainage, site 1 of Whitney Creek. Not surprisingly, fathead minnow and white suckers populations were the two fish distributed entirely throughout O'Fallon Creek and it's tributaries. In addition, four Cyprinids, creek chub, flat-head chub, sand shiner (*Notropis stramineus*), longnose dace and the Centrachid, green sunfish (*Lepomis cyanellus*) were found at various sites in the entire O'Fallon Creek drainage. Interestingly, two species of fish were found in the tributaries but never sampled in O'Fallon Creek. Lake chub populations inhabitated all three tributaries with the yellow bullhead (*Ictalurus natalis*) at site one of Whitney Creek. In O'Fallon Creek, the sand shiner was the most abundant species of reaches 2, 3 and 4, while the brassy minnow (*Hybognathus hankinsoni*) was the most abundant fish of reaches 1 and 5. The kite diagrams (Figure 8; and Figures 67, 69 and 73, Appendix), illustrate species distribution and relative abundance at the sampling locations on O'Fallon Creek and its' three tributaries.

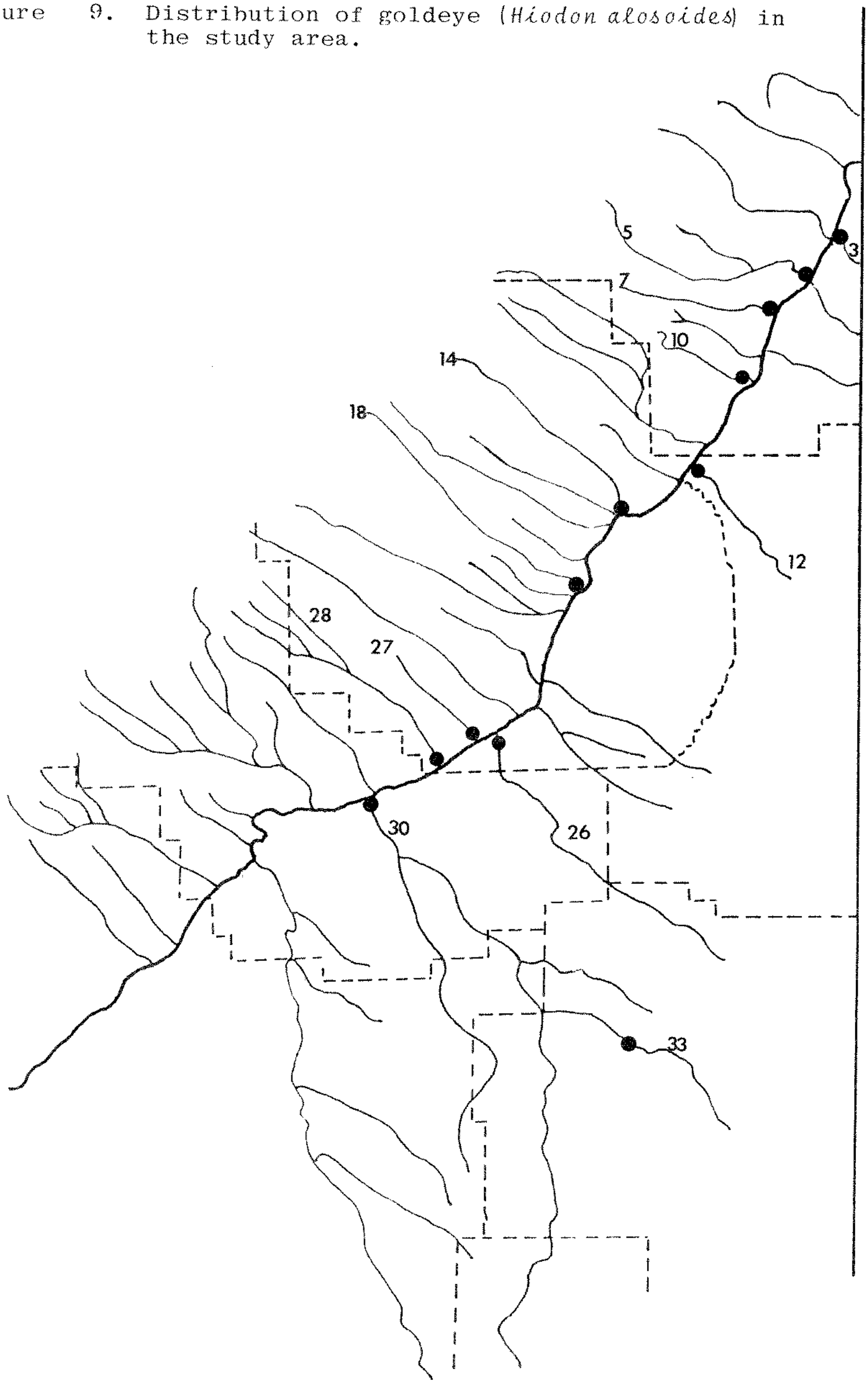
Distribution of Fish

As a general summary of fish species identified in the study area 1979-80, a short descriptive treatment of each species, grouped by families, is included in the following paragraphs. Maps of the study showing the distribution of each species individually is included. For a more indepth look at both fish distribution and relative abundance, kite diagrams for each stream having more than one sample site is presented in the Appendix, Figures 47-73.

Hiodontidae - Mooneye

The goldeye (*Hiodon alosoides*) is native to Montana (Brown 1971) and normally prefers the turbid waters of larger rivers (Scott and Crossman 1973). It was found exclusively at the mouth sites with the exception of one site on Sandstone Creek below South Sandstone Reservoir, Figure 9. Small goldeye, presumably first year, were found in Fox Creek, Bennie Peer Creek and Cabin Creek, suggesting that migrants from the Yellowstone River utilize these areas for spawning, and possibly rearing areas.

Figure 9. Distribution of goldeye (*Hiodon alosoides*) in the study area.

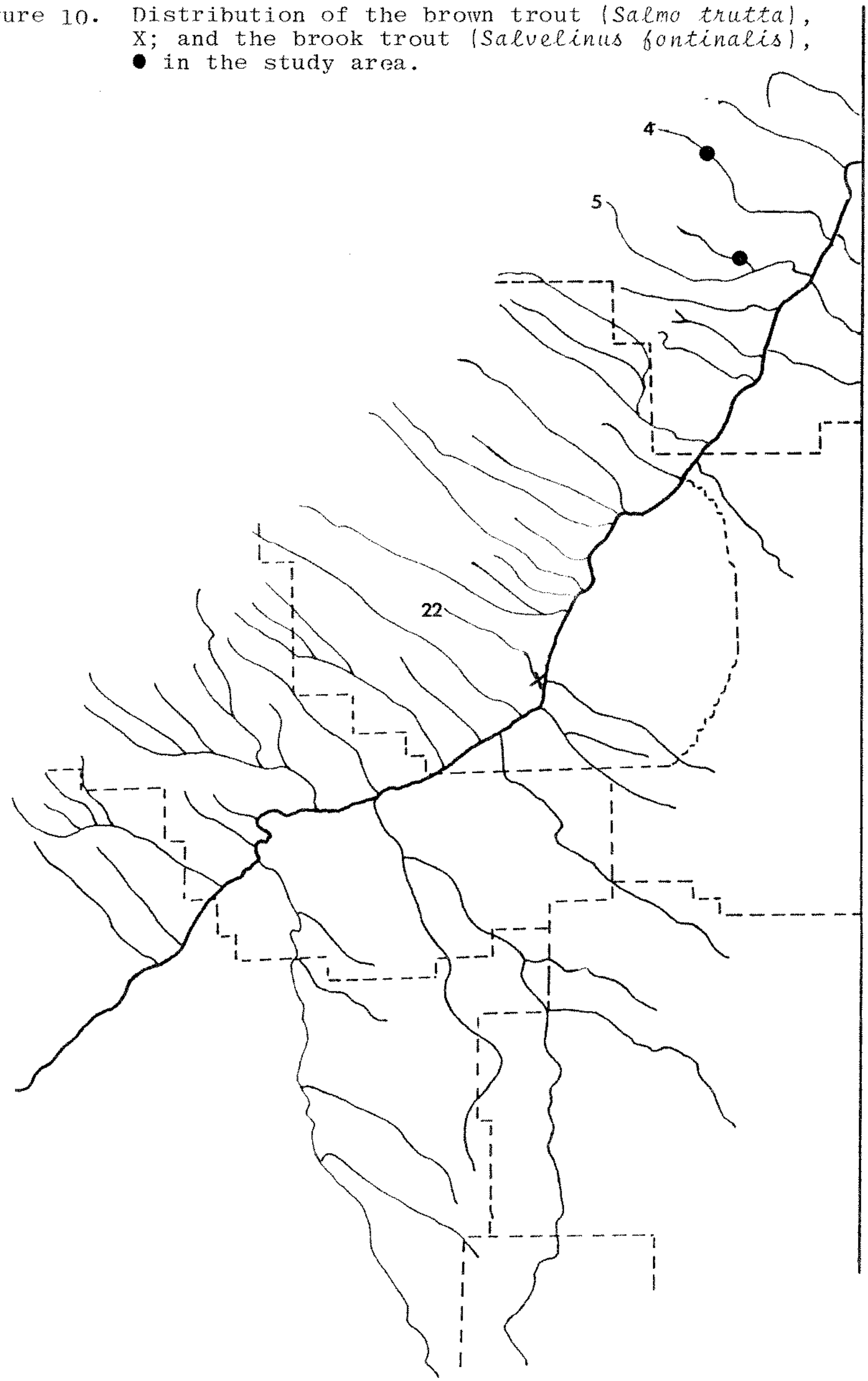


Salmonidae - Trout

Only one brown trout (*Salmo trutta*) was found during the two years of sampling. This fish occurred in Sand Creek near the mouth, Figure 10. The stream is characterized by a clean gravel substrate and good flow, a result of discharge from the Buffalo Rapids Water Project and irrigation runoff. The upper reaches above the canal were ephemeral. This trout is assumed to be a migrant from the Yellowstone River.

Brook trout (*Salvelinus fontinalis*) were found exclusively in Lone Tree and Fox Creeks. These two streams are adjacent drainages and both are clear with gravel bottoms. Local people talked of these trout being planted several years ago in various reservoirs along these streams. Apparently, the two populations are self-sustaining, as both streams are bisected by the Intake canal. In Lone Tree Creek, fish around 7 cm (total length) were captured and in Fox, the largest one captured was 15 cm. Several fish were seen in the small streams, but few were actually caught in the seine. An abundance of aquatic vegetation was noted in the two streams. Although the species diversity in Fox Creek was much greater than in Lone Tree, it was observed that 12 out of the 15 species identified on Lone Tree were also present on Fox.

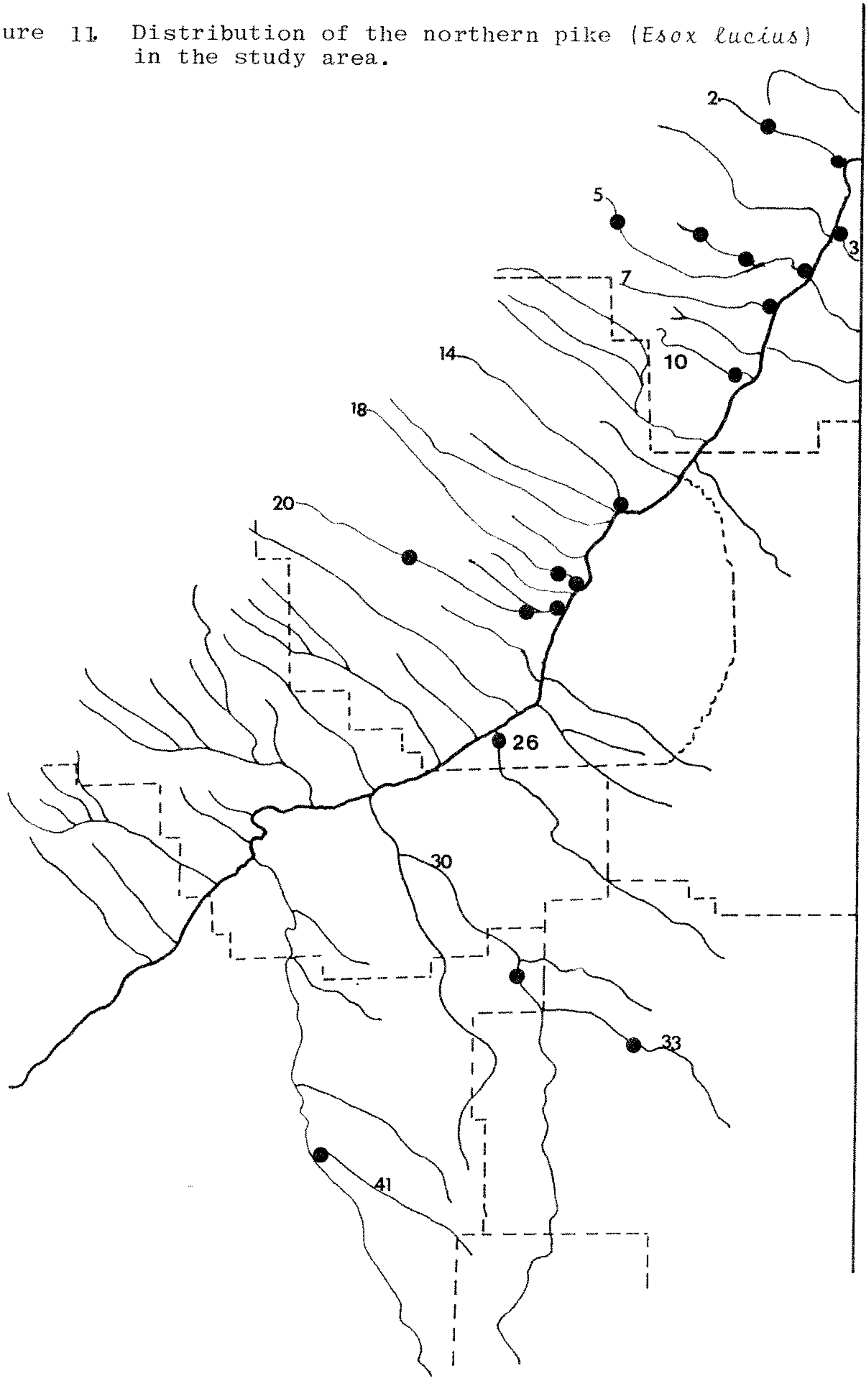
Figure 10. Distribution of the brown trout (*Salmo trutta*), X; and the brook trout (*Salvelinus fontinalis*), ● in the study area.



Esocidae - Pike

Northern pike were found primarily in the lower reaches of the streams, Figure 11. Gill net results seem to indicate that these fish utilize mouth reaches in a migratory sense. Pools containing northern pike on Sheep Creek and the upper sites of Upper Sevenmile Creek and First Hay Creek in 1979, were dry during the 1980 sampling season. When large enough, individuals were tagged. The largest captured was 788 mm and weighed 3.26 kg. A listing of northern pike weighed, measured and tagged is included in Appendix, Table 8.

Figure 11. Distribution of the northern pike (*Esox lucius*) in the study area.



Cyprinidae - Minnow

Carp (*Cyprinus carpio*) are omnivorous feeders and were widely distributed throughout the study area, occurring in 26 streams, (Figure 12). Carp prefer moderately warm water, tolerate turbidity, and can withstand low dissolved oxygen levels in polluted water. This introduced fish has achieved widespread distribution in Montana.

The golden shiner (*Notemigonus crysoleucas*) is believed to be native to eastern Montana but only sparingly distributed in the Missouri and Yellowstone drainages. Only four populations were sampled, and they were in Bennie Peer, O'Fallon, Harris, and Cottonwood Creeks, Figure 13. This minnow was found in the mouth reaches of Harris, Bennie Peer, and Cottonwood Creeks and an upper site on O'Fallon Creek. The specific habitat of this species is clear but sluggish water, and it would appear that the uppermost site of O'Fallon would best meet this criteria. It is suggested these minnows may have migrated into the other streams from the Yellowstone River. These fish were not found in later sampling efforts as water levels subsided on Bennie Peer, Harris, and Cottonwood Creeks.

The native creek chub (*Semotilus atromaculatus*) was formerly classified as a species of special concern. Brown (1971) indicated the fish to be quite rare, but recent studies have greatly extended its distribution. Copes (1978), in discussing the habitat of the creek chub, described preferred areas as having scoured substrates of sand, gravel and boulders with well defined riffles and deep pools with protective cover. Moshinko and Gee (1973) and King (1973) indicated similar habitat preferences for the creek chub. The presence of this species in the study area in large numbers was characterized by sites having these qualities. This fish was found in 35 streams (Figure 14).

The identity of northern redbelly dace (*Phoxinus eos*) was confirmed by Dr. Gould of Montana State University (personal communication). Brown (1971) had its distribution limited to the Missouri River system. This species appears to be limited to the lower end of the study area. Fox, Cottonwood, War Dance, Thirteenmile, Morgan, Lower Sevenmile, and Deer Creeks were found to have populations of this minnow (Figure 15). The minnow was found in upper reaches of all streams except in Cottonwood and War Dance, where it was found only at the mouth. The fish was first sampled on Thirteenmile Creek which according to Brown (1971) would be a classic example of this fishes' habitat requirements.

The flathead chub (*Hybopsis gracilis*) was found in 34 streams (Figure 16). Over 3/4 of these collections were in the mouth reach, and O'Fallon Creek had the chub dispersed throughout its drainage. This chub is known to inhabit large and small streams with normally high turbidities. Their habitat varies widely in regards to current velocity, substrate types and water depth. Two subspecies have been recognized in parts of their range, but both appear morphologically similar. One subspecies inhabits large rivers, the other small streams (Pflieger 1975) and the possibility exists of their presence in Montana.

A single sturgeon chub (*Hybopsis gelida*), a species considered uncommon in Montana, was collected on May 1, 1980. The individual, less than 3.5 cm in length, was found on Sears Creek (Figure 17), a stream characterized by a sand-gravel type substrate. Reigh and Elsen (1979) indicated that their collections of sturgeon chub showed a definite preference for gravel and rock substrates in areas with a moderate current. Stewart (1979) observed that the sturgeon chub and longnose dace occupied what appeared to be the same niche in the river ecosystem and stated that if one species was collected, it was common to collect the other. Results on Sears Creek showed that longnose dace were collected with the sturgeon chub. All recent collections of this species have been from the lower Yellowstone River and associated tributaries, particularly the Powder River.

The lake chub (*Couesius plumbeus*) is a common, widely distributed minnow found in 58% of the streams (Figure 18). According to Brown (1971) this fish typically favors a creek type habitat.

The emerald shiner (*Notropis atherinoides*) was most often found in the mouth section of the study streams (Figure 19), which may be accounted for by its pelagic nature spending most of its life history in the Yellowstone River. Emerald shiners are noted as being an important food item of sport fishes, particularly burbot, rainbow trout and northern pike (Scott and Crossman 1973). It was identified on 14 streams.

Sand shiners (*Notropis stramineus*) were found to be most widely distributed at the mouth sections of the study streams (Figure 20). King (1973) and Scott and Crossman (1973) indicated that the sand shiner is more common to larger streams Walker (1977) stated that this fish prefers a habitat with a coarse substrate, slight to moderate turbidity and a swift current. These findings greatly increase what was the known distribution of this species according to Brown (1971). It's distribution in Montana forms the western fringe of its range in the United States (Lee, et al. 1980).

The brassy minnow (*Hybognathus hankinsoni*) was first documented in Montana in 1926 in the O'Fallon Creek drainage. This herbivorous minnow was found in more than half of the study streams, which markedly increases this fishes distribution (Figure 21). Brown (1971) states that this species prefers clear, slow streams. Cope (1975) indicated that 95% of his brassy minnow collections were in slow runs or pools with mud bottoms. In this study, when brassy minnows were found in appreciable numbers, they were inhabiting the upper reaches of streams like Burns and Cherry Creeks (Figures 50 and 53 , Appendix) where the stream was characterized by no current, a silt or mud bottom and aquatic vegetation. These minnows tend to be abundant in habitats lacking or with few predators, as they seem to be very vulnerable to fish predation (Copes 1975). Brassys seem to be similar to fathead minnows in having a higher tolerance to harsh environments. The occurrence of this fish in Montana appears to be the western edge of its distribution in the United States (Lee, et al, 1980).

The plains and western silvery minnow (*Hybognathus placitus, H. nuchalis*) are considered together since positive identification involves dissection making field differentiation between the two species difficult. The plains and silvery minnows are believed to have very similar life histories. Twenty-three streams support populations of these minnows (Figure 22). The minnows are often locally abundant, and prefer larger streams. Over 70% of the samples were in the mouth sections, which appears to support their preference for larger streams.

The fathead minnow (*Pimephales promelas*) is common, wide-spread and very tolerant of the extreme conditions encountered in a prairie environment. Along with the white sucker, this fish appears to be a dominant species. It was found on 35 streams. It is known to be abundant where few other species are present (Walker 1977). The fathead minnow is cosmopolitan to the lower Yellowstone River drainage (Figure 23).

Longnose dace (*Rhinichthys cataractae*) are common and found in a variety of habitats. This minnow inhabits 33 of the study streams. This cosmopolitan fish was collected from mouth to headwater regions (Figure 24), however, it's preferred habitat is run or riffle reaches.

Figure 12. Distribution of carp (*Cyprinus carpio*) in the study area.

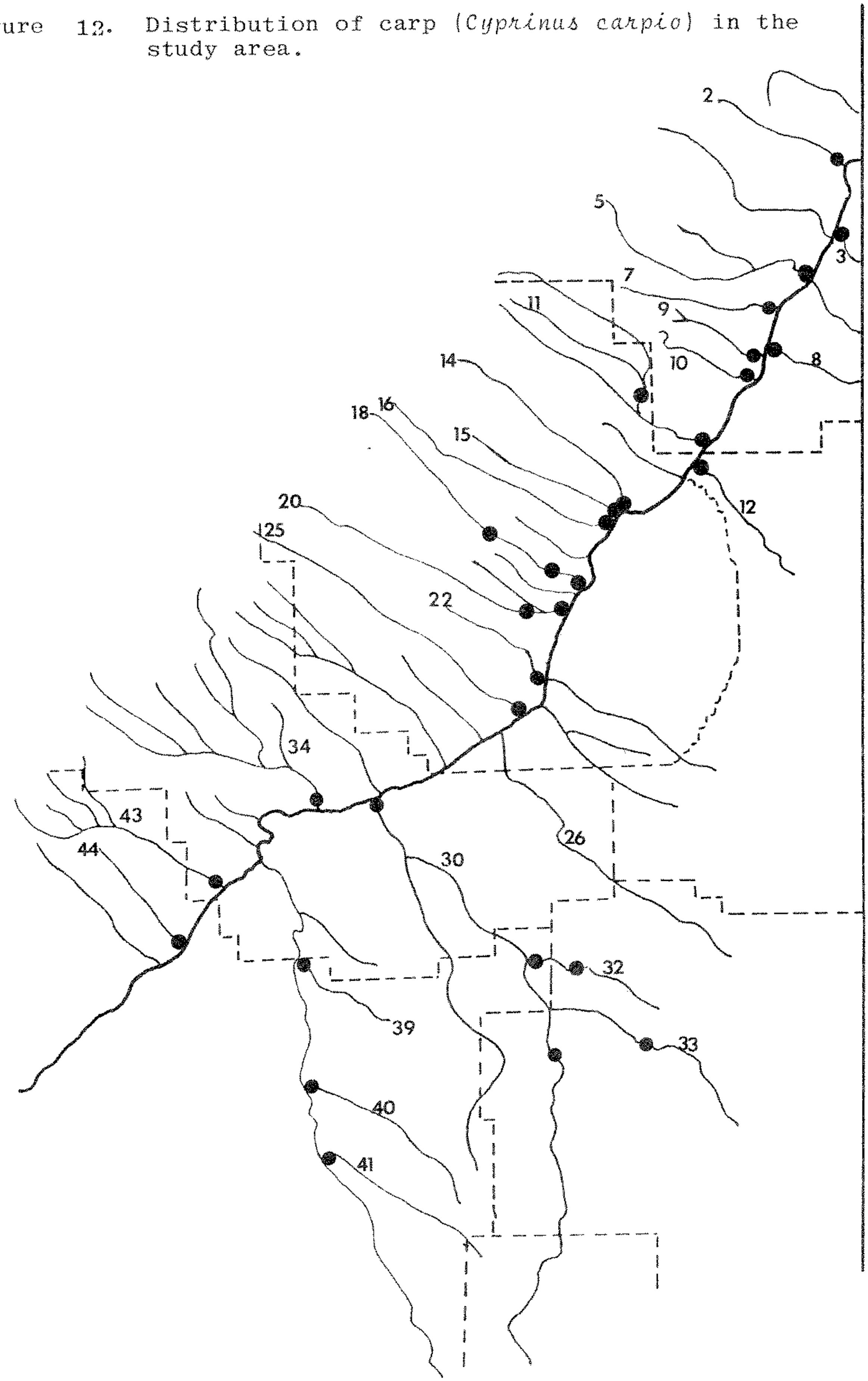


Figure 13 . Distribution of the golden shiner (*Notemigonus crysoleucas*) in the study area.

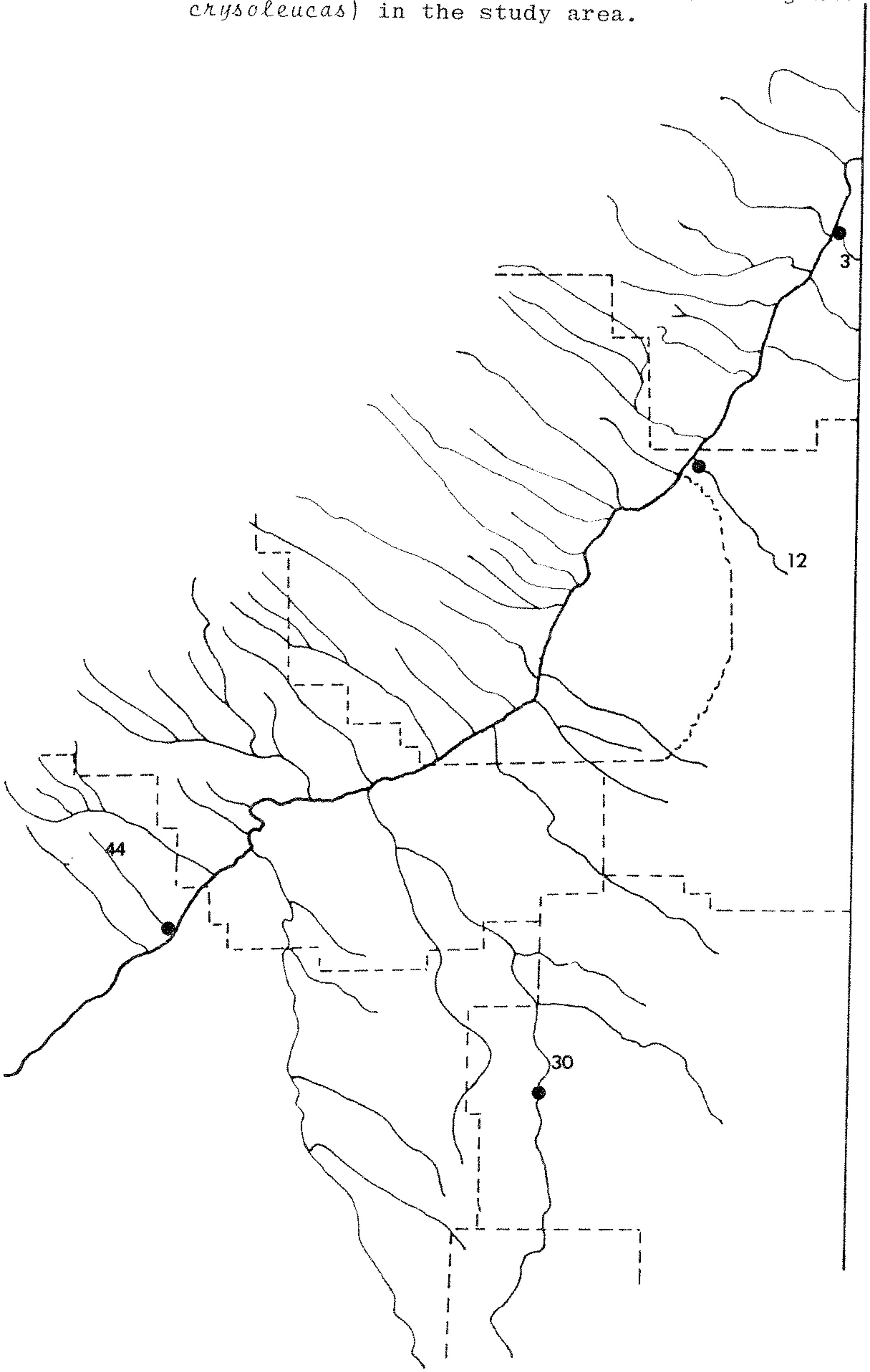


Figure 14. Distribution of the creek chub (*Semotilus atromaculatus*) in the study area.

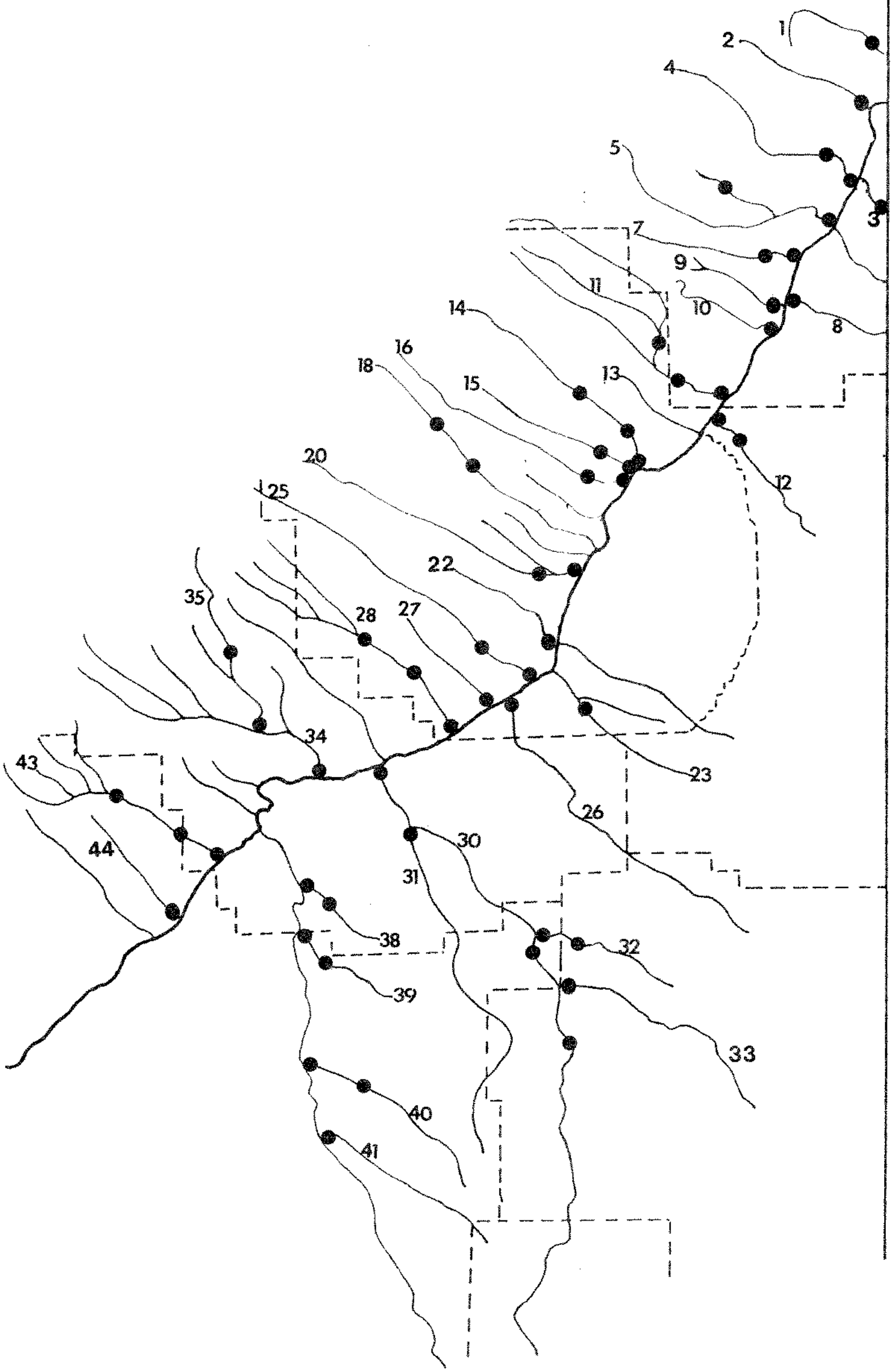


Figure 15 Distribution of the northern redbelly dace (*Phoxinus eos*) in the study area.

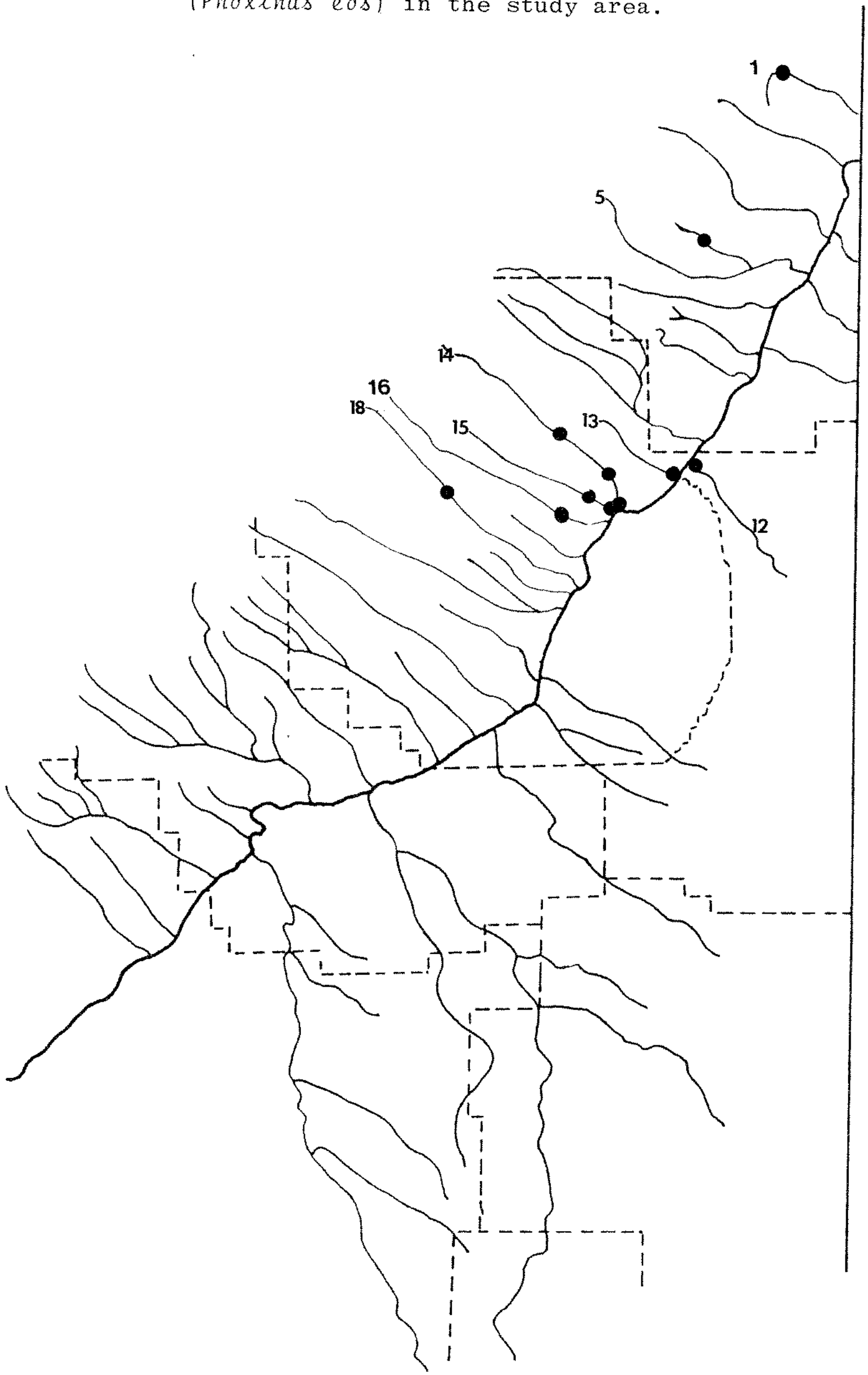


Figure 16. Distribution of the flathead chub (*Hybopsis gracilis*) in the study area.

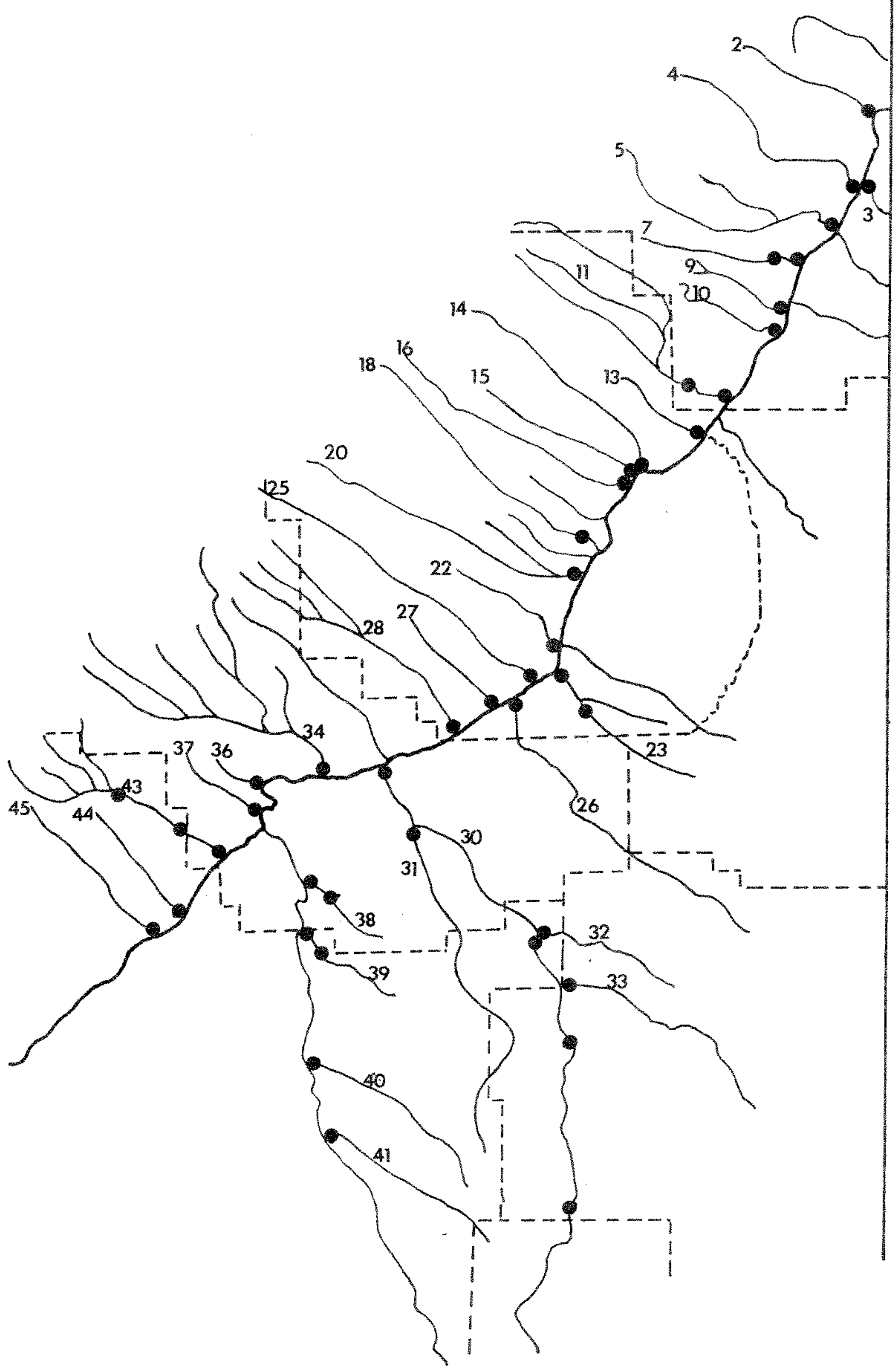


Figure 19. Distribution of the emerald shiner (*Notropis atherinoides*) in the study area.

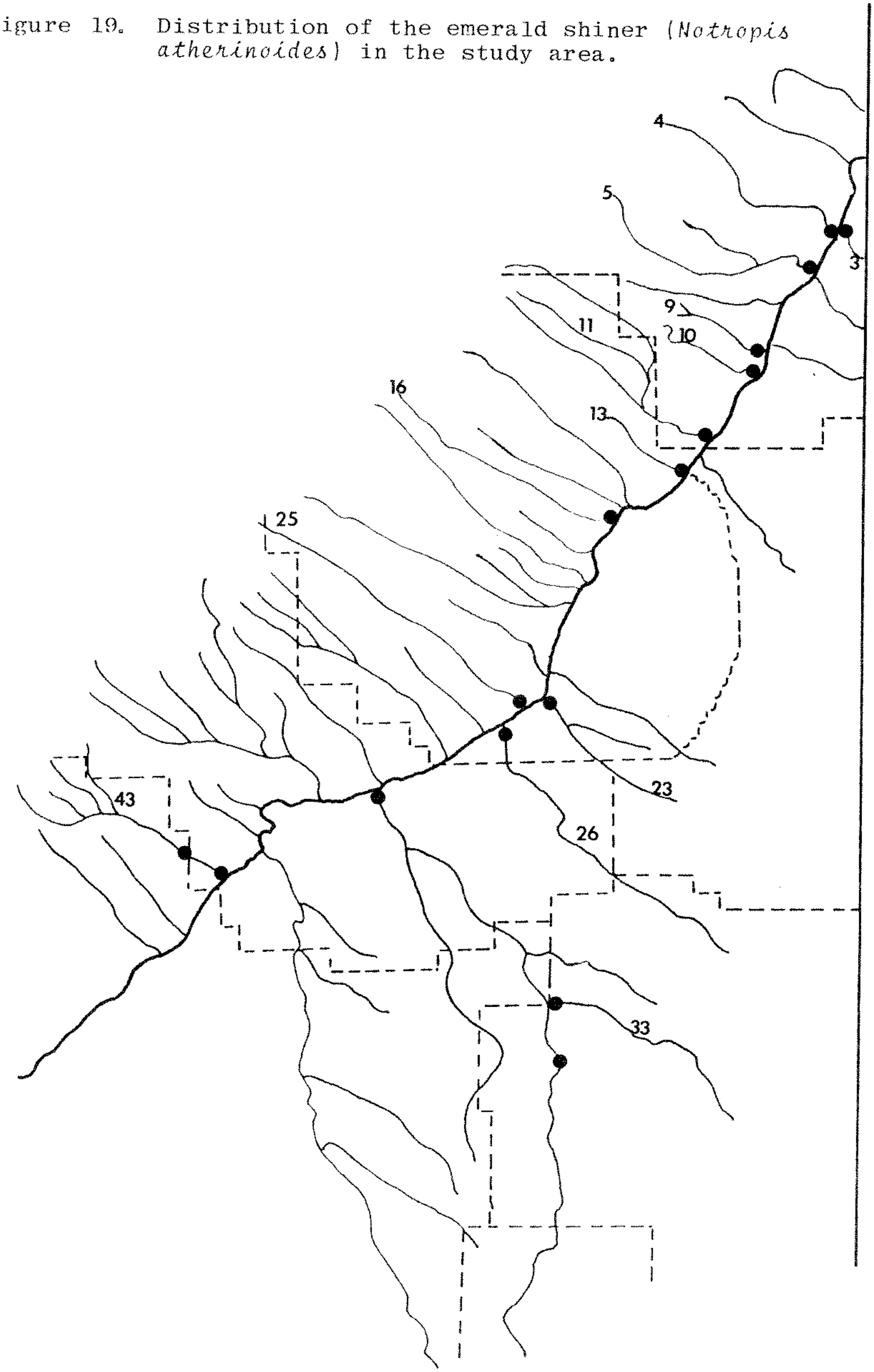


Figure 20. Distribution of the sand shiner (*Notropis stramineus*) in the study area.

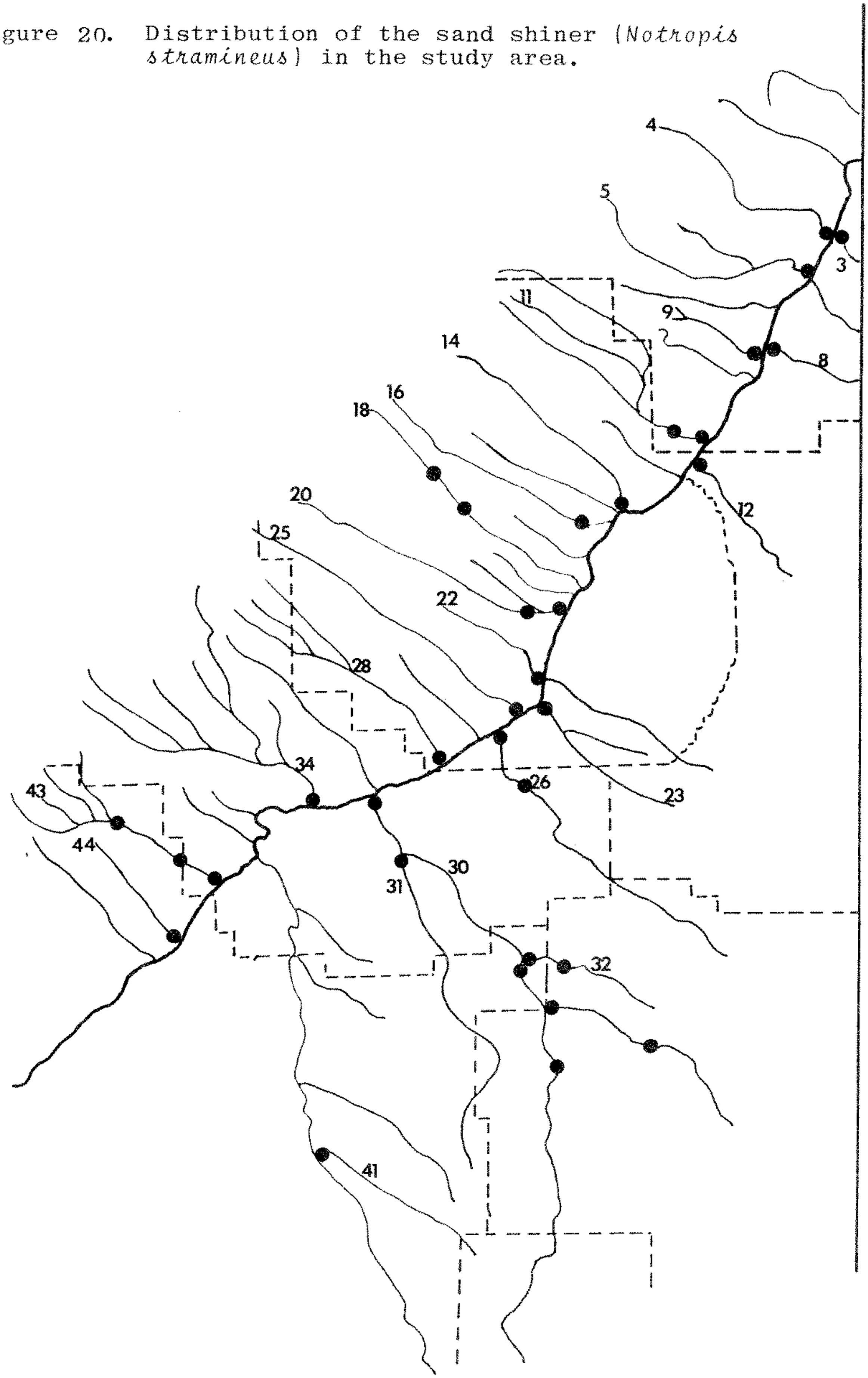


Figure 21 . Distribution of the brassy minnow (*Hybognathus hankinsoni*) in the study area.

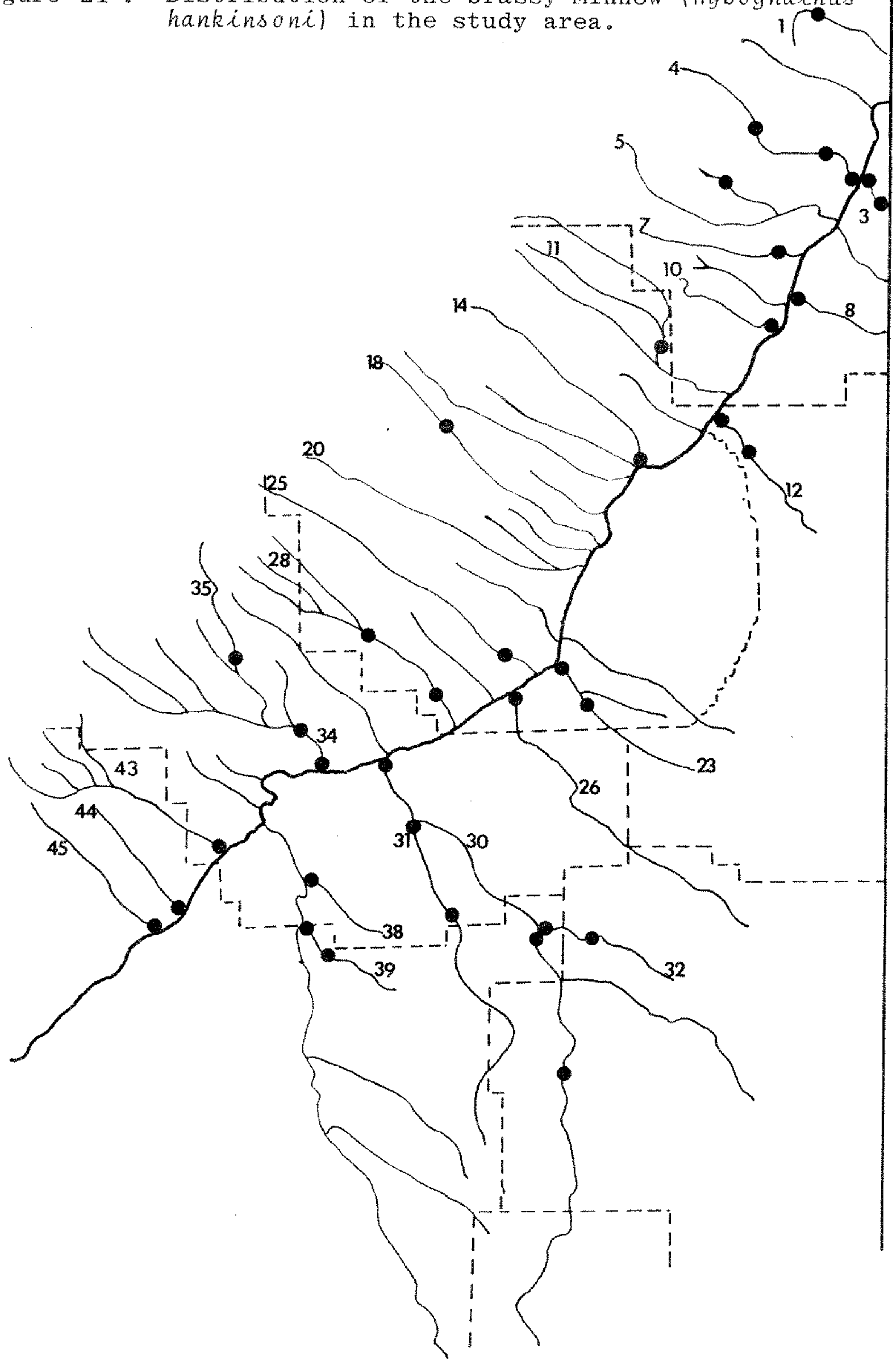


Figure 22. Distribution of Plains minnow-Western Silvery minnow (*Hybognathus placitus* - *Hybognathus nuchalis*) in the study area.

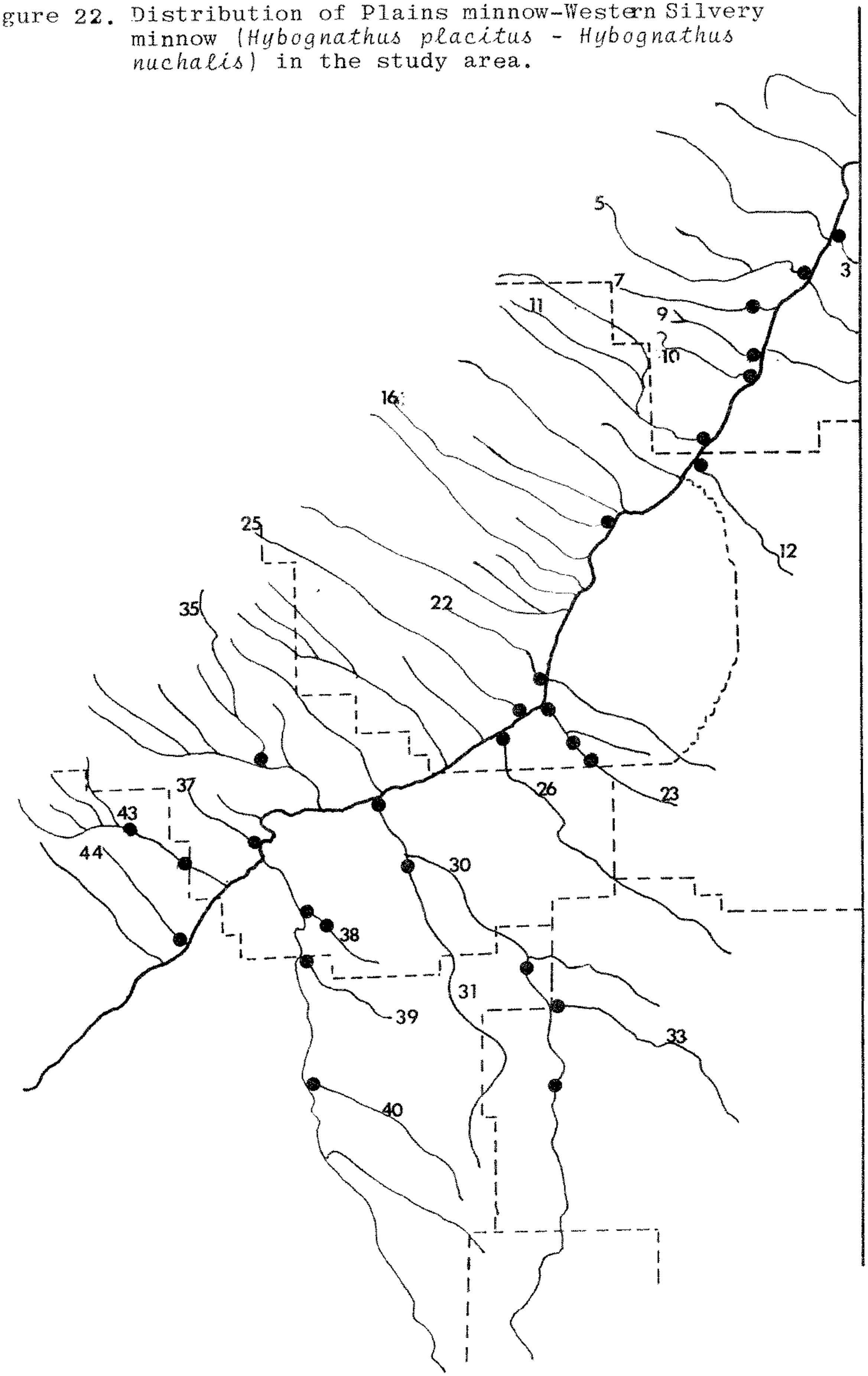


Figure 23. Distribution of the fathead minnow (*Pimephales promelas*) in the study area.

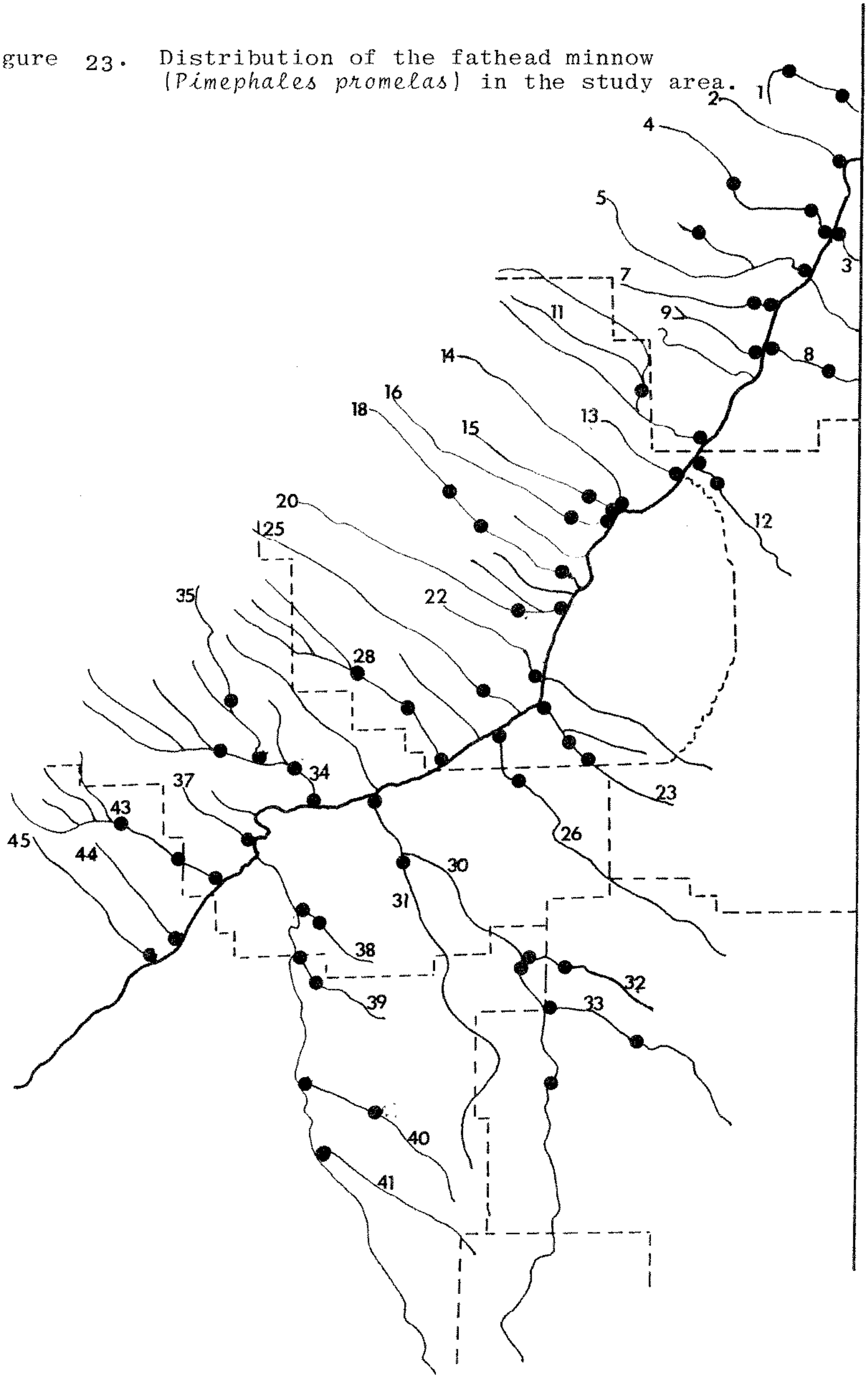
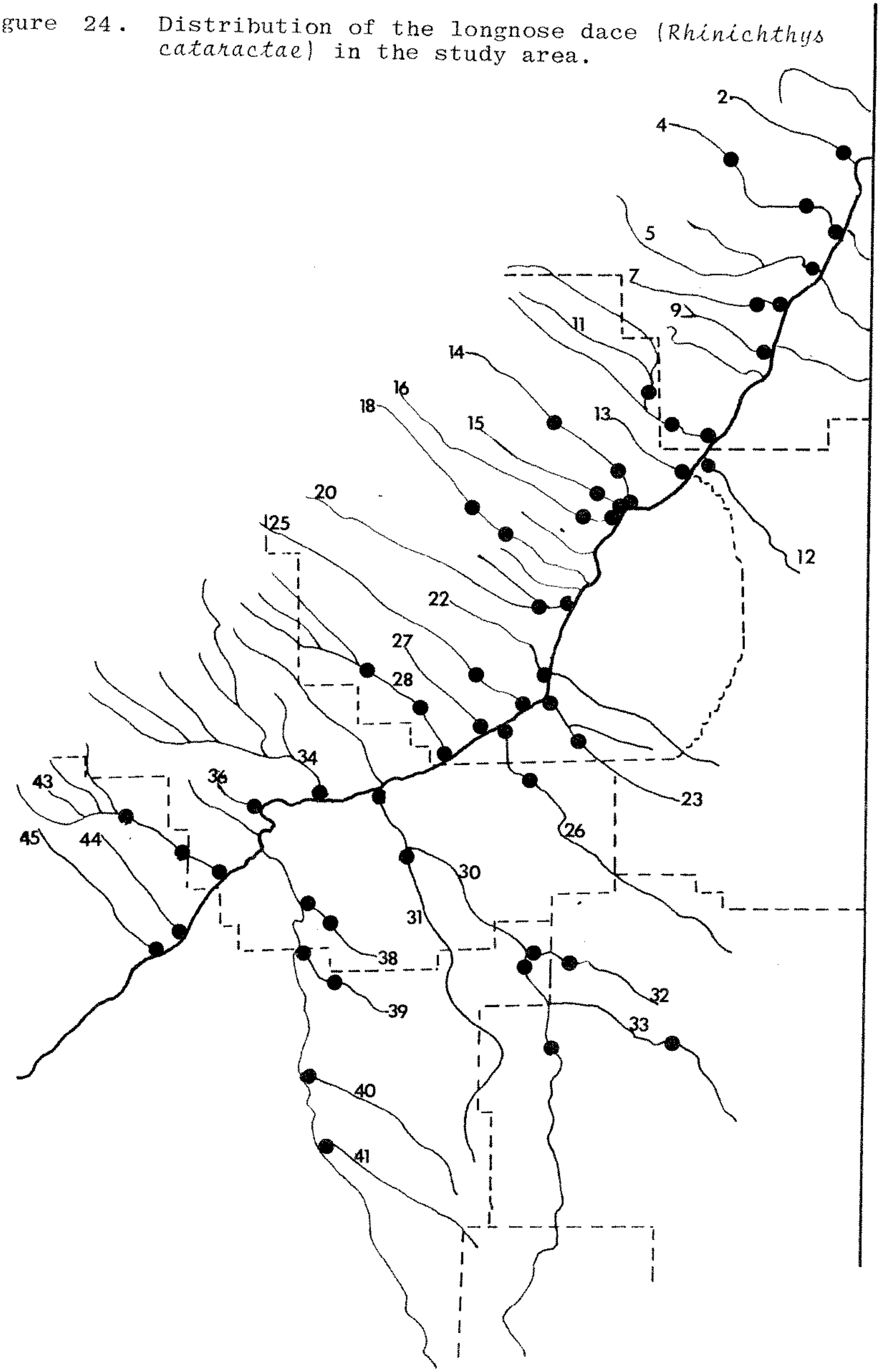


Figure 24. Distribution of the longnose dace (*Rhinichthys cataractae*) in the study area.



Catostomidae - Sucker

River carpsuckers (*Carpoides carpio*) are found in lower elevations and in almost every habitat type within it's range. This fish, which is largely a river inhabitant prefering pools and backwaters, was sampled almost entirely at mouth sections. This sucker was abundant in O'Fallon Creek and its largest tributary, Sandstone Creek (Figure 25).

The blue sucker (*Cycleptus elongatus*) is considered rare in Montana, but is widespread, throughout the Missouri and Mississippi Rivers. The preferred habitat is deep water with low turbidity and swift current. This sucker is found in large rivers and reservoirs (Brown 1971). The fish is tolerant of high turbidity if the current can prevent silt deposition (Pflieger 1975). Only two recordings of this fish were made, both times in the lower reach of O'Fallon Creek (Figure 26). Both fish were found in late April while boat shocking. Blue suckers are known to move into the Tongue River to spawn in the spring (Elser, personal communication). They are a highly mobile fish, which tends to be supported by data of Russ Penkal, Yellowstone River fisheries biologist, MFWP. While shocking the Yellowstone River in April 22, 1980, near Sidney, Montana, a blue sucker was tagged and released. About May 14, 1980, a farmer recovered this fish in a field south of Savage, Montana. This fish had to move up the Yellowstone River to the Intake Diversion, about 65-70 km, down the canal about 7 km into a feeder irrigation ditch around a kilometer, and ultimately onto the irrigated field. Since 1900, apparently, the blue sucker has declined in abundance (Pflieger 1975).

Smallmouth buffalo (*Ictiobus bubalus*) are found in both shallow and deep water over firm bottoms. They are distributed in rivers as well as impoundments. Individuals taken in this study were most often found at the mouth reach (Figure 27). Many fish sampled were small, and presumably were first year fish. Young fish were found in Crane, Thirteenmile, Deer, and Upper Sevenmile Creeks, all in June. The presence of these younger fish may be an indication that these areas are used for spawning and rearing.

Bigmouth buffalo (*Ictiobus cyprinellus*) were only found on four streams (Figure 28). Brown (1971) reports their habitat as large rivers and their impoundments. During this study they were taken on Shadwell, Cottonwood, Thirteenmile, and O'Fallon Creeks.

Shorthead redhorse (*Moxostoma macrolepidotum*) are widespread native suckers in the Yellowstone drainage (Figure 29). They seem to prefer shallow waters with a clean, rocky substrate. It's specific habitat is clear or turbid waters of larger rivers or creeks, intermediate temperatures and swift current. This sucker was taken in the mouth section of Crane, Shadwell, Burns, Cottonwood Thirteenmile, Deer, Clear, Cabin, and Upper Sevenmile Creeks. This fish appears to utilize the mouth section of these streams in a migratory manner, and as a spawning grounds.

Longnose suckers (*Catostomus catostomus*) are most abundant in cold, clear streams, but can be found in warmer waters. Individuals were sampled mainly at mouth sections (Figure 30). While this fish is found in all major drainages in the state, this represents part of the southern limit of its range (Lee et al. 1980).

The white sucker (*Catostomus commersoni*) is a dominant species of the study area, found in 36 of the streams (Figure 31). This sucker when abundant, is usually not found with other suckers. The white sucker is tolerant of a wide variety of habitats and is decidedly a small creek fish.

Mountain suckers (*Catostomus platyrhynchus*) are usually found in cold, clear streams with a clean gravel or sand bottom. This species is uncommon in the study area (Figure 32) found only on Thirteenmile, Lower Sevenmile, Clear, Cherry and O'Fallon Creeks, all typified by a sand-gravel substrate.

Figure 25 . Distribution of the river carpsucker (*Carpoides carpio*) in the study area.

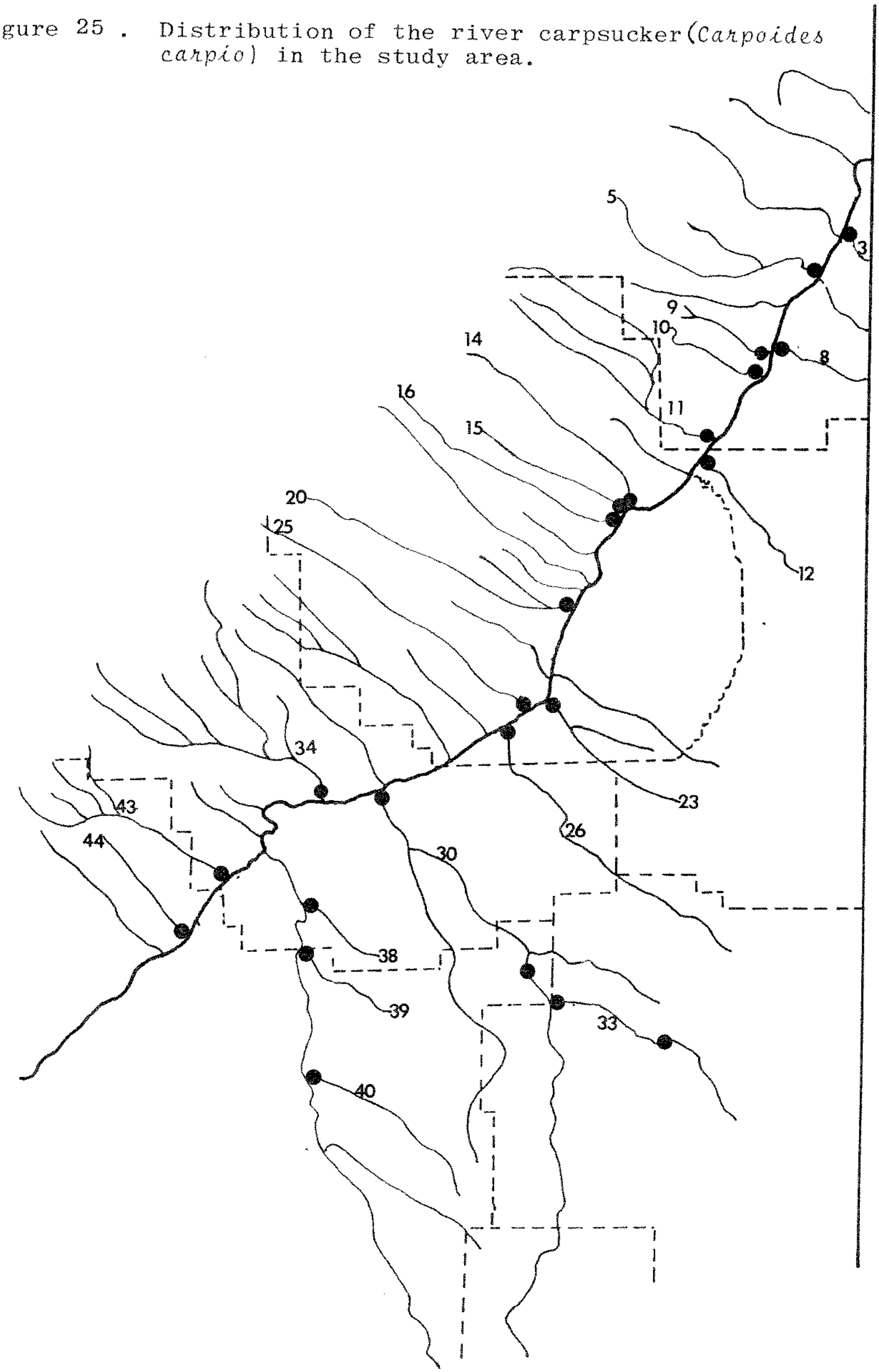


Figure 26. Distribution of the blue sucker (*Cycleptus elongatus*) in the study area.

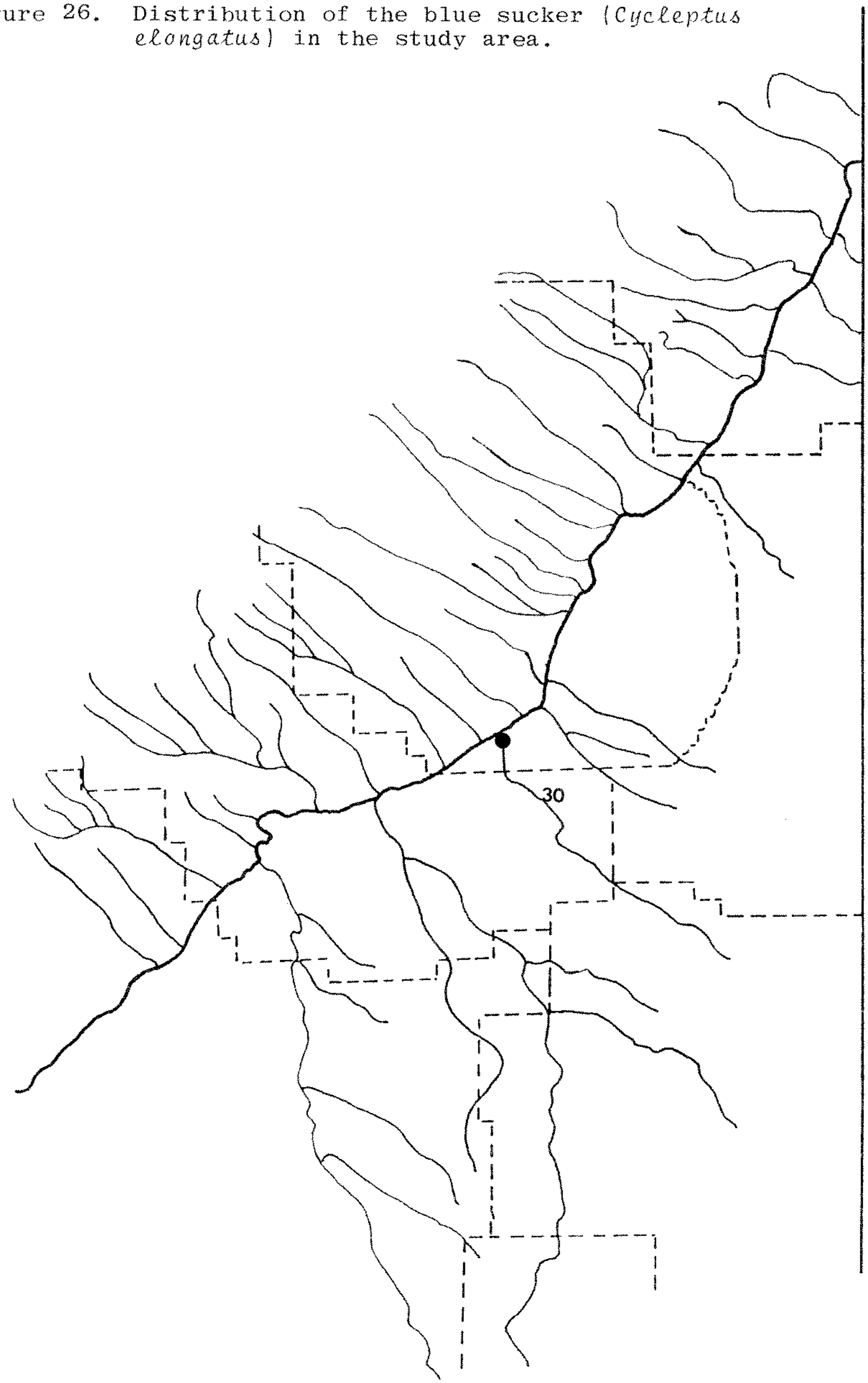


Figure 27. Distribution of the smallmouth buffalo (*Ictiobus bubalus*) in the study area.

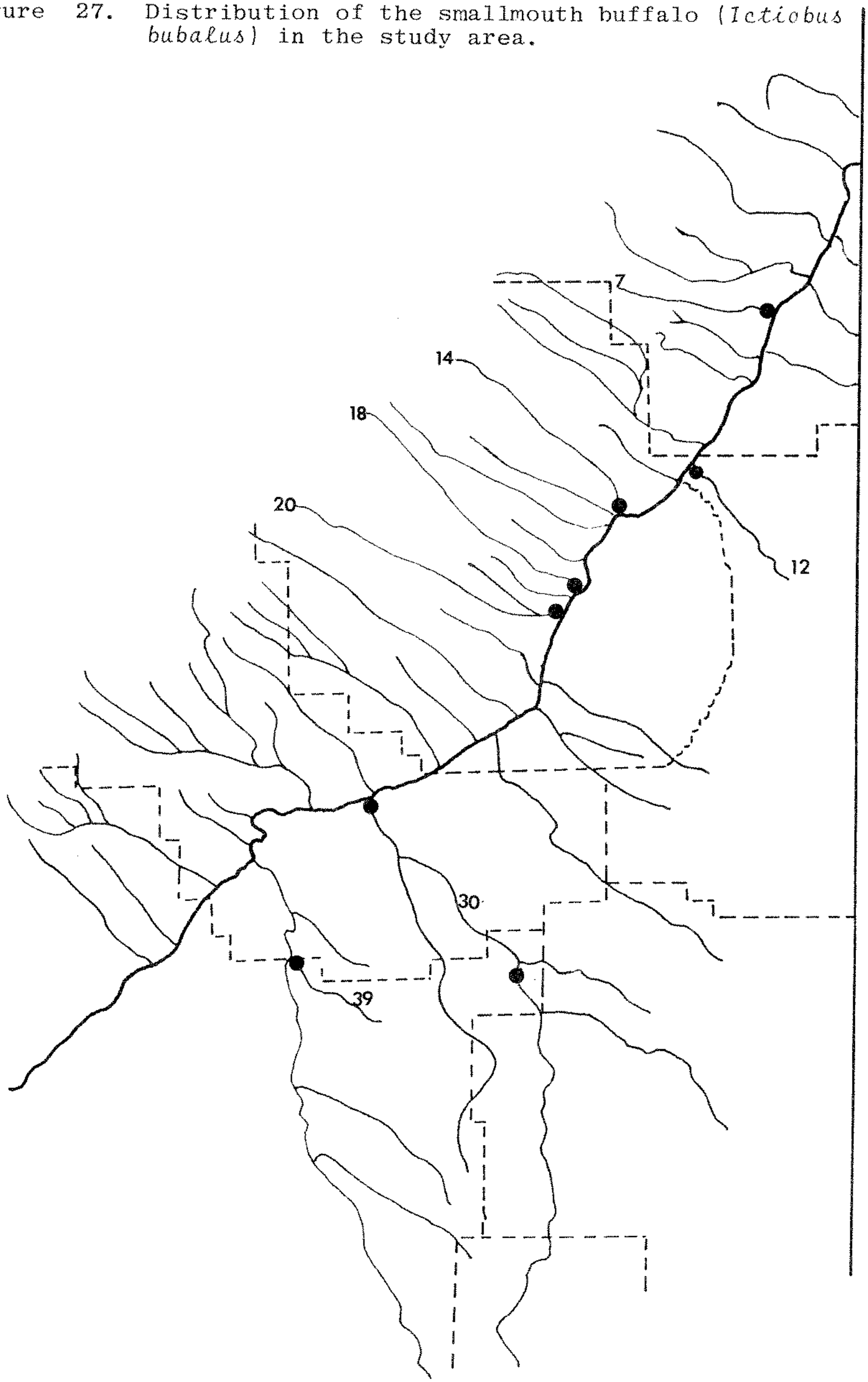


Figure 28. Distribution of the bigmouth buffalo (*Ictiobus cyprinellus*) in the study area.

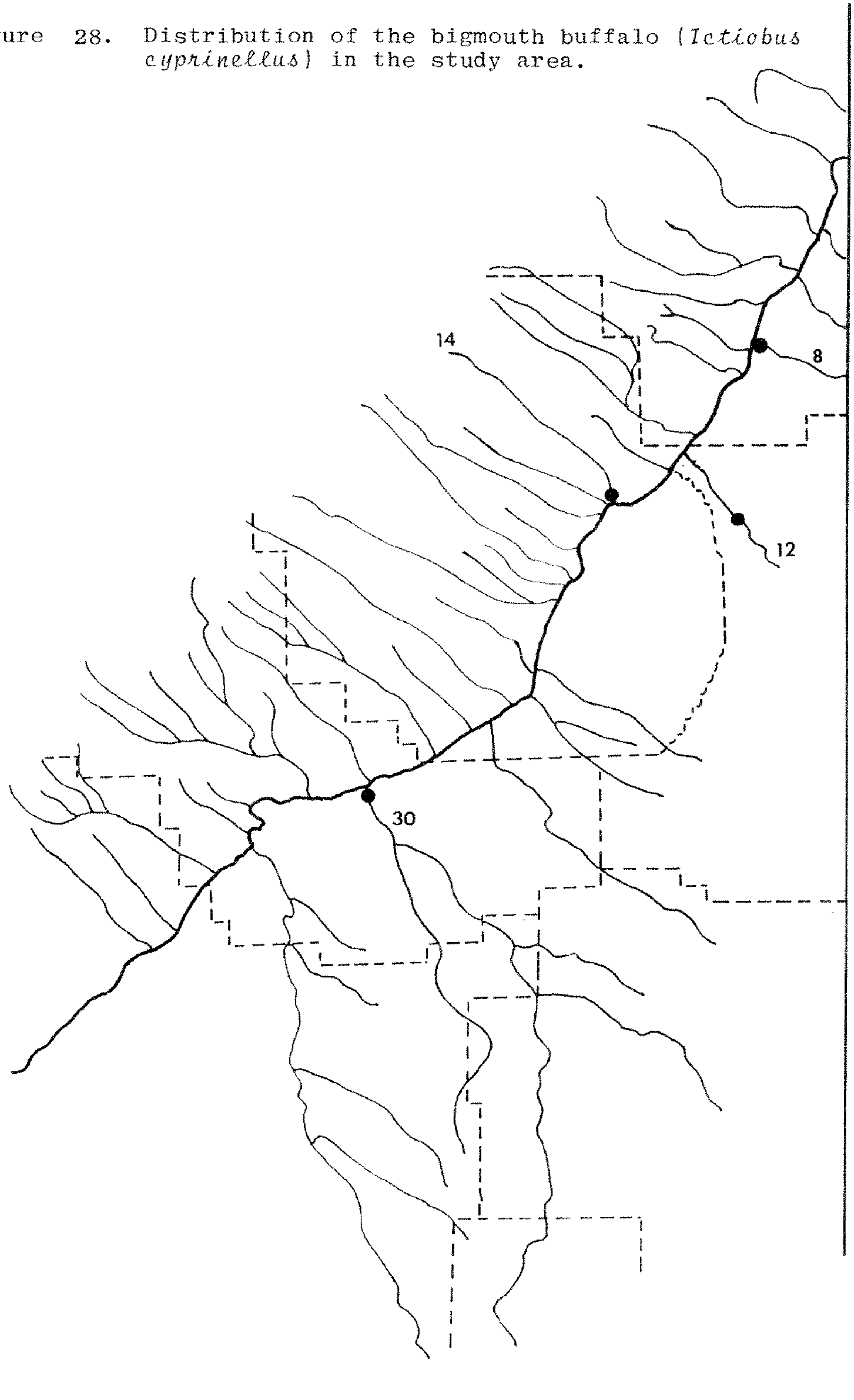


Figure 29. Distribution of the shorthead redhorse (*Moxostoma macrolepidotum*) in the study area.

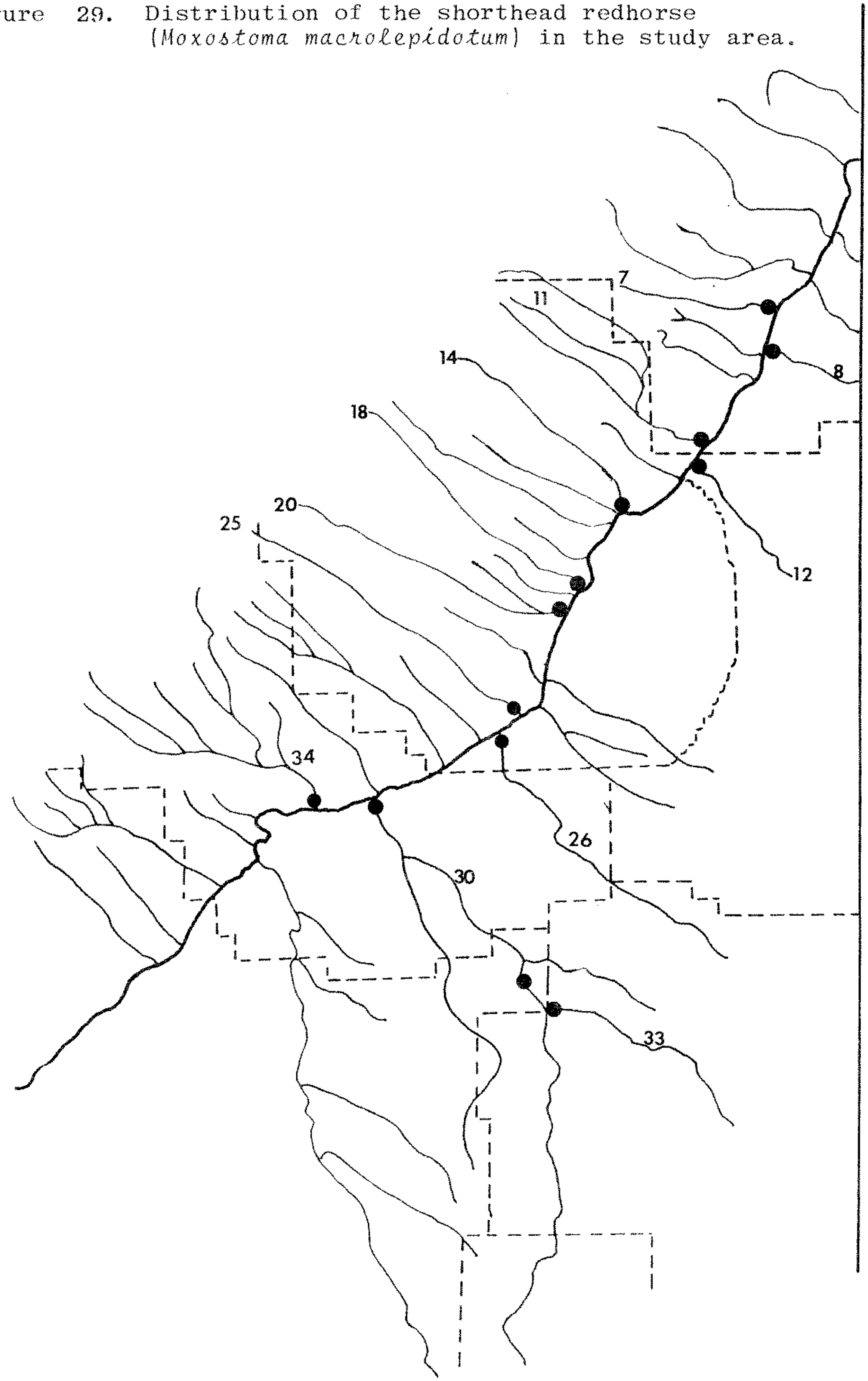


Figure 30. Distribution of the longnose sucker (*Catostomus catostomus*) in the study area.

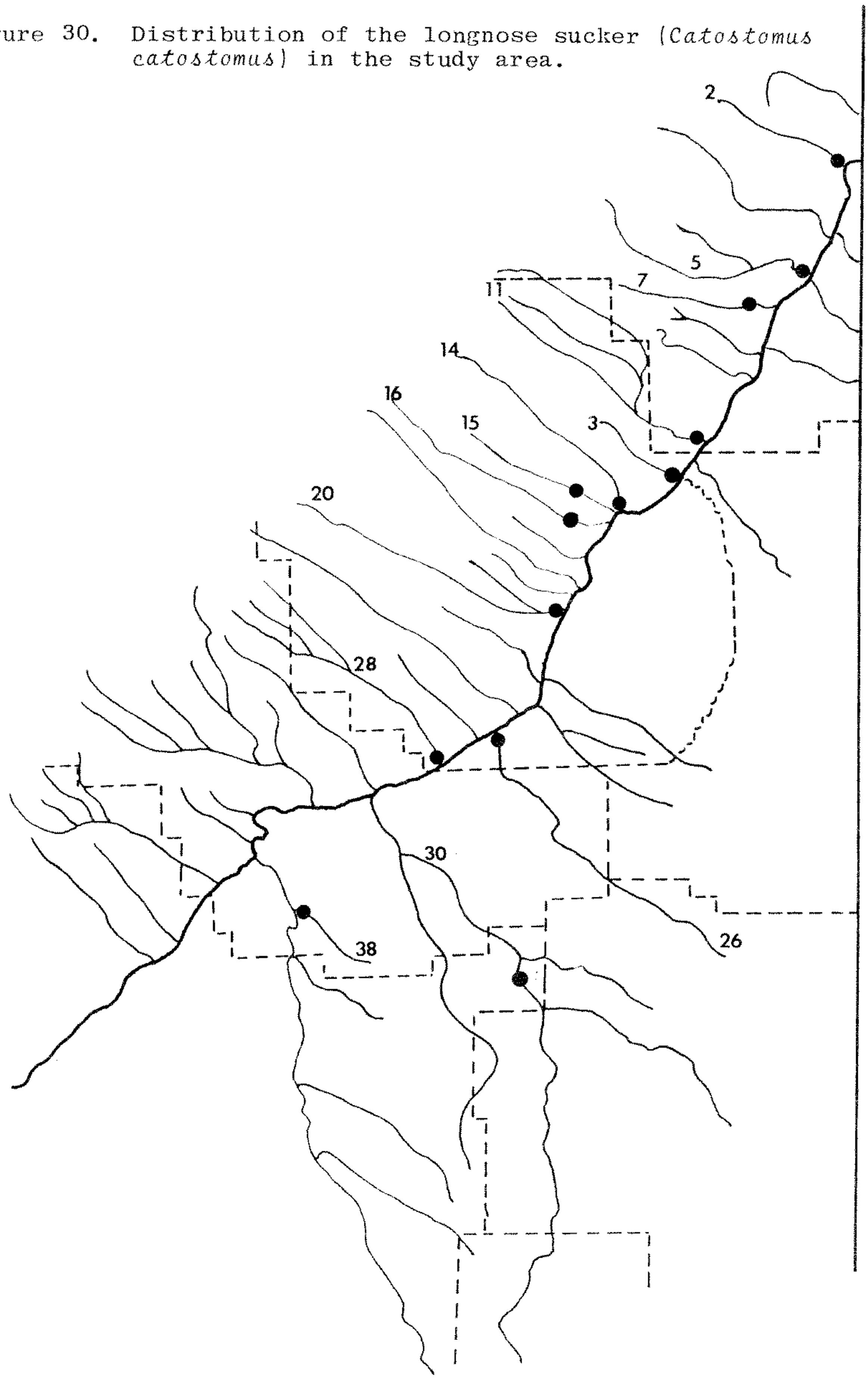


Figure 31 . Distribution of the white sucker (*Catostomus commersoni*) in the study area.

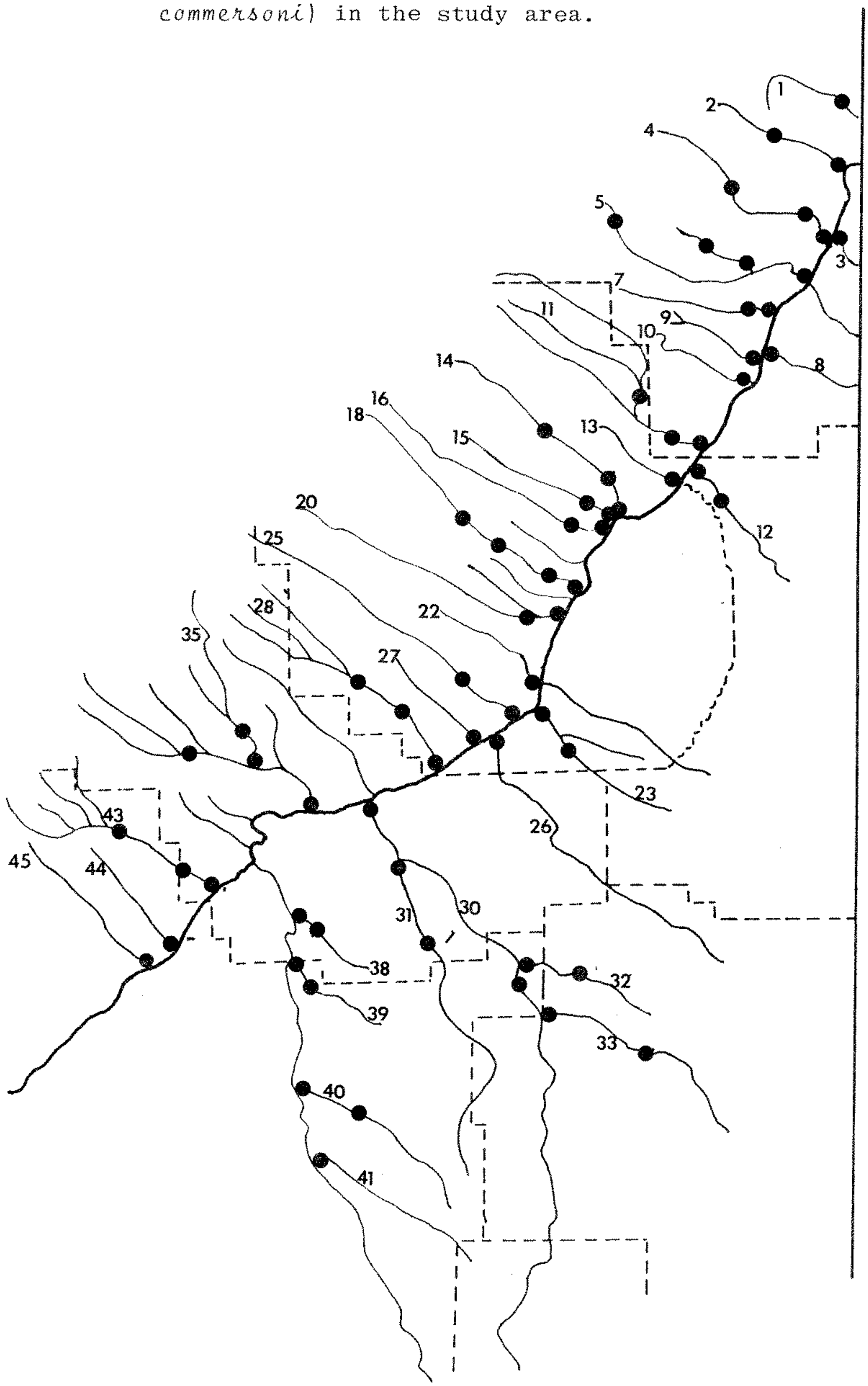
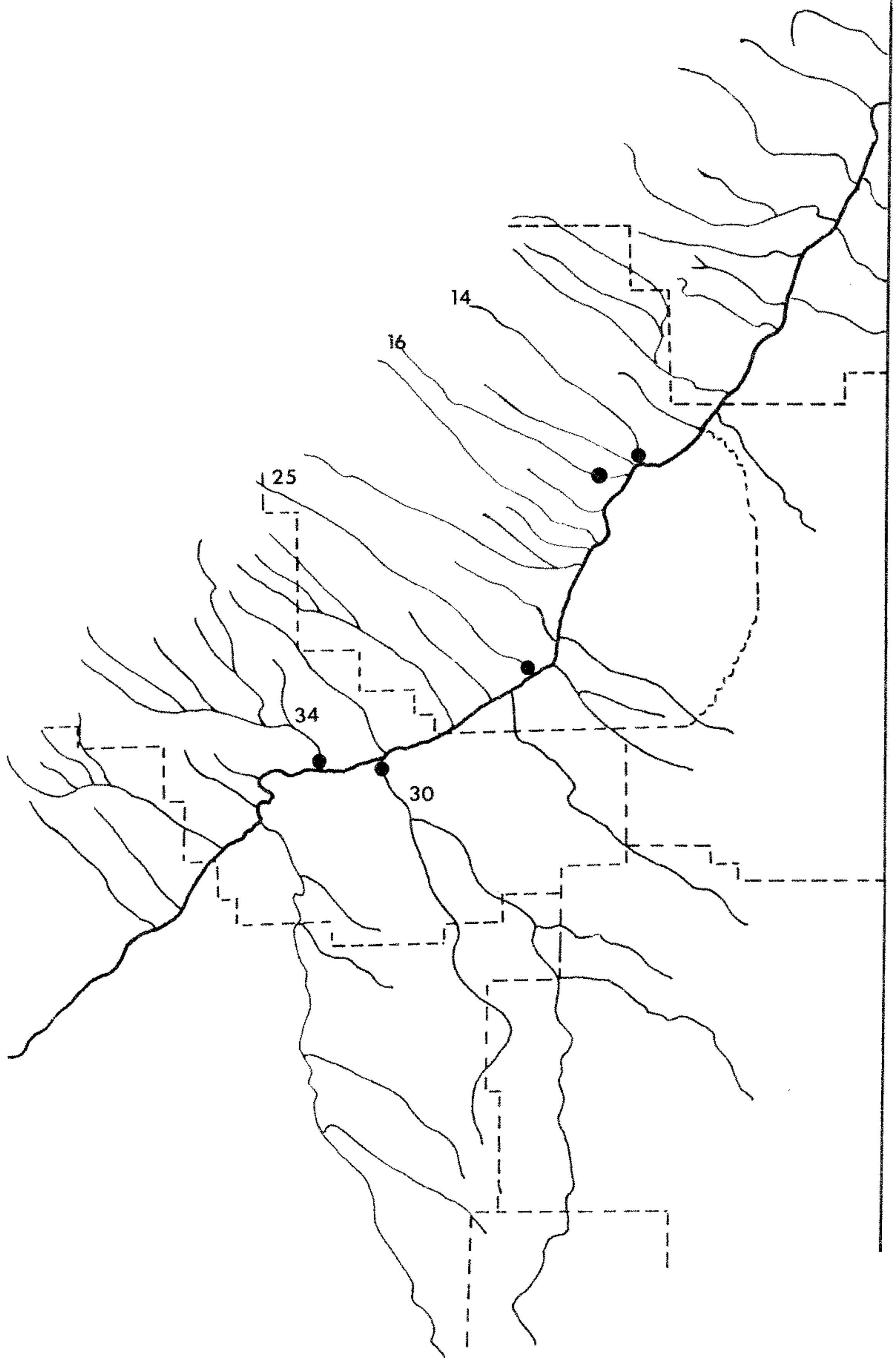


Figure 32. Distribution of the mountain sucker (*Catostomus platyrhynchus*) in the study area.



Ictaluridae - Catfish

Black bullheads (*Ictaluras melas*) are tolerant of low dissolved oxygen levels, high turbidities and temperature. This species was distributed throughout the study area (Figure 33). It's preferred habitats are pools of small, intermittent streams (Pflieger 1975), which helps explain its occurrence in the study area.

The yellow bullhead (*Ictalurus notalis*) is not native to Montana, and generally prefers clear streams with heavy aquatic vegetation and gravel substrates. The yellow bullhead where found was in association with the black bullhead, although not as widely distributed. This bullhead is more often found in or near streams with permanent flow (Figure 34).

The channel catfish (*Ictalurus punctatus*) is an important game fish of the study area. This fish was recorded in the mouth reaches of First Hay, Fox, Crane, Cottonwood, Thirteenmile, Deer, Upper Sevenmile, and Cabin Creeks (Figure 35). Catfish were also found throughout O'Fallon Creek, and the mouth of Sandstone Creek, it's largest tributary. Size ranged from a few centimeters to one individual measuring 760 mm, and weighing 3.90 kg (Table 7, Appendix). The larger cats were caught in gill nets, set at the mouth sections. These fish were probably moving out of the Yellowstone River on feeding and spawning runs.

Stonecats (*Noturus flavus*) are present throughout the Yellowstone drainage. Populations were found in the mouth of 12 streams although never caught in large numbers (Figure 36). Scott and Crossman (1973) summarized the stonecat's habitat preference as the riffles or rapids of moderate or large streams but noted that they do move into quieter waters to feed. The stonecats collected may have been moving out of the Yellowstone to utilize the mouths of these streams as feeding areas.

Figure 33. Distribution of the black bullhead (*Ictalurus melas*) in the study area.

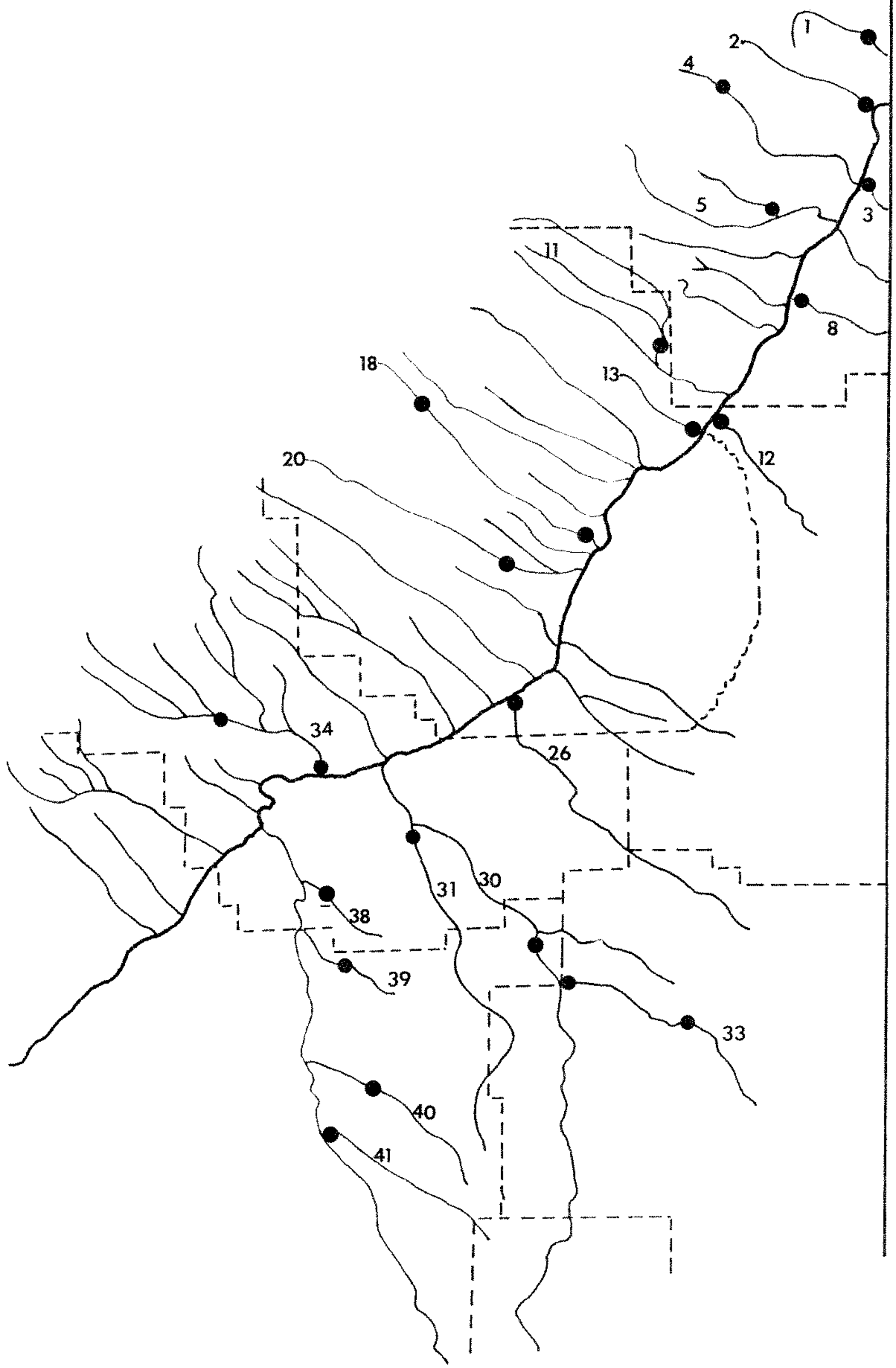


Figure 34. Distribution of the yellow bullhead (*Ictalurus natalis*) in the study area.

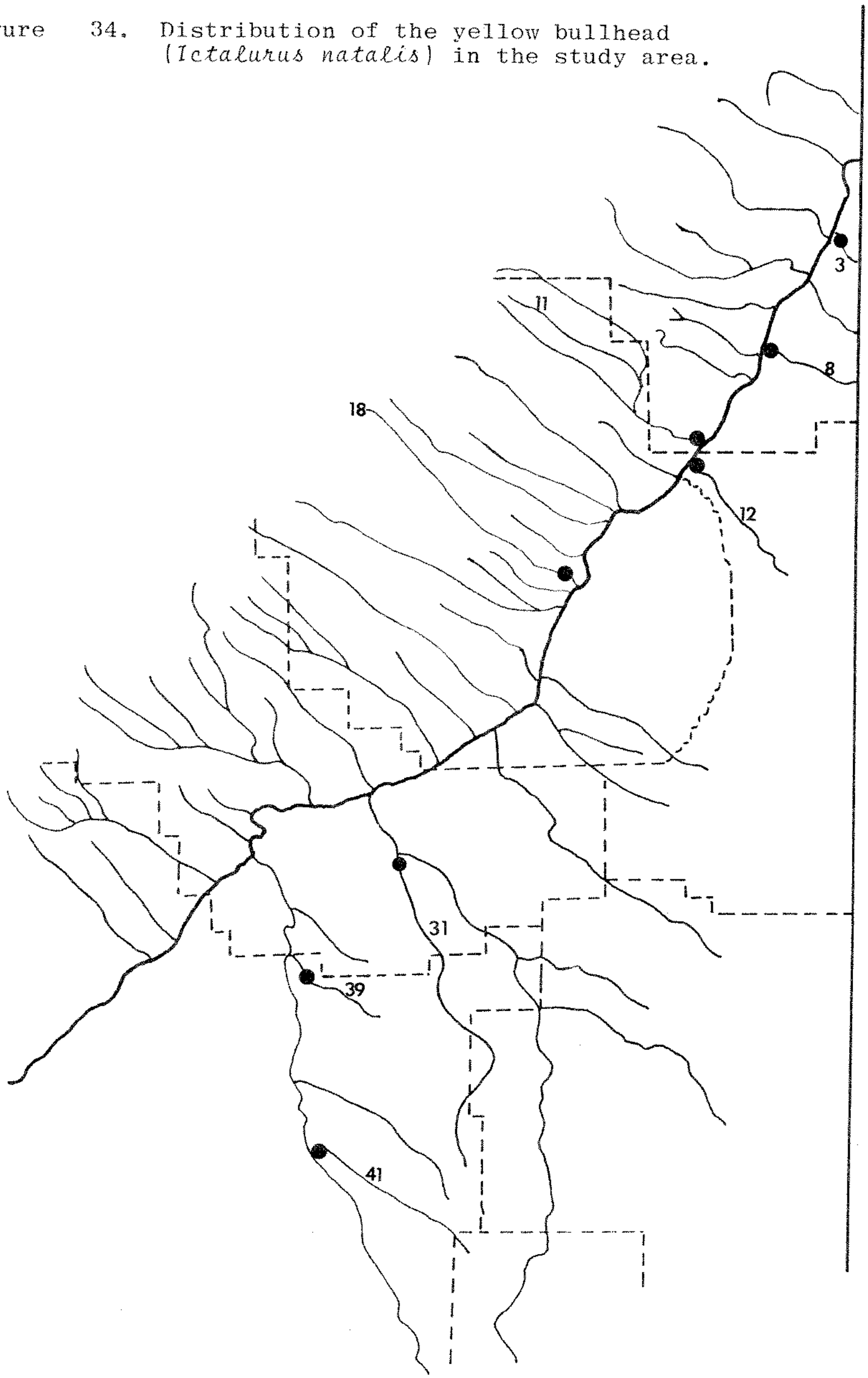


Figure 35. Distribution of the channel catfish (*Ictalurus punctatus*) in the study area.

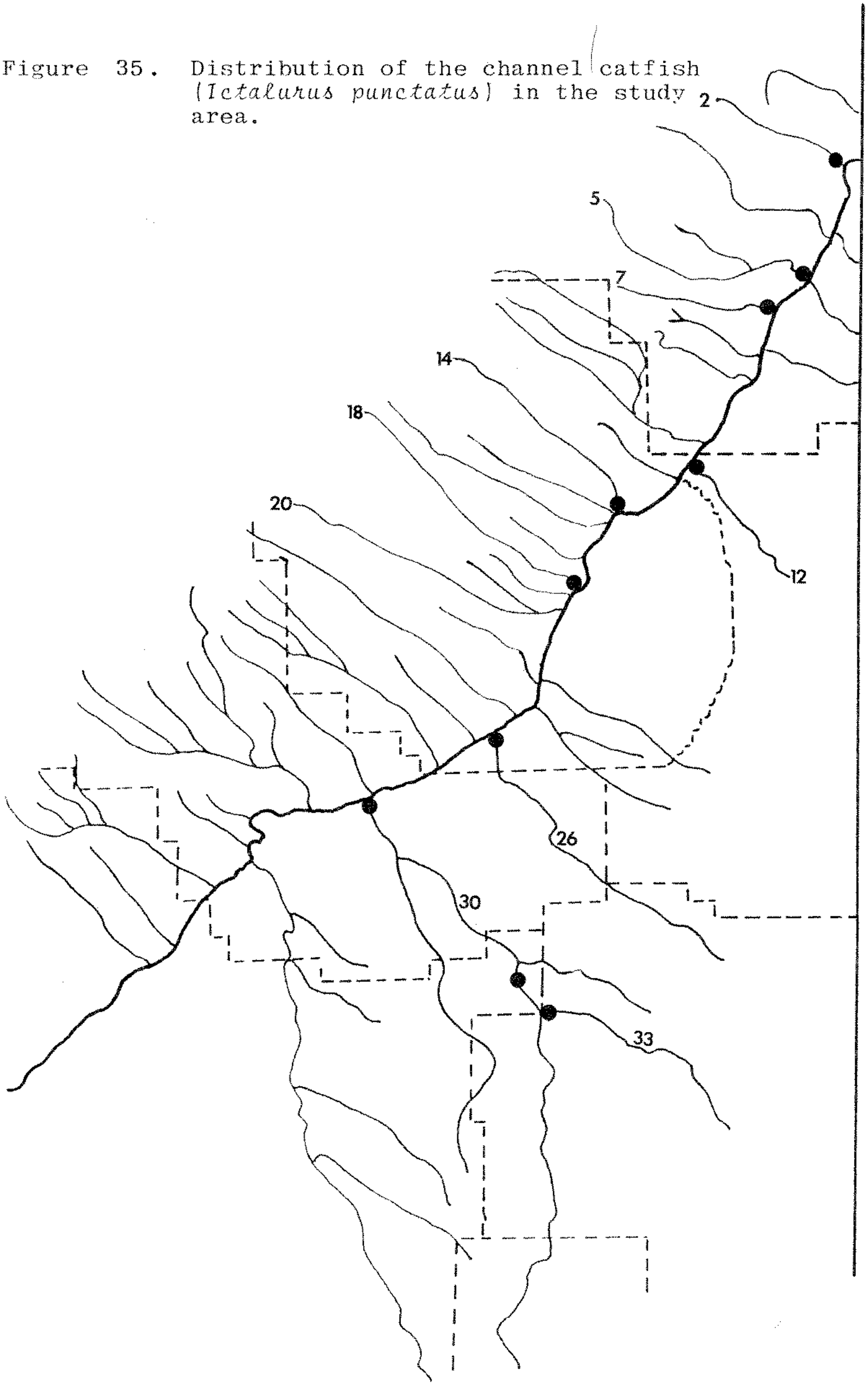
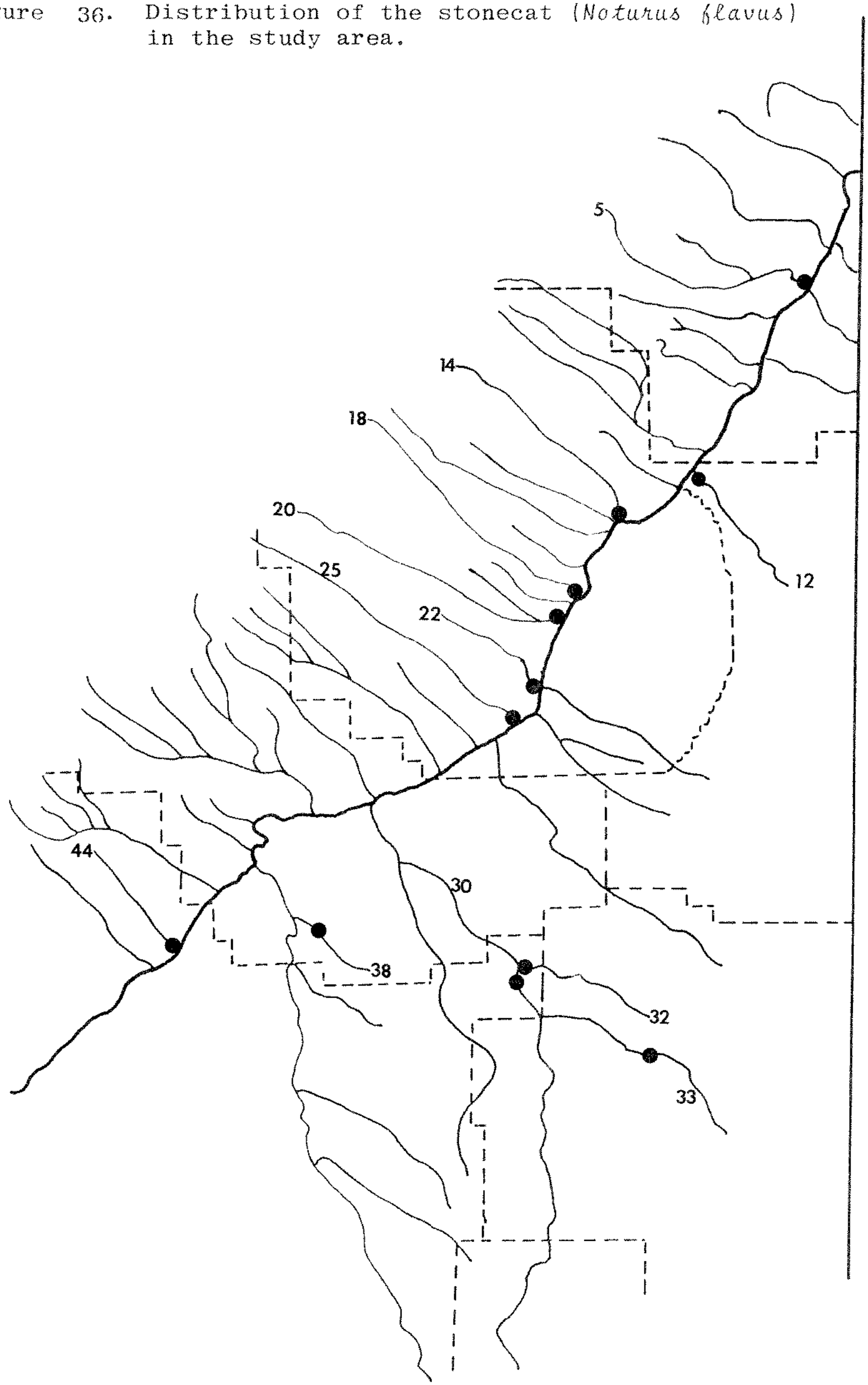


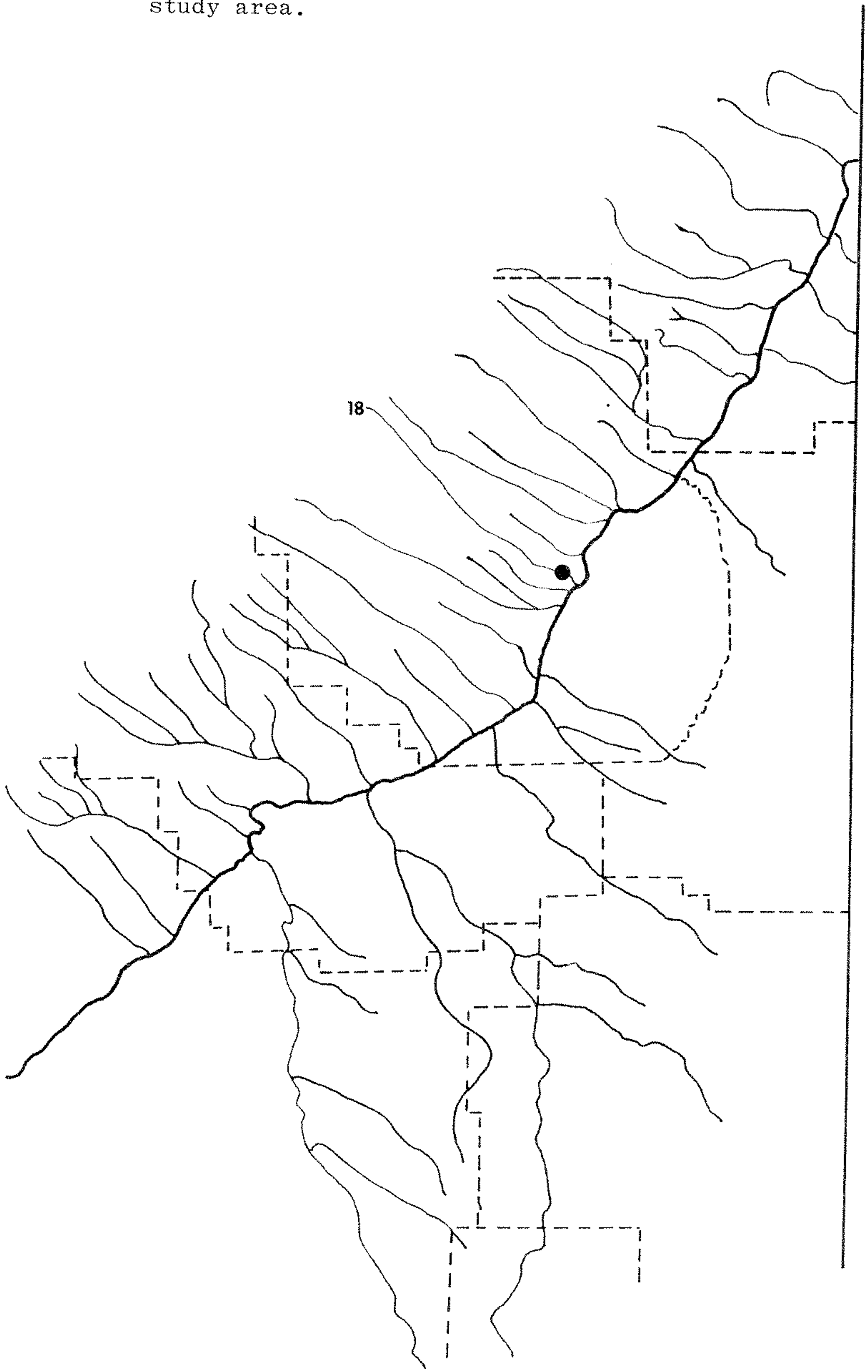
Figure 36. Distribution of the stonecat (*Noturus flavus*) in the study area.



Gadidae - Codfish

Two burbot (*Lota lota*) were collected on two occasions from Deer Creek in a temporarily spring fed pool (Figure 37). Both were collected in July, and were about 300 g and 175 mm. Habitat preference for this species is usually larger streams. This site is about 6.5 km from the mouth, and it has been suggested that the stream may be used in rearing of this species (Elser, personal communication). Montana forms part of the southern edge of the burbot range (Lee et al. 1980).

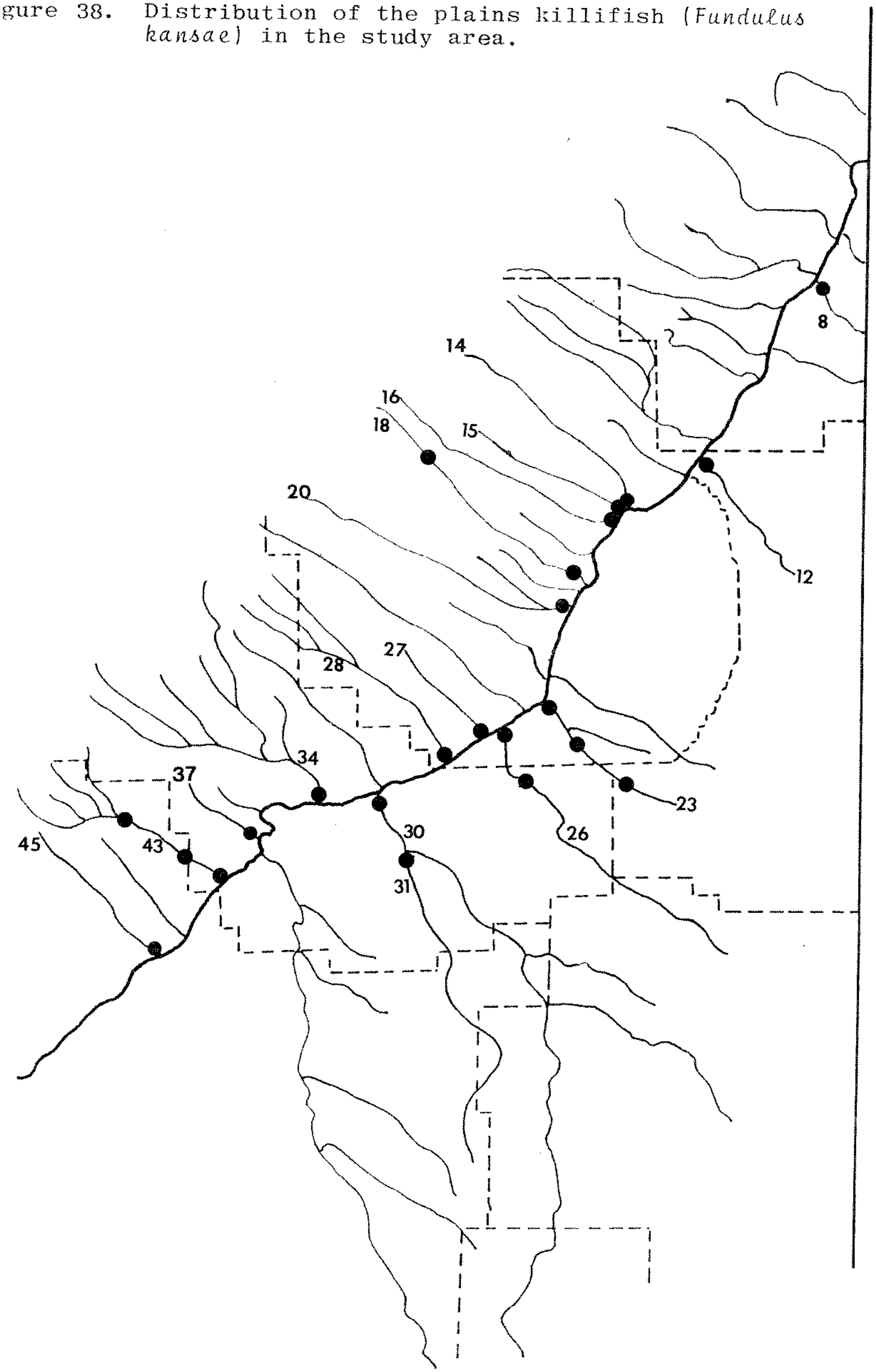
Figure 37. Distribution of the burbot (*Lota lota*) in the study area.



Cyprinodtidae - Killifish

Plains killifish (*Fundulus kansae*) were, until recently, considered a species of special concern. Although this fish was thought to have a very limited distribution, killifish populations were found on about 38% of the streams (Figure 38). A habitat investigation (both physical and chemical analyses) of plains killifish on several tributaries within the study area was performed by Claypool (1979). He found that this top-minnow was present in streams where the substrate was predominantly of a clay-silt type which may be directly related to the aquatic organisms present that are a preferred food. Other studies have suggested that killifish tolerance for high alkalinity may determine their stream association (Elser 1980).

Figure 38. Distribution of the plains killifish (*Fundulus kansae*) in the study area.



Gasterosteidae - Stickleback

Brook stickleback (*Culea inconstans*) is an interesting native fish limited in Montana to the eastern waters. This fish is tolerant of high salinities, but prefers smaller, clear streams with an abundance of aquatic vegetation. This fish was not especially confined to any particular stream reach (Figure 39) although it was generally more abundant at the upper sites.

Figure 40. Distribution of the green sunfish (*Lepomis cyanellus*) in the study area.

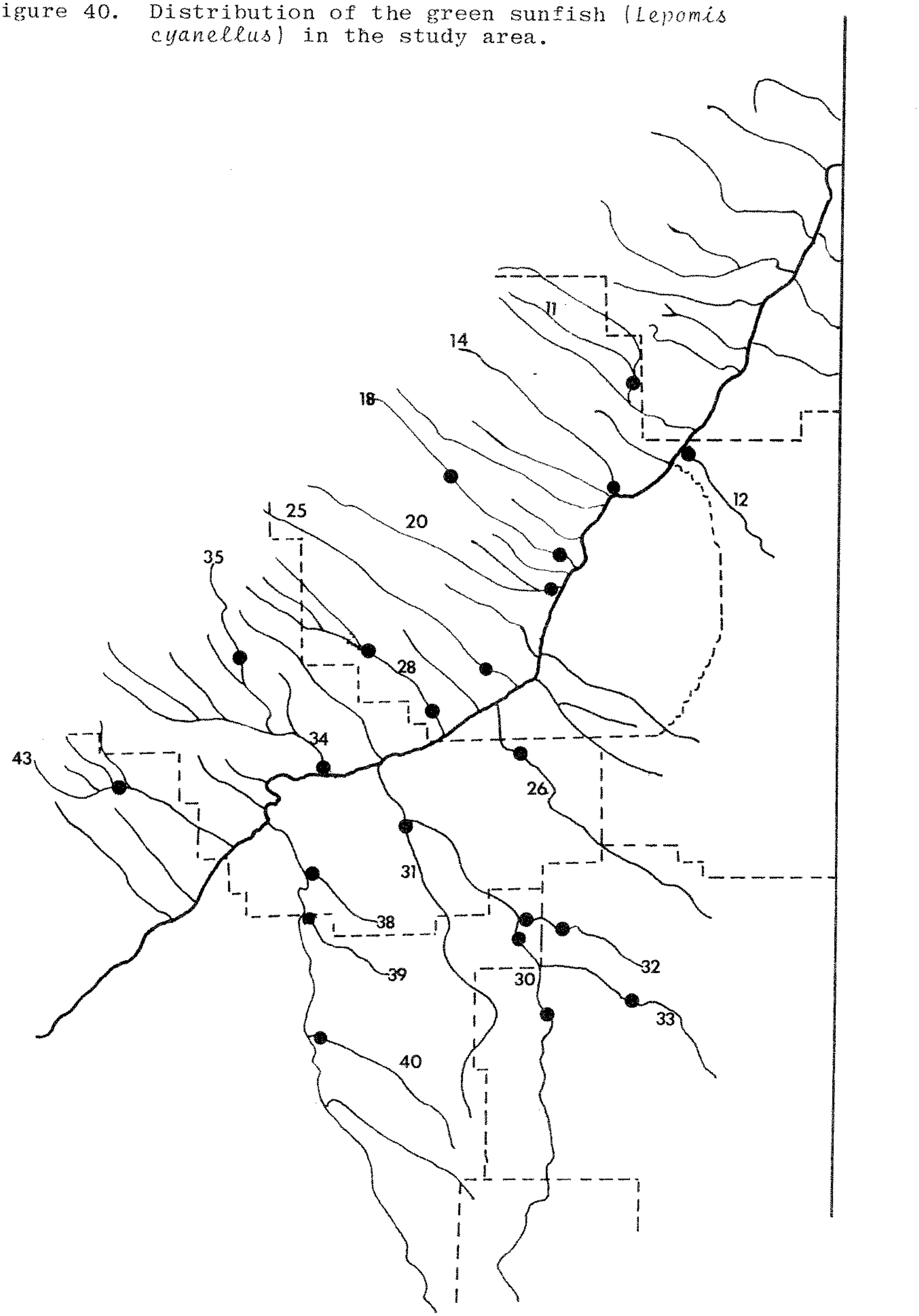


Figure 41. Distribution of pumpkinseed (*Lepomis gibbosus*), X; smallmouth bass (*Micropterus dolomieui*), ●; and bluegill (*Leopomis macrochirus*), O; in the study area.

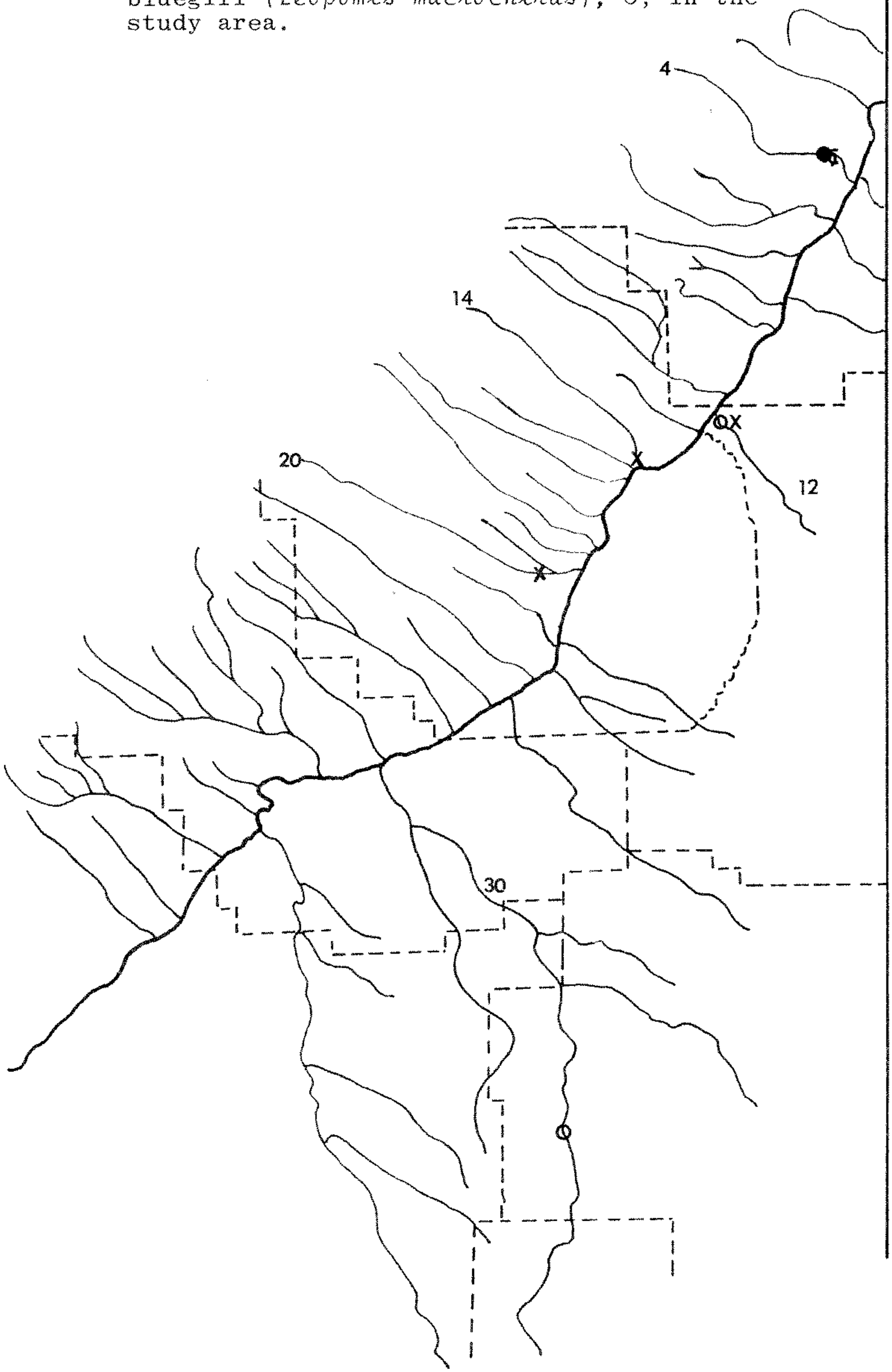
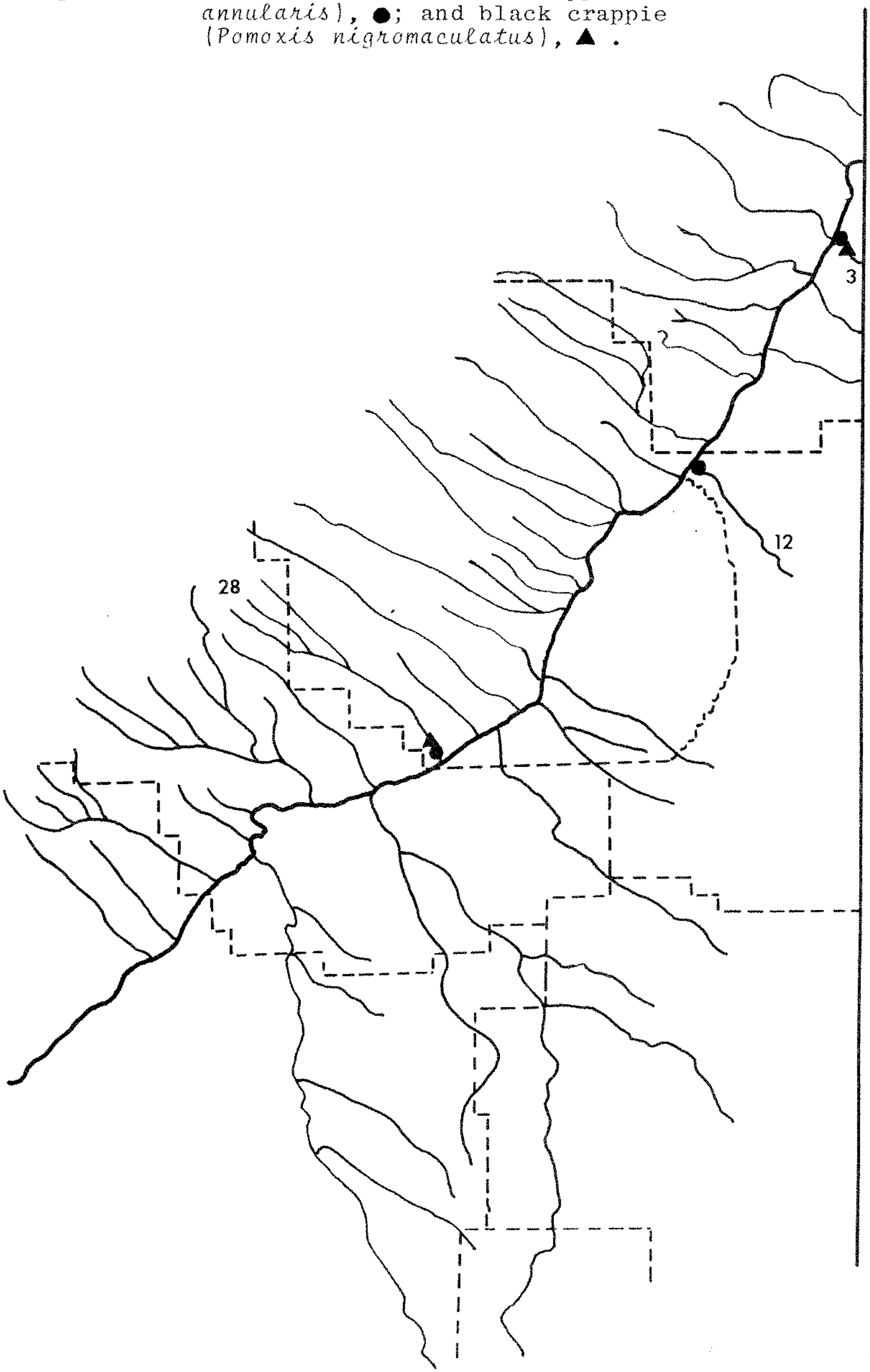


Figure 42. Distribution of white crappie (*Pomoxis annularis*), ●; and black crappie (*Pomoxis nigromaculatus*), ▲ .



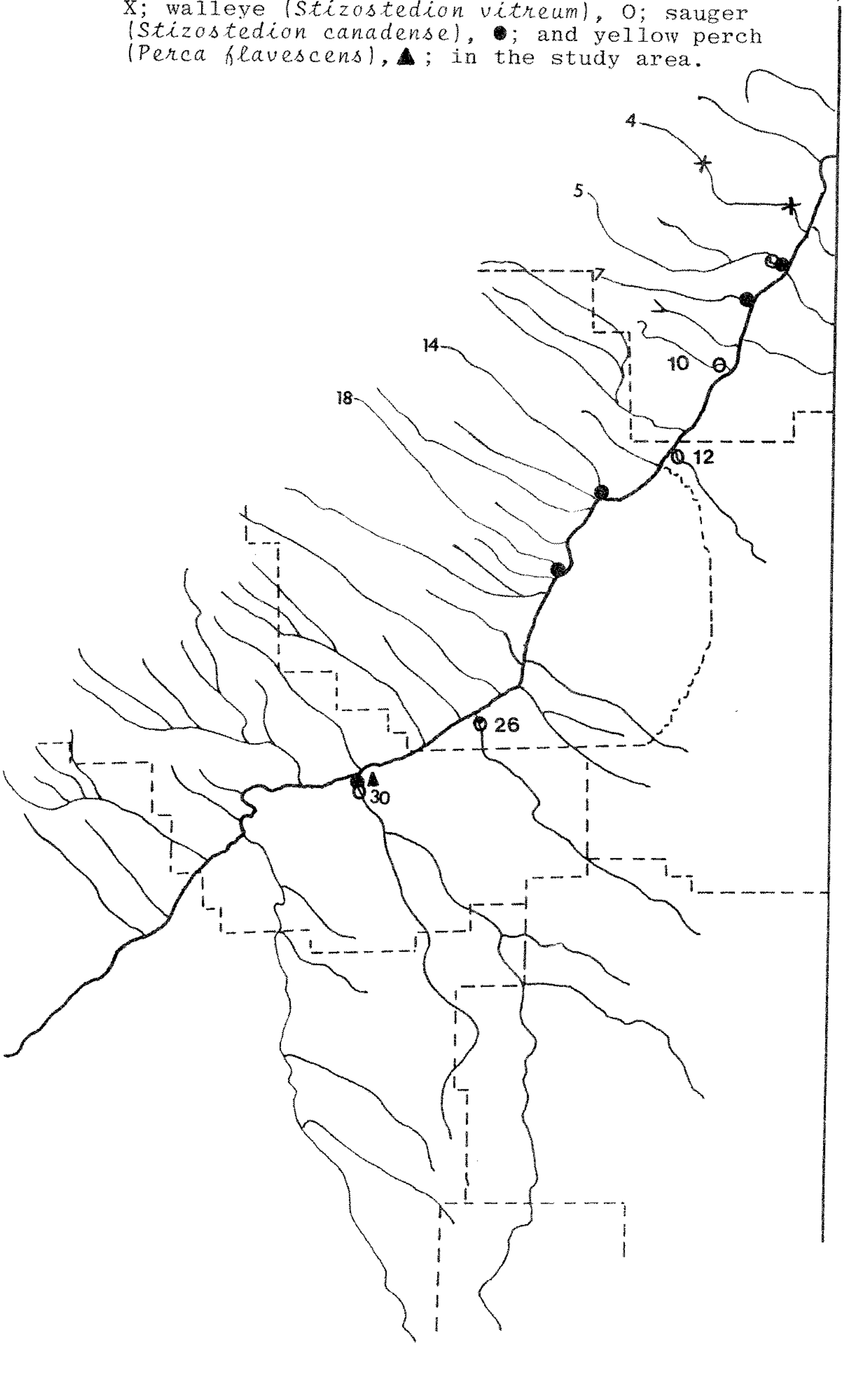
Percidae - Perch

Yellow perch (*Perca flavens*) were found exclusively at the mouth of O'Fallon Creek (Figure 43). All individuals were young-of-the-year identified during a sampling effort on July 18, 1980. This reach of O'Fallon is probably used as a spawning area for this species. Although an adaptable species, it prefers clear, open water.

Sauger (*Stizostedion canadense*) and walleye (*S. vitreum*) were caught in the mouth reaches of eight streams (Figure 43). Sampling was primarily with gill nets, and results suggest these fish were probably migrants from the Yellowstone River. Walleye, which are not native to Montana, averaged approximately 260 mm (total length) and weighed 148 g. The sauger, which are native, ranged in size from 100 g and 245 mm, to 800 g and 476 mm. All length-weight information collected for sauger and walleye is tabulated in Table 9, Appendix. Both species are a much sought after game fish.

The Iowa darter (*Etheostoma exile*) was found only in Lone Tree Creek (Figure 43). Little is known about its life history, but it seems to prefer clean, slow-flowing streams with solid bottoms, and abundant submergent aquatic vegetation. Montana is on the western fringe of its range (Lee et al. 1980).

Figure 43. Distribution of the Iowa darter (*Etheostoma exile*), X; walleye (*Stizostedion vitreum*), O; sauger (*Stizostedion canadense*), ●; and yellow perch (*Perca flavescens*), ▲; in the study area.



Classification of Streams

Montana Department of Fish, Wildlife, and Parks (1979) has developed a procedure for classifying Montana streams which can be useful in determining the importance of the aquatic resources of an area. The system is designed to assign each stream a species and habitat value and a sport fishery potential value. From these two criteria, then a fish resource value is assigned. This value is the higher of the first two values.

Each stream in the study area, with the exception of Threemile, Hatchet, Crooked, and Trail Creeks, was classified and ranked according to this system. Information obtained from this rating can aid Federal agencies in decisions concerning the leasing of Federal coal. This classification system has been previously utilized in this area on the streams included in the Beaver Creek study (Elser, et. al. 1978).

The habitat and species value (criterion 1) was determined by a point system in which the most points were awarded for important habitats of fishes of special concern. Fishes of special concern were defined as native fishes found in limited numbers and/or limited waters. Fewer points were awarded to less important habitats of fishes of special concern and/or the occurrence of widespread species found in substantial numbers. The least points were awarded for occurrence of non-indigenous species considered of minimal value. Points were also given for spring streams, esthetics and the value to the local community for scientific study, nature study, and/or recreation.

Sport fishery potential (criterion 2) was based on a point system in which points were awarded for (1) fish abundance as indicated by biomass or numbers and sizes of game or sport fish, (2) ingress (legal rights of the public to fish the reach or willingness of landowner to permit fishing), (3) esthetics, and (4) fishing pressure.

Each stream was rated and then assigned to one of the six value classes established. Each class is labelled as follows:

Value Class	Class Identification
1	Highest value fishery resource
2	High priority fishery resource
3	Substantial fishery resource
4	Limited fishery resource
5	Low value fishery resource
6	Not yet classified

The value and rating for each of the streams is listed in Table 6.

Eight streams received a value rating of 3, the highest rating assigned. In all cases this score was given for the habitat and

Table 6. Stream classification values for the study streams. Streams listed in order of entry into the Yellowstone.

	Species & Habitat		Sport Fishery Potential	
	Value	Class	Value	Class
Fourmile	2.0	4	4	5
First Hay	2.2	4	4	5
Bennie Peer	1.9	4	4	5
Lone Tree	7.2	3	10	4
Fox	5.2	3	13	3
Fox N.Fk.	5.4	3	11	4
Fox S.Fk.	5.2	3	9	4
O'Brien	.4	4	4	5
Crane	3.6	4	4	5
Shadwell	3.9	4	4	5
Sears	1.5	4	4	5
Dunlap	2.0	4	4	5
Burns	5.2	3	4	5
Cottonwood	5.5	3	4	5
War Dance	3.5	4	4	5
Thirteenmile	5.4	3	6	4
Morgan	3.2	4	4	5
Lower Sevenmile	4.3	4	4	5
Threemile	-	-	-	-
Deer	7.5	3	6	4
Dry		6		
Upper Sevenmile	5.3	3	4	5
Sand (R)		6		
Sand (L)	1.8	4	4	5
Cedar	3.9	4	4	5
Magpie		6		
Clear	3.1	4	4	5
Cabin	4.8	4	6	4
Crackerbox	1.9	4	4	5
Bad Route	2.1	4	4	5
Hatchet		-	-	-
O'Fallon (1)	5.5	3	6	4
(2)	6.0	3	6	4
(3)	4.5	4	4	5
Whitney	3.9	4	4	5
Pennel	3.9	4	4	5
Sandstone	4.0	4	4	5
Cherry	3.1	4	4	5
Brakett	2.1	4	4	5
Lost Man's	.6	4	5	4
Crooked	-	-	-	-
Ten Mile	3.8	4	4	5
Coal	3.2	4	4	5
Locate	4.0	4	4	5
Sheep	3.4	4	4	5
Trail	-	-	-	-
Custer	4.2	4	4	5
Harris	2.4	4	4	5
Muster	1.0	4	4	5

species value. The eight streams included Lone Tree, Fox, Burns, Cottonwood, Thirteenmile, Deer, Upper Sevenmile, and O'Fallon creeks. All of the streams, with the exception of O'Fallon creek are situated in the lower half of the study area. A significant source of point accumulation was a result of the high number of fish species on all eight streams. In only one instance, on the mainstem reach of Fox Creek, was a value of 3 assigned to both criteria. Fox Creek accumulated a high value for sport fishing potential due to high ratings for ingress, trout species biomass, and fishing pressure.

Burns Creek, one of the streams that received a class 3 rating, on the basis of species and habitat values, has been slated as a potential site for coal development in the near future. In fact, within the study area, identified strippable coal deposits (Missouri River Basin Commission, 1978) are situated over the same general area as the class 3 rated streams. A class 3 stream signifies a substantial fishery resource. The streams in the study with this rating merit special consideration should future development infringe on those drainages. They must be dealt with carefully to insure that as unique aquatic resources they are not lost.

Thirty-one streams were rated class 4. A majority of the study area then is classified as a moderate fishery resource. One of the creeks in this value class is Sears Creek. After the data for the study streams had been entered in the computer, an additional fish species was discovered. The sturgeon chub, a Montana "fish of special concern," was collected at the mouth section. Although, the addition of points for the presence of this species will not change the value class for this creek, further investigation of this stream should be considered to determine its importance as habitat for the sturgeon chub.

Two streams, Dry Creek and Magpie Creek were assigned class 6. This status is one of a negligible fishery resource or considered not yet classified. These streams were dry, which substantially affected their ratings.

DISCUSSION

Streams within the study area are all characteristically prairie type aquatic ecosystems. Most were largely composed of pools with some stream segments formed by pools interconnected by run and riffle areas. Nineteen hundred eighty, being a year of low precipitation, proved tough on the existence and survival of aquatic fauna in some areas. Man's influence in the study area was pronounced. Agriculture, cattle grazing, and especially irrigation diversions and canals directly affected the character of these drainages by altering water quality, affecting flow, and presumably directly influencing fish and aquatic invertebrate distribution. Esthetically, the area was rated as waters with natural beauty but lacking in pristine characteristics as a result of presence of human development.

Diptera, Ephemeroptera and Hemiptera were determined to be the most abundant and widely distributed groups of aquatic invertebrates. The invertebrate fauna identified were characteristic of the prairie stream environment with the diversity of organisms over the area being high. Future correlations of aquatic invertebrates and changes in water quality may be helpful in evaluating the impact that changes due to development might have on these aquatic systems.

The most common group of fish sampled were the cyprinids. This appears to be a general rule for prairie streams in this area since the adaptable, hardy species are more readily able to inhabit stream segments that pose a threat to the less well adapted species. Diversity and distribution of fish at most of the sites was relatively high indicating that productivity under present stream conditions is good. A drop in numbers or changes in community structure and/or composition might be an early warning that the system is being affected by an added stress.

Eight species of game fish utilize various streams in the area. In some instances, individuals were located at upper reaches but a majority of the collections were made at the mouth sections. In these instances, it appears that these are not resident individuals but rather transients from the Yellowstone River. Sampling efforts indicate that these mouth sections are utilized by a number of Yellowstone species presumably as feeding areas and in some cases as spawning and rearing areas. Young-of-the-year goldeye, white crappie, smallmouth buffalo and yellow perch were among the young-of-year species collected at mouth reaches. Consideration of the importance of these areas to various species is recommended when resource development decisions are made.

A majority of the streams were classified as a limited fishery resource, although eight streams received a classification of substantial fishery resource. In the classification system, streams rated higher from a species and habitat point of view. Waters that repeatedly demonstrated their uniqueness as prairie streams in terms of aquatic organism diversity, invertebrate numbers, and stream classification were O'Fallon, Lone Tree, Fox, Burns, Cottonwood, Thirteenmile, Deer, and Upper Sevenmile creeks. It is recommended that the quality of these streams be protected.

The adaptability and tolerance of aquatic fauna on the prairie is illustrated by the ability of the organisms to exist successfully in habitats less than optimum. For example, water temperatures in O'Fallon Creek were recorded as high as 31.1°C (88°F) and observed to remain high for extended lengths of time. Still, organisms were able to survive. At the same time, however, these organisms are part of a system in delicate balance. Further deterioration of some aspect of the environment might be more than the fauna could withstand. Changes to the aquatic systems in this study, if not carefully analyzed for resulting consequences, could ultimately cause a loss of inhabitants or a change in the makeup of those systems.

O'Fallon Creek proved to be a stream high in both fish and aquatic invertebrate diversity. Being classified as a potential fishery resource, as well, indicates that the integrity of this stream must be maintained. Should the coal beds in the upper end of the drainage become a strip mining area, the down-stream aquatic environment may be substantially altered. Depending on mining practices and degree of disturbance, changes in water quality will occur. Stream sediment load will increase and contamination of water from spoils will result. The cummulative impacts that mining would have on this drainage should be determined prior to development.

The prairie constitutes a distinct ecological division typified by harsh, extremely variable habitats. As a result, a unique assemblage of aquatic organisms capable of tolerating that environment, are associated with the system. The aquatic environment of the prairie has evolved in response to the seasonal fluctuations that have affected it for thousands of years. The continued natural function of the system depends on preservation of this natural variability within limits (Kushlan 1976, Gorman and Karr 1978). With the introduction of man-made conditions, the character and productivity of the aquatic community changes. Some of these conditions currently affect the streams in the area, but of special concern in the near future will be the impact that coal development will have on these streams. Water use will change and with that a change in water quality will result. The significance of these shifts in water use as well as land use must be assessed and when necessary, measures taken to protect resources from extreme alteration.

An assessment of the present status of this area in terms of aquatics was an important and necessary first step to understanding the area and providing baseline information prior to any large-scale future development. It is of utmost importance for the protection of the natural resources in the study area, that wise decisions be made.

APPENDIX

Table 7 . Length-weight measurements for channel catfish caught during 1979-1980 in the study area.

Stream	Site	Length(mm)	Weight(kg)	Date	Tag Number
Cottonwood	1	Fry		7-17-80	-
Crane	1	476	1.00	6-20-79	7-01533
Deer	1	535	1.30	6-19-79	7-02683
Fox	1	631	2.64	6-27-79	Mort
O'Fallon	1	488	1.09	4-26-79	7-01817
		624	2.80	4-26-79	7-01818
		520	1.36	4-26-79	7-01819
		515	1.49	4-26-79	7-01820
		705	3.90	4-26-79	7-01822
		760	3.90	4-26-79	7-01824
		613	2.85	4-30-79	7-02690
		408	570g	6-21-79	7-01535
		581	1.77	6-21-79	7-01536
		680	3.41	6-21-79	7-01537
		750	3.57	6-21-79	7-01538
		630	3.15	5-30-80	7-01502
	2	17 Fry		8-22-80	-
	3	217	70g	4-24-80	7-00815
		194	57g	4-24-80	7-00816
		263	160g	5-3-79	7-02687
		545	1.61	5-3-79	7-02693
		719	3.90	5-3-79	7-02722
		559	1.8	4-16-80	7-01517
		759	860g	4-17-80	7-01510
		410	830g	4-17-80	7-01513
		12 Fry		8- 5-80	-
	4	2 Fry		8-13-80	-
Sandstone	1	2 Young of Year		7-15-80	
Thriteenmile	1	490	1.16	6-18-79	7-01526
		625	3.72		7-01528
		445	795g		7-01530
		485	1.70		7-01540
		484	1.00		7-01547
		408	510g		7-01549
		471	760g		7-01550
		265	105g		-

Table 8 . Length-weight measurements for northern pike caught during 1979-1980 in the study area.

Stream	Site	Length (mm)	Weight (g)	Date	Tag Color or Number	Estimated Year Class
Bennie Peer	2	457	650	7-10-80	Purple flag	4
		238	270	7-10-80		2
Cabin	1	480	580	5-14-80	Green flag	3
Crane	1	788	3.26kg	6-20-79	Blue Flag	5
	1	695	2.00kg	6-20-79		5
		673	1.87kg	6-20-79		4
Deer	1	430	480	6-19-79	Gray Flag	4
	2	416	460	7-10-79		
		441	542	7-10-79		
		456	578	7-10-79		
		464	655	7-10-79		
	3	370	1.22kg	8-8-80		4
Dunlap	1	687	2.3 kg	4-22-80		7
First Hay	3	341	250	8-8-79	Green-no flag	3
Fox	1	800	2.77kg	6-27-79	Mort	5
	3	180	40	10-11-79	Mort	1
	3	158	45	10-11-79	Mort	1
	3	175	40	10-11-79	Mort	1
		172	40	10-11-79	Mort	1
		163	30	10-11-79	Mort	1
	4	175	25	10-13-79	Mort	1
	4	181	35	10-13-79	Mort	1
	4	175	30	10-13-79	Mort	1
O'Fallon	3	555	950	6-1-79	Red Flag	5
	3	557	1.1 kg	4-17-80		4
Sandstone	2	536	1.01kg	10-15-79	7-05200	4
		632	1.55kg	5-8-80	Orange Flag	4
		520	950	5-8-80		4
		360	290	5-8-80		2
		444	450	5-8-80		3
Sheep	1	322	230	5-25-79	Lt. Blue Flag	
		245	110	5-25-79		
Thirteenmile	1	281	170	6-19-79	White-no Flag	2
		649	1.75kg			5
		303	140			2
Upper Sevenmile	1	355	332	6-11-79	Lt Blue Flag	3
	2	290	355	6-14-79		3
		214	70	6-14-79		
		395	370	6-14-79		4

Table 8 . Continued.

Stream	Site	Length (mm)	Weight (g)	Date	Tag Color or Number	Estimated Year Class
War Dance	1	360	300	4-23-80	Brown-No Flag	2
		324	230	4-23-80		2
		333	240	4-23-80		2
		348	290	4-23-80		2
		336	270	4-23-80		2
		320	240	4-23-80		-
		352	290	4-23-80		2

Table 9. Length-weight measurements for sauger and walleye caught during 1979-1980 in the study area.

Stream	Site	Length (mm)	Weight (g)	Date	Tag Color	Estimated Year Class
			SAUGER			
Crane	1	283	140	6-20-79	Blue Flag	1
		250	327	6-20-79		3
		404	450	6-20-79		4
Deer	1	354	280	6-19-79	Gray Flag	4
		359	420	6-19-79		4
		329	270	6-19-79		4
		375	410	6-19-79		4
		418	600	6-19-79		4
		476	800	6-19-79		4
Fox	1	245	100	6-27-79		1
		244	100	6-27-79		1
		261	140	6-27-79		1
		334	298	6-27-79		2
		265	130	6-27-79		2
		255	120	6-27-79		2
		255	110	6-27-79		2
		251	110	6-27-79		2
		370	350	6-27-79		3
		290	150	6-27-79		3
		371	403	6-27-79		-
		260	120	6-27-79		-
O'Fallon	1	355	320	4-26-79	Red Flag	3
		340	280	5-30-80		3
		380	450	5-30-80		4
			WALLEYE			
Cabin	1	265	150	5-14-80		3
Dunlap	1	254	150	4-23-80		2
Fox	1	266	150	6-27-79		2
		-	160	6-27-79		2
O'Fallon	1	250	130	5-30-80	Red Flag	3

Table 10 A list of birds observed in the study area, April-November 1, 1979 and April-August 28, 1980.

Western grebe (YR)*	Mourning dove
White pelican (YR)	Screech owl
Double crested cormorant (YR)	Great horned owl
Great blue heron	Burrowing owl
Canada goose	Common nighthawk
Mallard	Belted kingfisher
Pintail	Common flicker
Greenwinged teal	Red-headed woodpecker
Blue winged teal	Eastern kingbird
American widgeon	Western kingbird
Northern shoveler	Horned lark
Wood duck	Violet-green swallow
Ring-necked duck	Rough-winged swallow
Common goldeneye	Barn swallow
Bufflehead	Black-billed magpie
Ruddy duck	Common crow
Common merganser	Black-capped chickadee
Turkey vulture	Brown thrasher
Red-tailed hawk	Robin
Rough-legged hawk	Western bluebird
Golden eagle	Mountain bluebird
Bald eagle	Northern shrike
Marsh hawk	Loggerhead shrike
Osprey (YR)	Starling
American kestrel	Yellow warbler
Sharp-tailed grouse	Yellow-rumped warbler
Sage grouse	American redstart
Ring-necked pheasant	House sparrow
Gray partridge	Western meadowlark
Turkey (Powder River)	Yellow-headed blackbird
Sora	Red-winged blackbird
Sandhill crane	Northern oriole
American coot (YR)	Brewer's blackbird
Killdeer	Common grackle
Black-bellied plover	Lazuli bunting
Long-billed curlew	American goldfinch
Upland sand piper	Rufous-sided towhee
Spotted sandpiper	Lark bunting
Marbled godwit	Vesper sparrow
Wilson's phalarope	Dark-eyed junco
California gull (YR)	Tree sparrow
Franklin's gull	Rough-winged sparrow
Rock dove (pigeon)	

* YR - Indicates that observation was made on the Yellowstone River.

All birds were positively identified. If identification questionable, was not included in this list.

Table 11. A list of mammals, reptiles and amphibians sited in the study area, April - November 1, 1979 and April - August 28, 1980.

Mammals	Reptiles	Amphibians
Mule deer	Garter snake	Lepoard frogs
Whitetail deer	Water snake	
Antelope	Rattlesnake	
Coyote	Snapping turtles	
Muskrat	Painted turtles	
Beaver	Bull snake	
Red Fox		
Prairie dogs		
Raccoon		
Jack rabbit		
Desert cottontail		
Big Brown Bat		
Skunks		
Field mice		
Ord's kangaroo rats		
Badger		

Table 12. A summary of all water chemistry data obtained during the 1979 field season.

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/1	Temperature °C	Turbity JTU
1	Fourmile	1	8-1-79	1890	11.5	8.5	410.4	22.2	10
		2	8-1-79	2200	2.0	8.5	974.7	25.6	40
2	First Hay	1	4-25-79	850	12.2	-	307.8	5.6	-
			8-28-79	1500	13.2	8.5	239.4	20.0	25
		2	8-8-79	1300	9.6	8.5	461.7	20.6	0
		3	8-8-79	3400	9.0	8.5	769.5	24.4	60
3	Bennie Peer	1	8-2-79	30	9.2	8.5	461.7	23.3	55
			10-17-79	1000	10.0	8.5	684	9.4	60
4	Lone Tree	1	10-11-79	520	9.4	8.5	530.1	11.7	10
		2	8-9-79	900	9.6	8.5	393.3	22.2	10
			10-3-79	490	8.7	8.5	410.4	11.1	0
		3	8-9-79	820	10.2	8.5	495.9	18.9	15
			10-3-79	550	13.0	8.5	461.7	11.1	0
5	Fox	1	6-20-79	300	-	8.5	136.8	20.0	210
			6-28-79	435	-	8.5	188.1	22.8	80-90
			10-17-79	500	14.4	8.5	427.5	10.0	30
		2	6-28-79	170	-	8.5	513	20.6	0
			10-11-79	710	11.1	8.5	478.8	13.9	10
		3	8-16-79	780	7.4	8.5	444.6	18.9	30
			10-3-79	2300	10.4	8.5	307.8	11.7	60
		4	6-30-79	4100		8.5	564.3	22.8	0
6	O'Brien	1	7-13-79	2225	-	7.5	769.5	16.7	45
7	Crane	1	6-20-79	410	-	8.5	256.5	16.1	90
			8-29-79	500	13.2	8.5	290.7	20.6	35
8	Shadwell	1	8-16-79	2200	16.2	10	837.9	27.8	500+
			10-17-79	2400	17.4	8.5	1231.2	14.4	50
		2	7-13-79	5000	-	9.0	598.5	22.2	95
			11-1-79	4500	11.8	8.5	2489.5	1.7	40
9	Sears	1	6-17-79	820	10.0	8.0	564.3	12.2	100
			8-29-79	550	11.8	9.0	273.6	20.0	35
10	Dunlap	1	5-16-79	1320	-	8.5	444.6	26.1	50
			8-29-79	500	13.4	8.5	205.2	21.1	-
11	Burns	1	4-16-79	725	12.1	8.5	-	8.9	-
		2	8-30-79	70	14.0	8.5	342	20.0	20
		2	7-2-79	1100	-	8.5	393.3	22.2	23
		3	8-30-79	4150	12.0	8.5	957.6	27.8	70

Table 12. Continued

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/l	Temperature °C	Turbity JTU
12	Cottonwood	1	9-14-79	1590	14.2	8.5	444.6	20.6	0
			10-16-79	1200	13.0	8.5	359.1	13.9	-
		2	8-15-79	1300		9.5	188.1	-	120
			10-4-79	2900	12.0	8.5	461.7	7.8	75
13	War Dance	1	5-16-79	-	-	8.5	444.6	26.1	50
			10-11-79	460	14.4	8.5	307.8	12.8	0
14	Thirteenmile	1	6-19-70	1120	-	8.5	735.3	18.5	0
		2	10-1-79	700	10.8	8.5	478.8	15.6	5
		3	8-7-79	1710	9.2	8.5	461.7	21.1	20
			10-2-79	700	10.8	8.5	478.8	15.6	5
15	Morgan	1	9-27-79	530	11.4	8.5	427.5	13.9	200
			10-24-79	1400	6.4	8.5	615.6	1.7	-
		2	9-27-79	430	9.0	8.5	376.2	16.1	60
			10-24-79	700	15.4	8.5	393.3	7.2	-
16	Lower Sevenmile	1	6-18-79	900	-	7.5	478.8	18.3	10
			10-10-79	1020	10.2	8.5	444.6	17.2	0
		2	6-19-79	1200	-	8.0	478.8	20.6	-
			10-24-79	1400	6.4	8.5	615.6	1.7	-
17	Threemile	-	-	-	-	-	-	-	-
18	Deer	1	6-18-79	1700	-	8.5	427.5	20.0	95
		3	7-3-79	1900	-	8.5	632.7	22.2	10
		4	7-19-79	1700	-	7.0	564.3	23.3	10
			7-23-79	2300	-	8.5	-	24.4	0
19	Dry	-	-	-	-	-	-	-	-
20	Upper Sevenmile	1	6-14-79	900	-	8.5	307.8	20.0	-
			8-8-79	700	15	8.5	376.2	21.7	30
		2	6-15-79	1400	-	7.0	461.7	14.4	-
			8-28-79	1500	11.0	8.5	598.5	22.2	20
		3	6-15-79	1400	-	7.0	461.7	14.4	-
21	Sand (R)	-	-	-	-	-	-	-	-
			6-14-79	500	-	8.5	256.5	20	0
22	Sand (L)		9-26-79	410	12.2	8.5	239.4	17.8	40
23	Cedar	1	6-25-79	1410	-	-	222.3	22.8	500+
			10-31-79	2180	13.4	8.5	359.1	6.7	28
		2	6-24-79	1300	-	-	290.7	27.8	500+
			8-31-79	4700	8.8	8.5	359.1	21.1	50
		3	7-25-79	1500	-	8.0	153.9	24.4	275

Table 12. Continued

No	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/l	Temperature ^{o}C	Turbity JTU
24	Magpie	-	-	-	-	-	-	-	-
25	Clear	1	9-27-79	700	14.4	8.5	461.7	19.4	30
		2	9-28-79	590	11.1	8.5	513	15.0	15
26	Cabin	1	7-26-79	950	-	9.5	359.1	21.1	50
			10-18-79	2700	13.8	8.5	290.7	15.0	0
		2	10-31-79	1020	15.2	8.5	617.6	3.9	3
27	Crackerbox	1	9-19-79	450	13.8	8.5	256.5	20	30
			10-30-79	500	19.8	8.5	444.6	10	25
28	Bad Route	1	6-12-79	800	-	8.5	256.5	23.3	0
			9-17-79	900	13.8	8.5	239.4	18.3	20
		2	9-17-79	-	18.4	8.5	393.3	20.0	0
			10-30-79	800	19.0	8.5	547.2	11.1	50
		3	9-18-79	1400	12.4	8.5	205.2	17.8	30
29	Hatchet	-	-	-	-	-	-	-	-
30	O'Fallon	1	5-4-79	1900	11.0	8.5	376.2	14.5	0
			5-31-79	1100	12.1	8.5	359.1	16.1	120
			7-9-79	1780	-	7.5	427.5	22.8	0
			7-31-79	1490	12.0	8.5	324.9	30.0	60
		2	3-29-79	350	12.0	-	-	2.2	-
			4-18-79	780	11.5	8.5	239.4	13.9	-
			7-9-79	2280	-	8.5	444.6	23.9	50
			7-31-79	2120	10.6	8.5	393.3	26.7	83
		3	3-29-79	300	14.0	-	-	1.7	25
			5-7-79	1420	12.2	8.5	359.1	10.0	25
			5-31-79	1950	10.8	8.5	444.6	16.1	35
			6-31-79	1900	-	8.5	581.4	26.7	45
			6-31-79	-	-	8.5	666.9	21.1	-
			7-9-79	2520	8.0	8.0	598.5	26.7	60
			9-20-79	800	9.4	8.5	547.2	21.1	30
31	Whitney	1	8-17-79	3400	16.4	9.5	495.9	25.6	0
		2	7-11-79	4300	-	9.5	324.9	24.4	-
			9-19-79	2400	9.2	9.0	342	14.4	20

Table 12. Continued.

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/l	Temperature °C	Turbity JTU
32	Pennel	1	5-7-79	2120	11.2	8.5	324.9	10.6	70
			9-20-79	1400	13.5	8.5	461.7	17.8	5
		2	9-10-79	2100	8.2	8.5	393.3	16.7	15
			10-12-79	1300	11.0	8.5	495.9	10.0	30
33	Sandstone	1	9-26-79	1060	9.3	8.5	615.6	16.7	25
		2	6-21-79	240	-	8.5	581.4	20.6	40
			9-24-79	1700	11.0	8.5	615.6	17.8	15
			10-15-79	1400	11.8	8.5	701.1	12.8	45
34	Cherry	1	6-3-79	-	-	8.5	444.6	10.0	0
			9-6-79	2200	11.0	8.5	666.9	26.1	20
		2	9-24-79	3300	11.4	8.5	991.8	18.9	20
35	Brakett	1	6-8-79	-	-	8.5	547.2	15.6	45
		2	9-6-79	2800	11.0	8.5	273.6	17.2	30
			10-9-79	-	-	8.5	376.2	11.7	-
36	Lost Man's	1	6-5-79	400	-	8.5	188.1	22.8	120
37	Crooked	1	6-11-79	380	-	8.5	752.4	32.2	-
38	Tenmile	1	5-8-79	1250	9.4	8.5	444.6	9.4	10
			9-21-79	2400	16.2	8.5	1043.1	21.7	80
		2	8-6-79	-	9.6	9.0	205.2	30.6	125
39	Coal	1	5-9-79	1720	10.7	8.5	632.7	10.0	75
			8-6-79	-	9.2	8.5	718.2	30.0	120
			8-20-79	1500	8.0	8.5	769.5	20.0	120
		2	8-20-79	2010	17.0	10	615.6	24.4	150
			8-23-79	2250	-	8.5	1265.4	23.3	60
			9-24-79	1900	11.0	9.0	1504.8	16.7	90
40	Locate	1	8-6-79	-	9.6	8.5	530.1	23.9	40
			8-24-79	2100	9.0	9.5	530.1	16.1	20
		2	8-6-79	1120	9.8	8.5	547.2	15.6	10
			9-24-79	700	8.6	8.5	564.3	10.0	10
41	Sheep	1	5-25-79	-	12.5	8.5	615.6	25.6	150
42	Trail	-	-	-	-	-	-	-	-
43	Custer	1	5-4-79	1900	11.0	8.5	376.2	14.5	0

Table 12. Continued

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/l	Temperature °C	Turbity JTU
43	Custer (cont.)		5-23-79	2400	9.2	-	478.8	24.4	-
			10-22-79	1100	16.4	8.5	478.8	8.9	-
		2	5-3-79	2400	9.2	8.0	564.3	24.4	100
			10-9-79	-	-	8.5	376.3	8.9	-
		3	8-3-79	-	10.4	7.5	1026	21.1	60
			10-23-79	1100	16.4	8.5	478.8	8.9	-
44	Harris	1	7-27-79	550	-	8.5	188.1	26.7	375
45	Muster	1	6-11-79	-	-	8.5	205.2	25.6	500+
			7-27-79	650	-	8.5	735.3	22.8	40

Table 13. Water chemistry data - 1980 field season.

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/l	Temperature °C	Turbity JTU
1	Fourmile	1	5-22-80	1800	11.5	8.5	666.9	21.1	32
		2	6-11-80	7100	8.6	8.5	598.5	20.6	18
2	First Hay	1	4-30-80	600	10	8.5	222.3	16.1	30
		2	4-30-80	2280	-	8.5	513	14.4	5
		3	4-30-80	4680	-	8.5	598.5	16.7	50
3	Bennie Peer	1	7-10-80	-	10.1	8.5	205.2	22.2	120
		2	7-10-80	-	11.2	8.5	1008.9	26.7	5
4	Lone Tree	1	7-17-80	800	16.0	8.5	222.3	18.3	80
		2	6-11-80	1220	8.8	8.5	393.3	15.6	15
		3	5-21-80	1400	10.8	8.5	513.	20.6	30
5	Fox	1	4-10-80	950	10.6	8.5	393.3	7.2	60
		2	4-10-80	1000	17.5	8.5	393.3	6.7	40
		3	4-10-80	890	10.2	8.5	444.6	6.1	30
			8-7-80	-	10.6	8.5	444.6	17.8	-
		4	7-1-80	24,000	12.0	10	222.3	28.9	22
6	O'Brien	2	7-10-80	-	10.1	8.5	205.2	22.2	120
7	Crane	1	7-31-80	-	14.2	8.5	307.8	18.3	-
		2	7-31-80	-	16.0	8.5	256.0	19.4	-
8	Shadwell	1	7-9-80	9000	10.0	8.5	1463.0	25.6	
		2	7-9-80	16,000	16.2	10	906.3	27.8	60
9	Sears	1	5-1-80	980	-	8.5	444.6	12.8	30
10	Dunlap	1	4-22-80	990	10.2	8.5	427.5	17.2	45
11	Burns	1	4-24-80	1550	6.6	8.5	547.2	18.3	50
		2	7-9-80	1700	7.2	8.5	547.2	21.7	55
		3	7-2-80	3500	9.5	8.5	478.8	18.9	45
		4	7-8-80	10,000	4.7	10	735.3	24.4	82
12	Cottonwood	1	7-17-80	3090	12.2	8.5	427.5	21.1	140
		2	7-11-80	3200	10	8.5	427.5	21.7	62
13	War Dance	1	4-23-80	1250	9.8	8.5	376.2	16.7	10
14	Thirteenmile	1	4-9-80	1400	14.4	8.5	478.8	15.6	5
			8-6-80	-	18.2	8.5	1177.8	25.6	-
		2	4-9-80	1430	14.0	8.5	461.7	8.9	20
			8-26-80	-	-	8.5	495.9	17.8	-
		3	4-23-80	2200	13.0	8.5	359.1	11.7	15

Table 13. Continued.

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PM	pH	Alkalinity mg/l	Temperature °C	Turbidy JTU
15	Morgan	1	4-24-80	950	8.2	8.5	478.8	12.8	5
		2	4-24-80	70	21.9	8.5	359.1	16.7	5
16	Lower Sevenmile	1	5-21-80	1780	7.1	8.5	513	23.9	5
		2	7-3-80	1950	5.1	8.5	598.5	16.1	0
17	Threemile		–	–	–	–	–	–	–
18	Deer	1	4-1-80	2800	12.7	8.5	769.5	8.3	50
		3	4-11-80	1740	14.2	8.5	547.2	6.7	40
			8-6-80	–	11.2	8.5	598.5	23.9	–
		4	–	–	–	–	–	–	–
19	Dry	–	–	–	–	–	–	–	–
20	Upper Sevenmile	1	4-29-80	950	3.0	8.5	307.8	18.9	–
			8-27-80	–	–	8.5	478.8	17.2	–
		2	4-29-80	1900	6.2	8.5	564.3	15.6	20
			8-27-80	–	–	8.5	461.7	14.4	–
		3	4-29-80	NO WATER –					
21	Sand (R)	–	–	–	–	–	–	–	–
22	Sand (L)	1	7-30-80	–	13.2	8.5	324.9	23.3	–
23	Cedar	1	5-15-80	5000	7.2	8.5	324.9	15.6	45
		2	5-15-80	1800	2.7	8.5	615.6	16.7	310
			8-8-80	–	–	8.5	495.9	20.6	–
		3	5-15-80	13,500	8.0	8.5	324.9	14.4	10
24	Magpie	–	–	–	–	–	–	–	–
25	Clear	1	8-27-80	–	–	8.5	290.7	19.4	–
		2	7-30-80	–	13.4	8.5	564.3	25.6	–
26	Cabin	1	5-14-80	620	15.5	8.5	171.0	17.2	125
			8-9-80	–	–	8.5	188.1	29.4	–
		2	10-31-80	3680	9.7	8.5	735.3	19.4	10
			8-9-80	–	–	8.5	513	22.8	–
27	Crackerbox	1	5-20-80	1130	13.8	8.5	239.4	19.4	1
			8-28-80	–	–	8.5	427.5	23.3	–
28	Bad Route	1	5-13-80	820	11.6	8.5	239.4	20.6	30
			8-28-80	–	–	8.5	222.3	17.8	–
		2	5-13-80	1600	15.6	8.5	495.9	15.0	20
			8-11-80	–	–	10	342.0	28.9	–
		3	5-20-80	2920	10.4	8.5	239.4	19.4	1
			8-11-80	–	–	8.5	393.3	23.3	–

Table 13. Continued.

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/1	Temperature °C	Turbidity JTU
29	Hatchet	-	-	-	-	-	-	-	-
30	O'Fallon	1	4-2-80	1400	-	8.5	376.2	6.7	-
			5-2-80	1400	-	8.5	273.6	17.8	70
			5-30-80	700	14.8	8.5	239.4	16.7	50
			6-26-80	-	10.2	8.5	171.0	23.9	-
			7-18-80	1600	-	8.5	324.9	22.8	70
		2	4-2-80	1200	-	8.5	324.9	5.0	-
			5-2-80	2900	-	8.5	478.3	20.0	8
			5-30-80	3400	7.6	8.5	513.	17.8	40
			6-26-80	-	7.4	8.5	701.1	23.9	70
			8-22-80	-	-	8.5	222.3	19.4	-
		3	4-2-80	1350	-	8.5	359.1	5.6	-
			4-17-80	1700	-	8.5	478.8	7.2	10
			5-2-80	2800	-	8.5	581.4	19.4	34
			5-30-80	2900	7.5	8.5	598.5	17.8	25
			6-26-80	-	6.3	8.5	701.1	24.4	70
			8-5-80	-	16.0	8.5	598.5	20.6	-
		4	6-27-80	3920	5.8	8.5	735.3	19.4	42
			8-13-80	-	-	10	940.5	21.1	-
		5	6-27-80	4250	13.2	8.5	718.2	21.1	40
			8-13-80	-	-	10	1350.9	27.2	-
31	Whitney	1	7-15-80	3200	12.6	8.5	615.6	23.9	50
			8-28-80	-	-	8.5	564.3	19.4	-
		2	5-8-80	6800	-	8.5	632.7	14.4	-
32	Pennel	1	4-17-80	2700	13.4	8.5	461.7	16.7	10
		2	4-17-80	2950	12.2	8.5	427.5	20.0	5
33	Sandstone	1	7-15-80	3200	12.6	8.5	615.6	23.9	50
		2	5-8-80	2380	-	8.5	547.2	13.3	-
			8-13-80	-	-	9.0	957.6	21.1	-
34	Cherry	1	5-5-80	2530	-	8.5	735.3	21.1	10
			8-12-80	-	-	8.5	359.1	21.1	-
		2	5-13-80	2500	9.6	8.5	444.6	10.6	0
			8-12-80	-	-	8.5	427.5	21.1	-
		3	8-12-80	-	-	8.5	393.3	22.8	-
		4	5-5-80	8000	-	8.5	837.9	23.3	30
			8-12-80	-	-	9.0	324.9	23.3	-

Table 13 . Continued.

No.	Creek	Site	Date	Conductivity umhos/cm	Dissolved Oxygen PPM	pH	Alkalinity mg/1	Temperature °C	Turbidity JTU
35	Brakett	1	5-12-80	4700	7.3	8.5	872.1	15.6	-
			8-12-80	-	-	8.5	530.1	15.6	-
		2	5-12-80	3950	8.2	8.5	376.2	14.4	-
			8-12-80	-	-	8.5	307.8	16.7	-
36	Lost Man's	1	7-29-80	-	-	8.5	581.4	25.6	-
37	Crooked	1	7-28-80	-	8.6	-	444.6	28.9	-
38	Tenmile	1	5-6-80	1100	-	8.5	495.9	20.6	0
			7-15-80	1300	20	8.5	461.7	23.9	20
		2	5-6-80	900	-	8.5	564.3	11.7	15
			7-16-80	800	9.7	-	205.2	24.4	500+
39	Coal	1	5-6-80	3120	-	8.5	718.2	23.3	-
			8-14-80	-	-	8.5	649.8	20.0	-
		2	5-7-80	4780	-	8.5	1145.7	17.8	-
			8-14-80	-	-	8.5	684.	19.4	-
40	Locate	1	4-21-80	3000	10.7	8.5	718.2	12.8	5
			8-14-80	-	-	8.5	632.7	13.3	-
		2	4-21-80	2200	7.8	8.5	495.9	17.8	-
			8-13-80	-	-	8.5	478.8	15.6	-
41	Sheep	1	4-21-80	4300	13.8	8.5	735.3	20.0	90
42	Trail	-	-	-	-	-	-	-	-
43	Custer	1	4-18-80	3800	7.0	8.5	615.6	13.9	30
			8-21-80	-	-	8.5	393.3	27.2	-
		2	4-15-80	3200	11.8	8.5	427.5	16.1	2
			8-21-80	-	-	8.5	393.3	23.3	-
		3	4-15-80	1990	8.0	8.5	530.1	11.1	47
			4-21-80	-	-	8.5	136.8	-	-
44	Harris	1	4-18-80	1500	14.8	8.5	632.7	23.3	22
			5-27-80	350	7.4	8.5	119.7	20.6	85
			8-21-80	-	-	8.5	205.2	21.1	-
45	Muster	1	4-18-80	3200	13.4	8.5	735.3	22.8	40

Figure 44. The 7-day average maximum and minimum temperatures at the mouth of O'Fallon Creek, 1979.

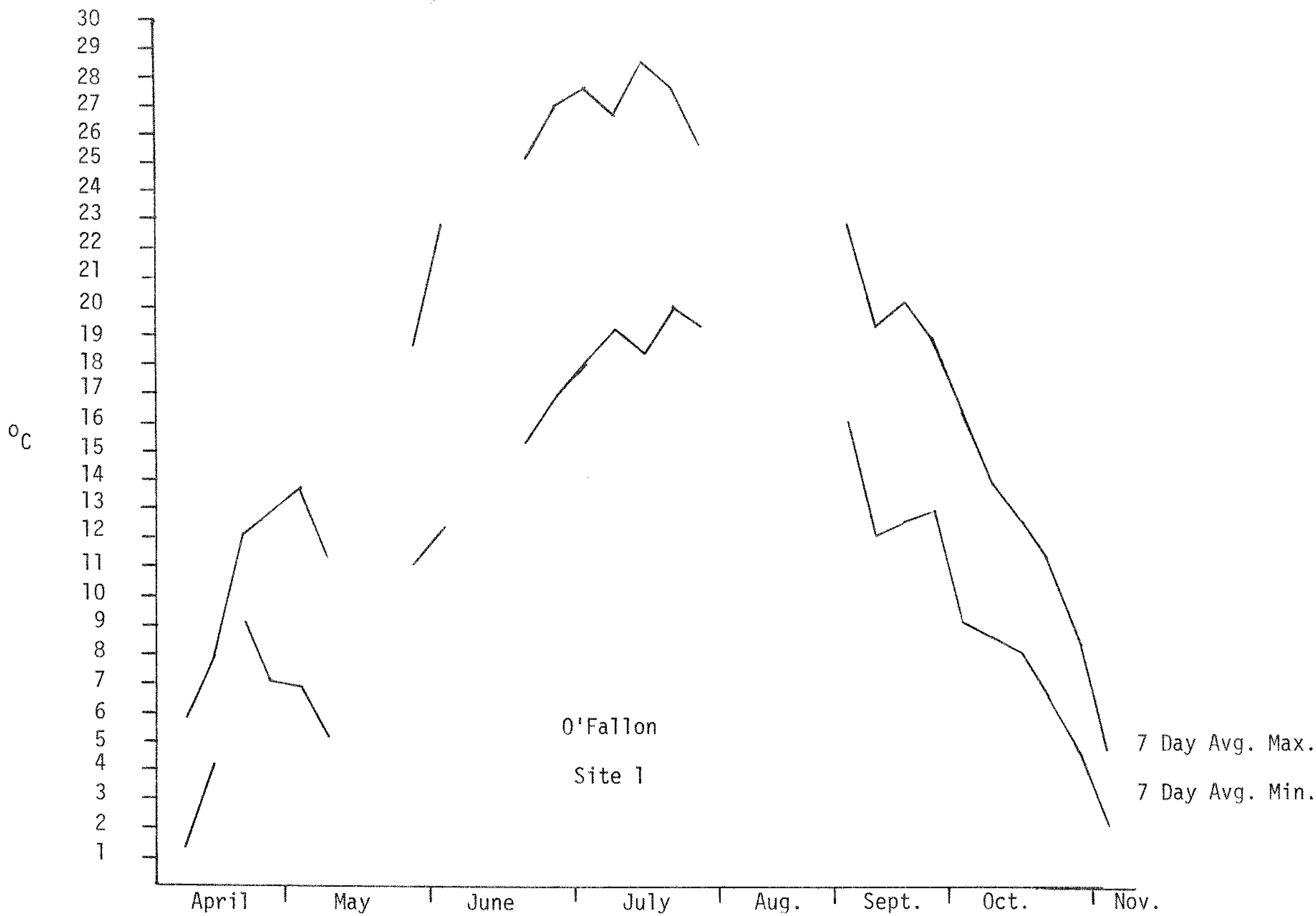


Figure 45. The 7-day average maximum and minimum temperatures at site 2 on O'Fallon Creek, 1979.

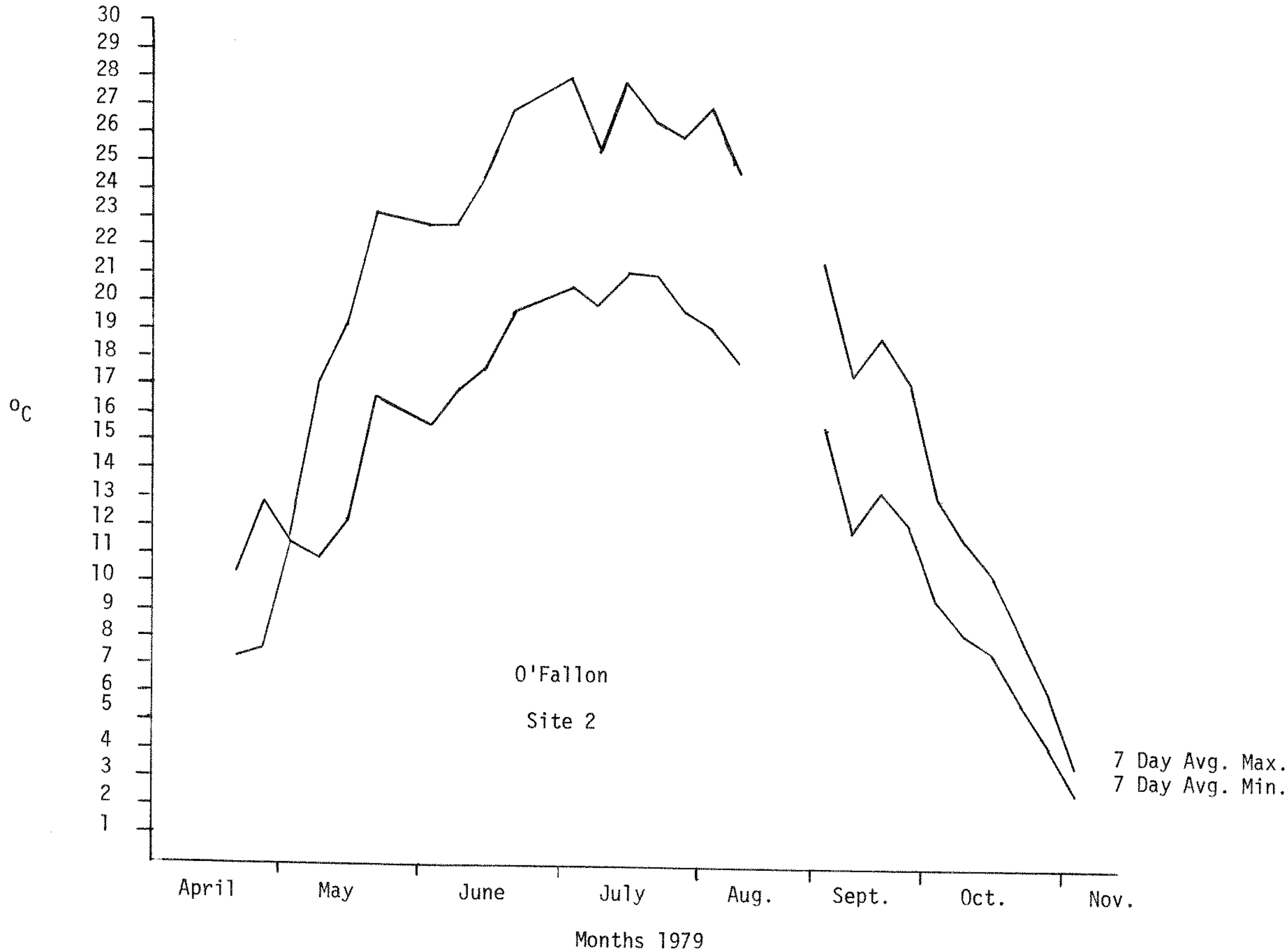
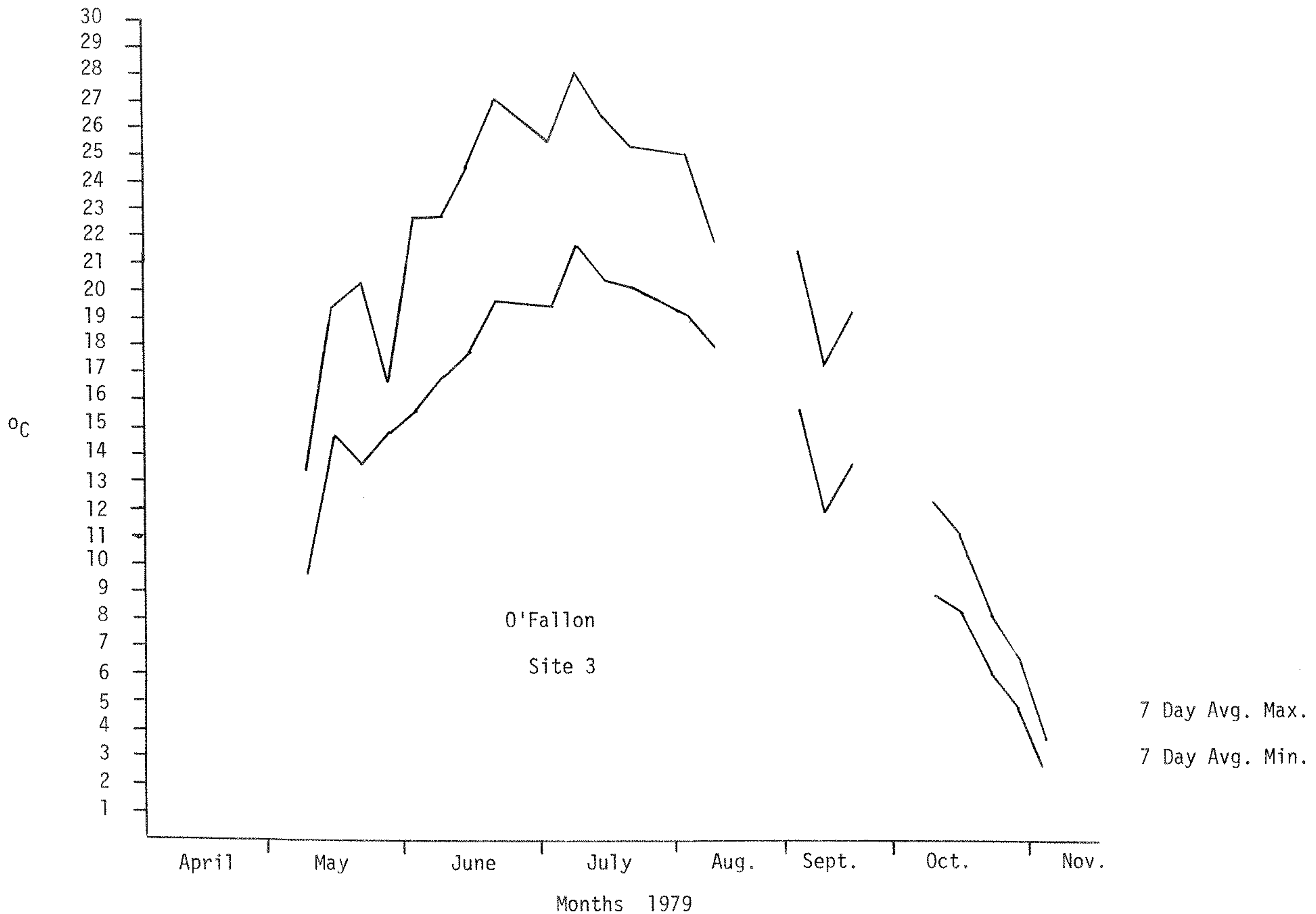


Figure 46. The 7-day average maximum and minimum temperatures at site 3 on O'Fallon Creek, 1979.



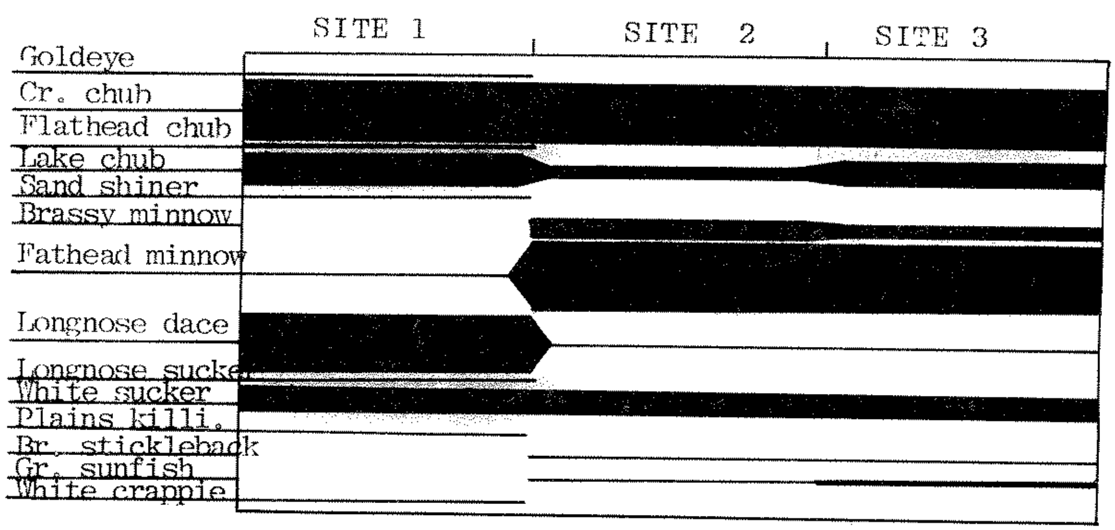


Figure 47. Kite diagram showing the distribution and relative abundance of fish species in Bad Route Creek, 1979-1980.

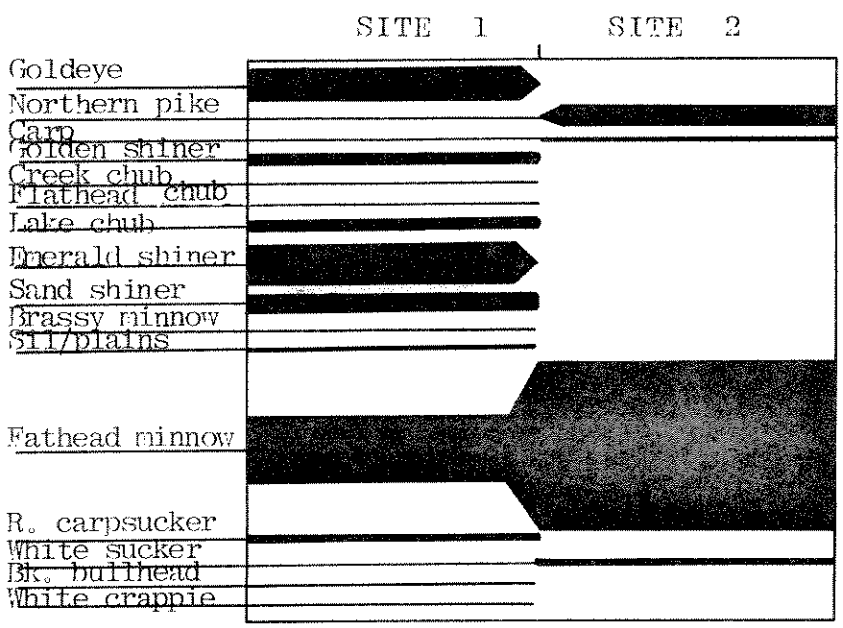


Figure 48. Kite diagram showing the distribution and relative abundance of fish species in Bennie Peer, 1979-1980.

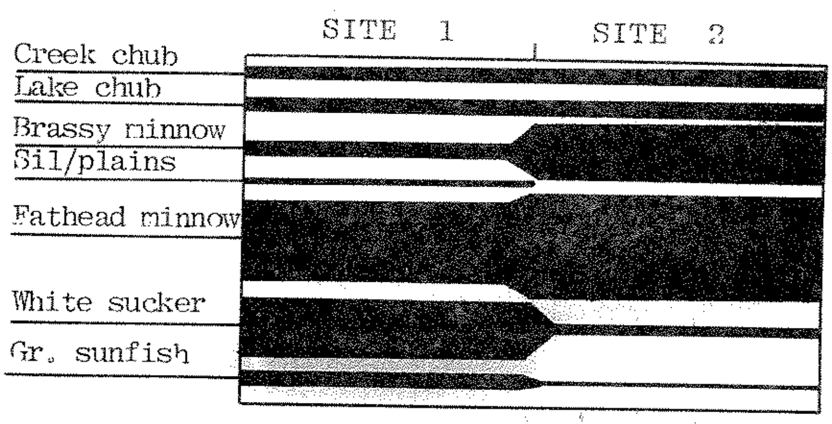


Figure 49. Kite diagram showing the distribution and relative abundance of fish species in Brakett Creek, 1979-1980.

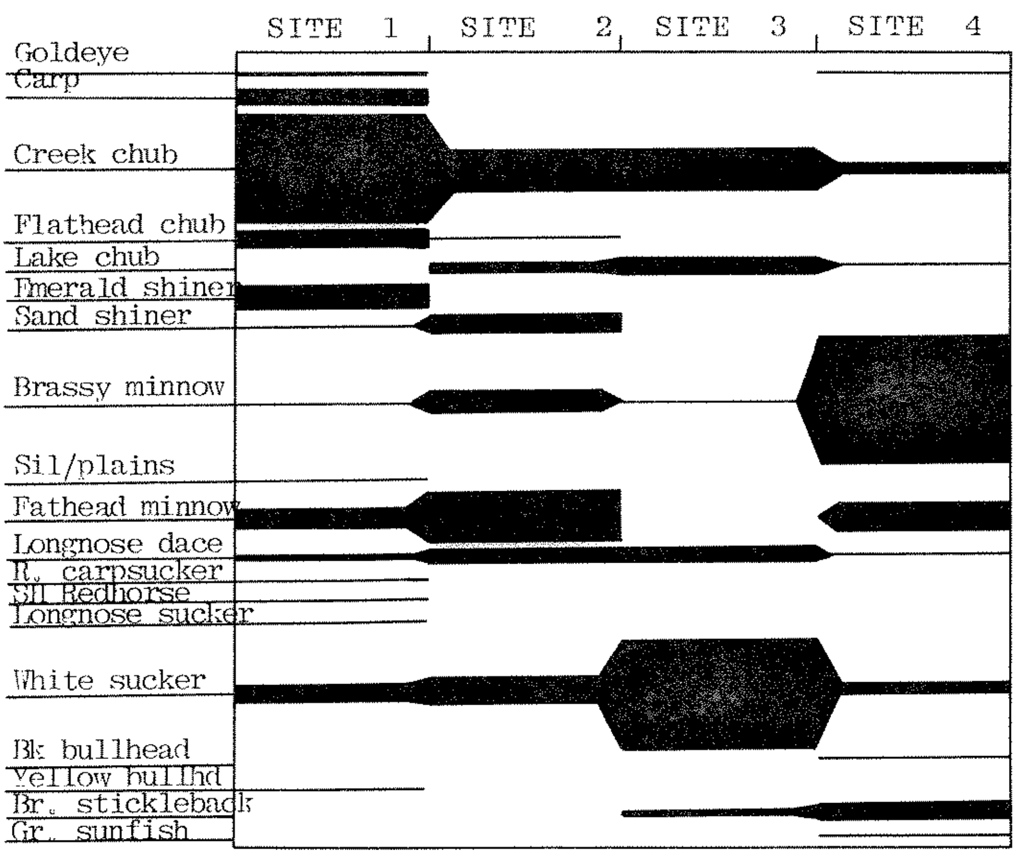


Figure 50. Kite diagram showing the distribution and relative abundance of fish species in Burns Creek, 1979-1980.

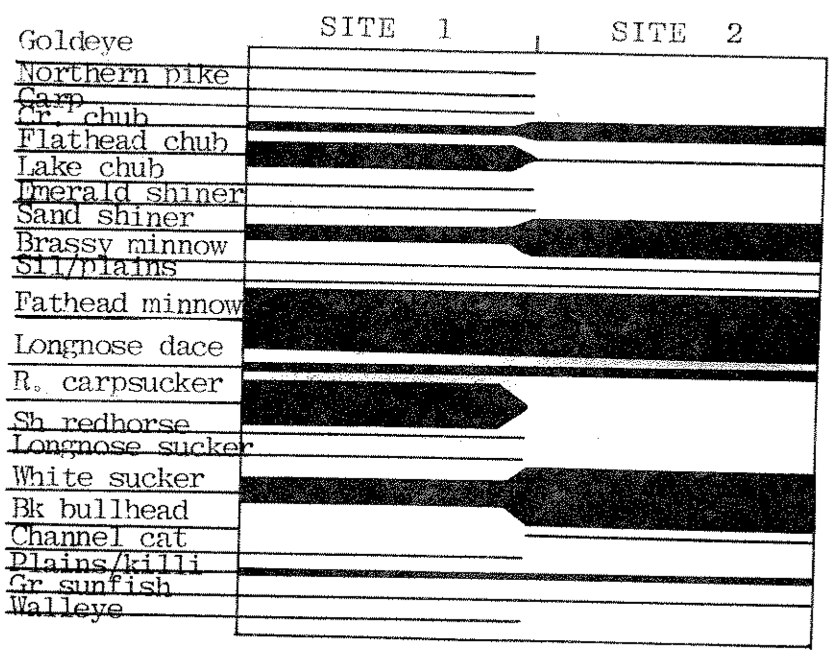


Figure 51. Kite diagram showing the distribution and relative abundance of fish species in Cabin Creek, 1979-1980.

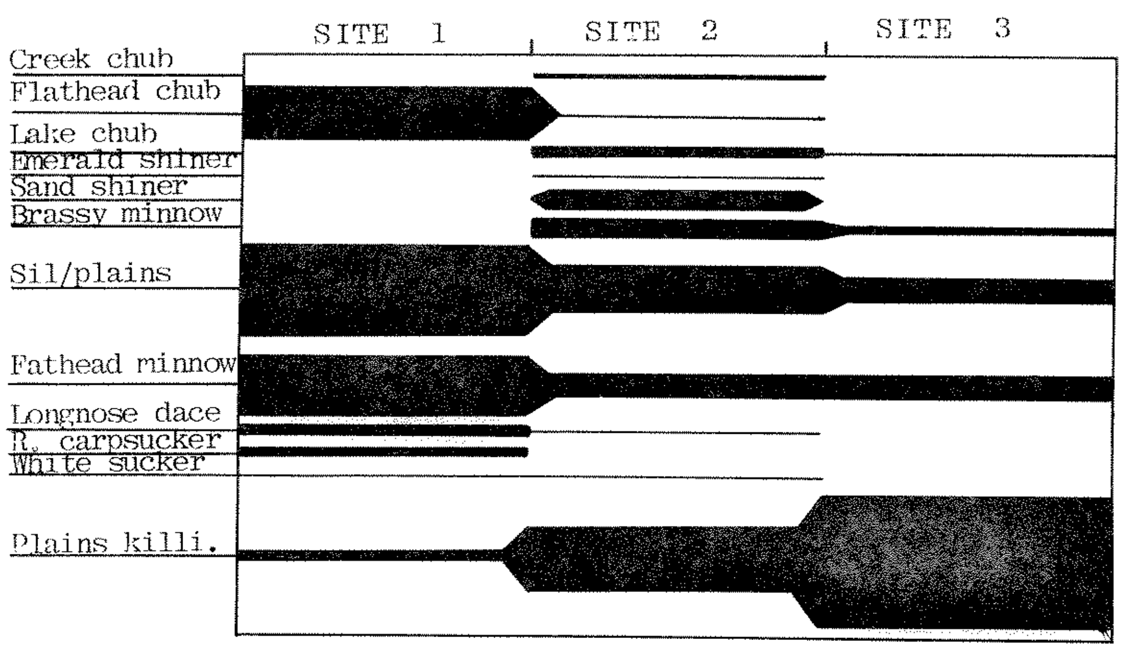


Figure 52. Kite diagram showing the distribution and relative abundance of fish species in Cedar Creek, 1979-1980.

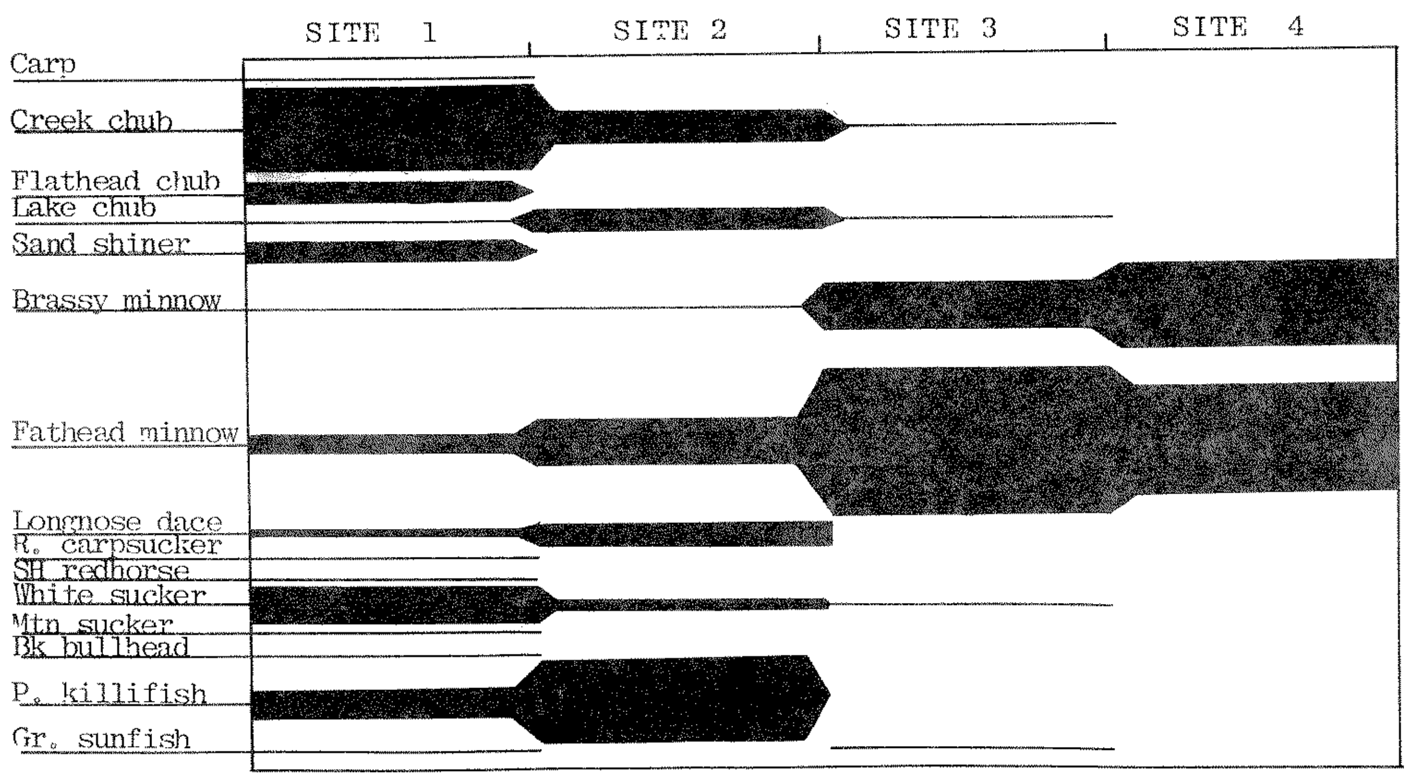


Figure 53. Kite diagram showing the distribution and relative abundance of fish species in Cherry Creek, 1979-1980.

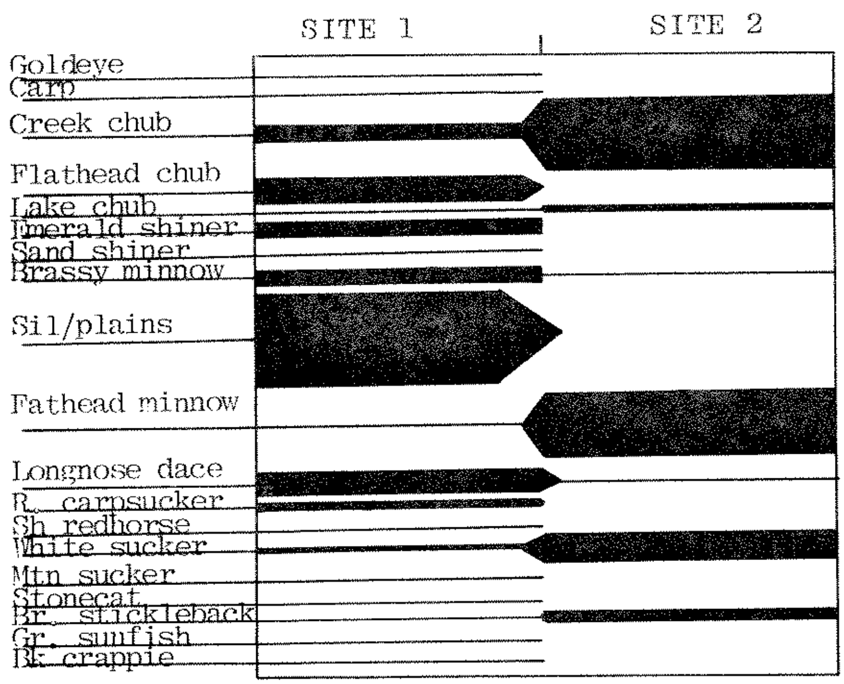


Figure 54. Kite diagram showing the distribution and relative abundance of fish species in Clear Creek, 1979-1980.

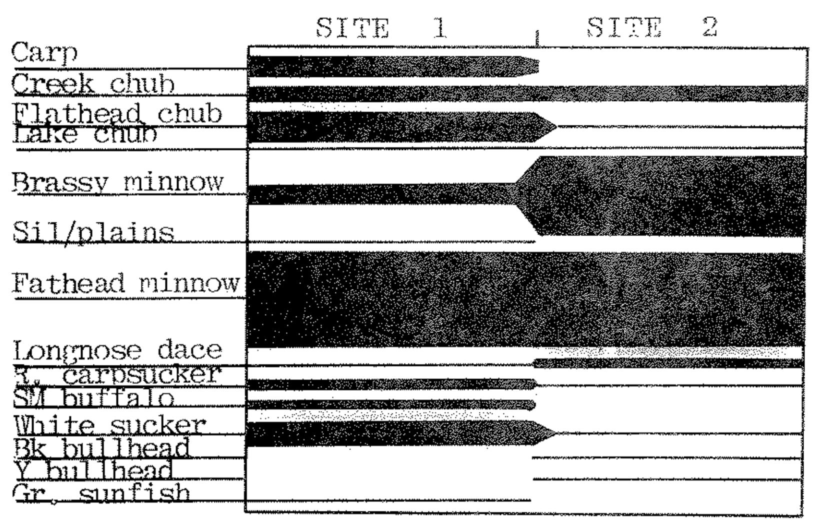


Figure 55. Kite diagram showing the distribution and relative abundance of fish species in Coal Creek, 1979-1980.

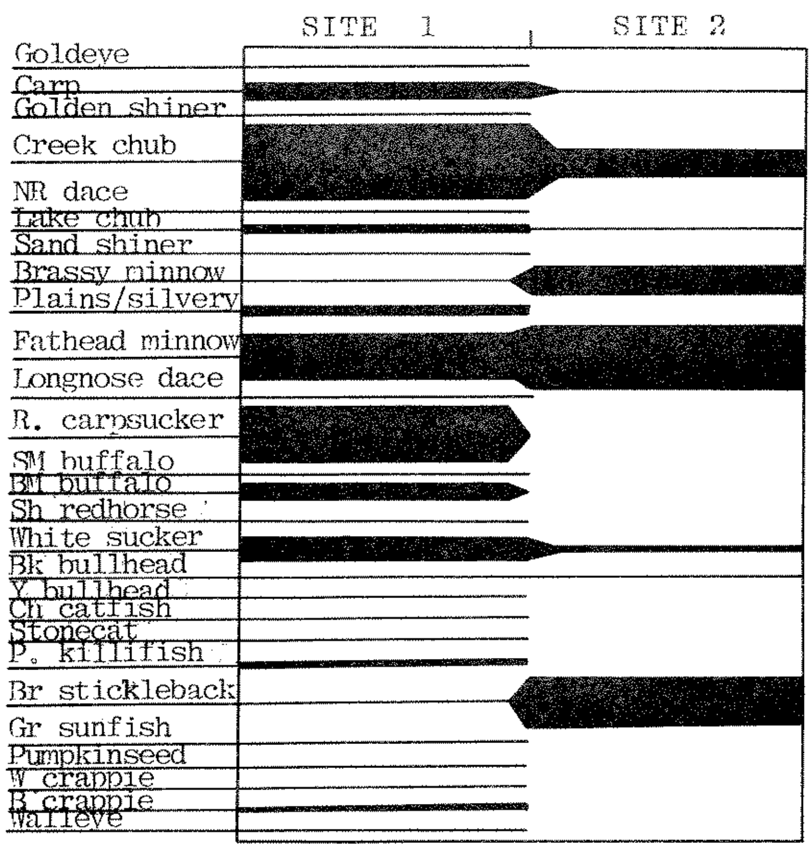


Figure 56. Kite diagram showing the distribution and relative abundance of fish species in Cottonwood Creek, 1979-1980.

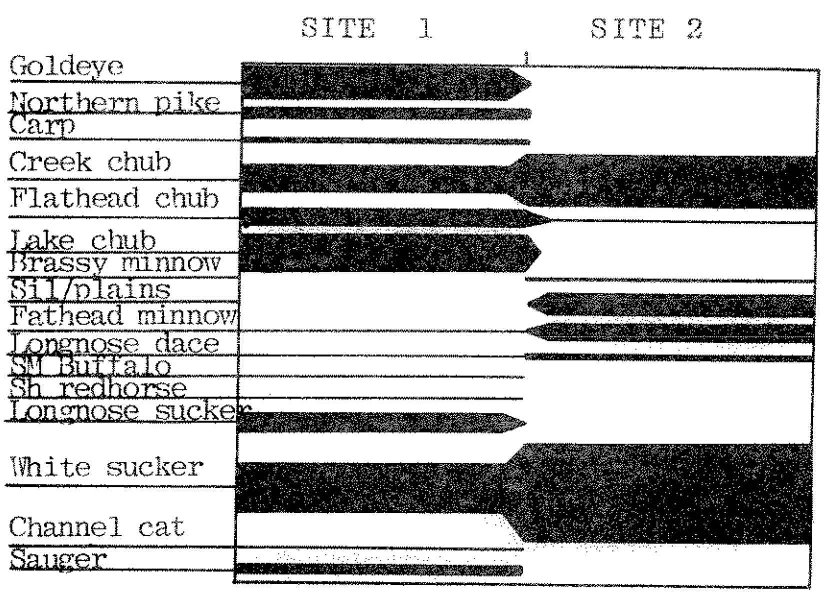


Figure 57 . Kite diagram showing the distribution and relative abundance of fish species in Crane Creek, 1979-1980.

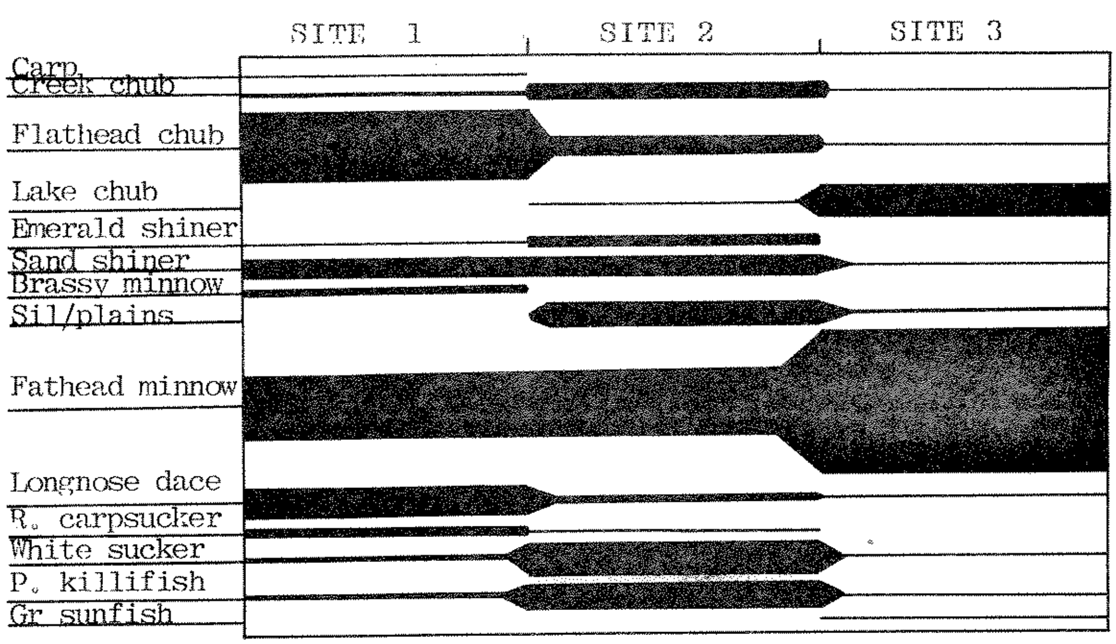


Figure 58. Kite diagram showing the distribution and relative abundance of fish species in Custer Creek, 1979-1980.

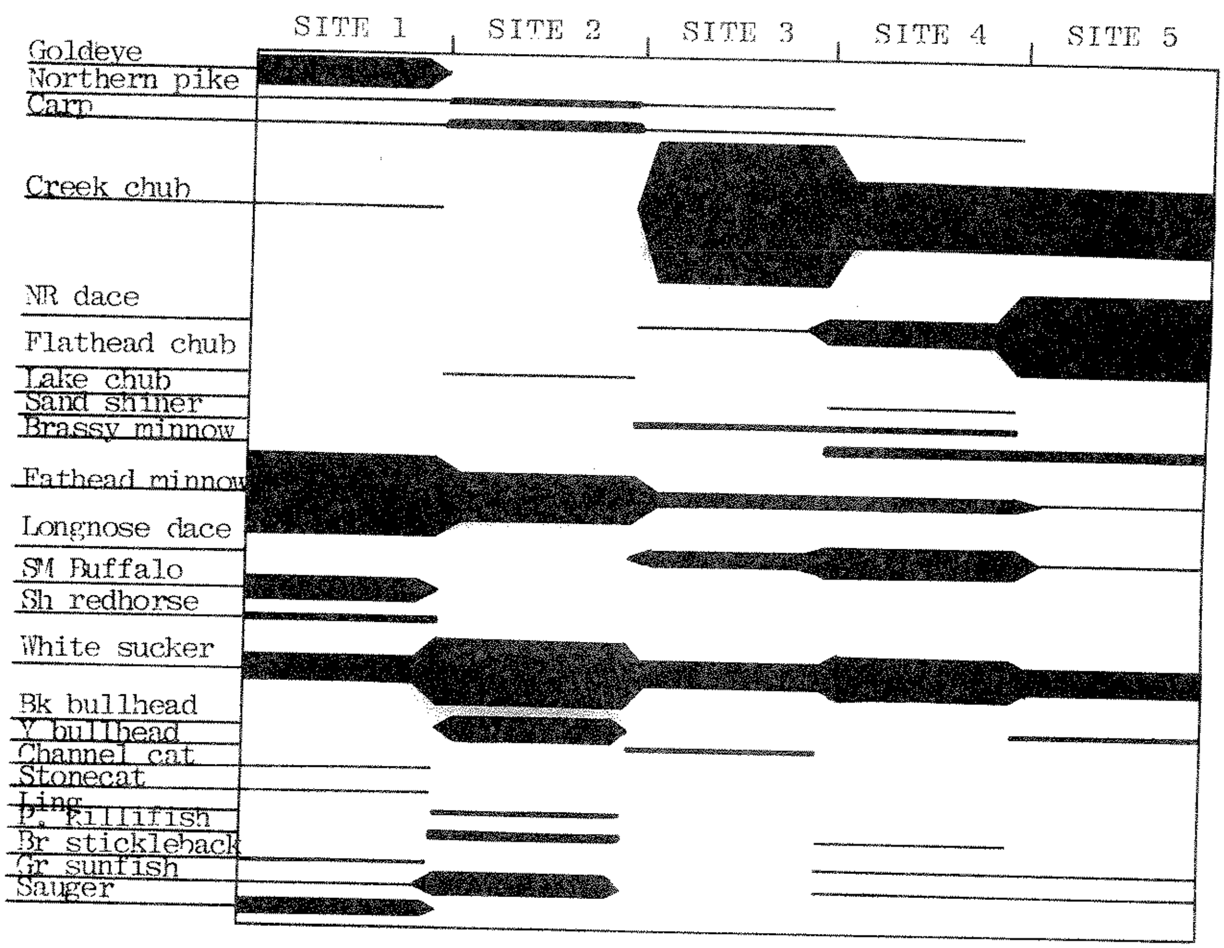


Figure 59. Kite diagram showing the distribution and relative abundance of fish species in Deer Creek, 1979-1980.

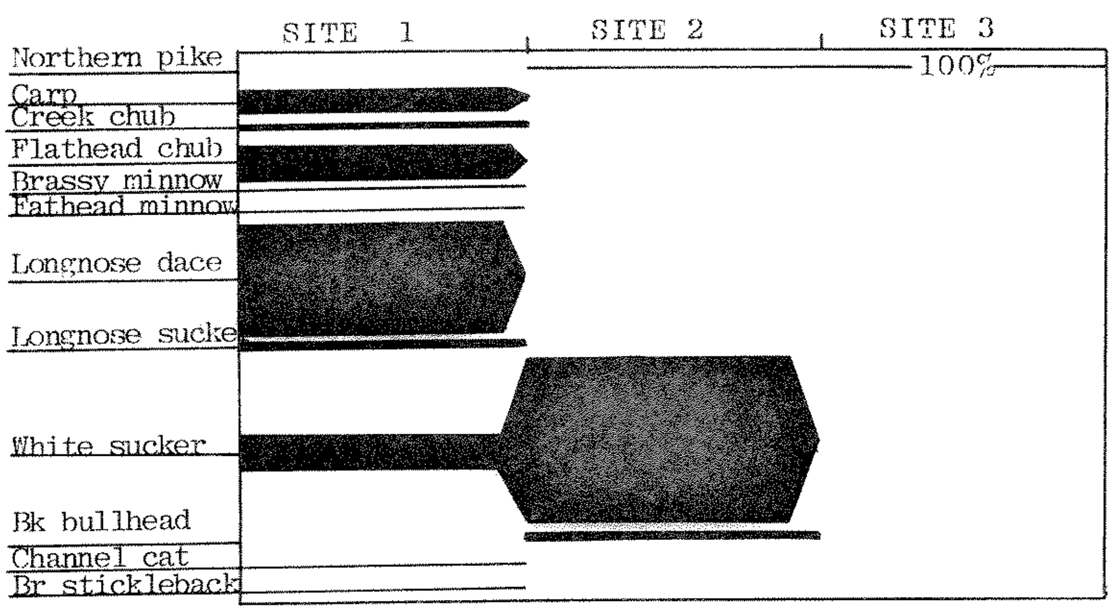


Figure 60. Kite diagram showing the distribution and relative abundance of fish species in First Hay Creek, 1979-1980.

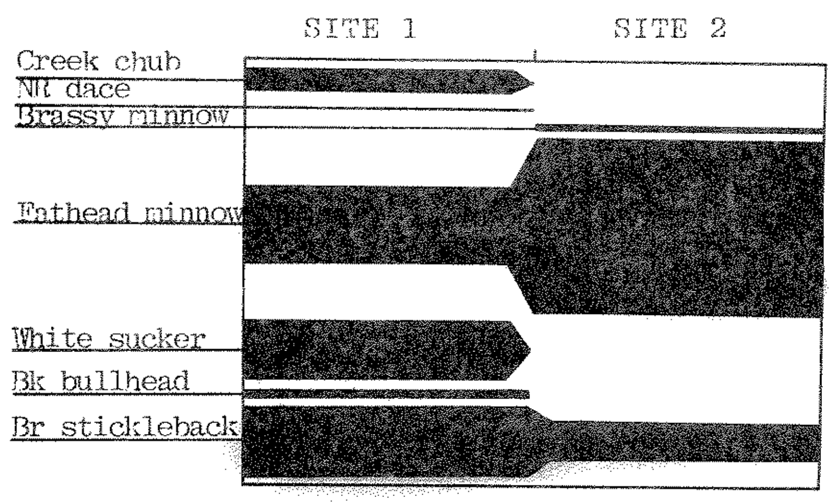


Figure 61. Kite diagram showing the distribution and relative abundance of fish species in Fourmile Creek, 1979-1980.

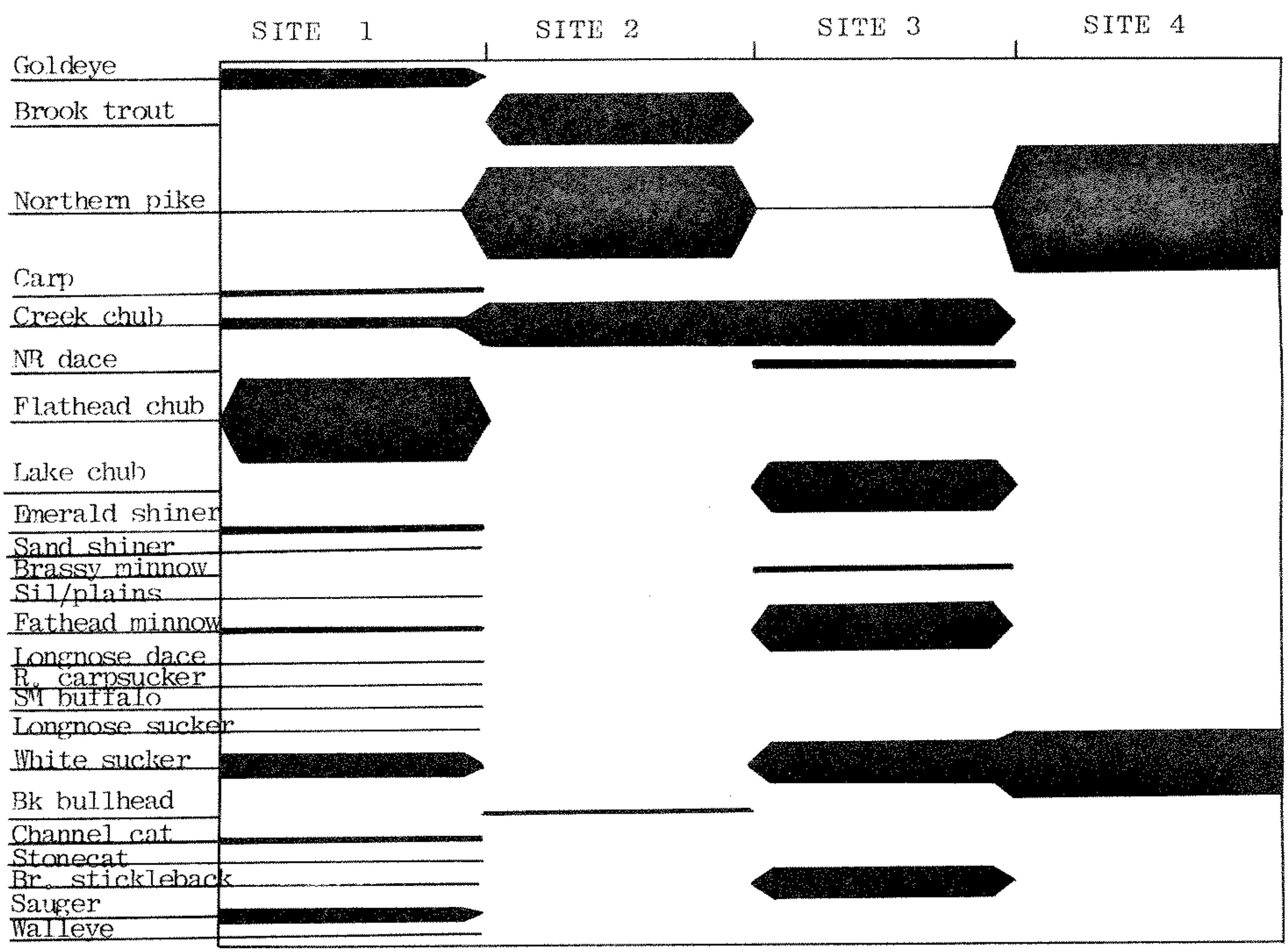


Figure 62 Kite diagram showing the distribution and relative abundance of fish species in Fox Creek, 1979-1980.

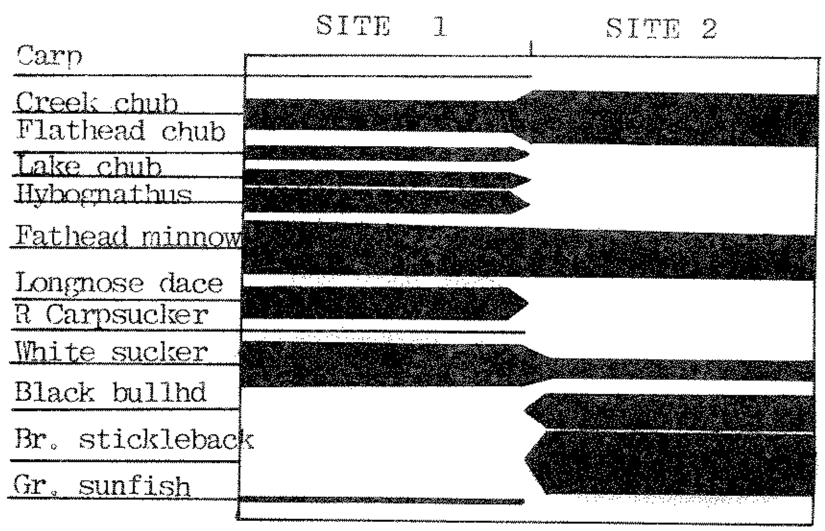


Figure 63. Kite diagram showing the distribution and relative abundance of fish species in Locate Creek, 1979-1980.

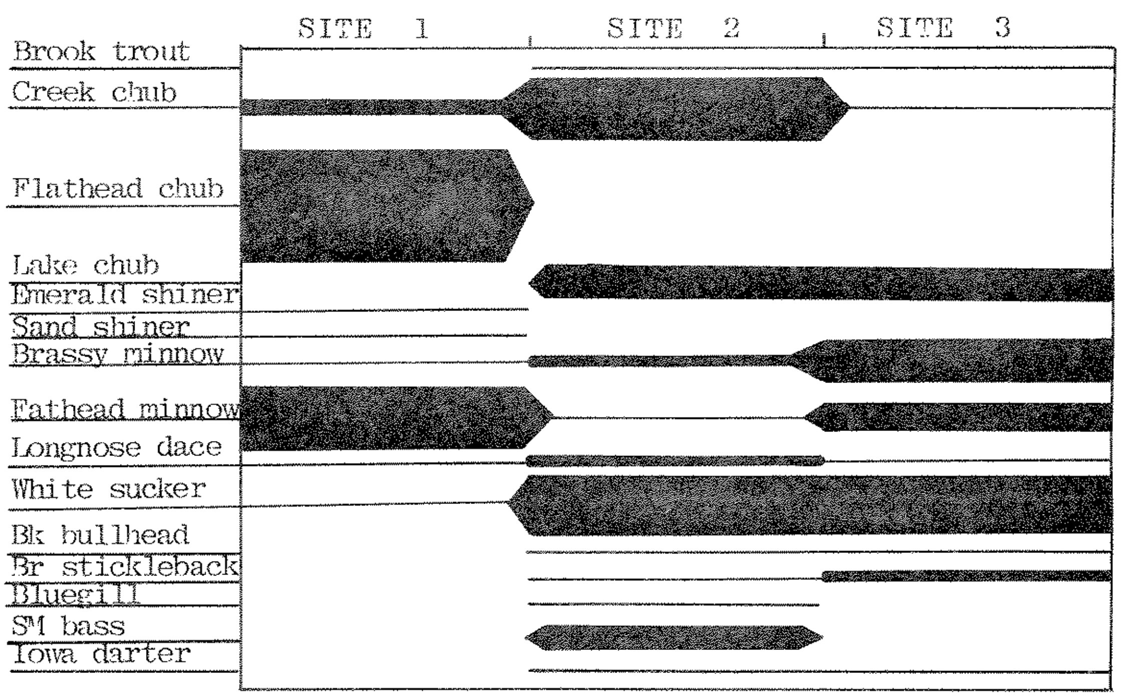


Figure 64. Kite diagram showing the distribution and relative abundance of fish species in Lone Tree Creek, 1979-1980.

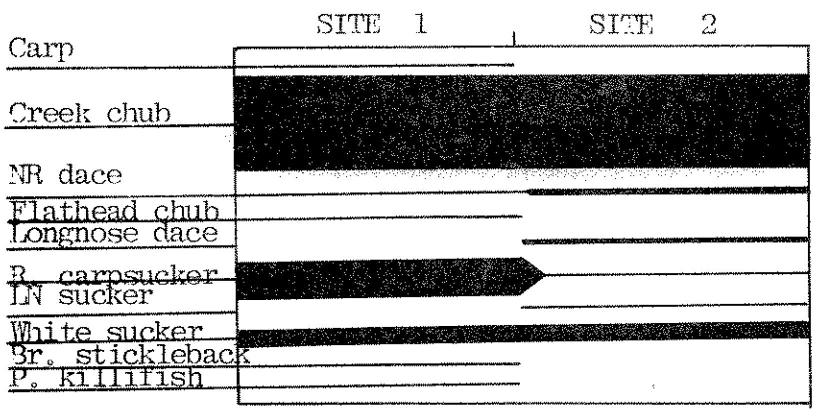


Figure 65 Kite diagram showing the distribution and relative abundance of fish species in Morgan Creek, 1979-1980.

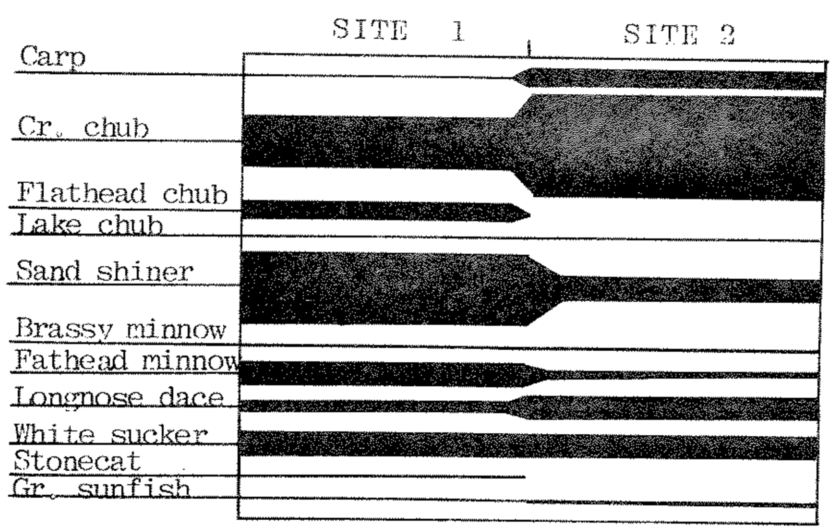


Figure 66. Kite diagram showing the distribution and relative abundance of fish species in Pennel Creek, 1979-1980.

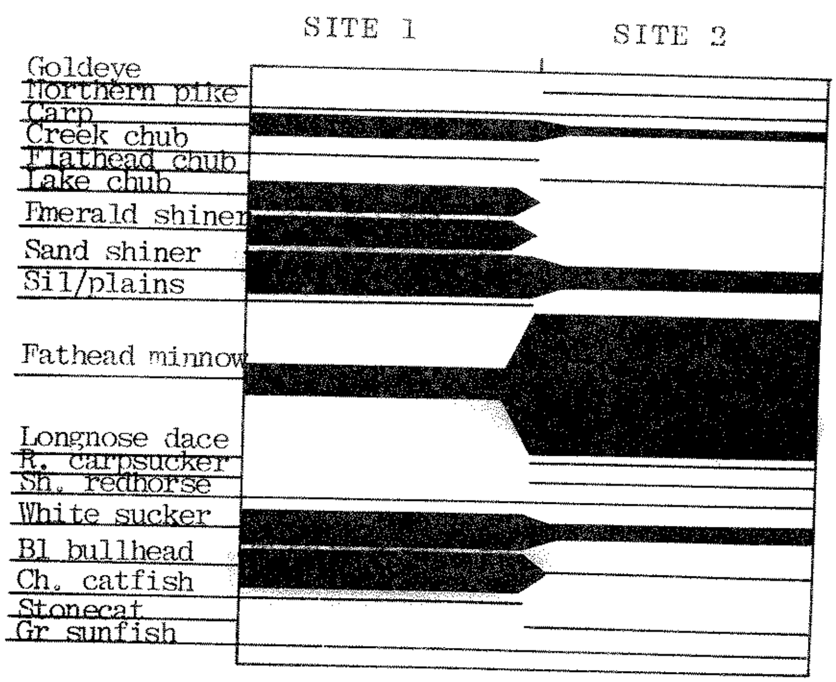


Figure 67. Kite diagram showing the distribution and relative abundance of fish species in Sandstone Creek, 1979-1980.

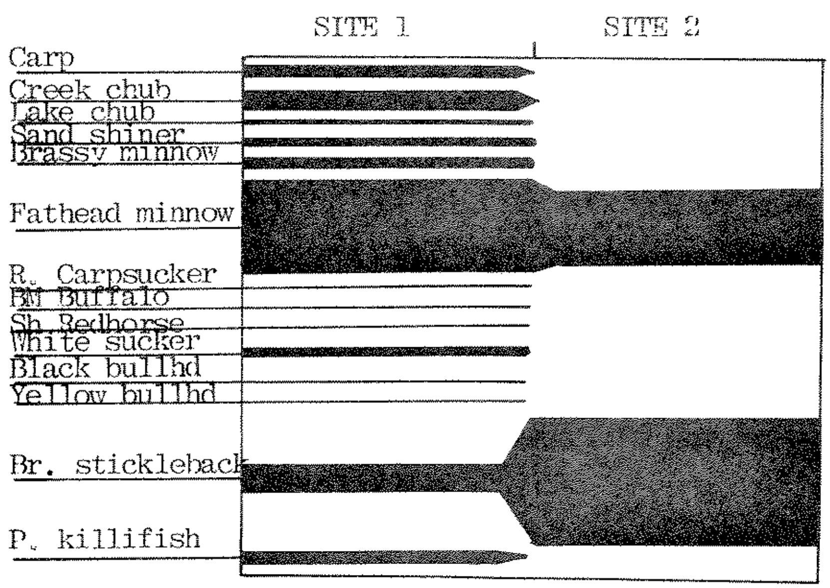


Figure 68. Kite Diagram showing the distribution and relative abundance of fish species in Shadwell Creek, 1979-1980.

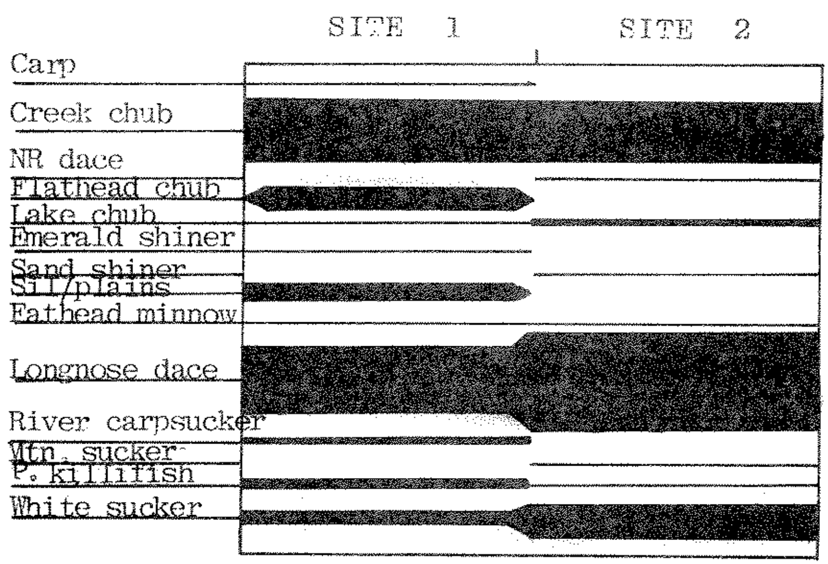


Figure 69. Kite diagram showing the distribution and relative abundance of fish species in Lower Sevenmile Creek, 1979-1980.

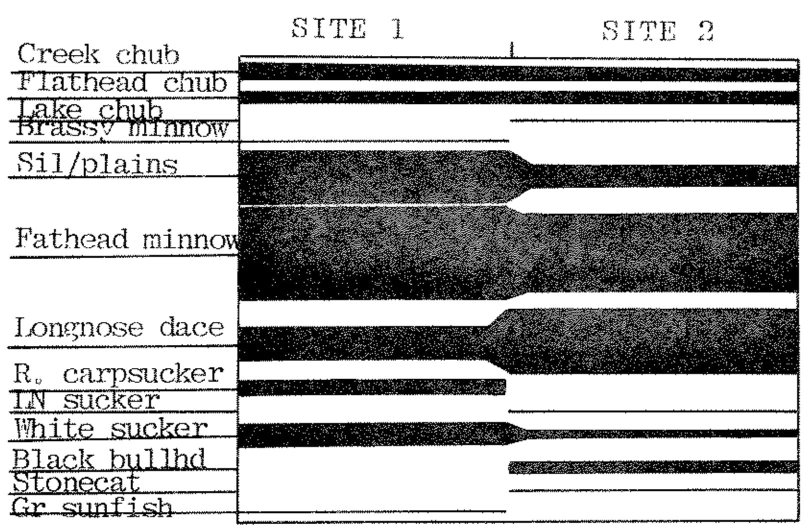


Figure 70. Kite diagram showing the distribution and relative abundance of fish species in Tenmile Creek, 1979-1980.

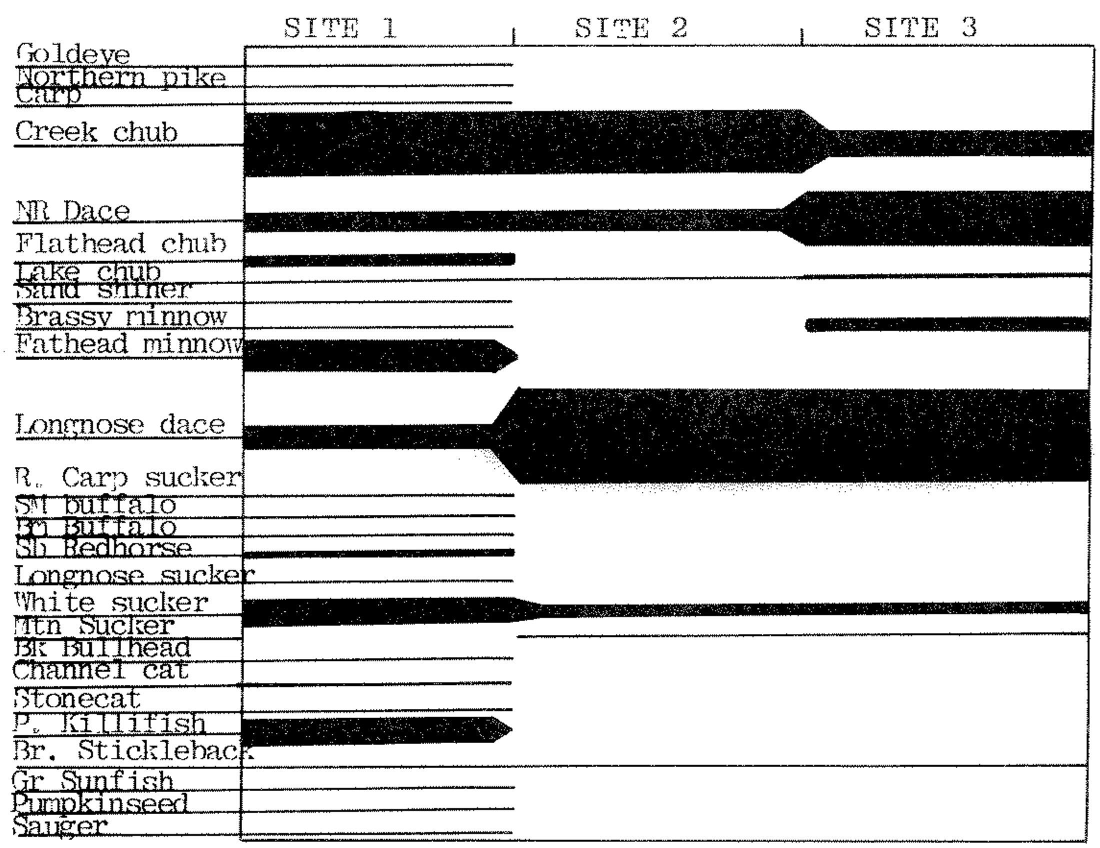


Figure 71. Kite diagram showing the distribution and relative abundance of fish species in Thirteenmile Creek 1979-1980.

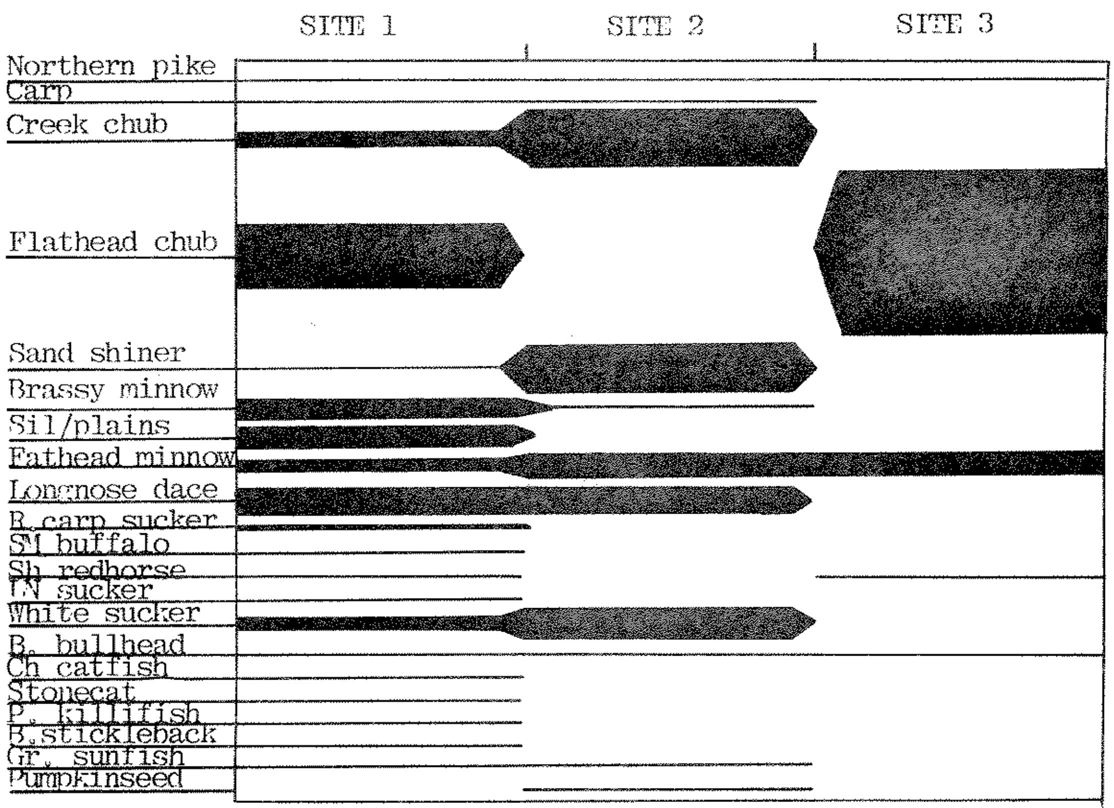


Figure 72. Kite diagram showing the distribution and relative abundance of fish species in the Upper Sevenmile Creek, 1979-1980.

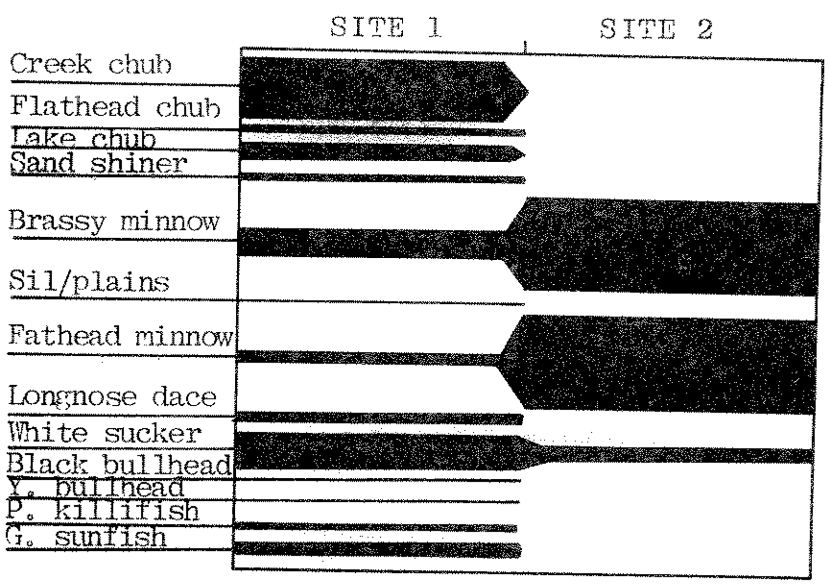


Figure 73. Kite diagram showing the distribution and relative abundance of fish species in Whitney Creek, 1979-1980.

SUPPLEMENT

Diversity Indices:

Diversity indicies were calculated for streams in the study area. Results are included in Table 14 . Meanings of the values were taken from Newell (1977). Healthy communities indicated by the high Shannon-Weaver index (d) (3.0 being high) included Fox Creek, Cottonwood Creek, Clear Creek, Cabin Creek, Whitney Creek, Locate Creek, and O'Fallon Creek.

Equitability, according to Newell (1977), is sensitive to even slight levels of degradation. Good values are considered to be from 0.0 to 0.3. The values determined for equitability indicated that the study streams were healthy communities.

Redundancy values are a measure of the repetition of information within a community. It is an expression of dominance of one or more species and is inversely proportional to the wealth of the species. Creeks which had smaller values for redundancy and thus indicated a large choice of species were Cedar, Clear, Whitney, Pennel, Locate, and Custer creeks.

Evenness indicates whether species abundances are equal or differ from one another. Accordingly, the greater the differences in species abundances the smaller the evenness. Most values for evenness were similar. Dunlap Creek and Sandstone Creek had the lowest values.

Species richness is a measure of the number of species, the higher the values the larger the number of species. Creeks with the higher values included Fox Creek, Cottonwood Creek, Clear Creek, Whitney Creek, Locate Creek, and Custer Creek.

Table 14 . Shannon-Weaver diversity indices for study streams. Symbols (d), Max (d), and min (d) refer to diversity, maximum diversity and minimum diversity, respectively.

Stream	(d)	Max (d)	Min (d)	Redundancy	Evenness	Equitability	Species Richness
Fourmile	1.9382	2.8073	.0606	.3164	.6904	.1907	1.7475
First Hay	2.2467	3.5849	.3830	.4179	.6267	,2776	1.9691
Bennie Peer	2.7839	3.9999	.1732	.3177	.6959	.2799	2.5040
Lone Tree	2.7015	3.9068	.0590	.3132	.6914	.2330	2.4685
Fox	3.2883	4.5849	.2727	.3006	.7171	.3321	2.9561
O'Brien	–	–	–	–	–	–	–
Crane	2.8641	3.9999	.6026	.3343	.7160	.3650	2.4991
Shadwell	1.9940	3.8073	.0719	.4854	.5237	.1788	1.8151
Sears	2.4237	3.4594	.6049	.3628	.7006	.3394	2.0842
Dunlap	1.4446	3.4594	.4963	.6799	.4176	.1930	1.2516
Burns	2.5354	4.2479	.0552	.4084	.5968	.2093	2.3260
Cottonwood	3.1457	4.7548	.1592	.3501	.6615	.2863	2.8593
War Dance	2.2717	3.8073	.2929	.4369	.5966	.2572	2.0144
Thirteenmile	2.7725	4.7004	.0942	.4185	.5898	.2354	2.5370
Morgan	2.0817	3.5849	.0938	.4305	.5806	.1993	1.8823
Lower Sevenmile	2.3254	3.3073	.0905	.3987	.6107	.2157	2.1096
Threemile	–	–	–	–	–	–	–
Deer	2.4464	4.5235	.0831	.4677	.5408	.2078	2.2386
Dry	–	–	–	–	–	–	–
Upper Sevenmile	2.8401	4.3923	.1113	.3625	.6466	.2549	2.5852
Sand (R)	–	–	–	–	–	–	–
Sand (L)	1.9086	3.3219	.2676	.4627	.5745	.2282	1.6803
Cedar	2.5686	3.5849	.0656	.2887	.7165	.2329	2.3357
Magpie	–	–	–	–	–	–	–
Clear	3.0478	4.2479	.1260	.2911	.7174	.2830	2.7647
Cabin	2.9136	4.3923	.1125	.3455	.6633	.2619	2.6517
Crackerbox	1.3334	2.5849	.1313	.5100	.5158	.1555	1.1779
Bad Route	2.5069	3.8073	.0359	.3448	.6584	.2041	2.3027
Hatchet	–	–	–	–	–	–	–

Table 14. Continued.

Stream		(d)	Max (d)	Min (d)	Redundancy	Evenness	Equitability	Species Richness
O'Fallon	1	2.8432	4.3923	.0909	.3601	.6473	.2478	2.5953
	2	2.7465	3.8073	.5708	.3277	.7213	.3570	2.3895
	3	2.9650	4.2479	.0970	.3090	.6979	.2648	2.7001
	4	2.4361	3.9068	.1135	.3877	.6235	.2314	2.2047
	5	1.5995	3.3219	.0636	.5286	.4815	.1487	1.4507
Whitney		2.9002	3.7004	.1430	.2249	.7837	.2932	2.6070
Pennel		2.5005	3,4594	.1116	.2864	.7228	.2500	2.2505
Sandstone		1.8298	4.1699	.0703	.5708	.4388	.1574	1.6723
Cherry		2.5343	3.9068	.0538	.3432	.6614	.2200	2.3642
Brakett		2.0087	2.8073	.0321	.2877	.7155	.1792	1.8295
Lost Man's		1.6691	1.9999	.6988	.2542	.8345	.3551	1.3140
Crooked		1.4038	1.9999	.2613	.3428	.7019	.2157	1.1881
Tenmile		2.3797	3.7004	.0955	.3663	.6430	.2254	2.1543
Coal		2.2478	3.8073	.1068	.4214	.5904	.2139	2.0338
Locate		2.9236	3.5849	.0517	.1871	.8155	.2561	2.6675
Sheep		2.4305	3.3219	.3288	.2978	.7316	.3033	2.1271
Trail		–	–	–	–	–	–	–
Custer		2.8938	3.8073	.0357	.2422	.7600	.2355	2.6583
Harris		2.0557	3.8073	.1034	.4729	.5399	.1947	1.8610
Muster		1.6063	2.5849	.1561	.4029	.6214	.1939	1.4123