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MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

AN ANALYSIS OF THE AQUATIC RESOURCES OF THE HANGING WOMAN CREEK AND OTTER CREEK DRAINAGES, MONTANA

FINAL REPORT

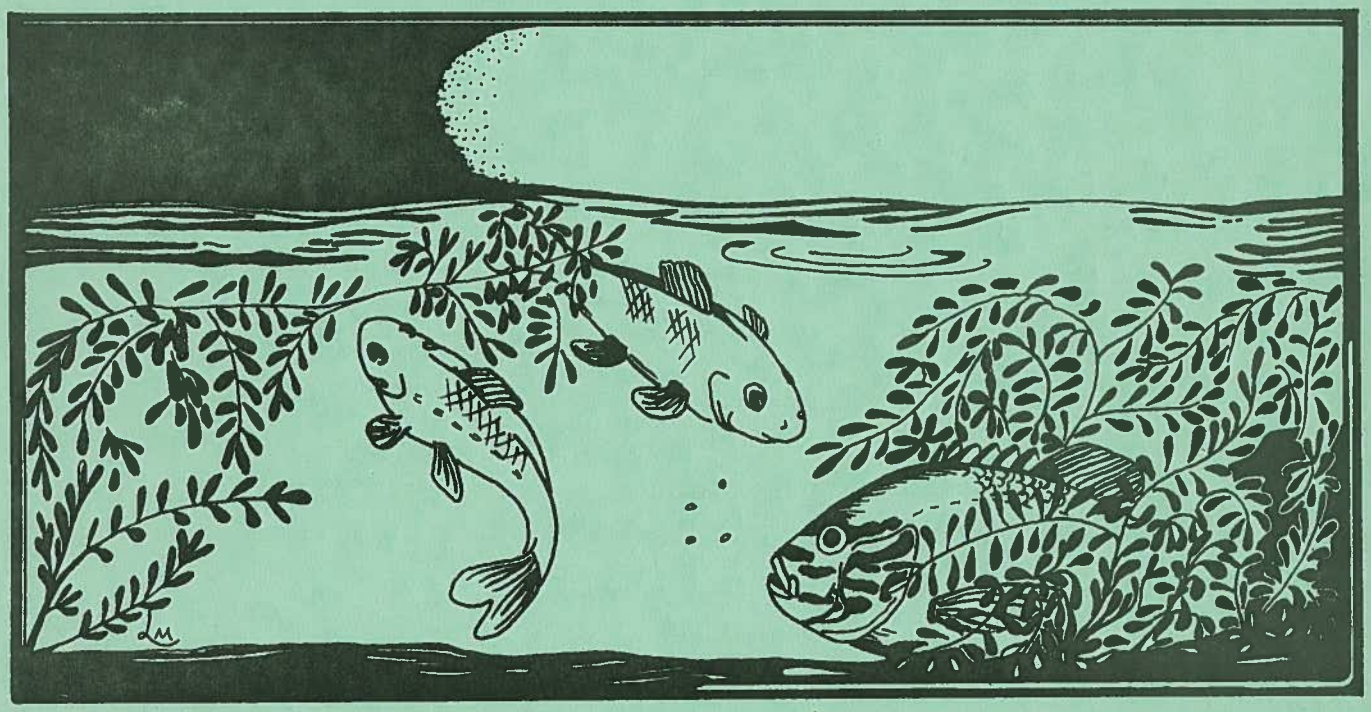

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TABLE OF CONTENTS

Introduction..... 1
Study Area..... 1
Location..... 1
Study Streams..... 1
Stream Condition..... 1
Land and Water Use..... 3
Coal..... 4
Methods..... 4
Results..... 6
Stream Characteristics..... 6
Riparian Analysis.....13
Chemical Parameters.....16
Water Temperature.....21
Aquatic Macroinvertebrates.....26
Shannon-Weaver Diversity Indicies.....27
Fish.....36
Distribution.....36
Species Composition.....38
Spring Trapping and Electrofishing Results.....43
Hanging Woman Creek.....43
Otter Creek.....45
Shannon-Weaver Diversity Indicies.....52
Classification of Streams.....55
Discussion.....56
Literature Cited.....61

LIST OF FIGURES

1. The study area showing all streams included in the investigation..... 2

2. Temperature data on Otter Creek, site 1, for 1980.....22

3. Temperature data on Otter Creek, site 1, for 1981.....23

4. Temperature data on Hanging Woman Creek, site 1, for 1980....24

5. Temperature data on Hanging Woman Creek, site 1, for 1981....25

6. Results showing the number of fish collected during spring trapping in 1980 (-) and 1981 (---) on Hanging Woman Creek...44

7. 1980 Hanging Woman trapping results comparing the movements of white sucker (-), shorthead redhorse (---), and river carpsucker (-·-·-·).....46

8. Results showing the number of fish collected during spring trapping in 1980 (-) and 1981 (---) on Otter Creek.....47

9. 1980 Otter Creek trapping results comparing movements of white sucker (-), shorthead redhorse (---), and river carpsucker (-·-·).....49

10. 1981 Otter Creek trapping results comparing movements of white sucker (-), shorthead redhorse (---), and river carpsucker (-·-·).....50

11. Movement of white sucker and shorthead redhorse females (-) and males (---) into the mouth section of Otter Creek by species and year.....51

LIST OF TABLES

1. Coal reserves, acreage, and tons per acre, selected coal deposits..... 5

2. Stream drainage characteristics for Otter Creek. Symbols represent: E-excellent, G-good, F-fair, P-poor, N-none..... 8

3. Stream drainage characteristics for Otter Creek tributaries. Symbols represent: E-excellent, G-good, F-fair, P-poor, N-none..... 9

4. Stream drainage characteristics for Hanging Woman Creek. Symbols represent: E-excellent, G-good, F-fair, P-poor, N-none.....10

5. Stream drainage characteristics for Hanging Woman tributaries, Poker Jim Creek and O'Dell Creek. Symbols represent: E-excellent, G-good, F-fair, P-poor, N-none.....11

6. A breakdown (in percent) of the basal density by category for sites in the Otter Creek drainage.....14

7. A breakdown (in percent) of the basal density by category for sites in the Hanging Woman Creek drainage.....14

8. Distribution of streamside vegetation by species for the Otter Creek drainage.....17

9. Distribution of streamside vegetation by species for the Hanging Woman Creek drainage, Poker Jim Creek and O'Dell Cr..19

10. Distribution of macroinvertebrates in the study area, 1980-1981.....28

11. Shannon-Weaver diversity indicies for macroinvertebrates by stream in the study area. Symbols (d), max (d) and min (d) refer to diversity, maximum diversity and minimum diversity..34

12. Taxonomic status, scientific and common names of fish sampled in the study area..... 37

13. Distribution of fish species in the study area..... 39

14. Species composition expressed as numbers caught and percent of total sample at each Hanging Woman Creek sample site, 1980-1981. Percent in parenthesis..... 40

15. Species composition expressed as numbers caught and percent of total sample at each Otter Creek sample site 1980-1981. Percent in parenthesis..... 41

LIST OF TABLES (CONTINUED)

16. Percent composition of species collected at tributary sites. (P) indicates that species is present but number unknown.....42

17. Shannon-Weaver diversity indicies for fish species in the study area. Symbols (d), max (d) and min (d) refer to diversity, maximum diversity and minimum diversity.....53

18. Stream classification values for streams in the Hanging Woman Creek-Otter Creek study..... 57

Appendix Tables

A. A list of all study streams and sample sites investigated. The location numbers are based on the federal system of land subdivision..... 65

B. List of scientific and common names for streamside plant species identified at study sites..... 67

C. Woody species expressed as percent basal density for sites in the Otter Creek drainage..... 68

D. Grasses, sedges and rushes expressed as percent basal density for sites in the Otter Creek drainage. TV indicates terrestrial vegetation..... 69

E. Forbs expressed as percent basal density for sites in the Otter Creek drainage..... 70

F. Woody species expressed as percent basal density for all sites in the Hanging Woman drainage, Poker Jim Creek and O'Dell Cr.. 71

G. Grasses, sedges and rushes expressed as percent basal density for all sites in the Hanging Woman drainage, Poker Jim Creek and O'Dell Creek..... 72

H. Forbs expressed as percent basal density for all sites in the Hanging Woman drainage, Poker Jim and O'Dell Creeks..... 73

I. A summary of water chemistry data for the Otter Creek drainage, 1980-1981..... 74

J. A summary of water chemistry data for the Hanging Woman Creek drainage, 1980-1981..... 77

K. Information collected on sport fish, mouth of Hanging Woman Creek, 1980-1981..... 79

L. Information collected on sport fish, mouth of Otter Creek, 1980-1981..... 80

ABSTRACT

An aquatic inventory of the Hanging Woman Creek drainage, the Otter Creek drainage, Poker Jim Creek and O'Dell Creek was conducted during 1980 and 1981. The streams under study were typical prairie type streams located in an agricultural area. Hanging Woman Creek and Otter Creek were the most permanent streams investigated.

Twenty-five species of fish representing six families were identified. The largest group of species were the cyprinids. Five species of sport fish including, smallmouth bass (*Micropterus dolomieui*), northern pike (*Esox lucius*), sauger (*Stizostedion canadense*), walleye (*Stizostedion viteum*) and channel catfish (*Ictalurus punctatus*) were identified in the lowest reaches of Hanging Woman Creek and Otter Creek. Northern pike and smallmouth bass utilize these waters in the spring as spawning and rearing areas. Three other species, white sucker (*Catostomus commersoni*), shorthead redhorse (*Moxostoma macrolepidotum*) and river carpsucker (*Carpoides carpio*) also migrate from the Tongue River in a particular pattern of movement to utilize these waters for spawning. Streams were classified according to Montana Fish, Wildlife and Parks stream classification procedure and determined to have ratings of a limited fishery resource or a substantial fishery resource.

Aquatic macroinvertebrate diversity was generally high in the study area. The majority of individuals collected represented seven orders of the class Insecta. Diptera was the most common order, occurring in 90% of the streams sampled.

In most instances, the streams are characterized by a well defined riparian zone. An analysis of stream conditions indicate that the area has not suffered excessive use and/or damage as a result of agriculture, stock grazing or natural causes. A ratio of the pool, run, and riffle areas for all study sites within the study area was determined to be 7:11:1, respectively. Silt and muck-type bottoms were the most common substrate encountered.

INTRODUCTION

In recent years attention has been directed towards the coal deposits of southeastern Montana and the potential for their development. Within the study area, federal coal reserves in the Hanging Woman Coal Area cover 30,178 acres (12,213 ha) and contain 1,558,658,000 tons of coal. In the Otter Creek area (Moorhead Coal Area) 2,369,314,000 tons of coal underlie 30,933 acres (12,519 ha) (USDI 1981). In anticipation of mineral development, the Bureau of Land Management has contracted with Montana Fish, Wildlife and Parks to conduct baseline inventory studies on the natural resources of the area prior to coal reviews and leasing. This project was designed as an aquatic inventory of the Hanging Woman Creek and Otter Creek drainages and Poker Jim and O'Dell creeks. The objectives were to collect baseline biological data on the aquatic and riparian resources of the study area. The two year project was initiated in April 1980 and field work was concluded in November 1981. The information collected will serve as a guide during the coal lease reviewing process and aid in decisions regarding resource development.

STUDY AREA

Location

The study area is located in southeastern Montana covering portions of Rosebud, Bighorn, and Powder River counties. The drainages are tributaries of the Tongue River and form part of the Coalwood and Decker-Birney Planning Units of the Miles City BLM District. A map identifying the area and study streams is presented in Figure 1.

Study Streams

The Otter Creek basin drains an area of 1,831 km^2. The creek heads near the Montana-Wyoming border and flows north 144.8 river kilometers to its confluence with the Tongue River near Ashland. Thirteen side drainages as well as the mainstem of Otter Creek were investigated. The Hanging Woman Creek basin drains an area of 1217 km^2. It originates in Wyoming and flows north in Montana, 48.3 river kilometers, entering the Tongue River at Birney. The mainstem and eight tributaries of this drainage were part of the study. Two additional streams, Poker Jim Creek and O'Dell Creek, located between the Hanging Woman and Otter drainages, and also tributaries of the Tongue River, were included in this aquatic inventory.

Stream Condition

Water in a stream is considered to consist of two sources. The first is ground water that is discharged into the stream. The second is direct-runoff which enters the system after precipitation or snowmelt (Knapton and McKinley 1977). During 1980 and 1981,

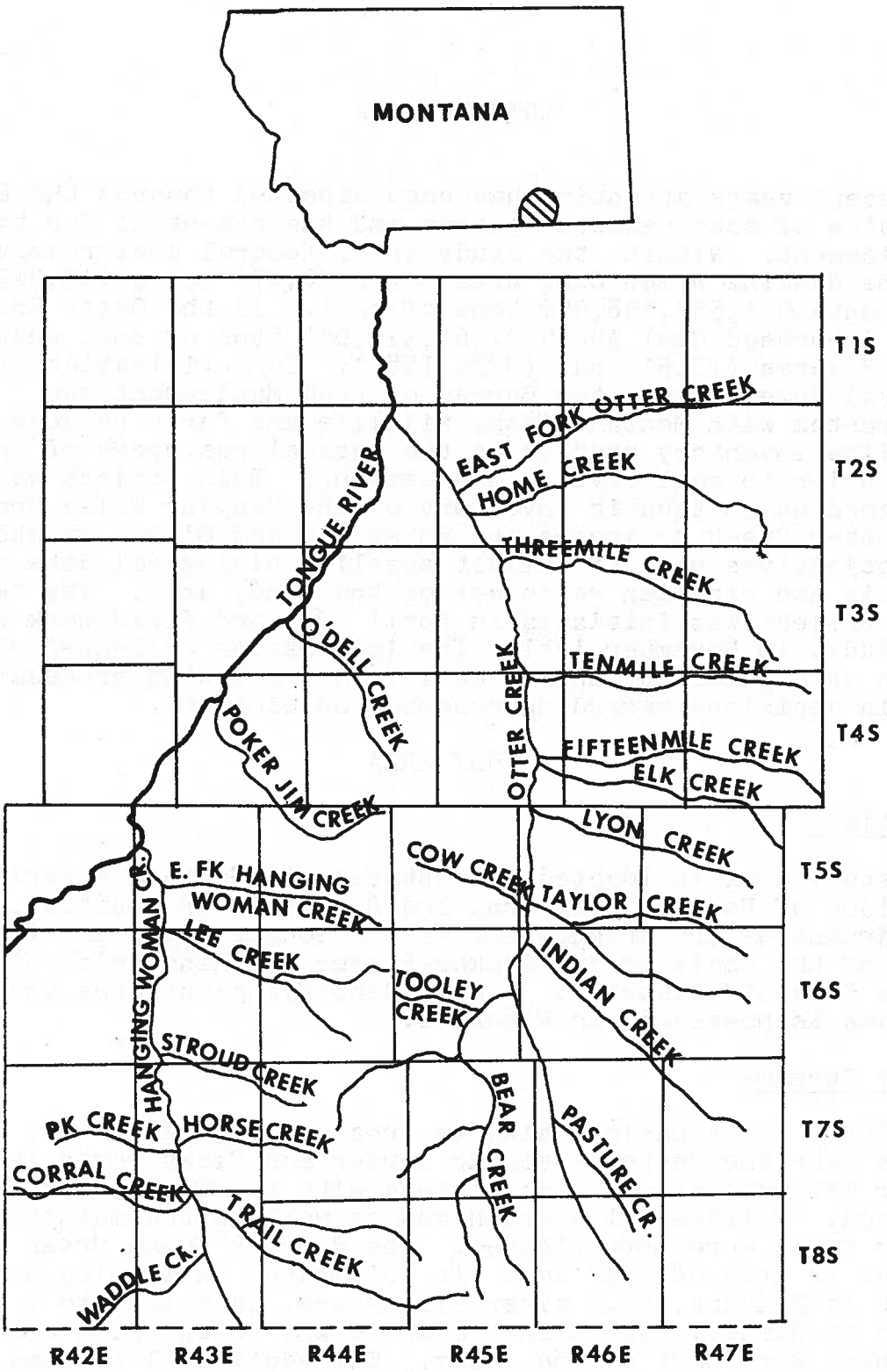


Figure 1. The study area showing all streams included in the investigation.

the major source of water to the stream channels in the study area was ground water discharge. The mild winters during the study contributed little in the way of precipitation and runoff. During the remaining portions of the year, especially early spring and summer which are generally the wettest seasons, this area experienced lower than normal precipitation levels. In comparing the precipitation records for 1978 (a wet year) and 1980, the average difference between the two years (combining information from the Birney and Otter recording stations) was 8.36 inches (USDC 1981).

Due to the lack of a replenishing water supply, the creeks did not exhibit typical high spring flows. Water levels at the mouths of Hanging Woman Creek and Otter Creek rose only as a result of backwater from the higher flowing Tongue River. Even under dry conditions, Hanging Woman Creek and Otter Creek were the most permanent streams in the study, containing water throughout most of their lengths. The remaining streams which were ephemeral or intermittent in nature contained water along lengths of the channels intersecting the water table and in areas fed by spring water. Occasional rains temporarily added moisture to some dry sites.

The situations encountered during the study are part of the natural periodic phenomena of the plains. Prairie streams are considered to be a less than stable environment as a result of fluctuations in water levels (Paloumpis 1958). Factors affecting the aquatic community include depth of the stream, rate of flow, permanency of the stream, temperature change and variation in physical characteristics (Thompson and Hunt 1930). These water quality characteristics, along with a host of other environmental factors, interact to affect aquatic conditions which determine the changing character of the stream and ultimately the structure of the aquatic community. Thus, this study is an observation of prairie streams as they exist under stressed conditions. The qualitative and quantitative composition of the biota reflect this environment and therefore, will act as indicators of environmental degradation in the future.

Land and Water Use

At the present time, this area is predominately agricultural. The principal use of rangeland is for livestock grazing. Fertile lands adjacent to the drainages are under cultivation for hay. Along Hanging Woman Creek approximately 1240 acres of land are irrigated (Knapton and McKinley 1977), while in the Otter Creek drainage approximately 4,200 acres are under irrigation. A buffer strip of riparian vegetation separates the hay meadows and grazing pastures from the actual stream channel for much of both drainages. Another primary use of water in both drainages is stock watering. Small reservoirs and stock ponds are numerous throughout the study area.

Coal

The interest in the Powder River Coal Region of eastern Montana is for the known reserves of low-sulfur, subbituminous and lignite coal that can be extracted by surface-mining methods. These deposits are earmarked for use in coal-fired power generating and coal gasification plants (USDI 1977). The North Central Power Study (North Central Power Study Coordinating Committee 1971) identified 21 potential power plants in the Montana portion of the Northern Great Plains, many associated with the coal reserves of these drainages. An indepth analysis of the quality and richness of coal in southeastern Montana is documented by Matson and Blumer (1973). The information detailed in that report includes coal deposits associated with the creeks and area comprising this study. Table 1 summarizes information on selected strippable coal deposits underlying major portions of the study area.

METHODS

Sample sites on Otter Creek and Hanging Woman Creek were distributed throughout the length of each creek. Due to the intermittent nature of the tributary streams, sites were located where the most effective sampling could be accomplished. The coordinates for all streams and sample sites is presented in Appendix A.

Bureau of Land Management stream survey forms were completed for each sample site in the study area using the formats described in Cuplin et al. (1974), USDA (1975), Duff and Cooper (1976) and Mt. Fish, Wildlife and Parks (1980) as a guide. The survey summarized stream characteristics and conditions for each site.

In 1980, with the aid of the stream survey forms, input forms for the Interagency Stream Fishery Data Base were completed for each stream. This procedure, developed by Montana Fish, Wildlife and Parks (1980), assigns each stream a fishery resource value which includes a species and habitat value and a sport fishing potential value. This system, utilized in other recent aquatic studies and stream investigations has proven of value in categorizing streams.

Each site was tested for several water chemistry parameters. A Hach model AL-36B determined dissolved oxygen, phenolphthalin alkalinity, methyl orange alkalinity, pH and CO_2. Water temperature was measured with a Taylor thermometer. A Taylor 30-day recording thermograph was placed at the mouth reach of Hanging Woman Creek and a Partlow 31-day recording thermograph placed at the lowest reach of Otter Creek. Temperatures were recorded in ^{o}F and converted to ^{o}C.

Aquatic invertebrates, sampled during both years of the study, were collected using a modified kick sample technique with a timed 60 second interval for each collection. Four 30-day

Table 1 . Coal reserves, acreage, and tons per acre, selected coal deposits. 1/

Coal deposit	Coal bed	Reserves Millions tons	Acreage	Acreage Tons/acre
Poker Jim Lookout	Anderson & Dietz	872.65	19,609	44,501
Hanging Woman Creek	Anderson	1,583.29	30,547	51,830
	Dietz	1,120.96	43,654	25,678
West Moorhead	Anderson	883.74	19,660	44,949
	Dietz	397.49	20,416	19,469
	Canyon	690.19	22,547	30,611
Poker Jim-ODell Creek	Knobloch	373.29	7,890	47,311
	Knobloch	564.78	7,187	78,581
Otter Creek	Knobloch	2,075.55	25,791	80,475
Ashland	Knobloch	2,696.20	27,200	99,125
	Sawyer, A and C	357.49	20,262	17,643
Yager Butte	Elk & Dunning	1,175.86	26,924	43,673
	Cook	312.02	14,507	21,507
Threemile Buttes	Canyon & Ferry	225.40	13,836	16,289
Home Creek Butte	Canyon & Ferry	217.21	4,851	44,774

1/ Matson and Blumer (1973)

basket samplers (Clancey 1978) were placed at the mouth reaches of Hanging Woman Creek and Otter Creek on April 1, 1981. Each invertebrate sample collected was preserved in the field with 10% formalin and later identified in the lab. In conjunction with invertebrate sampling, an analysis of substrate materials, water chemistry data and collection site (pool, run or riffle area) were obtained.

A major portion of fish sampling involved the use of seines. A 9.0 x 1.2 meter, 6 mm bag seine was particularly effective. During the early spring, traps constructed of reinforcing bar and chicken wire were set at the mouths of Hanging Woman Creek and Otter Creek. Movement upstream of the traps was effectively blocked by placement of 2.5 cm mesh chicken wire on either side of the trap, extending from the trap to the stream bank. The chicken wire was secured on either end by metal fence posts and the bottom edge was weighted with rocks. As backwater from the Tongue River raised the water level of the two tributaries such that fish were able to pass the trap area, electrofishing gear was used. The electrofishing boat design is described by Clancey (1980). Baited minnow traps were utilized at sites where other methods proved less successful.

Fish were identified and numbers of each species recorded during the trapping collections and for each electrofishing run. All fish were weighed, measured, and fin punched. Game fish of sufficient size were tagged using numbered red Floy tags. Scales were taken from below the dorsal fin on the left side and age class later determined in the lab.

Photos recording stream condition were taken at each sample site. Slides presenting an upstream and downstream view were labelled according to the creek, site, date, and view.

An attempt was made to determine flows within the study area using a pygmy current meter and metric wading rod, model 1205 and 1256, respectively (Scientific Instruments, Inc., Milwaukee, Wisconsin). A lack of water movement at study sites resulted in flow measurements at only two locations, the North Fork Taylor Creek and Otter Creek site 6. A comprehensive reporting of stream flow measurements for various streams in the study area can be obtained from Water Resource Data for Montana (U.S.G.S. 1981).

RESULTS

Stream Characteristics

Several stream parameters were analyzed for each study site. The percentage of pool, run and riffle areas of each reach was determined. For tributary streams this rating was averaged into one ratio on streams with more than one site. Each stream was rated according to substrate types, and pools were assigned a pool class rating according to size, depth and

cover. An analysis of stream condition was also made and a rating of excellent, good, fair, poor, or none given for each of the categories: subsurface cover, stream channel stability, high stream cover, stream bank condition, and stream bank stability. Tables 2, 3, 4 and 5 summarize the results for all study streams. The water stage during these surveys ranged from moderate (bottom and one-half of lower banks wetted) to dry (essentially no flow; water may stand in bottom depressions) (U.S.D.A. 1975).

Summarizing the results for the pool, run, and riffle areas, the overall ratio was determined to be 7:11:1, respectively. A breakdown of these three stream characteristics for the Otter Creek and Hanging Woman Creek sites indicates that runs comprise the greatest portion of the stream sections analyzed. Considering the intermittent nature of the streams observed, it would be expected that the sites would be composed primarily of pools. However, stream sections rated as a run often consisted of standing water in a portion of the stream where the channel was similar in width and depth along it's length. In contrast, a pool was identified as an area of deeper waters, usually formed by depression in the stream bottom and often characterized by more sheltered surroundings. Riffle areas, which were uncommon, were characterized by shallow, flowing water through stream sections where channel width was greatly reduced.

On Otter Creek, runs comprised 50% or more of the stream channel at all sites with the exception of site 8 which had no water present. The ratio of pools, runs and riffles was 5:12:1, respectively. For Otter Creek tributaries the ratio was 12:19:1, indicating a more equal composition of pools and runs for sites analyzed. The Hanging Woman mainstem consisted of pool and run areas in almost equal proportion with riffle areas much less abundant. The ratio was determined to be 12:15:1. A comparison of this ratio by individual sites indicates that in four out of six sites, pools and runs were of nearly equal proportion with site 2 consisting of 85% runs and site 4, 70% pools. Hanging Woman tributaries were largely composed of pools and runs with a ratio of 5:4:1.

Each pool was rated according to size, depth, and cover, then assigned a pool class. For each reach, the percentage of pools in each pool class, using a 100% total, was determined. Pool classes were assigned using the following criteria (Duff and Cooper 1976):

Size (Measurements refer to the longest axis of the intersected pool).

3 - Pool larger or wider than average width of stream.
2 - Pool as wide or long as average stream width.
1 - Pool much shorter and narrower than average stream width.

Table 2. Stream drainage characteristics for Otter Creek. Symbols represent: E - excellent, G - good, F - fair, P - poor, N - none.

	Otter Creek Sites									
	1	2	3	4	5	6	7	8	9	10
Ratio of (%):										
Pool	30	24	35	20	9	20	40		50	10
Run	65	66	55	80	90	60	55		50	90
Riffle	5	10	10		1	20	5			
Pool bottom types (%):										
Boulders			10			7				
Rubble		5	5		1	9				
Gravel		15	5		19	4	3			5
Fines	100	80	80	100	80	80	97		100	95
Run bottom types (%):										
Boulders			15			5				
Rubble		5	10		5	5				
Gravel	10	15	5		5	5	5			5
Fines	90	80	70	100	90	85	95		100	95
Riffle bottom type (%):										
Boulders			20			8				
Rubble	10	15	10			35				
Gravel	80	60	60		20	45	8			
Fines	10	35	10		80	12	92			
Proportion of pool area by pool quality class (%):										
Class 1		50								
Class 2			100							
Class 3	30	50		20		50	33		80	
Class 4	70			70	100		67		20	100
Class 5				10		50				
Stream condition ratings:										
Subsurface cover	F	F	G	G	G	F	N	N	G	N
Stream channel stability 1/	F	F	F	G	G	G	G	F	G	P
High stream cover	G	P	E	F	G	P	P	F	E	P
Stream bank condition	G	E	E	G	G	F	G	F	G	F
Stream bank stability	G	G	G	G	E	F	G	G	G	F

1/ Duff and Cooper (1976)

Table 3. Stream drainage characteristics for Otter Creek tributaries. Symbols represent: E - excellent, G - good, F - fair, P - poor, N - none.

	East Fork Otter	Home Creek	Threemile Creek	Tenmile Creek	Fifteenmile Creek	Elk Creek	Lyon Creek	Taylor Creek	Cow Creek	Indian Creek	Horse Creek	Bear Creek	Tooley Creek	Pasture Creek
Ratio of (%):														
Pool		20			30	70	90	20	10	40				30
Run		80			70	30	10	65	80	60				70
Riffle								15	10					
Pool bottom types (%):														
Boulders														
Rubble								5	5					
Gravel		10						5	40					
Fines		90			100	100		90	55	100				100
Run bottom types (%):														
Boulders														
Rubble								5	10					
Gravel		20						20	70					
Fines		80			100	100		75	20	100				100
Riffle bottom type (%):														
Boulders														
Rubble								35	10					
Gravel								15	70					
Fines								50	20					
Proportion of pool area by pool quality class (%):														
Class 1														
Class 2							5	25	50					30
Class 3					20		20	40	30					30
Class 4		100			80	100	75	35	20	100				40
Class 5														
Stream condition ratings:														
Subsurface cover	N	N	N	N	F	F	G	F-G	G	G	P	N	N	G
Stream channel stability	F-G	F	F	F	G	G	G	F	F-G	G	F	F	G	G
High stream cover	F-G	F	G	F	F	F	G	F	G	G	G	F	P	E
Stream bank condition	F-G	E	G	F	F	F	G	F-G	F	F-G	G	F	F	G
Stream bank stability	F-G	F	G	F	F	F	G	F-G	F-G	G	G	F	F	G

Table 4. Stream drainage characteristics for Hanging Woman Creek. Symbols represent: E - excellent, G - good, F - fair, P - poor, N - none.

	Hanging Woman Creek Sites					
	1	2	3	4	5	6
Ratio of (%):						
Pool	40	10	50	70	50	40
Run	50	85	50	29	50	55
Riffle	10	5		1		5
Pool bottom types (%):						
Boulders	5			5		
Rubble		10		20		
Gravel	5	10	20	5		5
Fines	90	80	80	70	100	95
Run bottom types (%):						
Boulders				5		
Rubble	5	10		15		
Gravel	5	20	50	20		7
Fines	90	70	50	60	100	93
Riffle bottom type (%):						
Boulders				20		
Rubble	10	10		10		
Gravel	10	45		10		7
Fines	80	45		60		93
Proportion of pool area by pool quality class (%):						
Class 1		100				
Class 2	60		100			40
Class 3	40			20		
Class 4				80	100	60
Class 5						
Stream condition ratings:						
Subsurface cover	F	F	F	F	F	F
Stream channel stability	F	G	F	F	G	F
High stream cover	F	P	P	F	F	P
Stream bank condition	F	G	G	F	F	F
Stream bank stability	F	G	F	G	F	F

Table 5. Stream drainage characteristics for Hanging Woman tributaries, Poker Jim Creek and O'Dell Creek. Symbols represent: E - excellent, G - good, F - fair, P - poor, N - none.

	East Fork Hanging Wo. Creek	Leg Creek	Stroud Creek	Horse Creek	PK Creek	Corral Creek	Trial Creek	Waddle Creek	Poker Jim Creek	O'Dell Creek
Ratio of (%):										
Pool	30	50	55		100		10	45		
Run	50	45	30				90	35		
Riffle	20	5	15					20		
Pool bottom types (%):										
Boulders			5							
Rubble	5		15							
Gravel	15	10	30				5			
Fines	80	90	50		100		95	100		
Run bottom types (%):										
Boulders			5							
Rubble	5	10	10							
Gravel	20	15	20				5			
Fines	75	75	65				95	100		
Riffle bottom type (%):										
Boulders										
Rubble	20	10	10							
Gravel	25	15	30							
Fines	55	75	60							
Proportion of pool area by pool quality class (%):										
Class 1										
Class 2					66		100			
Class 3			50					25		
Class 4			50		34			75		
Class 5										
Stream condition ratings:										
Subsurface cover	P	F	P	N	P	N	F	P	N	N
Stream channel stability	F-G	F	G	F	G	F-G	F-G	F	F	G
High stream cover	G	P	P	F	F	F	F	F-P	F	F
Stream bank condtiion	G	F	F	F	F	F	G-E	F	F	F
Stream bank stability	G	F	F	F	G	F	G	F-G	F	F

Depth Ratings	Cover Ratings
3 - over 1 m	3 - abundant cover
2 - 60 cm - 1 m	2 - partial cover
1 - under 60 cm	1 - exposed

* Sum of 5 must include 2 for depth and 2 for cover

Total Ratings	Pool Class
8 - 9	1
7	2
5 - 6*	3
4 - 5	4
3	5

Otter Creek was composed of pools in all five classes, the majority being in classes 3 and 4. Four reaches had pools rated class 4 composing greater than 75% of the reach. Four reaches had pools rated class 3 that comprised from 25% to 50% of the reach. Site 2 on Otter Creek was the only station with class 1 pools, which composed 50% of the reach. Otter Creek tributaries consisted primarily of class 4 pools.

Hanging Woman Creek had pools rated from class 1 through class 4 with the greatest percentage of pools in class 2 and class 4 categories. The lower sections of the drainage, sites 1 through 3, consisted of the higher classed pools while class 4 pools composed the major portion of pools at the upper reaches. Hanging Woman site 2 was the only site with class 1 pools. This class composed 100% of the pools in that reach. The tributaries of Hanging Woman consisted mainly of class 4 pools.

The substrate particle size was rated for each stream character (pool, run, riffle). The four categories used were boulders (over 26 cm), rubble (6.4-26 cm), gravel (2 mm-6.4 cm) and fines (under 2 mm). The fines category included organic muck . Hardpan or bedrock was also considered in the original analysis, then eliminated when no sites included this substrate type.

The fines category, silt and muck-type bottoms, was the most common substrate encountered. With the exception of a lower percentage of fines on Cow Creek (55%), fines composed between 80 and 100 percent of the substrate in the pool areas of the Otter Creek drainage. A similar high percentage of fines was observed in the pool areas of the Hanging Woman Creek drainage. Run areas in both drainages were also largely composed of fines with the exception of Cow Creek, which was composed of 10% rubble, 70% gravel and 20% fines. Riffle areas, comprising a small portion of the stream channels, consisted primarily of gravel and fines. With the exception of Hanging Woman Creek, site 6, all riffle areas included some proportion of rubble as part of the substrate material.

Five categories of stream conditions including subsurface cover, stream channel stability, high stream cover, stream bank condition, and stream bank stability were classified for each reach. All sites on the Hanging Woman Creek and Otter Creek mainstem were analyzed. The tributaries were each given one rating. Results are summarized in Tables 2, 3, 4, and 5.

Subsurface (instream) cover was rated as good, fair, poor or none as determined by the concealment (logs, rocks, underwater undercut banks, turbulent surface, water color, bottom color) for fish. The instream cover was rated fair on all Hanging Woman Creek sites and fair to good on seven of the ten Otter Creek sites. Instream cover for tributary sites, including Poker Jim Creek and O'Dell Creek, rated from good to none illustrating the variable character typical of prairie streams.

The category of stream channel stability was evaluated according to the criteria outlined in U.S.D.A. Stream Reach Inventory and Channel Stability Evaluation (1975). The stream channel analysis consisted of a subjective evaluation of various stream components. The subsequent ratings provide a generalized assessment of stream channel conditions. A rating of fair to good was given for all sites in both drainages with the exception of a "poor" rating at Otter Creek site 10. Raw banks contributed to this rating. For Poker Jim Creek and O'Dell Creek ratings of fair and good, respectively, were assigned.

The three remaining categories, high stream cover, stream bank condition, and stream bank stability were rated using the criteria outlined in Duff and Cooper (1976). The interrelationship between these three categories led to a similarity in ratings between the three. Overall, high stream cover for the study streams was considered fair to excellent. In some instances, grazing contributed to sites rated as poor, however, natural conditions more often dictated present stream morphology. Stream bank condition and stream bank stability rated fair to excellent for the streams.

In general, this information on stream condition would indicate that both drainages have not suffered excessive use and/or damage as a result of agriculture, stock grazing or natural causes. However, it should be emphasized that these ratings are a result of site specific analyses and therefore should be considered generalized ratings that do not necessarily describe conditions for all portions of the stream.

Riparian Analysis

Plant species in the riparian zone, as defined in U.S.D.I. (1979), were identified and the composition determined for each study site. This information provides a summary, in qualitative form, of the most prominent species and their percent composition. Diversity of plants at various points within the drainages is also indicated.

For each study site, the percent basal density for each of the five categories: woody species, grasses-sedges-rushes, forbs, litter, and bare ground or rock was determined using a 100% total. Then, within each of the first three categories, individual species were identified and basal density by species using 100% for each category was determined. Tables 6 and 7 summarize the percent basal density by category for all study sites.

Table 6 . A breakdown (in percent) of the basal density by catagory for sites in the Otter Creek drainage.

	Otter Creek										East Fork Otter		Home	Threemile	Tenmile	Fifteenmile	Elk	Lyon	Taylor			Cow				Indian		Horse	Bear	Tooley	Pasture
	1	2	3	4	5	6	7	8	9	10	1	2							1	2	3	1	2	3	4	1	2				
Woody species	65	10	TR	-	30	27	-	25	5	-	70	90	-	70	-	10	-	50	28	20	15	-	48	90	80	70	5	100	5	15	30
Grasses sedges rushes	20	90	90	100	67	68	100	67	55	75	25	10	100	25	98	90	100	50	66	65	80	-	52	5	20	30	90	TR	45	75	60
Forbs	TR	TR	10	TR	3	TR	-	-	30	25	TR	-	-	-	TR	TR	TR	-	-	5	-	-	-	TR	-	-	5	TR	45	-	10
Litter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	TR
Bare ground & rock	15	-	-	-	-	5	-	8	10	TR	5	-	-	5	2	-	-	-	6	10	5	-	-	5	-	-	-	-	5	10	-

Table 7. A breakdown (in percent) of the basal density by catagory for sites in the Hanging Woman Creek drainage.

	Hanging Woman Creek						East Fork Hanging Woman			Lee		Stroud		Horse	PK	Corral		Trail		Waddle			Poker Jim	O'Dell
	1	2	3	4	5	6	1	2	3	1	2	1	2			1	2	1	2	1	2	3		
Woody species	71	18	10	3	-	10	100	90	70	60	60	90	TR	-	8	30	25	40	5	-	-	TR	50	40
Grass sedges rushes	24	72	90	77	92	75	TR	7	30	40	35	5	75	-	92	45	55	60	95	90	100	100	32	40
Forbs	TR	10	TR	20	8	10	-	3	-	-	5	TR	10	-	TR	20	-	-	-	5	TR	TR	8	-
Litter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bare ground & rock	5	-	-	-	-	5	-	-	-	-	-	5	15	-	-	5	20	-	-	5	-	-	10	20

The grasses-sedges-rushes category composed the greatest proportion of vegetation in the Otter Creek drainage. Sixty-five percent of the sites had plants in this category comprising greater than 50% of the reach. Twenty-three percent of the sites in that drainage consisted of greater than 50% woody species. Grasses-sedges-rushes were more prominent in the flat open areas with woody species more common in rugged or varying terrain. A small percentage of forbs were found in the Otter Creek drainage. Bare ground never rated more than 15% at any site. Surrounding characteristics dictated vegetative types.

Hanging Woman Creek, site 1, and sites on the lowest three Hanging Woman tributaries consisted mainly of woody species. The remaining Hanging Woman Creek sites and upper tributaries were largely composed of plants in the grasses-sedges-rushes category. Forbs were identified in small numbers as in the Otter Creek drainage. Little bare ground was observed at most stations with the exception of a rating of 20% at Corral Creek, site 2. Horse Creek, an ephemeral stream, had no riparian vegetation.

Poker Jim Creek consisted of 50% woody species and 32% grasses-sedges-rushes. O'Dell Creek, parallelling Poker Jim Creek through similar terrain consisted of 40% woody species and 40% grasses-sedges-rushes. Silver sage (*Artemesia cana*) was the prominent woody species in both drainages.

Plants under each of the categories: woody species, grasses-sedges-rushes, and forbs were identified, when possible, to species. In several cases, particularly when the stream was ephemeral, the streambank vegetation included plants other than the characteristic riparian-type species or consisted entirely of adjacent terrestrial vegetation. In these cases, the most prominent terrestrial plants were included in the species list (Appendix B) and their composition determined in relation to other species.

Species identified under each category and their percent composition for each site in the Otter Creek drainage are presented in Appendix C, D, and E. Fourteen woody plants were identified to species. Sites where woody species comprised 50% or more of the drainage included Otter Creek site 1, East Fork Otter Creek sites 1 and 2, Threemile Creek, Lyon Creek, Cow Creek sites 3 and 4, Indian Creek site 1, and Horse Creek. Box elder was the most widely distributed woody species occurring at 42% of the sites analyzed. Wood's rose was the second most common at 39% of the sites.

Twelve plants in the grasses-sedges-rushes category were identified to species in the Otter Creek drainage. Combining all sites where this category made up 50% or more of the plants present, the greatest portion of species were bulrushes. Creeping sedge-rush, prairie cordgrass, and the common cattail

were also very common. Prairie cordgrass was the most widely distributed occurring at 62% of these sites. Bulrush and foxtail barley were also widely distributed, each occurring at 52% of the sites. Species identified under the forbs category were generally found in trace amounts throughout the Otter Creek drainage.

Identification of species for the three plant categories and their composition in the Hanging Woman Creek drainage are presented in Appendix F, G, and H. Seven sites in this drainage were comprised of 50% or more woody species. Species with the highest overall composition for these sites were willows (*Salix* spp.) and green ash. These species were also the most widely distributed for these sites. Considering species distribution for all sites in the drainage, boxelder, Wood's rose and green ash were the most widely distributed occurring at 36%, 32% and 27% of the sites, respectively.

Thirteen sites, including Hanging Woman Creek sites 2 through 6 and tributary sites in the upper drainage, were found to have 50% or more of each reach in the grasses-sedges-rushes category. Of the species in this category, prairie cordgrass, creeping sedge-rush and foxtail barley were found in abundance and also were the three most widely distributed species. Very few forbs were identified in this drainage.

Plant species distribution for the Otter Creek drainage is presented in Table 8 and for the Hanging Woman Creek drainage in Table 9. Species diversity was highest on the Otter Creek mainstem. Of the tributaries, East Fork Otter Creek, Cow Creek and Horse Creek had the highest vegetative diversity. In the Hanging Woman drainage, vegetation along the mainstem was highly diverse as well as along the tributaries, East Fork Hanging Woman Creek and Stroud Creek. Topographic, geologic and edaphic factors contribute to this diversity (U.S.D.I. 1977). Poker Jim Creek and O'Dell Creek were low in species diversity at the sections observed.

Chemical Parameters

Water chemistry data is presented in Appendix I and J. All sites on Hanging Woman Creek contained water. On Otter Creek, all sites with the exception of site 8 contained water. The tributaries of these creeks were intermittent or ephemeral in nature. Poker Jim Creek and O'Dell Creek were ephemeral. Often sites considered dry, temporarily contained water following precipitation. A site was considered dry when no water was present over portions of the drainage actually observed or when small amounts (5 cm or less) were present only in the lowest depressions of the stream channel at isolated locations.

The pH ranged from 7.0-8.5. A similar trend in pH was indicated throughout the Hanging Woman and Otter drainages. Eighty-two

Table 8. Distribution of streamside vegetation by species for the Otter Creek drainage.

	Otter Creek										East Fork Otter	Home	Threemile	Termile	Fifteenmile	Elk	Lyon	Taylor	Cow	Indian	Horse	Bear	Tooley	Pasture
	1	2	3	4	5	6	7	8	9	10														
Woody species																								
Acer negundo	X	X	X	X		X					X		X					X		X		X		
Artemesia cana								X															X	
Fraxinus pennsylvanica	X										X		X					X	X		X			X
Juniperus scopulorum																			X		X			
Pinus spp.																			X		X			
Populus deltoides	X	X						X			X										X			X
Prunus virginiana											X		X							X				
Ribes spp.											X		X					X						
Ribes americanum																			X		X			
Ribes aureum						X													X					
Ribes cereum																			X					
Ribes setosum				X															X		X			
Rosa spp.	X		X						X		X							X		X				X
Rosa woodsii						X					X		X		X	X	X	X	X		X			
Salix spp.						X											X							
Salix exigua	X																							
Sheperdia argentia											X													
Sypmphoricarpos occidentalis								X	X		X							X	X	X				X
Grass-Sedges-Rushes																								
Agropyron spp.																								
Agropyron elongatum				X																				
Agropyron trachycaulum						X							X											
Alopercus pratensis																			X		X			
Bromus spp.		X			X		X						X											
Bromus inermis							X																	
Bromus japonicus				X									X											
Carex lanuginosa						X												X	X					
Eleocharis palustris	X		X		X	X	X							X				X	X					
Hordeum jubatum		X	X	X	X	X	X		X	X		X					X		X	X	X	X		
Phalaris arundinacea		X		X																				
Poa pratensis																		X			X			

Table 8. Continued

	Otter Creek										East Fork Otter	Home	Threemile	Tenmile	Fifteenmile	Elk	Lyon	Taylor	Cow	Indian	Horse	Bear	Tooley	Pasture
	1	2	3	4	5	6	7	8	9	10														
Grasses-Sedges-Rushes continued																								
Scirpus spp.		X		X	X	X	X		X		X				X	X	X							X
Spartina pectinata	X	X	X	X	X	X	X		X			X			X	X	X			X	X	X		X
Typha latifolia			X		X	X	X										X							
Forbs																								
Asclepia spp.				X	X		X		X		X													
Cirsium spp.		X					X				X													X
Cirsium arvense																			X					
Glycyrrhiza lepidota							X				X													
Humulus luputus											X							X						
Mentha arvensis																					X			
Helianthus spp.		X				X			X													X		
Brassica spp.		X																						

Table 9. Distribution of streamside vegetation by species for the Hanging Woman Creek drainage, Poker Jim Creek and O'Dell Creek.

	Hanging Woman Cr						East Fork Hanging Woman	Lee	Stroud	Horse	PK	Corral	Trail	Waddle	Poker Jim	O'Dell
	1	2	3	4	5	6										
Woody Species																
Acer negundo	X	X		X			X					X	X			
Artemesia cana												X		X	X	X
Cornus stolonifera							X									
Fraxinus pennsylvanica	X	X					X	X	X							
Juniperus scopulorum									X							
Pinus spp.			X					X								
Populus deltoides								X	X				X			
Prunus virginiana	X															
Ribes spp.				X												
Ribes americanum							X		X							
Ribes aureum							X									
Ribes cereum									X							
Rosa spp.									X							
Rosa woodsii							X		X		X					
Salix spp.	X	X					X	X	X				X			
Salix exigua	X															
Symphoricarpos occidentalis							X		X							
Grasses-Sedges-Rushes																
Agropyron spp.				X	X											
Agropyron elongatum																X
Agropyron trachycaulum		X	X				X									
Agrostis spp.							X									
Bromus spp.		X	X		X			X								
Bromus inermis							X									
Carex lanuginosa											X					
Eleocharis palustris		X	X	X	X						X		X	X		
Elymus cinereus				X		X		X								
Equisetum				X												
Hordeum jubatum		X			X	X	X		X		X		X	X		
Phalaris arundinacea			X				X									
Scirpus spp.	X	X	X	X	X	X		X	X							

Table 9. Continued

	Hanging Woman Creek						East Fork Hanging Woman	Lee	Stroud	Horse	PK	Corral	Trail	Waddle	Poker Jim	O'Dell
	1	2	3	4	5	6										
Grasses-Sedges-Rushes Cont.																
Spartina pectinata	X		X	X	X	X			X		X		X	X		
Typha latifolia		X					X									
Forbs																
Asclepia spp.		X												X		
Glycyrrhiza lepidota		X														
Mentha arvensis							X									
Helianthus spp.		X			X	X		X								

percent of the readings in each of these drainages ranged between 7.4-7.8. For total hardness, a wide range of values was determined for the area. In the Otter Creek drainage, values ranged from 239.4 mg/l to 4668.1 mg/l. Tributary readings were within this range and values were comparable to the mainstem. Values in the Hanging Woman Creek drainage ranged from 256.4 to 11,970 mg/l. Values on the tributaries were generally lower than the mainstem of Hanging Woman Creek. Total alkalinity values ranged from 171.1 - 940.5 mg/l in the Hanging Woman drainage and 188.1 - 803 mg/l in the Otter drainage. Values for CO_2 varied from 0-190 mg/l over the study area. The highest readings were taken at tributaries sites in standing pools of water. Readings were found to be between 20 and 70 mg/l, 75% of the time. Dissolved oxygen readings ranged from 0-17 mg/l on Hanging Woman Creek and tributaries and 1-21 mg/l on Otter Creek and tributaries. In using a field kit, a point is reached where values for tests being run will no longer be accurate measurements. Using the Hach AL-36 B kit, values determined for total alkalinity and total hardness above 342 mg/l cannot be considered accurate. For CO_2, values are good up to 100 mg/l.

Water Temperature

Daily water temperature variations were recorded over both years of the study at the mouth of Hanging Woman Creek and Otter Creek. Information derived from the two thermograph locations is illustrated in Figures 2, 3, 4, and 5.

On Otter Creek, the 7-day maximum and 7-day average temperatures were higher in 1980 than in 1981. The range between the maximum and minimum temperatures over corresponding 7-day periods was also generally greater in 1980. In the spring, temperatures in 1980 increased earlier than in 1981. June temperatures in 1980 were as high as the highest temperature in 1981. The highest temperature reached in 1980 was 29.4°C (85°F) on July 6. In 1981, this high was 26.1°C (79°F) on July 7 and 15.

Temperatures on Hanging Woman Creek, comparing the 7-day maximum, 7-day average, and 7-day minimum, were all lower in 1980 than in 1981. The 7-day maximum temperatures in 1980 were lower than the 7-day minimum temperatures of 1981 over almost every 7-day period. The highest temperature reached in 1980 was 24.4°C (76°F) on July 10. In 1981, the highest temperature was 31.7°C (89°F) recorded on July 7.

In comparing the two thermograph locations, Hanging Woman Creek exhibited a smaller variation between highs and lows over each 7-day period for both years. The average difference between the 7-day maximum and 7-day minimum temperatures for Hanging Woman Creek was 4.5 degrees in 1980 and 5.2 degrees in 1981 while on Otter Creek this range averaged 8.8 degrees in 1980 and 6.7 degrees in 1981. Accordingly, the average difference between the 7-day mean maximum and 7-day mean minimum temperatures was also

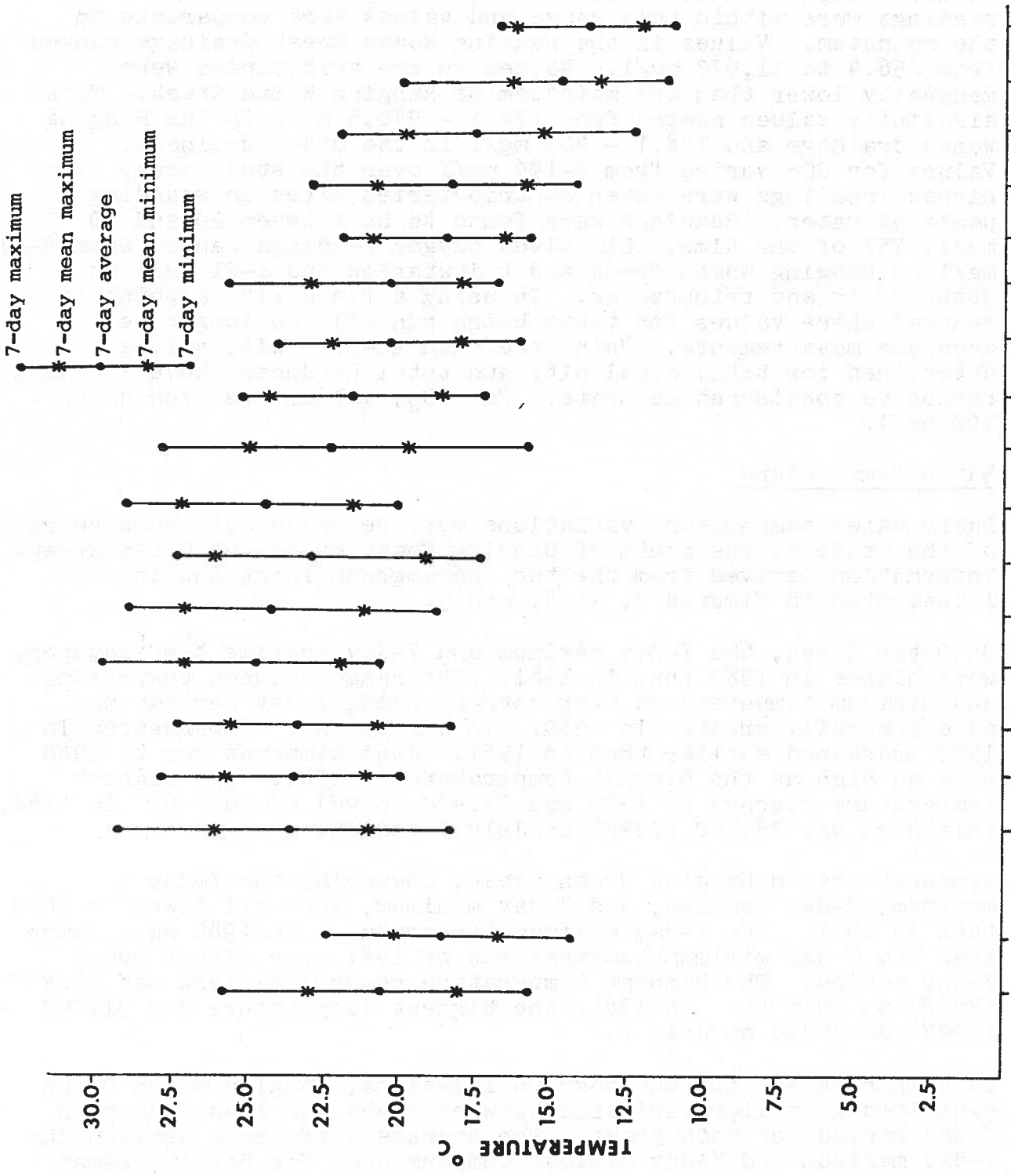
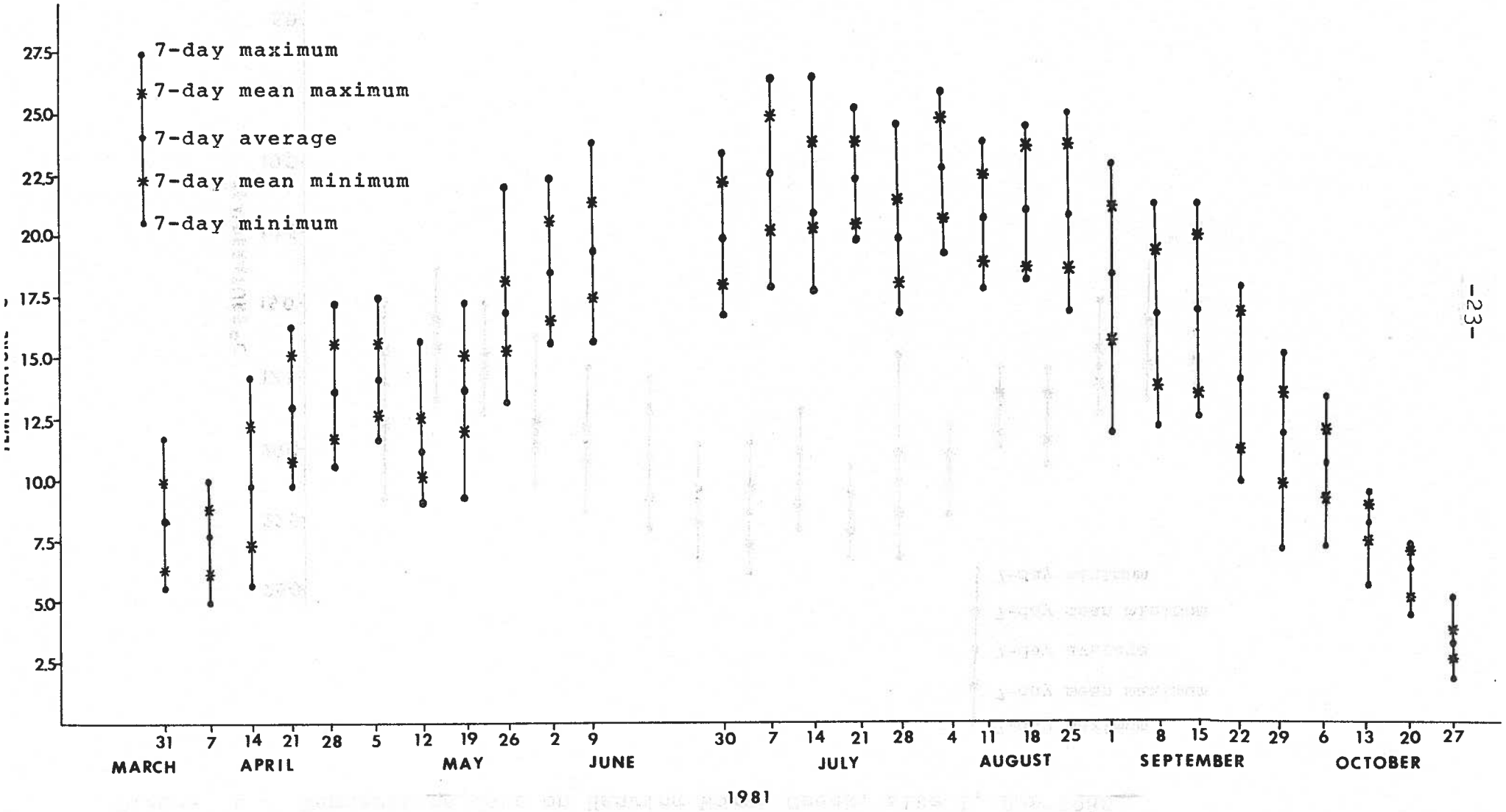


Figure 2. Temperature data on Otter Creek, site 1, for 1980.

Figure 3 . Temperature data on Otter Creek, site 1, for 1981.



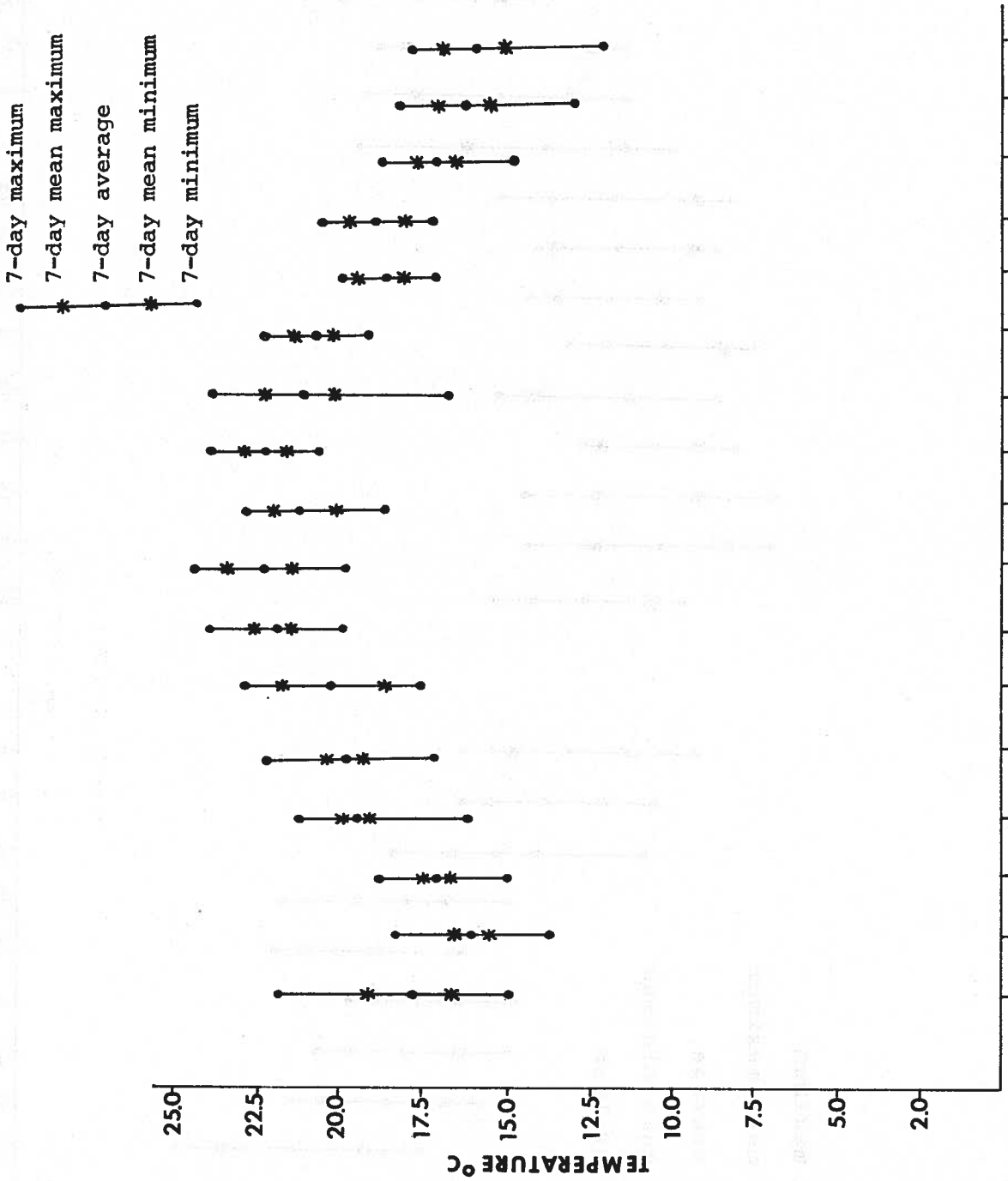
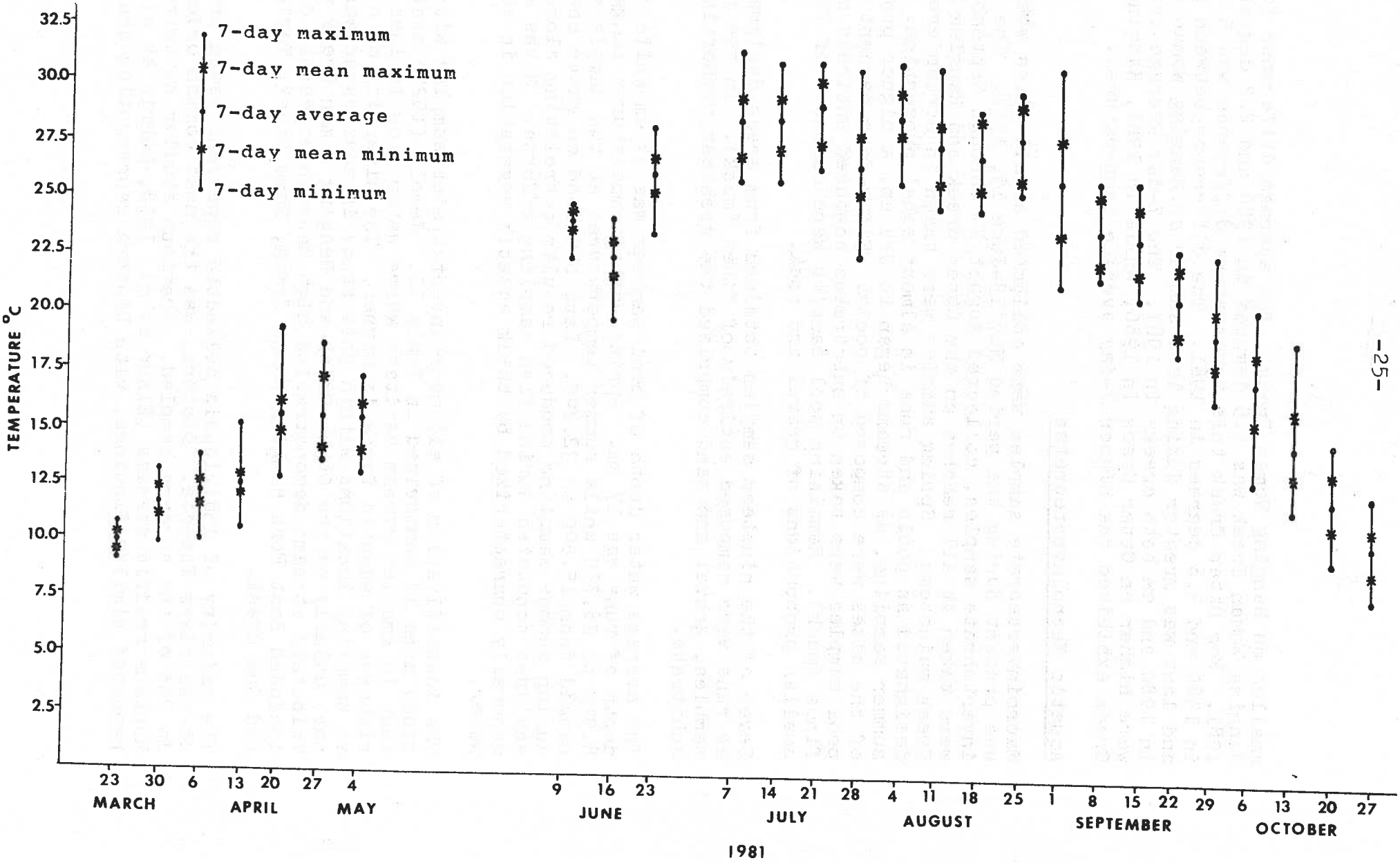


Figure 4. Temperature data on Hanging Woman Creek, site 1, for 1980.

Figure 5. Temperature data on Hanging Woman Creek, site 1, for 1981.



smaller on Hanging Woman Creek. The average difference for Hanging Woman Creek was 1.5 degrees in 1980 and 2.2 degrees in 1981. For Otter Creek this temperature difference was 5 degrees in 1980 and 3.8 degrees in 1981. The difference between highs and lows was greater during late summer on Hanging Woman Creek in 1980 and on both creeks in 1981. The 7-day average temperatures were higher on Otter Creek in 1980, while in 1981, Hanging Woman Creek exhibited the higher 7-day average temperatures.

Aquatic Macroinvertebrates

Macroinvertebrate samples were collected at all sites where water was present during the period May 13-June 19, 1981. The summer invertebrate samples, collected August 24 through September 1, were taken at all reaches on the Otter Creek and Hanging Woman Creek mainstems. Spring samples were taken in stream areas designated as pools and runs in almost equal proportion. During summer sampling, as streams began to dry up, a higher proportion of the sites were composed of pools. Fifty-four percent of the pool samples were taken on substrates composed entirely of fines (muck). Remaining pool samples were composed of fines with smaller proportions of gravel and rock.

Seven of the nineteen samples obtained from areas designated as runs were composed entirely of fines (muck). In the remaining samples, gravel and sand comprised the greatest proportion of the substrate.

The average water depth of pool samples was 34 cm while average depth of runs was 17 cm. Spring water temperatures ranged from 8.9°C to 26.7°C while summer temperatures at the sample sites ranged from 15.6°C to 32.2°C. Data obtained on water chemistry during summer sampling produced results correlating closely to analyses conducted during fish sampling efforts. Sites were generally characterized by thick aquatic vegetation in standing water.

The identification of all macroinvertebrates sampled within the study area is summarized in Table 10. Jewell (1927) states that in smaller stream habitats where water flow is less, the richness of aquatic fauna is higher. The diversity of organisms at sampling locations within this study in most cases was high, particularly on the Otter Creek and Hanging Woman Creek mainstems. Tributary streams demonstrating high macroinvertebrate diversity included East Fork Hanging Woman Creek, Home Creek, Taylor Creek and Cow Creek.

The majority of individuals collected represent seven orders of the class Insecta. Diptera, was the most common order occurring in 90% of the streams sampled. Previous studies on eastern Montana prairie streams (Elser et al. 1978; Morris et al. 1981) reported similar findings, with Diptera representing the most

common order of aquatic invertebrates in those study areas. Diptera, represented by 11 families and 57 genera, had the highest diversity of the orders. Thirty-four percent of the total number of individuals collected were identified as members of this order. The largest family represented was the chironomidae which included 38 genera. This is not surprising as chironomid species are adapted to a wide range of environmental gradients and are known to inhabit every type of aquatic and semi-aquatic habitat (Coffman 1978). Micropsectra and Chironomidae pupa were the most widely distributed Dipterans, each occurring at 58% of the sample sites.

Odonata (damselflies and dragonflies) were present on 65% of the streams sampled. Five families and 11 genera represented this order, with *Ishnura* spp. being the most widely distributed. This genus alone represented 81% of the individuals collected in this order. Morris et al. (1981) also found this genus to be the most widely distributed of the Odonata group on tributaries to the lower Yellowstone River. Elser et al. (1978) observed this genus to be distributed throughout Beaver Creek, a stream in eastern Montana similar to streams in this study.

Ephemeroptera (mayflies), a group found in a wide variety of environmental conditions (Bell 1969; Schmidt 1977; Schwehr 1977), were present at 70% of the sites analyzed. The two most widely distributed of the mayflies were *Callibaetis* sp. and *Caenis* sp. These two genera were also dominant forms on Beaver Creek (Elser et al. 1978) and Sarpy Creek (Clancey 1978).

Tricoptera (caddisflies), although not abundant, were distributed throughout the study area. *Cheumatopsyche* sp., a genus tolerant of diverse environmental conditions (Schwehr 1977), was the most common caddisfly encountered.

No individuals belonging to the order Plecoptera (stoneflies) were identified. However, at three sites within the Tongue River (two situated near the mouth of Hanging Woman Creek and one near Otter Creek), Gore (1975) identified five species belonging to this order.

Hyallela azteca was a common amphipod found to be widely distributed in both drainages. Habitats where this species was encountered ranged from standing pools containing thick organic debris and muck type bottoms to clearer stream channels consisting of gravel substrates. In terms of numbers of individuals, this species comprised 17.4% of the total number of individuals collected.

Shannon-Weaver Diversity Indicies

Shannon-Weaver diversity indicies for the macroinvertebrates are presented in Table 11. An explanation of the indicies is contained under the section on fish. It must be emphasized that

Table 10. Distribution of macroinvertebrates in the study area, 1980-1981.

	Hanging Creek						Woman																														
	1	2	3	4	5	6	E. Fk. Hanging Woman	Lee	Stroud	Horse	PK	Trail	Waddle	Otter Creek 1	2	3	4	5	6	7	9	10	Home	Fifteenmile	Elk	Lyon	Taylor	Cow	Indian	Horse	Bear	Tooley	Pasture				
EPHEMEROPTERA																																					
Baetidae																																					
Baetis sp.							x																					x									
Callibaetis sp.			x	x	x	x	x	x			x					x			x	x	x		x		x	x	x		x								
Caenidae																																					
Caenis sp.	x	x	x	x	x						x			x	x	x	x	x	x	x	x		x				x										
Leptophlebiidae																																					
Choroterpes sp.														x																							
Heptageniidae																																					
Heptagenia		x																																			
ODONATA																																					
Aeshnidae																																					
Aeshna sp.		x	x		x																x	x					x					x					
Gomphidae																				x																	
Gomphus sp.																					x																
Ophiogomphus sp.		x														x																					
Libellulidae																																					
Libellula sp.													x								x						x		x								
Sympetrum sp.						x			x						x	x	x			x	x							x									
Coenagrionidae																																					
Argia sp.			x	x																x							x	x		x						
Amphiagrion sp.						x														x																	
Coenagrion sp.					x			x			x					x		x																			
Enallgma sp.						x													x																		
Ishnura spp.			x	x	x	x					x				x	x		x	x	x					x			x									
Lestidae								x																													
Lestes sp.	x				x								x										x						x								
HEMIPTERA																																					
Corixidae																																					
Corixid nymphs	x												x	x							x					x											
Palmacorixa gilletti	x													x																							
Sigara spp.																					x																
Sigara alternata	x				x										x																						

Table 10. Continued

	Hanging Woman Creek						E. Fk. Hanging Woman	Lee	Stroud	Horse	PK	Trail	Waddle	Otter Creek									Fifteenmile	Elk	Lyon	Taylor	Cow	Indian	Horse	Bear	Tooley	Pasture
	1	2	3	4	5	6								1	2	3	4	5	6	7	9	10	Home									
Gerridae																																
Gerris sp.																												x				
Gerris remigis		x																														
Mesoveliidae																																
Mesovelia sp.	x	x	x			x														x												
Notonectidae																																
Notonecta spinosa					x																		x									
Notonecta undulata					x																											
Naucoridae																																
Ambrysus mormon															x				x													
TRICOPTERA																																
Hydropsychidae															x											x		x		x		
Cheumatopsyche sp.		x	x	x											x			x								x		x	x	x		
Hydropsyche				x											x					x		x										
Phryganeidae																																
Ptilostomis sp.					x																											
Hydroptilidae															x													x				
Limnephilidae	x			x										x																x		
Glyphopsyche sp.																							x									
Hesperophylax sp.							x																				x					
Limnephilus sp.		x										x											x			x	x					
Polycentropidae																																
Polycentropus sp.	x			x										x														x				
MEGALOPTERA																																
Sialidae																																
Sialis sp.	x		x	x											x																	
COLEOPTERA																																
Dropidae																																
Helichus striatus																											x		x			
Dytiscidae																																
Agabus spp.						x							x										x			x	x	x	x			
Dytiscus sp.																											x					
Derovatellus																				x							x		x			

Table 10. Continued.

	Hanging Woman Creek													Otter Creek																					
	1	2	3	4	5	6	E. FK. Hanging Woman	Lee	Stroud	Horse	FK	Trail	Waddle	1	2	3	4	5	6	7	9	10	Home	Fifteenmile	Elk	Lyon	Taylor	Cow	Indian	Horse	Bear	Tooley	Pasture
Hydrophorus sp.	x				x	x																					x	x					
Deronectes sp.						x																											
Hygrotus sp.						x							x	x						x							x						
Rhantus																						x											
Elmidae																																	
Dubiraphia sp.	x	x	x	x										x					x	x							x						
Microcylloepus sp.													x		x																		
Optioservus sp.	x						x														x							x			x		
Stenelmis sp.			x										x		x						x						x			x			
Haliplidae																																	
Haliplus spp.					x	x	x			x			x							x	x		x			x	x		x		x		
Hydrophilidae																																	
Berosus sp.					x								x	x																			
Cymbiodyta sp.								x				x																					
Helophorus sp.																							x										
Paracymus sp.			x																									x					
Tropisternus sp.						x														x													
DIPTERA																																	
Tipulidae															x																		
Erioptera sp.																	x																
Hexatoma sp.							x																				x	x					
Pilaria sp.							x																					x					
Antocha																												x					
Pedicia																																	
Simulidae																																	
Simulium sp.		x	x	x			x								x				x	x		x			x		x	x	x				
Ceratopogonidae																																	
Culicoides sp.						x																											
Tribe Stilobezziini							x								x					x							x	x					
Chironomidae																																	
Pupa	x		x	x	x	x	x				x		x	x	x				x	x	x		x		x	x	x	x			x		
Tanypodinae																																	
Ablabesmyia sp.														x					x										x				

Table 10. Continued.

	Hanging Woman Creek													Otter Creek																					
	1	2	3	4	5	6	E. Fk. Hanging Woman	Lee	Stroud	Horse	FK	Trail	Waddle	1	2	3	4	5	6	7	9	10	Home	Fifteenmile	Elk	Lyon	Taylor	Cow	Indian	Horse	Bear	Tooley	Pasture
Larsia sp.																				x			x					x						
Macropelopia sp.							x						x										x					x						
Paramerina sp.																				x														
Procladius sp.	x					x								x						x							x		x					
Psectrotanypus sp.																								x		x								
Tanypus sp.				x				x				x				x				x					x	x		x						
Thienemannimyia group*	x			x			x				x			x													x	x						
Diamesinae																																		
Prodiamesa			x																															
Odontomesa sp.							x													x			x											
Chironominae																																		
Chironomus sp.	x	x	x		x	x	x	x						x	x	x					x		x	x	x	x		x		x				
Cryptochironomus sp.														x																				
Cryptotendipes sp.		x		x																x														
Dicrotendipes sp.	x	x	x	x	x						x		x	x		x				x	x					x	x				x			
Glyptotendipes sp.																							x											
Microtendipes sp.											x					x							x											
Parachironomus sp.	x	x	x											x																				
Paratendipes sp.																				x							x							
Phaenopsectra spp.					x		x	x																		x	x	x		x				
Polypedilum				x										x																				
Psuedochironomus sp.		x												x		x																		
Stictochironomus			x																															
Cladotanytarsus sp.						x								x							x													
Paratanytarsus sp.		x	x	x	x	x					x			x				x																
Rheotanytarsus sp.														x																				
Tanytarsus	x	x	x			x								x		x					x													
Micropsectra sp.	x						x	x					x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x				
Orthocladinae																																		
Corynonuera sp.				x										x							x						x							
Cricotopus sp.																												x						
Cricotopus bicinctus group																											x							

* a group of four genera which cannot be separated at this time.

Table 10. Continued.

	Hanging Woman Creek													Otter Creek																					
	1	2	3	4	5	6	E. Fk. Hanging Woman	Lee	Stroud	Horse	PK	Trail	Waddle	1	2	3	4	5	6	7	9	10	Home	Fifteenmile	Elk	Lyon	Taylor	Cow	Indian	Horse	Bear	Tooley	Pasture
C. (Isocladius) Sylvestris group						x							x			x		x		x	x		x				x		x					
Cricotopus or *Orthocladius***							x											x				x	x			x		x						
Orthocladius				x																														
Parakiefferiella sp.		x									x																							
Parametriocnemus sp.																												x						
Paraphaenocladius sp.																							x											
Psectrocladius spp.							x	x			x							x		x	x									x				
Rheocricotopus sp.																							x	x		x								
Stratiomyidae																																		
Euparyphus sp.		x					x																							x				-32-
Hedriodiscus or *Odontomyia* sp.**													x										x				x	x		x				
Ptychopteridae																																		
Ptychoptera sp.																												x						
Empididae																																		
Clinocera sp.																													x					
Athericidae																																		
Atherix sp.							x																											
Tabanidae																																		
Chrysops sp.					x	x							x							x							x							
Tabanus sp.							x													x								x						
Psychodidae																																		
Pericoma sp.																											x	x						
Culicidae																																		
Aedes (campestris & dorsalis)								x					x																					
Anopheles freeborni																											x							
Culex tarsalis															x	x					x						x							
AMPHIPODA																																		
Talitridae																																		
Hyallela azteca	x		x	x	x	x	x	x			x			x		x	x	x	x	x	x		x	x	x		x	x			x			
GASTROPODA																																		
Lymnaeidae																																		
Lymnaea sp.													x											x			x	x						
Physidae																																		

** some species of these two genera cannot be separated.

Table 10. Continued.

	Hanging Woman Creek														Otter Creek																							
	1	2	3	4	5	6	E. Fk. Hanging Woman		Lee		Stroud		Horse	PK	Trail		Waddle	1	2	3	4	5	6	7	9	10	Home		Fifteenmile		Elk		Lyon	Taylor		Cow		Indian		Horse		Bear		Tooley		Pasture
Physa	x	x	x	x	x	x			x						x			x		x			x	x	x		x							x		x		x		x				x
Planorbidae																																														
Gyraulus sp.	x			x										x									x	x					x				x		x		x						
Helisoma																					x																							
PELECOPODA																																													
Sphaeriidae																																													
Pisidium sp.																			x					x										x		x								
ANNELIDA																																													
Hirudinea																																													
Erpobdellidae																					x	x																					
Glossiphoniidae				x															x															x									
Oligochaeta																						x																					
Naididae																																													
Nais																																													
Nais communis	x																							x													x						
Dero sp.	x	x																					x																				
Ophiodonais sp.	x																																												
Tubificidae																																													
Immature with capilliform chaetae			x															x	x				x	x			x							x									
Immature without capilliform chaetae		x	x		x		x								x			x	x	x				x	x			x		x				x			x						
Rhyacodrilus							x																																						
Limnodrilus hoffmeisteri					x										x			x	x					x					x	x													
L. udekemianus																	x							x																				
NEMATAMORPHA																																				x									

Table 11. Shannon-Weaver diversity indicies for macroinvertebrates by stream in the study area. Symbols (d), max (d) and min (d) refer to diversity, maximum diversity and minimum diversity, respectively.

Stream	Site	(d)	Max (d)	Min (d)	Redundancy	Evenness	Equitability	Species Richness
Hanging Woman Cr.	1	3.1770	4.5849	1.7493	.4964	.6929	.4731	2.7039
	2	3.8980	4.5235	2.8695	.3781	.8617	.6838	3.2142
	3	3.6213	4.5849	2.0475	.3797	.7898	.5635	3.0578
	4	2.7035	4.6438	.5875	.4783	.5821	.3112	2.3923
	5	2.2306	4.5235	.4104	.5574	.4931	.2439	1.9866
	6	2.7118	4.4594	.8703	.4869	.6081	.3482	2.3636
East Fork Hanging Woman Cr.		2.8316	4.6438	.3754	.4245	.6097	.2999	2.5316
Lee Creek		2.4078	3.5849	1.4547	.5525	.6716	.4203	1.9875
Stroud Creek		0.0000	0.0000	0.0000	-	-	-	-
Horse Creek		0.0000	0.0000	0.0000	-	-	-	-
PK Creek		2.4052	3.7004	.4076	.3933	.6499	.2956	2.1095
Trail Creek		2.4056	2.5849	2.4076	1.0000	.9306	.8018	1.6037
Waddle Creek		2.7099	4.2479	.7069	.4343	.6379	.3437	2.3662
Otter Creek	1	3.9316	4.9068	1.2403	.2659	.8012	.5087	3.4229
	2	3.4841	4.5849	1.6496	.3750	.7599	.5108	2.9733
	3	3.3252	4.1699	1.2171	.2860	.7974	.4866	2.8385
	4	2.6464	2.8073	2.5219	.5637	.9426	.7966	1.8497
	5	3.1008	3.4594	2.0256	.2500	.8963	.6319	2.4689
	6	2.3465	3.9068	.5976	.4715	.6006	.3031	2.0434
	7	3.2565	5.3219	.3788	.4178	.6119	.3184	2.9381
	9	2.8548	4.5235	.8059	.4488	.6311	.3568	2.4979
	10	2.3219	2.3219	2.3219	-	-	-	-
Home Creek		3.5257	4.5235	.5054	.2483	.7794	.4009	3.1248
Fifteenmile Cr.		1.9302	3.1699	1.3474	.6802	.6089	.3652	1.5650

Table 11. Continued

Stream	Site	(d)	Max (d)	Min (d)	Redundancy	Evenness	Equitability	Species Richness
Elk Creek		2.3424	3.4594	1.0313	.4600	.6771	.3784	1.9639
Lyon Creek		1.6936	3.7004	.4424	.6159	.4576	.2118	1.4817
Taylor Creek		3.9427	5.3575	1.0011	.3247	.7359	.4561	3.4865
Cow Creek		4.3328	5.2094	1.0638	.2114	.8317	.5181	3.8146
Indian Creek		2.9647	4.3219	1.0044	.4090	.6859	.4024	2.5622
Horse Creek		1.1083	3.9068	.3936	.7965	.2836	.1310	.9772
Bear Creek		3.1279	3.3219	2.5849	.2631	.9416	.7501	2.3778
Tooley Creek		0.0000	0.0000	0.000	-	-	-	-
Pasture Creek		0.0000	0.0000	0.000	-	-	-	-

due to the small sample size, asymptotic diversity is not reported here.

In most instances, the higher diversity (d) values were obtained on the Hanging Woman Creek and Otter Creek mainstems. However, several tributaries including Home Creek, Taylor Creek and Bear Creek had values greater than 3 indicating good species diversity. The highest ($\bar{d}$) value recorded was Cow Creek with 4.33. Four tributaries had a value of 0 indicating the presence of only one species.

Redundancy values were lowest (indicating a larger choice of species) at the lower reaches of Otter Creek and several of its tributaries. Values were generally higher in the Hanging Woman drainage.

Evenness values were similar for most of the study area. Calculations indicated that most species abundances were nearly equal. The raw data supports this conclusion. Although a large number of different species were identified, only a few individuals of each species were collected.

Equitability values were not good for the study area indicating levels of habitat degradation as defined by Newell (1977). However, these values have a similar range to those calculated for Upper Young's Creek (Schmidt 1977), a tributary of the Tongue River near the Montana-Wyoming border. These values may be indicative of prairie stream conditions characteristic to this area.

Species richness values, indicating the number of species present, were higher on the Hanging Woman Creek and Otter Creek mainstems. However, three Otter Creek tributaries, Home Creek, Taylor Creek and Cow Creek reported three of the five highest values calculated.

Baseline data collected on the aquatic invertebrates of the area provides a general understanding of the community structure and composition as it presently exists. Although diversity and density of invertebrate communities vary seasonally as a result of natural cyclic fluctuations, they remain relatively stable from year to year (Isom 1978). The response of invertebrate communities to a change in habitat quality is by adjustments in community structure. Thus, aquatic invertebrates obtain importance as indicators of both subtle and significant change in water quality. By monitoring changes in the invertebrate community, a change in the water quality of the area can be detected.

FISH

Distribution

During the study, 25 species of fish representing six families were identified. A taxonomic breakdown of these families is

presented in Table 12. All names are in accordance with American Fisheries Society (1980) standard nomenclature.

Table 12. Taxonomic status, scientific and common names of fish sampled in the study area.

Family	Scientific Name	
Esocidae	*Esox lucius*	Northern pike
Cyprinidae	*Cyprinus carpio*	Carp
	Notemigonus crysoleucas	Golden shiner
	Semotilus atromaculatus	Creek chub
	Hybopsis gracilis	Flathead chub
	Couesius plumbeus	Lake chub
	Notropis stramineus	Sand shiner
	Hybognathus hankinsoni	Brassy minnow
	Pimephales promelas	Fathead minnow
	Rhinichthys cataractae	Longnose dace
Catostomidae	*Carpoides carpio*	River carpsucker
	Moxostoma macrolepidotum	Shorthead redhorse
	Catostomus catostomus	Longnose sucker
	Catostomus commersoni	White sucker
Ictaluridae	*Ictalurus melas*	Black bullhead
	Ictalurus natalis	Yellow bullhead
	Noturus flavus	Stonecat
Centrarchidae	*Ambloplites rupestris*	Rock bass
	Lepomis cyanellus	Green sunfish
	Lepomis gibbosus	Pumpkinseed
	Micropterus dolomieui	Smallmouth bass
	Pomoxis annularis	White crappie
Percidae	*Perca flavescens*	Yellow perch
	Stizostedion canadense	Sauger
	Stizostedion vitreum	Walleye

The greatest number of species belonged to Cyprinidae, a family well represented in the small streams of eastern Montana. Four species of sport fish representing three different families were found to occur in the area. These species included northern pike, smallmouth bass, sauger, and walleye. In previous sampling efforts, another game fish, the channel catfish, was found at the mouth reaches of both Hanging Woman and Otter creeks (Mt. Dept. FWP, unpublished data). The rock bass considered a game fish in other states although not holding that status in Montana (Brown 1971) was also identified.

A distribution listing of all fish species occurring in the study area is presented in Table 13. From this table, a structure of species occurrence is revealed. Fishes characteristic of larger bodies of water, noteably the Esocidae, Percidae and most species of Castostomidae, and Centrarchidae, are shown to be present at the lowest reaches of Hanging Woman Creek and Otter Creek. The cyprinids on the other hand, as well as the white sucker, green sunfish, and pumpkinseed, are more widely distributed through both drainages. The lake chub, white sucker, and brassy minnow were the three most widely distributed species, having occurrences in the study area of 93.3%, 60.0%, and 53.3%, respectively. All species identified were found previously in both drainages (Elser et al. 1980).

Seven additional species are known to be present in the study area (Elser et al. 1980), including emerald shiner, plains minnow/western silvery minnow, smallmouth buffalo, channel catfish, bluegill, and black crappie. Variations in stream conditions, time of sampling, and changes in fish movement could have contributed to the absence of these species during the current study.

Species Composition

Species composition for Hanging Woman Creek is tabulated in Table 14. At the lowest reach, the white sucker is by far the most common comprising 40.2% of the population. Through the mid-portions of the drainage the fathead minnow, white sucker, green sunfish and pumkinseed, in various combinations, dominate the composition of fishes. Fathead minnow numbers remain high in the upper portions of the drainage while brassy minnow numbers increase to relatively the same proportion. At Hanging Woman Creek, site 6, the lake chub comprises 92.4% of the total sample. Species diversity decreased with consecutive upstream sites as would be expected.

Table 15 shows species composition for Otter Creek. As on Hanging Woman Creek, the white sucker was the most common species at the lower reaches, Otter Creek sites 1 and 2, where it composed 42.1% and 58.7% of the sample, respectively. This species remains prominent at the upstream sites. At site 3, the golden shiner, brassy minnow, pumpkinseed, white sucker, and fathead minnow make up 91% of the sample in almost equal proportion to one another. The pumpkinseed increases in prominence at sites 4 and 5 with the lake chub dominating the species composition at the remainder of the upstream sites. In comparing the Hanging Woman Creek and Otter Creek results, a similar progression in species distribution occurs with consecutive upstream sites.

Seven species were identified on the tributary sites. The species and their percent composition are shown in Table 16. Thirteen of the twenty-two streams (59.1%) contained fish in some portion of their drainages. Lake chubs were present in all

Table 13. Distribution of fish species in the study area.

	Hanging Woman Creek						Waddle	Trail	Corral	PK	Horse	Stroud	Lee	E. Fk. Hang. Wn.	Otter Creek										Pasture	Tooley	Bear	Horse	Indian	Cow	Taylor	Lyon	Elk	Fifteenmile	Tenmile	Threemile	Home	East Fork Otter
	1	2	3	4	5	6									1	2	3	4	5	6	7	8	9	10													
Northern pike	x																																				
Carp	x	x	x		x	x									x																						
Golden shiner	x	x													x	x	x																				
Creek chub																	x	x		x																	
Flathead chub															x	x																					
Lake chub		x	x	x		x				x		x		x		x	x	x	x	x	x		x		x			x		x					x		
Sand shiner		x	x		x											x	x																				
Brassy minnow		x	x	x	x	x							x		x		x	x	x	x	x		x		x			x		x					x		
Fathead minnow		x	x	x	x	x							x	x	x	x	x		x	x						x											
Longnose dace	x	x	x	x										x															x								
River carpsucker	x														x																						
Shorthead redhorse	x	x	x											x	x	x	x																				
Longnose sucker			x																																		
White sucker	x	x	x	x	x	x							x	x	x	x	x	x	x	x			x			x		x	x	x		x				x		
Black bullhead	x	x	x												x	x	x	x	x	x																	
Yellow bullhead	x														x																						
Stonecat	x														x																						
Rock bass	x														x																						
Green sunfish	x	x	x	x	x									x	x	x	x																				
Pumpkinseed	x	x	x													x	x	x	x	x																
Smallmouth bass	x														x	x																					
White crappie	x	x													x																						
Yellow perch	x	x													x																						
Sauger	x																																				
Walleye	x														x																						

Table 14. Species composition expressed as numbers caught and percent of total sample at each Hanging Woman Creek sample site, 1980-1981. Percent in parenthesis.

	1	2	3	4	5	6
Northern pike	2 (.4)					
Carp	14 (2.8)	1 (.1)	3 (.7)		6 (2.3)	7 (.2)
Golden shiner	7 (1.4)	21 (2.7)				
Lake chub		2 (.3)	26 (5.9)	5 (.6)		4141 (92.4)
Sand shiner		4 (.5)	1 (.2)		4 (1.5)	
Brassy minnow		9 (1.1)	31 (7.1)	54 (6.9)	19 (7.1)	
Fathead minnow		149 (19.0)	25 (5.7)	257 (32.9)	149 (56.0)	122 (2.7)
Longnose dace	3 (.6)	1 (.1)	3 (.7)	26 (3.3)		175 (3.9)
River carpsucker	83 (16.4)					
Shorthead redhorse	48 (9.5)	1 (.1)	1 (.2)			
Longnose sucker			1 (.2)			
White sucker	204 (40.2)	108 (13.7)	204 (46.5)	131 (16.9)	51 (19.2)	36 (.8)
Black bullhead	30 (5.9)	3 (.4)	1 (.2)			
Yellow bullhead	1 (.2)					
Stonecat	4 (.8)					
Rock bass	7 (1.4)					
Green sunfish	18 (3.6)	43 (5.5)	15 (3.4)	307 (39.4)	18 (6.8)	
Pumpkinseed	13 (2.6)	406 (51.7)	128 (29.2)			
Smallmouth bass	24 (4.7)					
White crappie	41 (8.1)	22 (2.8)				
Yellow perch	4 (.8)	16 (2.0)				
Sauger	1 (.2)					
Walleye	3 (.6)					

Table 15. Species composition expressed as numbers caught and percent of total sample at each Otter Creek sample site 1980-1981. Percent in parenthesis.

	1	2	3	4	5	6	7	8	9	10
Carp	34(2.5)									
Golden shiner	182(13.6)	101(15.6)	393(24.5)							
Creek chub			3(.2)	37(2.2)		1(.1)				
Flathead chub	10(.7)	1(.2)								
Lake chub		11(1.7)	1(.1)	280(16.9)	3(.7)	275(32.7)	70(98.6)		1554(99.9)	
Sand shiner		4(.6)	95(5.9)							
Brassy minnow	40(3.0)		297(18.5)	336(20.3)	5(1.1)	126(15.0)	1(1.4)		2 (.1)	
Fathead minnow	38(2.8)	17(2.6)	232(14.5)		1(.2)	30(3.6)				
River carpsucker	86(6.4)									
Shorthead redhorse	250(18.6)	20(3.1)	7(.4)							
White sucker	565(42.1)	380(58.7)	249(15.5)	601(36.3)	246(55.5)	345(41.1)				
Black bullhead	25(1.9)	33(5.1)	27(1.7)	15(.9)	5(1.1)	5(.6)				
Yellow bullhead	1(.07)									
Stonecat	23(1.7)									
Rock bass	21(1.6)									
Green sunfish	5(.4)	1(.2)	17(1.1)							
Pumpkinseed		77(11.9)	283(17.7)	385(23.3)	183(41.3)	58(6.9)				
Smallmouth bass	29(2.2)	2(.3)								
White crappie	41(3.1)									
Yellow perch	13(1.0)									
Walleye	1(.07)									

Table 16 . Percent composition of species collected at tributary sites. (P) indicates that species is present but number unknown.

	Hanging Woman Tributaries								Otter Creek Tributaries													
	Waddle	Trail	Corral	PK	Horse	Stroud	Lee	East Fork Hanging Woman	Pasture	Tooley	Bear	Horse	Indian	Cow	Taylor	Lyon	Elk	Fifteenmile	Tenmile	Threemile	Home	East Fork Otter
Lake chub				100		100		55.3	100		84.8	100	58.5	43.1	83.0		42.4	100			9.1	
Brassy minnow							85				12.3		41.0	52.5	13.4		51.5				90.9	
Fathead minnow							14.3	3.6					.3									
Longnose dace								24.2						1.3								
Shorthead redhorse								P														
White sucker							.7	14.4			2.9		.3	3.0	4.0		6.1				P	
Green sunfish								3.3														

streams containing fish with the exception of Lee Creek. In five streams, the lake chub was the only species found. The brassy minnow and white sucker were the second two most commonly occurring species present on 8 and 7 streams, respectively. Both species were identified on the same five streams. The East Fork of Hanging Woman Creek had the greatest diversity of species of all the tributaries. In earlier sampling efforts (MT. Dept. FWP, unpublished data), the brassy minnow was also taken in the East Fork. In general, the diversity of the tributary streams could be considered low with one or two species dominating the total sample. Due to the character of these tributary streams it is not surprising that the diversity of fishes is low. Without the higher flows of spring, fish movement and reintroduction, even if only temporary, were inhibited. The chances of survival of fish occupying an area were also diminished as a result of an increasingly stressed environment.

Spring Trapping and Electrofishing Results

Traps were placed at the mouth reaches of Hanging Woman and Otter creeks during the springs of both years of the study to sample migrant fishes moving out of the Tongue River. During June of 1981, electrofishing was employed when high water rendered the traps ineffective. In 1980, traps were fished from April 11 through June 20. In 1981, traps were utilized from April 9 through May 25. Electrofishing gear was then employed during the high water in June. By late June the water levels of both creeks had subsided and traps were again stationed in their original locations. By this time, however, several days of sampling indicated that spring movements from the Tongue River had subsided and the traps were removed.

During sampling, traps were checked generally every other day. A record was kept of species, number of individuals, length-weight information and those in spawning condition. The results presented here emphasize data obtained using the traps with inclusion of information obtained during the shocking runs.

Hanging Woman Creek

The number of fish collected on Hanging Woman Creek at each trap set for 1980 and 1981 is illustrated in Figure 6. The number collected was generally higher in 1980 with exception of the June collections, probably as a result of using the electrofishing gear in 1981 which may have been a more effective means of sampling. Although numbers collected at each trap were generally greater in 1980, the diversity of species was higher in 1981.

The first appearance of smallmouth bass for both years occurred on May 6. In 1980, the first ripe female smallmouth bass was collected on May 7. Individuals in spawning condition in 1981 were collected late in the sampling (June 11). Collections

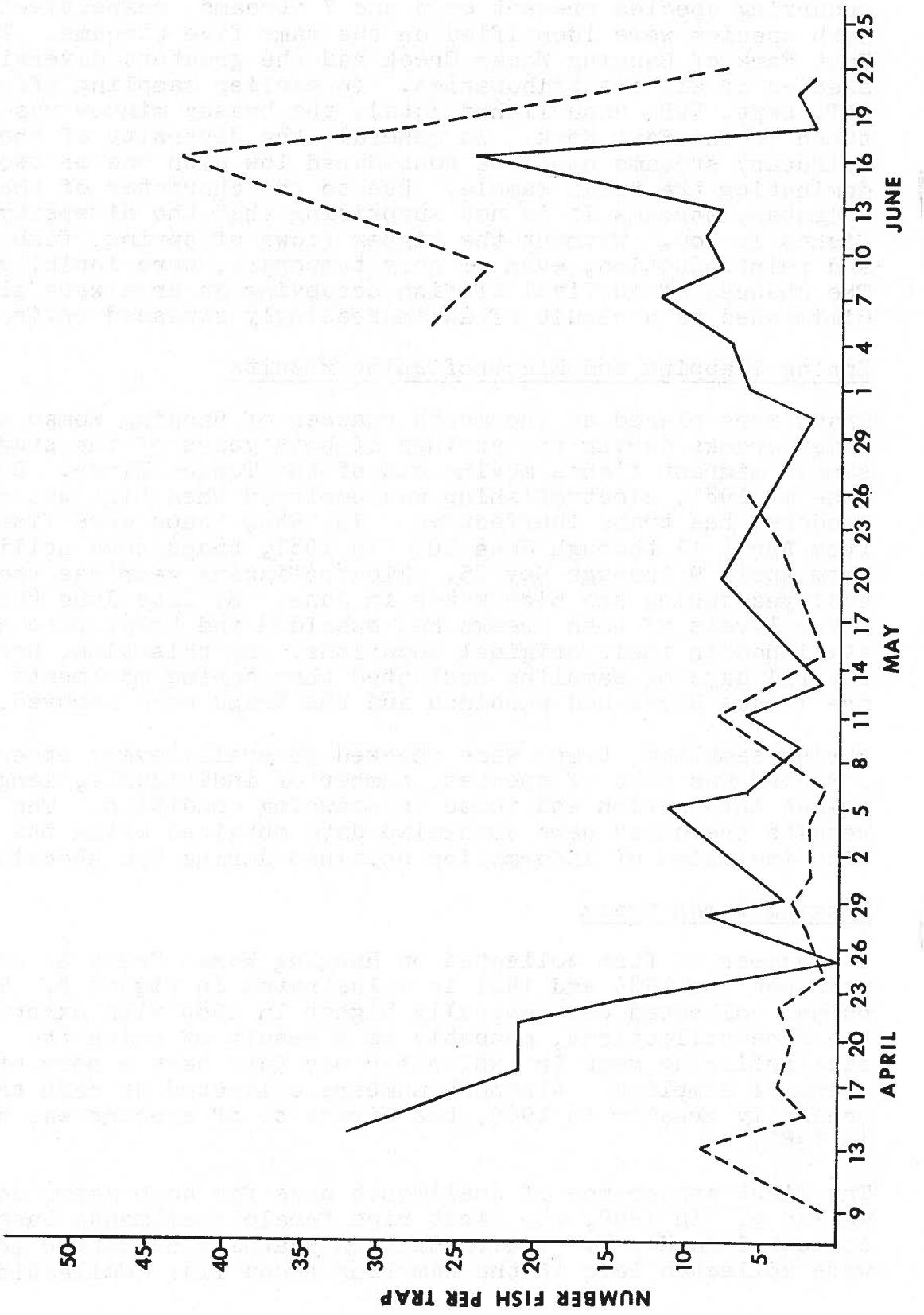


Figure 6 . Results showing the number of fish collected during spring trapping in 1980 (-) and 1981 (---) on Hanging Woman Creek.

involved the use of traps in 1980 and both traps and the electrofishing boat in 1981. Other game fish collected included six northern pike, May 13 through June 18, 1980, two sauger caught on nearly the same date, 6-2-80 and 6-5-81, and three walleye collected 6-4-80 and 6-16-81. One walleye was determined to be a ripe female. No other individuals were found in spawning condition. Seven rock bass were taken on June 4 and 13, 1980 and from May 22 through June 16, 1981.

The three most abundant species collected during trapping were the white sucker, shorthead redhorse and river carpsucker. Each comprised 52.5%, 12.7% and 12.3%, respectively, of the total sample during spring trapping. A definite pattern in movement of these species into Hanging Woman Creek was observed during the spring of 1980 (Figure 7). White sucker numbers were high during the early portions of April, decreasing rather abruptly after April 22, and replaced toward the end of April by the shorthead redhorse. Although their numbers don't reach a high peak, they are more numerous than the white sucker. The river carpsucker follows, moving into Hanging Woman Creek during June. River carpsucker numbers peak by June 16, 1980 and quickly drop off to zero by June 20. A similar analysis was attempted with the 1981 results, however, fewer numbers of individuals of these three species were collected and the pattern was not recognized.

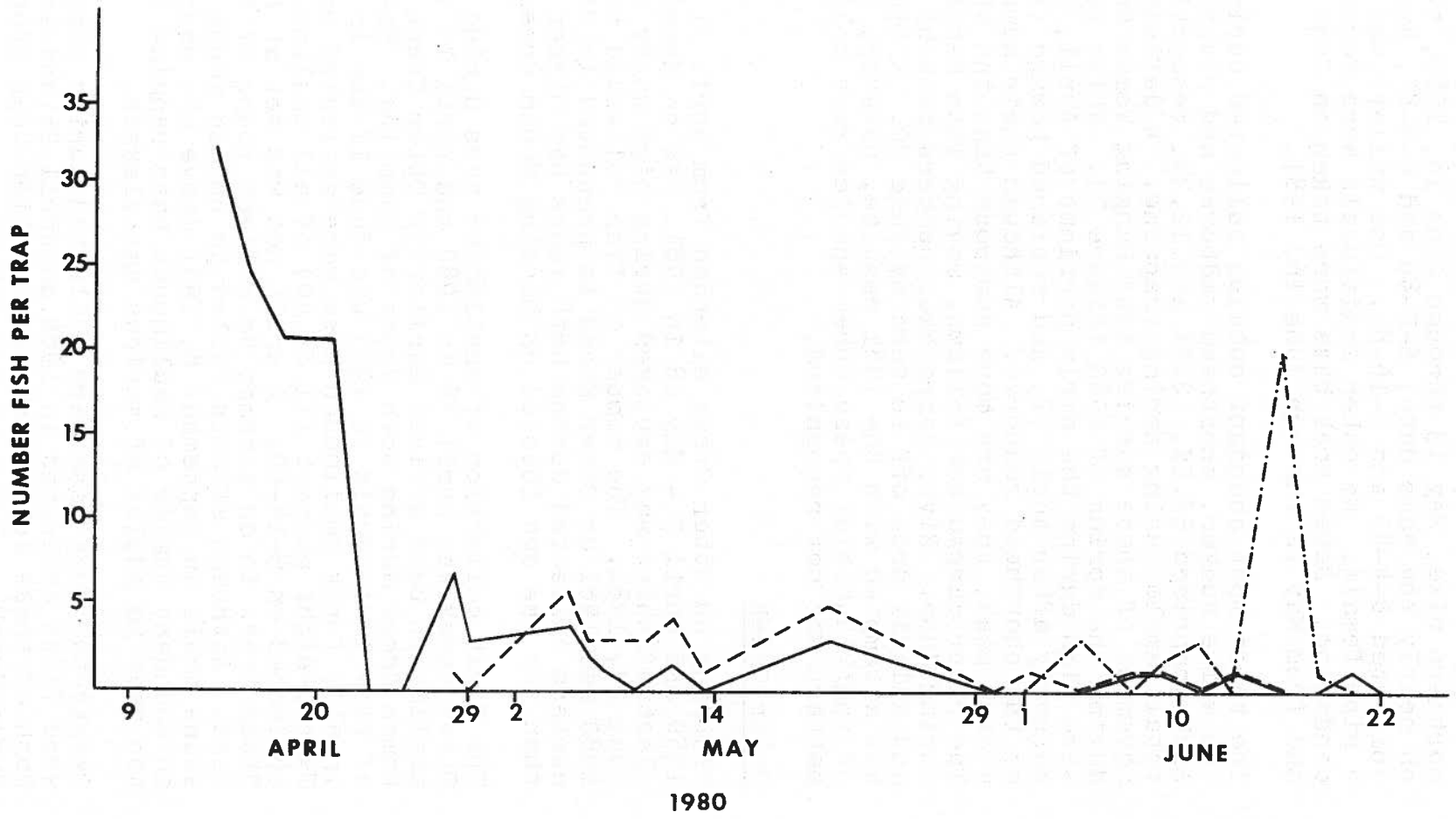
Otter Creek

Trapping on Otter Creek extended from April 11 - June 20 in 1980 and April 9 - May 28 in 1981. As on Hanging Woman Creek, electrofishing was employed during high water from June 5 - June 22, 1981. The number of fish collected per trap set for 1980 and 1981 on Otter Creek is presented in Figure 8. The numbers collected during both years was higher at this trap than for the one located on Hanging Woman Creek.

The first collection of smallmouth bass during trapping in Otter Creek was April 28 in 1980 and April 16 in 1981. The smallmouth bass arrived earlier in Otter Creek than in Hanging Woman Creek during both years of sampling. The first indication of ripe individuals in 1980 was June 11 and in 1981, June 8. In all, forty smallmouth bass were collected on Otter Creek. Twenty-eight percent (11 of 40) of all smallmouth bass were collected on 5-14-80. A drift net was set at the mouth of Otter Creek in an attempt to collect young of the year smallmouth bass. Although efforts failed to obtain young by this means, seine hauls on September 8, 1981 above the mouth site produced an abundant number of smallmouth bass ranging from young of the year to adults of various age classes.

Twenty-two rock bass were collected during trapping. Rock bass were first collected in 1980 on April 25 and in 1981 on May 13. Both of these collections are earlier than those made on Hanging Woman Creek.

Figure 7. 1980 Hanging Woman trapping results comparing the movements of white sucker (-), shorthead redhorse (---), and river carpsucker (-·-·).



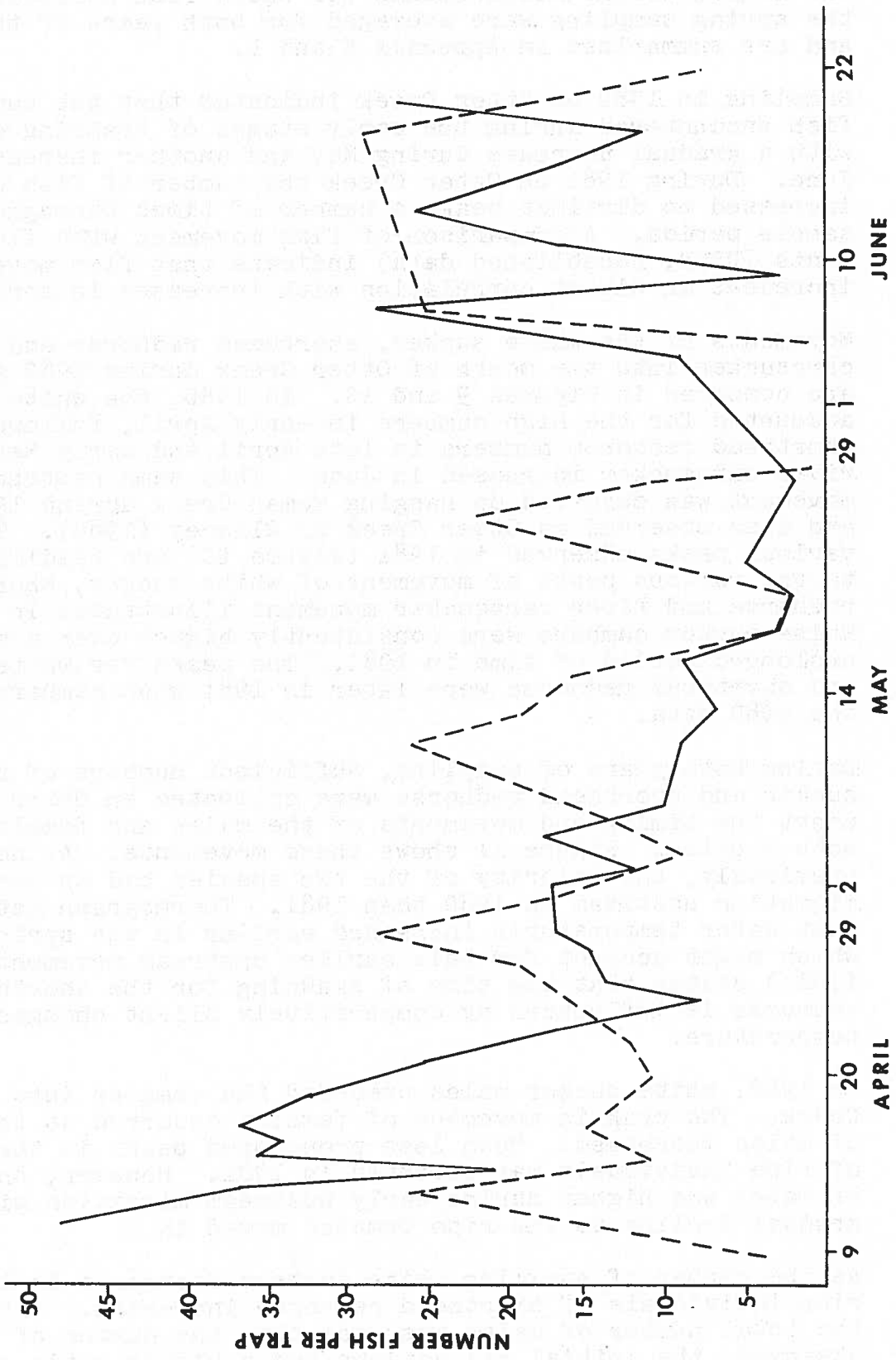


Figure 8. Results showing the number of fish collected during spring trapping in 1980 (-) and 1981 (---) on Otter Creek.

The length-weight measurements for sport fish collected during the spring sampling were averaged for both years of the study and are summarized in Appendix K and L.

Sampling in 1980 on Otter Creek indicated that the number of fish encountered during the early stages of trapping were high, with a gradual decrease during May and another increase during June. During 1981 on Otter Creek the number of fish collected increased to distinct peaks a number of times throughout the sample period. A comparison of fish movement with flow measurements (USGS, unpublished data) indicate that fish movement increases in direct correlation with increases in spring flows.

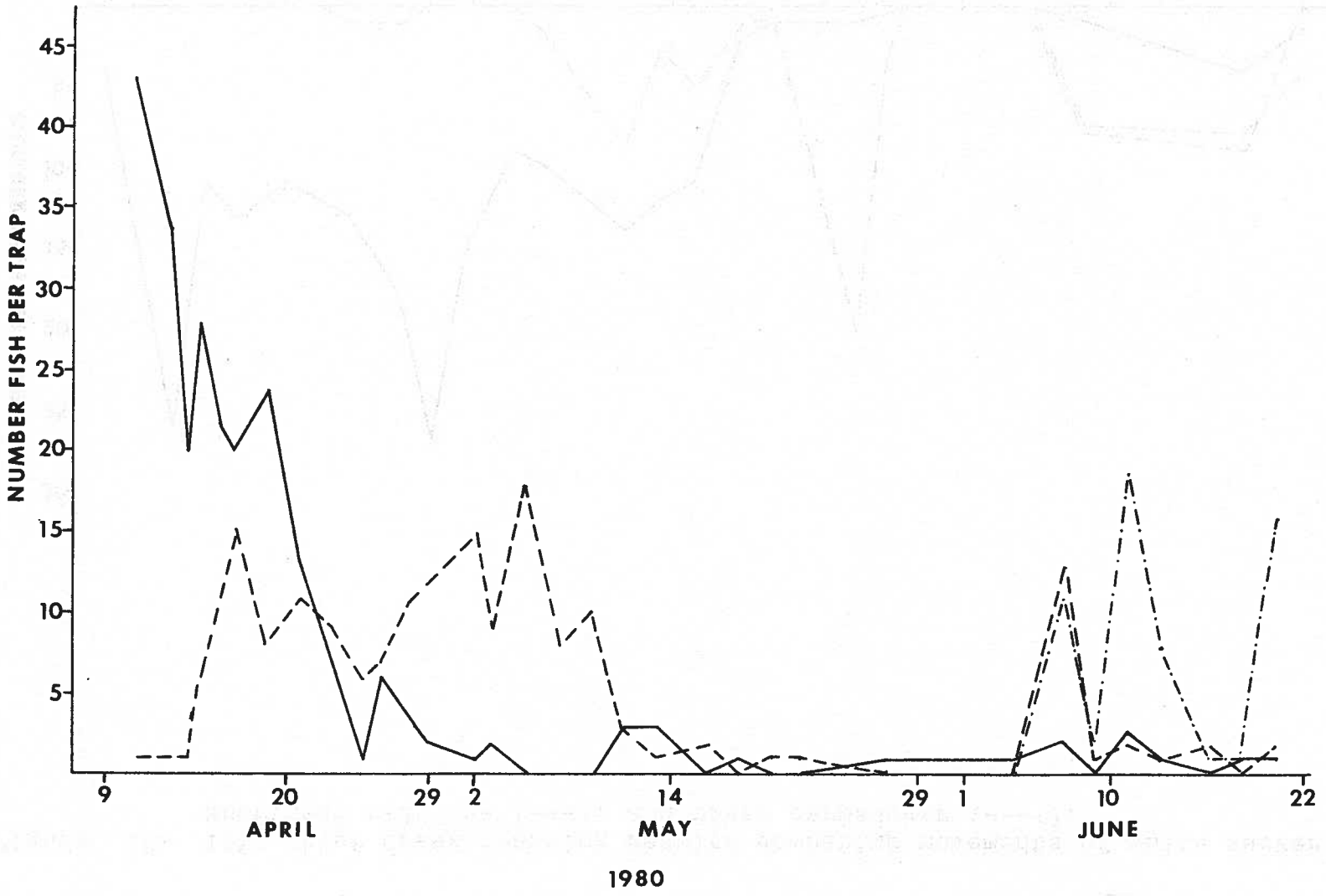
Movements of the white sucker, shorthead redhorse and river carpsucker into the mouth of Otter Creek during 1980 and 1981 are compared in Figures 9 and 10. In 1980, the white sucker accounted for the high numbers in early April, followed by shorthead redhorse numbers in late April and early May while river carpsucker increased in June. This same pattern of movement was observed on Hanging Woman Creek during 1980 and also observed on Otter Creek by Clancey (1980). The various peaks observed in 1981 (Figure 10) are readily compared to the various peaks of movement of white sucker, shorthead redhorse and river carpsucker movement illustrated in Figure 8. White sucker numbers were consistently higher over a more prolonged period of time in 1981. The peaks for white sucker and shorthead redhorse were later in 1981 when compared with the 1980 data.

During both years of sampling, sufficient numbers of ripe white sucker and shorthead redhorse were collected on Otter Creek to chart the timing and movements of the males and females of both species. Figure 11 shows these movements. As noted previously, the majority of the two species had an earlier migration upstream in 1980 than 1981. Thermograph data indicated that water temperatures increased earlier in the spring of 1980 which might account for this earlier upstream movement. Meyer (1961) states that the time of spawning for the shorthead redhorse is influenced by comparatively slight changes in water temperature.

In 1980, white sucker males preceded the females into Otter Creek. The peak in movement of females occurred as the number of males decreased. Much less pronounced peaks in the movement of ripe individuals was observed in 1981. However, the number of males was higher during early upstream migration with a gradual decline as the ripe females moved in.

As the number of spawning white suckers decreased in 1980, ripe individuals of shorthead redhorse increased. Although the total number of males was less than the number of females observed, the initial collections had a higher ratio of males to

Figure 9. 1980 Otter Creek trapping results comparing movements of white sucker (-), shorthead redhorse (---), and river carpsucker (-·-·).



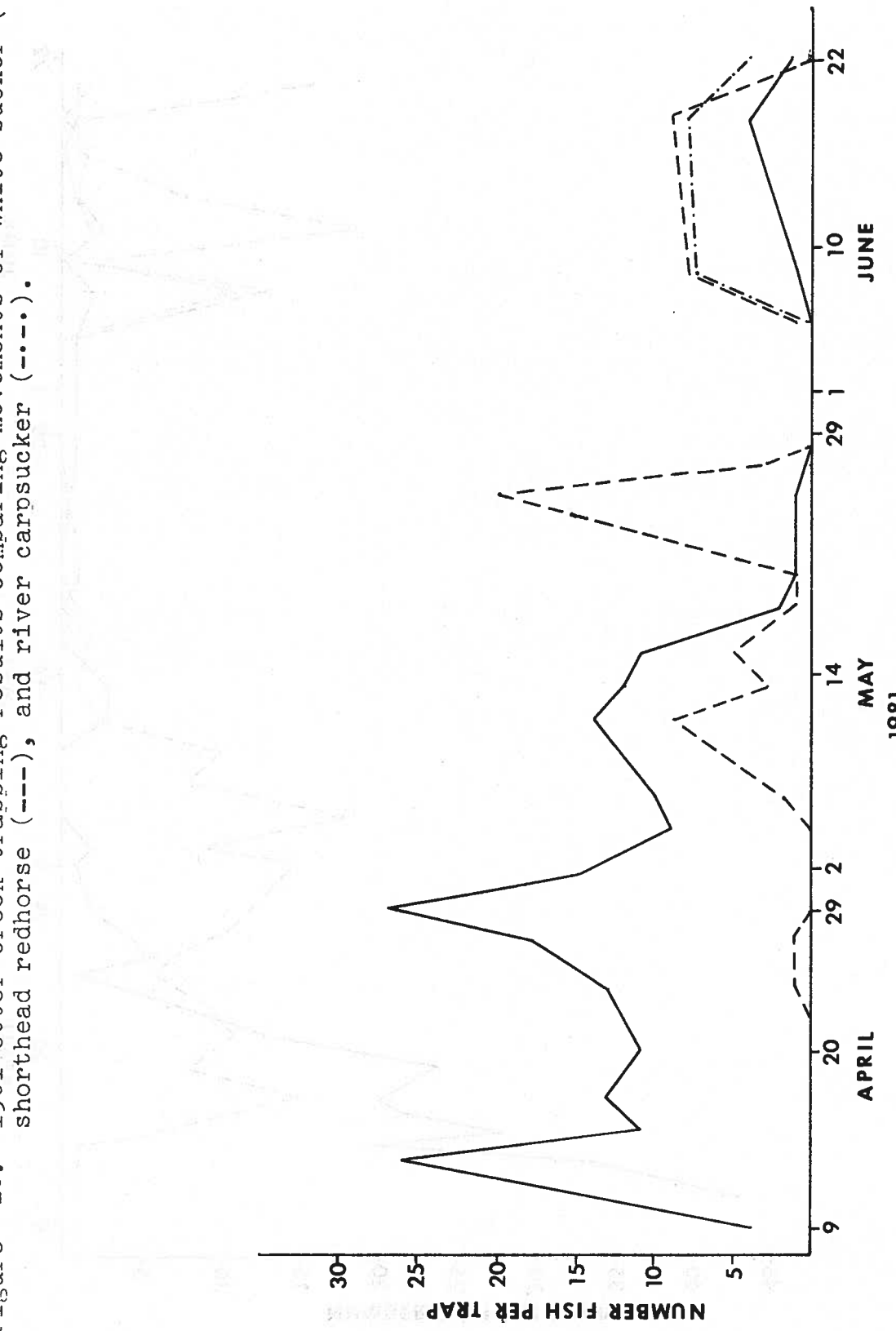
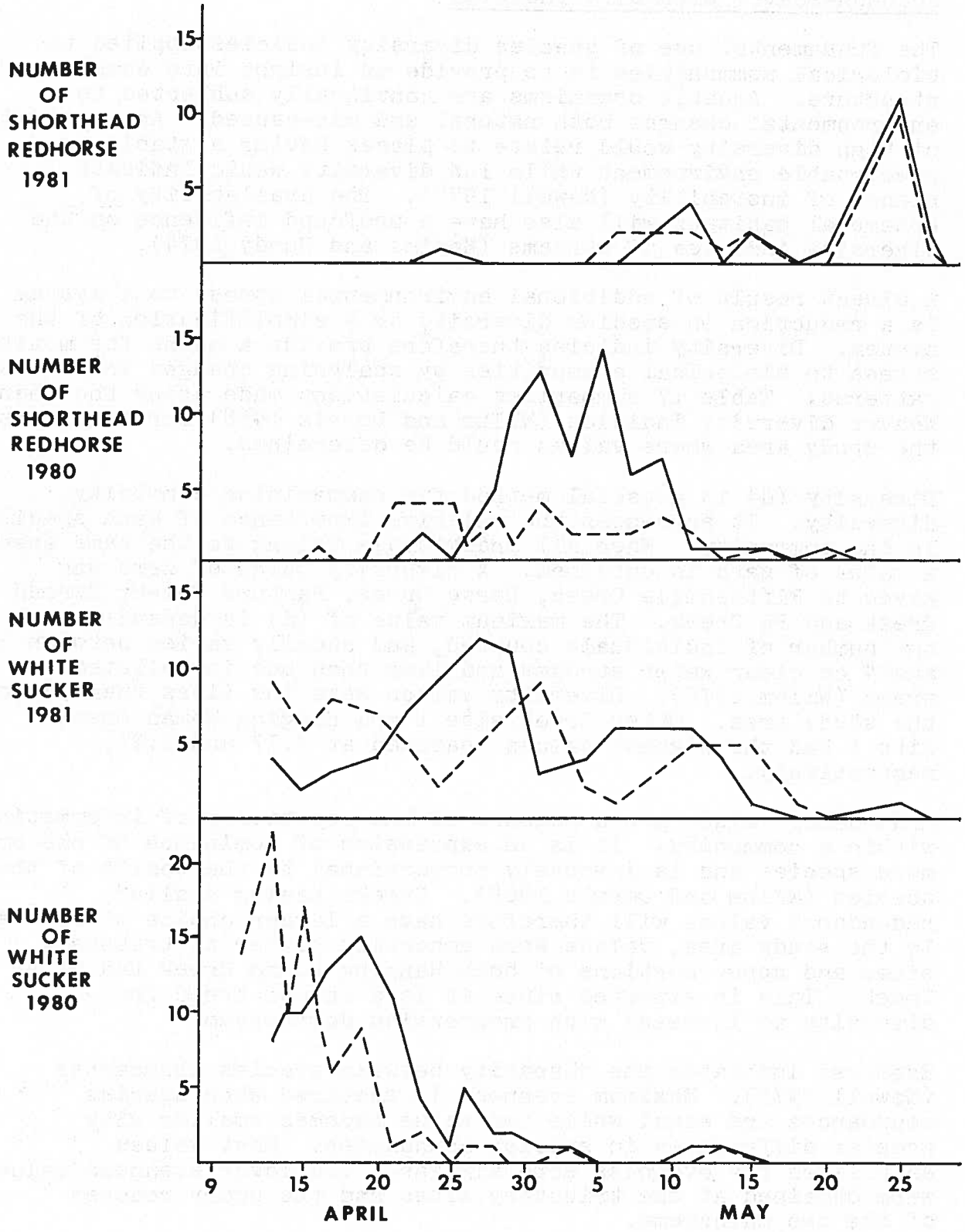


Figure 10. 1981 Otter Creek trapping results comparing movements of white sucker (—), shorthead redhorse (– – –), and river carpsucker (—·—·—).

Figure 11. Movement of white sucker and shorthead redhorse females (-) and males (---) into the mouth section of Otter Creek by species and year.



females. Spring movement of shorthead redhorse in 1981 occurred later than in 1980. Numbers of males and females collected were similar throughout sampling.

Shannon-Weaver Diversity Indicies

The fundamental use of species diversity indicies applied to biological communities is to provide an insight into community structure. Aquatic organisms are continually subjected to environmental changes both natural and man-caused. An expression of high diversity would relate to places having a stable or predictable environment while low diversity would indicate places of instability (Newell 1977). The availability of ephemeral habitats will also have a profound influence on the diversity indicies of streams (Harima and Mundy 1974).

A direct result of additional environmental stress to a system is a reduction in species diversity or a simplification of the system. Diversity indicies therefore provide a means for monitoring stress to biological communities by analyzing changes in diversity patterns. Table 17 summarizes calculations made using the Shannon-Weaver diversity indicies (Wilhm and Dorris 1968) for all sites in the study area where values could be determined.

Diversity (d) is a useful method for summarizing community diversity. It expresses the relative importance of each species in the community. When all individuals belong to the same species a value of zero is obtained. A diversity value of zero was given to Fifteenmile Creek, Horse Creek, Pasture Creek, Stroud Creek and PK Creek. The maximum value of (d) is dependent on the number of individuals counted, and usually varies between 3 and 4 on clear water streams and less than one in polluted areas (Wilhm 1970). Diversity values were low (less than 3) for the study area. Otter Creek site 1 and Hanging Woman Creek site 1 had the highest values measured at 2.77 and 2.91, respectively.

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 (Wilhm and Dorris 1968). Creeks having smaller redundancy values will therefore have a larger choice of species. In the study area, values were generally higher at tributary sites and upper portions of both Hanging Woman Creek and Otter Creek. This is expected since it is a common trend for diversity to increase with progression downstream.

Evenness indicates the disparity between species abundances (Newell 1977). Maximum evenness is acquired when species abundances are equal while the value becomes smaller with greater differences in species abundances. Most values calculated for evenness were similar. The lower evenness values were obtained at the tributary sites and the upper reaches of the two mainstems.

Table 17. Shannon-Weaver diversity indicies for fish species in the study area. Symbols (d), max (d) and min (d) refer to diversity, maximum diversity and minimum diversity, respectively.

Stream	Site	(d)	Max (d)	Min (d)	Redundancy	Evenness	Equitability	Species Richness
Otter	1	2.7692	4.0874	.1389	.3338	.6774	.2659	2.5033
	2	1.9465	3.4594	.1664	.4594	.5626	.2084	1.7381
	3	2.6779	3.4594	.0753	.2309	.7740	.2515	2.4264
	4	2.1052	2.5849	.0366	.1882	.8144	.1969	1.9083
	5	1.2128	2.5849	.1154	.5556	.4691	.1379	1.0748
	6	1.9587	2.8073	.0796	.3111	.6977	.2016	1.7571
	7	.1067	1.0000	.1067	.9999	.1067	.0173	.0894
	8	-	-	-	-	-	-	-
	9	.0141	1.0000	.0077	.9934	.0141	.0013	.0128
	10	-	-	-	-	-	-	-
Hanging Woman	1	2.9058	4.1699	.3488	.3308	.6968	.3233	2.5824
	2	2.1702	3.8073	.1827	.4516	.5700	.2256	1.9445
	3	2.1239	3.5849	.2556	.4388	.5924	.2419	1.8819
	4	1.9664	2.5849	.0708	.2460	.7607	.2046	1.7617
	5	1.6964	2.5849	.1898	.3709	.6562	.2134	1.4829
	6	.4999	2.3219	.0121	.7888	.2153	.0412	.4587
Otter Creek Tributaries								
Home		.8166	1.5849	.8166	1.0000	.5152	.2278	.5888
Elk		1.2628	1.5849	.3904	.2696	.7967	.2503	1.0125
Fifteenmile		.0000	-	-	-	-	-	-
Taylor	1	.8139	1.5849	.0091	.4892	.5135	.0710	.7429
N. Fork	2	.7621	1.5849	.0258	.5277	.4808	.0781	.6840
S. Fork	3	.7556	1.5849	.0345	.5349	.4767	.0814	.6741
Cow	2	.1927	1.0000	.0233	.8264	.1927	.0219	.1708
Indian	2	1.1406	1.9999	.0258	.4352	.5703	.1094	1.0312

Table 17 . Continued

Stream	Site	(d)	Max (d)	Min (d)	Redundancy	Evenness	Equitability	Species Richness
Horse		.0000	-	-	-	-	-	-
Bear		.7231	1.5849	.0155	.5491	.4562	.0682	.6548
Pasture		.0000	-	-	-	-	-	-
Hanging Woman Creek Tributaries								
East Fork Hanging Woman	1	1.8265	2.3219	.3096	.2461	.7866	.2720	1.5545
East Fork Hanging Woman	2	.1654	1.0000	.1654	1.0000	.1654	.0308	.1345
Lee		.2732	1.5849	.1997	.9469	.1724	.0436	.2296
Stroud		.0000	-	-	-	-	-	-
PK		.0000	-	-	-	-	-	-

Equitability, a ratio of the observed $\bar{d}$ to a maximum theoretical diversity, is computed as though all individuals were equally distributed among the species. Increases in equitability values indicate a more even distribution of species. According to Newell (1977), equitability is sensitive to even slight levels of degradation. Good values are considered to be from 0.0 to 0.3. Values for the study area are within this range.

Species richness is a measure of the number of species present with the increase in value indicating a larger number of species (Hurlbert 1971). The highest values were obtained at sites on the mainstems of Hanging Woman Creek and Otter Creek.

Classification of Streams.

Montana Department of Fish, Wildlife and Parks (1980) 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. The higher value class of these two criteria then is the assigned fishery resource value.

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 are 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

Each reach in Otter Creek and Hanging Woman Creek and all remaining study streams were classified and ranked according to this system. The assigned points and value class for each of the streams are presented in Table 18. These ratings provide another block of information to be utilized in the management decision-making process. It also ranks the streams in this study in relation to other streams in eastern Montana which have also been classified under this system.

The highest value rating obtained was a class 2 (species and habitat criteria) on Hanging Woman Creek, reach 1. This value class is defined as a high priority fishery resource which is of considerable significance in this area. Special consideration should be given to this reach of stream and areas within the drainage potentially affecting it. This will provide protection against a loss in the quality of the fishery that presently exists.

The remaining five reaches of Hanging Woman Creek, five reaches of Otter Creek, and three additional streams, tributaries of Otter Creek, received a value rating of 3. In all instances, this value was given for the species and habitat value. The source of high point accumulation for the Otter Creek and Hanging Woman Creek reaches were a result of the large number of fish species with additional points for esthetics and springs. The tributaries, Horse Creek, Indian Creek and Cow Creek, acquired their point accumulation for esthetics and springs.

Of the remaining Otter Creek tributaries, five were rated class 4, a moderate fishery resource, one was rated class 5, a limited fishery resource and five creeks considered dry were assigned class 6. The class 6 status is considered a negligible fishery resource or one not yet classified.

For the Hanging Woman Creek tributaries, Stroud Creek, Lee Creek, and East Fork Hanging Woman Creek (all situated in the lower portion of the drainage) were rated class 4. The five remaining tributaries were considered not yet classified. Poker Jim Creek and O'Dell Creek were also assigned a class 6 rating.

DISCUSSION

The area encompassed in this study is an ecologically diverse prairie ecosystem. Although low precipitation levels during the course of the study intensified a generally harsh aquatic system, the aquatic fauna were diverse and abundant where conditions allowed. The water resources of the area are a precious commodity both to aquatic life and the people inhabiting the area. Water resource use at the present time by man supports the local, agriculturally-based economy.

The study streams are characteristic of the prairie type aquatic ecosystems associated with this region of Montana. The streams are natural, structurally diverse water courses. Typically,

Table 18. Stream classification values for streams in the Hanging Woman Creek-Otter Creek study.

OTTER CREEK AND ASSOCIATED TRIBUTARIES

Stream	Species & Habitat Points	Species & Habitat Value Class	Sport Fishery Potential Points	Sport Fishery Potential Value Class
Otter Creek				
Reach 1	6.4	3	4	5
Reach 2	5.8	3	4	5
Reach 3	6.2	3	4	5
Reach 4	5.2	3	4	5
Reach 5	4.6	4	4	5
Reach 6	5.3	3	4	5
Reach 7	3.6	4	4	5
Reach 8		6		
Reach 9	3.8	4	4	5
Reach 10		6		
Pasture Creek	3.4	4	4	5
Tooley Creek		6		
Bear Creek	4.0	4	4	5
Horse Creek	6.1	3	6	4
Indian Creek	7.1	3	5	4
Cow Creek	6.3	3	6	4
Taylor Creek	4.1	4	4	5
Lyon Creek		6		
Elk Creek	.1	5	4	5
Fifteenmile Creek	3.1	4	4	5
Tenmile Creek		6		
Threemile Creek		6		
Home Creek	.3	4	4	5
East Fork Otter Creek		6		

Table 18 . Continued

Stream	Species & Habitat Points	Species & Habitat Value Class	Sport Fishery Potential Points	Sport Fishery Potential Value Class
HANGING WOMAN CREEK AND ASSOCIATED TRIBUTARIES				
Hanging Woman Creek				
Reach 1	10.1	2	7	4
Reach 2	8.8	3	6	4
Reach 3	8.5	3	5	4
Reach 4	7.4	3	5	4
Reach 5	7.6	3	5	4
Reach 6	7.5	3	5	4
Waddle Creek		6		
Trail Creek		6		
Corral Creek		6		
PK Creek		6		
Horse Creek		6		
Stroud Creek	3.3	4	4	5
Lee Creek	.5	4	4	5
East Fork Hanging Woman Creek	4.7	4	4	5
OTHER TONGUE RIVER TRIBUTARIES				
Poker Jim Creek		6		
O'Dell Creek		6		

streams of this type have a good buffering capacity. Meanders lessen the effects of floods, pools offer refuge to fish during dry times, and the shade produced by streamside vegetation lessens heat loads and decreases the oxygen robbing effects of algal bloom (Gorman and Karr 1978).

Stream condition ratings indicated that the drainages under study are not excessively abused by agricultural activities nor deteriorated as a result of natural processes. Stream bank vegetation ranged from thick brush and trees to grasses to sparse plant growth and sagebrush. In most areas, the riparian zone was well developed, although several of the intermittent and ephermeral streams had less well defined riparian habitats. The riparian zone and surrounding watershed play an important role in the quality of aquatic habitat (AFS 1980). Often streams are energy dependent on the riparian vegetation and the watershed (Kennedy 1977). Riparian vegetation also influences the ability of a stream to support a fishery (Gerhart 1979) as well as determining species composition (Patton 1977, Karr and Schlosser 1977). Protection of the riparian zone will insure a more stable aquatic habitat and maintain the quality of the aquatic resources.

The diversity of aquatic macroinvertebrates was generally high in the study area. Diptera was the most diverse and widely distributed order, which is typical of streams in prairie-type habitats. Data collections were readily correlated with results obtained in several other studies in eastern Montana. An assessment of the structure of macroinvertebrate communities in their present state provides a basis from which to determine changes to the aquatic environment.

The most common fish in the study area consisted of species comprising the Cyprinidae. The diversity of fishes was highest on the Hanging Woman Creek and Otter Creek mainstems, particularly in the lower reaches, as a result of an influx of species from the Tongue River. At these sites, species associated with larger waters and game species were present. The upper portions of Hanging Woman and Otter creeks and their tributaries supported small stream fishes. Only the hardiest of species capable of withstanding high summer temperatures and low oxygen levels were identified in the less permanent, isolated waters.

In regards to species composition, it has been suggested that in any grouping of fish populations there are two categories of individuals, those that are sedentary and abundant and those that are uncommon and highly mobile. Making this assumption then, a majority of the individuals present throughout the year will comprise only a few species (Harima and Mundy 1974). Within the streams studied, this phenomenon characterized the populations of fish sampled. It was particularly evident when comparing individual sampling runs during the course of the field season as well as in the final commulative results. Species which were numerous in the sampling area tended to remain so throughout sampling while composition of less common species was observed to change.

Hanging Woman Creek and Otter Creek can be considered to be aquatic habitats of significant importance to game fish in the Tongue River. Five species of sport fish are known to enter the lowest reaches of these two streams. Northern pike and smallmouth bass migrate from the Tongue River in the spring to utilize these slower waters as spawning and rearing areas. Considering the limited available habitat for smallmouth bass and rock bass in eastern Montana, the value of these water resources to the Tongue River fishery is evident. Protection of habitat in the lower reaches of Hanging Woman Creek and Otter Creek from degradation of the immediate surroundings (stream bank cover, substrate characteristics and/or water quality) should be a high priority in management considerations.

The fishery resource value ratings obtained for study area streams indicate that the majority of streams were rated either a limited fishery resource or a substantial fishery resource. These ratings were derived for the species and habitat criteria. The highest value, identified as a high priority fishery resource, was obtained for Hanging Woman Creek, site 1. It is evident that the lower reaches of Hanging Woman Creek and Otter Creek provide a viable fishery. In protecting these areas, special consideration must be given to the affects that developmental changes in the upper portions of these drainages will have on the quality of these downstream sites.

The aquatic communities of the prairie are delicately balanced systems. For example, it is a misconception that warm water species have a greater capacity for tolerating temperature increases. Tests comparing cold water and warm water species indicate that warm water species are more susceptible to temperature changes since, in many cases, they are living at or near their lethal level (Karr and Schlosser 1977). Slight changes to an aquatic ecosystem on the prairie in some areas then, might have a devastating effect on organisms within the aquatic community. Management decisions, therefore, must be thoroughly evaluated prior to initiation of resource development, in order to determine the magnitude of consequences to the aquatic systems of the area.

In light of future energy development in this area, an assessment of the aquatic resources in their present state was essential. An adequate data base provides background information from which sound management decisions can be made. It also serves as a basis for detecting future changes to the aquatic environment resulting from watershed degradation.

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Waters referred to:

Otter Creek	21-0725
East Fork Hanging Woman Creek	21-0400
East Fork Otter Creek	no code
Home Creek	no code
Three Mile Creek	no code
Fifteenmile Creek	no code
Elk Creek	no code
Lyon Creek	no code
Taylor Creek	no code
Indian Creek	no code
Pasture Creek	no code
Cow Creek	no code
Tooley Creek	no code
Bear Creek	no code
O'Dell Creek	no code
Poker Jim Creek	no code
Lee Creek	no code
Stroud Creek	no code
Horse Creek	no code
Pike Creek	no code
Corral Creek	no code
Trail Creek	no code
Waddle Creek	no code

Key words:

Streams, Prairie
Habitat
Temperature/environment/
Bottom characteristics
Vegetation, riparian
Pike, northern
Minnows
Suckers
Catfishes, fresh-water
Sunfishes
Bass, rock
Perches
Insects, aquatic
Species diversity
Distribution

Appendix A . A list of all study streams and sample sites investigated. The location numbers are based on the federal system of land subdivision.

Stream	Sites	Legal Description
Otter Creek and Associated Tributaries		
Otter Creek	1	T3S,R44E,S2 CD
	2	T3S,R45E,S19 DB
	3	T4S,R45E,S22 BD
	4	T5S,R45E,S2 BD
	5	T5S,R45E,S26 AB
	6	T6S,R46E,S19 CA
	7	T7S,R45E,S13 DB
	8	T8S,R46E,S6 DB
	9	T8S,R46E,S18 DA
	10	T9S,R46E,S4 BD
East Fork Otter Creek	1	T3S,R45E,S20 BC
	2	T2S,R46E,S35 AC
Home Creek	1	T3S,R45E,S29 DB
Threemile Creek	1	T4S,R45E,S3 DD
Tenmile Creek	1	T5S,R45E,S1 BB
Fifteenmile Creek	1	T5S,R46E,S18 CD
Elk Creek	1	T5S,R45E,S25 BC
Lyon Creek	1	T6S,R46E,S5 BC
Taylor Creek	1	T6S,R46E,S33 CA
North Fork	2	T6S,R46E,S35 AD
South Fork	3	T7S,R46E,S10 AD
Cow Creek	1	T6S,R46E,S30 BD
	2	T6S,R45E,S25 BB
	3	T6S,R45E,S21 AD
	4	T6S,R45E,S17 DC
Indian Creek	1	T7S,R46E,S6 DC
	2	T7S,R46E,S22 DA
Horse Creek	1	T6S,R45E,S33 BD
Bear Creek	1	T7S,R45E,S27 AC
Tooley Creek	1	T7S,R45E,S28 AA
Pasture Creek	1	T8S,R46E,S17 CB
Hanging Woman Creek and Associated Tributaries		
Hanging Woman Creek	1	T6S,R43E,S18 BD
	2	T7S,R43E,S5 AC
	3	T7S,R43E,S30 CB
	4	T8S,R43E,S17 DD
	5	T9S,R43E,S4 AD
	6	T9S,R43E,S35 CA
East Fork Hanging Woman Creek	1	T6S,R43E,S20 DB
	2	T6S,R44E,S29 BD
	3	T6S,R44E,S28 DB
Lee Creek	1	T6S,R43E,S32 DD
	2	T7S,R44E,S18 BD

Appendix A continued.

Stream	Sites	Legal Description
Hanging Woman Creek and Associated Tributaries Continued		
Stroud	1	T7S,R43E,S32 DD
	2	T8S,R43E,S2 AC
Horse Creek	1	T8S,R43E,S22 BC
PK Creek	1	T8S,R43E,S28 AD
Corral Creek	1	T9S,R43E,S4 AB
	2	T9S,R42E,S1 BD
Trail Creek	1	T9S,R43E,S3 DD
	2	T9S,R44E,S27 AB
Waddle Creek	1	T9S,R43E,S15 CC
	2	T9S,R43E,S29 DB
	3	T10S,R43E,S5 AC
Other Tongue River Tributaries		
Poker Jim Creek	1	T5S,R43E,S17 DB
O'Dell Creek	1	T4S,R44E,S31 BD

Appendix B . List of scientific and common names for streamside plant species identified at study sites.

Catagory	Scientific Name	Common Name
Woody species	*Acer negundo*	Boxelder
	Artemesia cana	Silver sage
	Cornus stolonifera	Red dogwood
	Fraxinus pennsylvanica	Green ash
	Juniperus scopulorum	Rocky mountain juniper
	Pinus spp.	Pine genus
	Populus deltoides	Plains cottonwood
	Prunus virginiana	Chokecherry
	Ribes spp.	Gooseberry-current genus
	Ribes americanum	Black current
	Ribes aureum	Gold current
	Ribes cereum	Squaw current
	Ribes setosum	Red-shoot gooseberry
	Rosa spp.	Rose genus
	Rosa woodsii	Wood's rose
	Salix spp.	Willow genus
	Salix exigua	Slender willow
	Sheperdia argentia	Buffaloberry
	Symphoricarpos occidentalis	Western snowberry
Grasses-Sedges-Rushes	*Agropyron* spp.	Wheatgrass
	Agropyron elongatum	Tall wheatgrass
	Agropyron trachycaulum	Slender wheatgrass
	Agrostis	Bentgrass
	Alopercus pratensis	Meadow foxtail
	Bromus spp.	Brome genus
	Bromus inermis	Smooth brome
	Bromus japonicus	Japanese brome
	Carex lanuginosa	Woolly sedge
	Eleocharis palustris	Creeping sedge-rush
	Elymus cinereus	Basin wildrye
	Equisetum	Horsetail; scouring rushes
	Hordeum jubatum	Foxtail barley
	Phalaris arundinacea	Reed canarygrass
	Poa pratensis	Kentucky bluegrass
	Scirpus spp.	Bulrush genus
	Spartina pectinata	Prairie cordgrass
	Typha latifolia	Common cattail
Forbs	*Asclepia* spp.	Milkweed genus
	Cirsium spp.	Thistle genus
	Cirsium arvense	Canadian thistle
	Glycyrrhiza lepidota	Licorice
	Humulus luputus	Common hop
	Mentha arvensis	Field mint
	Helianthus spp.	Maximillion sunflower
	Brassica spp.	Mustard

Appendix C . Woody species expressed as percent basal density for sites in the Otter Creek drainage.

	Otter Creek										East Fork Otter		Home	Threemile	Tenmile	Fifteenmile	Elk	Lyon	Taylor			Cow				Indian		Horse	Bear	Tooley	Pasture
	1	2	3	4	5	6	7	8	9	10	1	2							1	2	3	1	2	3	4	1	2				
Acer negundo	8	100	50	80		57					40	33		20					25	25						71	100		100		
Artemisia cana								30																						100	
Fraxinus pennsylvanica	23										30	39		21					18				42	28				30			40
Juniperus scopulorum																							27					TR			
Pinus spp.																									63			TR			
Populus deltoides	38	TR						65			15																	15			5
Prunus												11		13												29					
Ribes spp.											5			TR							67										
Ribes americanum																								28				20			
Ribes aureum						25																			19						
Ribes cereum																							TR								
Ribes setosum				20																				16				10			
Rosa spp.	8		50						70		5																TR				35
Rosa woodsii						18						11		13	100		60	50	75	33		31	28	18			25				
Salix spp.						TR								33			40														
Salix exigua	23																														
Sheperdia argentia											5																				
Symphoricarpos occidentalis								5	30		TR	6							7						TR		TR				20

Appendix D. Grasses, sedges and rushes expressed as percent basal density for sites in the Otter Creek drainage. TV indicates terrestrial vegetation.

	Otter Creek										East Fork Otter		Home	Threemile	Tenmile	Fifteenmile	Elk	Lyon	Taylor			Cow				Indian		Horse	Bear	Tooley	Pasture
	1	2	3	4	5	6	7	8	9	10	1	2							1	2	3	1	2	3	4	1	2				
Agropyron elongatum				10																											
Agropyron spp. *trachycaulum*						6								TR																	
Alopercus pratensis																							TR					25			
Bromus spp.		39			TR		15							40																	
Bromus inermis							10																								
Bromus japonicus				TR										60																	
Carex lanuginosa						TR															50		48	100							
Eleocharis palustris	10		12		TR	9	15									44			40	80	50		39								
Hordeum jubatum		22	10	45	5	10	6		20	TR		5						24					13				88	25	50		
Phalaris arundinacea		22		5																											
Poa pratensis																			16									25			
Scirpus spp.		11		20	9	7	20		10				95			12	50	30												20	
Spartina pectinata	40	6	3	20	13	4	4		60				TR			44	50	16									6	25	20		65
Typha latifolia			70		73	37	25											30													
Unid. Grasses																															
Sedges	50		5				5		10	100	TV	TV			TV				22	20		TV			100	TV	6		30	TV	15

Appendix E. Forbs expressed as percent basal density for sites in the Otter Creek drainage.

	Otter Creek										East Fork Otter		Home	Threemile	Tenmile	Fifteenmile	Elk	Lyon	Taylor			Cow				Indian		Horse	Bear	Tooley	Pasture
	1	2	3	4	5	6	7	8	9	10	1	2							1	2	3	1	2	3	4	1	2				
Asclepias spp.				TR	TR		TR		TR		10																				
Cirsium spp.		10					TR				10																				TR
Cirsium arvense																								100							
Glycyrrhiza lepidota							TR				80																				
Humulus lupulus											TR									100											
Mentha arvensis																											100				
Helianthus spp.		20				TR			TR																			10			
Brassica spp.		10																													
Various weeds	100	60	100	100	100	TR			100	60						100	100											80		100	

Appendix F . Woody species expressed as percent basal density for all sites in the Hanging Woman drainage, Poker Jim Creek and O'Dell Creek.

	Hanging Woman Creek						East Fork Hanging Woman Creek			Lee		Stroud		Horse	PK	Corral		Trail		Waddle			Poker Jim	O'Dell
	1	2	3	4	5	6	1	2	3	1	2	1	2			1	2	1	2	1	2	3		
Acer negundo	4	50		100			10									40	100	20	80					
Artemisia cana																60						100	100	100
Carnus stolonifera									20															
Fraxinus pennsylvanica	53	25					61	27			40	20												
Juniperus scopulorum												2												
Pinus ponderosa			100								TR													
Populus deltoides											60	5						80						
Prunus	4																							
Ribes spp.				TR																				
Ribes americanum									5			3												
Ribes aureum									TR															
Ribes cereum													40											
Rosa spp.												50												
Rosa woodsii								10	7				40		37									
Salix spp.	31	25					16	63		100			20				20							
Salix exigua	8																							
Sheperdia argentia																								
Symphoricarpos occidentalis						100						20			63									
Unknown							13																	

Appendix G. Grasses, sedges and rushes expressed as percent basal density for all sites in the Hanging Woman drainage, Poker Jim Creek and O'Dell Creek.

	Hanging Woman Creek						East Fork Hanging Woman Creek			Lee		Stroud		Horse	PK	Corral		Trail		Waddle			Poker Jim	O'Dell
	1	2	3	4	5	6	1	2	3	1	2	1	2			1	2	1	2	1	2	3		
Agropyron spp.				16	TR																			
Agropyron elongatum																								100
Agropyron trachycaulum		6	TR				TR																	
Agrostis									68															
Bromus spp.		13	12		4					15														
Bromus inermis							TR	TR																
Carex lanuginosa															72									
Eleocharis palustris		6	17	22	11										22					10	60			
Elymus cinereus				22		11				35														
Equisetum				TR																				
Hordeum jubatum		6			5	11			TR	20		100	15		4				5	TR	40	50		
Phalaris grundinacea			28					TR	TR															
Poa pratensis																								
Scirpus	TR	6	10	6	20	3				10			65											
Spartina pectinata	40		33	28	60	75							20		2				80	20		50		
Typha latifolia		TR						100		20														
Unid Grasses, sedges	60	63																	15	70				

Appendix H . Forbs expressed as percent basal density for all sites in the Hanging Woman drainage, Poker Jim and O'Dell creeks

	Hanging Woman Creek						East Fork Hanging Woman Creek			Lee		Stroud		Horse	PK	Corral		Trail		Waddle			Poker Jim	O'Dell
	1	2	3	4	5	6	1	2	3	1	2	1	2			1	2	1	2	1	2	3		
Asclepias spp.		20																		TR				
Glycyrrhiza lepidota		20																						
Mentha arvensis								100																
Helianthus spp.		20			80	15					30													
Various weeds	100	40		100	20	85					70	100	100		100	100				100	100	100		

Appendix I. A summary of water chemistry data for the Otter Creek drainage, 1980-1981.

Stream		Date	pH	Total Hardness mg/l	Total Alkalinity mg/l	CO_2 mg/l	D.O. mg/l	Temp.
Otter Creek	1	8-5-80	7.4	1350.9	632.7	50	8	-
		10-14-80	7.6	940.5	615.6	30	7	7.2
		4-1-81	8.0	1026.0	461.7	30	9	10.6
		8-24-81	7.7	1008.9	581.4	25	-	28.9
	2	4-80	7.8	1248.3	530.1	30	9	13.3
		8-14-80	7.5	786.6	-	45	7	-
		10-14-80	7.7	906.3	684.0	65	9	10.0
		4-16-81	7.5	1179.9	615.6	50	5	11.7
		7-6-81	7.6	923.4	581.4	45	6	21.1
		8-26-81	7.7	718.2	564.3	55	9	21.7
	3	4-80	7.7	1402.2	564.3	30	7	11.1
		8-5-80	7.5	1556.1	495.9	20	9	-
		10-14-80	7.6	1214.1	513.0	105	12	10.6
		4-1-81	7.5	1077.3	461.7	20	11	10.6
		7-1-81	8.5	1111.5	188.1	45	21	32.2
		8-26-81	8.0	1231.2	478.8	-	7	26.7
	4	4-80	7.6	1453.5	307.8	30	5	-
			7.6	1521.9	581.4	10	15	-
		10-14-80	7.8	1214.1	530.1	40	13	11.1
		4-23-81	7.4	1761.3	547.2	40	7	16.7
		7-6-81	7.5	1316.7	410.4	10	14	28.9
		8-27-81	7.8	1077.3	-	95	8	25.6
	5	4-80	7.8	1453.5	530.1	30	9	14.4
		8-14-80	7.6	1248.3	-	25	13	-
		10-25-80	7.8	1008.9	410.4	40	12	3.3
		4-8-81	8.2	1162.8	461.7	40	8	10.0
		7-9-81	7.5	1094.8	410.4	20	20	26.7
		8-27-81	7.8	940.5	376.2	-	10	21.7
	6	4-80	7.9	1504.8	530.1	35	10	-
		8-14-80	7.7	1368.0	-	25	20	-
		10-25-80	7.7	991.8	461.7	40	14	3.9
		4-7-81	7.7	1402.2	513.0	25	10	8.3
		7-1-81	7.4	1214.1	478.7	40	10	25.0
		8-25-81	7.7	1282.5	393.3	35	19	27.2
	7	5-28-80	7.6	1710.0	-	40	18	-
		10-25-80	8.0	1539.0	444.6	10	13	7.2
			7.6	1385.1	393.3	50	10	-
		4-7-81	7.8	1641.6	444.6	25	12	11.7
		7-1-81	7.6	1692.9	564.3	45	9	21.7
		8-25-81	8.0	1710.0	342.0	35	13	32.2
	8	4-80	Dry					
		7-22-80	Dry					
	9	5-28-80	7.8	3864.6	-	45	15	-
		8-7-80	7.7	4086.9	290.7	2	12	-
		10-25-80	7.7	2547.9	494.9	8	-	6.7
		6-2-81	7.8	2308.5	444.6	40	10	24.4
		8-27-81	8.0	2599.2	290.7	-	12	26.7
	10	4-24-80	7.6	4668.1	530.1	50	10	-
		4-14-81	Dry					

Appendix I . Continued

Stream	Date	pH	Total Hardness mg/l	Total Alkalinity mg/l	CO_2 mg/l	D.O. mg/l	Temp °C
Pasture 1	4-80	7.6	3266.1	-	50	17	-
	11-6-80	7.4	2565.0	752.4	25		6.7
	6-2-81	7.7	2240.1	478.8	40	8	29.4
Tooley 1	4-24-80	7.7	1265.4	547.2	65	8	21.1
	4-27-81	dry					
	7-8-81	dry					
Bear 1	4-24-80	7.5	1521.0	495.9	70	9	21.1
	8-7-80	7.6	1675.8	410.4	35	9	-
	10-30-80	7.8	1675.8	547.2	55	-	-
	8-5-81	dry					
Horse 1	5-12-80	7.6	1111.5	478.8	35	11	-
	11-6-80	7.7	1145.7	564.3	25	-	3.3
	4-14-81	dry					
	7-9-81	7.4	1111.5	513.0	90	5	12.2
Indian 1	5-15-80	7.6	2325.6	649.8	65	8	-
	11-6-80	dry					
	4-14-81	dry					
2	5-15-80	7.3	1487.7	513.0	55	7	-
	10-29-80	7.6	1556.1	547.2	35	-	-
	4-14-80	7.7	1727.1	359.1	85	11	18.9
Cow 1	4-10-80	dry					
	4-7-81	dry					
2	4-80	7.5	632.7	547.2	35	10	-
	8-5-80	7.0	718.2	444.6	70	2	-
	10-28-80	7.3	581.4	342.0	40	-	-
	4-6-81	7.9	684.0	376.2	40	10	5.0
	7-9-81	7.5	718.2	393.3	40	9	17.8
3	4-80	7.0	324.9	376.2	35	9	-
	10-28-80	7.7	239.4	256.5	24	-	-
	4-6-81	7.7	342.0	342.0	15	9	5.6
	7-9-81	8.0	-	239.4	20	7	20.6
4	10-28-80	dry					
	4-6-81	dry					
	7-9-81	dry					
Taylor 1	5-12-80	7.7	1214.1	495.9	40	9	-
	8-11-80	7.7	1162.8	478.8	20	18	-
	10-29-80	7.6	974.7	495.9	30	-	-
	4-7-81	8.2	1162.8	495.9	20	16	11.7
	7-3-81	8.5	991.8	393.3	20	15	25.6
2	5-12-80	8.0	1162.8	478.8	50	8	-
	8-11-80	7.7	1333.8	-	90	8	-
	10-29-80	7.6	1128.6	564.3	80	-	-
	4-7-81	7.5	1094.4	564.3	25	12	5.6
	7-3-81	7.3	1214.1	410.4	35	2	23.3
3	5-12-80	7.5	1248.3	410.4	50	9	-
	8-11-80	7.7	1077.3	-	55	9	-
	10-29-80	7.8	1026.0	410.4	55	-	-
	4-8-81	7.7	1077.3	376.3	45	12	12.2
	7-3-81	7.5	1231.2	324.9	50	8	26.7

Appendix I. Cont.

Stream		Date	pH	Total Hardness mg/l	Total Alkalinity mg/l	CO_2 mg/l	D.O. mg/l	Temp. °C
Lyon	1	5-80	Dry					
		4-23-81	7.4	872.1	410.4	35	5	10.0
		7-6-81	7.7	957.6	444.6	15	12	27.2
Elk	1	5-80	Dry					
		8-14-80	7.6	1470.6	-	40	4	-
		11-6-80	7.6	-	684.0	50	-	6.1
		4-23-81	7.5	1487.7	478.8	85	7	14.4
		7-9-81	Dry					
Fifteen-mile	1	5-1-80	7.8	1282.5	598.5	55	11	20.0
		8-14-80	Dry					
		6-2-81	7.6	1402.2	615.6	40	5	21.1
		7-9-81	Dry					
Threemile	1	5-80	Dry					
		10-80	Dry					
		7-14-81	Dry					
Home	1	5-80	Dry					
		10-28-80	7.8	1350.9	752.4	110	10	5.6
		4-16-81	7.6	1299.6	803.0	45	8	15.6
		7-6-81	7.9	889.2	632.7	170	4	18.9
East Fork Otter	1	5-80	Dry					
		10-80	Dry					
		4-16-81	Dry					
		8-81	Dry					
	2	5-80	Dry					
		10-28-80	Dry					
		4-16-81	Dry					
		8-81	Dry					

Appendix J. A summary of water chemistry data for the Hanging Woman Creek drainage, 1980-1981.

Stream				pH	Hardness mg/l	Alkalinity mg/l	CO_2 mg/l	D.O. mg/l	Temp. °C
Hanging Woman		1	10-8-80	7.3	1333.8	547.2	60	10	-
			3-24-81	7.2	923.4	-	30	10	10.0
			4-1-81	7.7	974.7	615.6	65	9	10.0
			9-1-81	7.7	256.5	171.0	20	6	15.6
		2	4-22-80	7.5	1521.0	547.2	45	8	-
			10-8-80	8.5	1641.6	495.9	45	9	-
			4-13-81	7.7	1453.5	478.8	25	10	11.7
			7-8-81	7.8	1316.7	461.7	45	6	22.8
			9-1-81	7.5	1197.0	461.7	20	7	20.0
		3	4-22-80	7.7	1590.3	513.0	40	9	-
			8-18-80	7.6	1436.3	461.7	40	10	-
			10-9-80	7.3	1504.8	649.8	90	6	-
			4-13-81	7.7	1316.7	513.0	30	10	11.7
			7-8-81	7.6	1197.0	376.2	15	16	26.7
			9-1-81	7.6	1282.5	427.5	45	10	18.3
		4	5-6-80	7.6	1710.0	564.3	65	9	-
			8-20-80	7.8	1556.1	393.3	30	15	-
			10-9-80	8.5	1607.4	342.0	35	9	12.8
			4-15-81	7.6	1419.3	393.3	65	9	15.9
			7-20-81	7.3	1162.8	290.7	35	8	22.2
			9-1-80	7.5	1214.1	410.4	25	10	20.0
		5	5-6-80	7.5	2941.2	581.4	75	8	-
			8-20-80	8.0	11970.0	307.8	0	9	-
			10-10-80	7.5	2394.0	581.4	80	8	5.6
			4-15-81	7.8	2359.8	376.2	90	10	15.6
			7-20-81	8.5	2240.1	513.0	60	9	24.4
			9-1-80	7.6	2120.4	393.3	20	15	23.3
		6	6-19-80	7.4	3556.8	786.6	100	7	-
			10-10-80	7.5	3933.0	940.5	22	3	10.0
			4-21-81	7.5	3420+	872.1	60	8	11.7
			7-20-81	7.4	2565+	598.5	45	-	30.6
			9-1-81	7.6	2821.5	598.5	125	9	20.0
Waddle	1		10-24-80	Dry					
			4-30-81	7.4	4086.9	632.7	45	7	15.6
			7-20-81	Dry					
	2		10-24-80	Dry					
			4-21-81	Dry					
			7-20-81	Dry					
	3		10-24-80	Dry					
			4-30-81	Dry					
			7-20-81	Dry					
Trail	1		8-20-80	Dry					
			10-80	Dry					
			4-30-81	Dry					
			7-20-81	Dry					
	2		4-30-81	7.7	5557.5+	649.8	50	11	15.6
			7-21-81	7.9	3420+	256.5	15	17	26.7

Appendix J . Continued

Stream			pH	Total Hardness mg/l	Total Alkalinity mg/l	CO_2 mg/l	D.O. mg/l	Temp. °C
Corral	1	8-20-80	Dry					
		10-80	Dry					
		4-21-81	Dry					
		7-20-81	Dry					
	2	10-80	Dry					
		4-30-81	Dry					
		7-21-81	Dry					
PK	1	6-19-80	7.5	1197.0	615.6	75	7	-
		8-20-80	Dry					
		4-21-81	Dry					
		7-20-81	8.0	1248.3	718.2	30	8	24.4
Horse	1	10-80	Dry					
		5-4-81	Dry					
		7-21-81	Dry					
Stroud	1	10-24-80	7.8	-	564.3	10	11	3.9
		4-21-81	Dry					
		7-21-81	Dry					
	2	6-19-80	7.5	940.5	581.4	55	8	-
		4-21-81	7.4	1060.2	598.5	30	5	12.8
		7-20-81	7.5	1043.1	786.6	8	-	27.8
Lee	1	6-80	7.8	957.6	666.9	25	16	-
		4-13-81	7.4	855.0	530.1	45	9	10.0
		7-8-81	7.7	820.8	581.4	60	0	20.0
	2	10-27-80	Dry					
		4-13-81	Dry					
East Fork Hanging Woman	1	6-9-80	7.6	820.8	547.2	55	10	-
		8-18-80	7.7	684.0	513.0	40	10	-
		10-17-80	7.7	615.6	530.1	30	9	6.7
		4-17-81	7.8	666.9	410.4	35	10	15.6
		7-13-81	7.7	615.6	444.6	35	8	18.3
	2	6-9-80	7.4	872.1	410.4	75	9	-
		8-18-80	7.4	837.9	547.2	5	10	-
		10-17-80	7.4	701.1	478.8	14	10	4.4
		4-6-81	7.4	803.7	513.0	50	11	11.7
		7-13-81	7.4	786.6	222.3	75	10	15.0
	3	6-9-80	7.6	410.4	307.8	40	8	-
		8-18-80	7.5	393.3	342.0	35	9	-
		10-17-80	7.4	359.1	359.1	35	7	10.0
		4-6-81	7.8	376.2	239.4	35	6	6.1
		7-13-81	7.4	376.2	393.3	25	6	15.0

Appendix K. Information collected on sport fish, mouth of Hanging Woman Creek, 1980-1981.

Species	Date	Length (mm)	Weight (g)	Sex	Tag Number
Northern pike	5-13-80	961			08274
	5-20-80	757	2200	Male	
		780	2980		05796
	6-2-80	724	2500		08287
	6-11-80	225	150		08293
	6-18-80	690	2300		08304
Smallmouth bass	5-6-80	222	140		
	5-7-80	298	350	Female	07518
	5-8-80	366	650		08605
		372	850		08606
		342	560		08607
		292	251		08608
		290	303		08609
	5-12-80	311	375		08267
		178	60		
		285	300		08268
		350	620		08269
		304	360		08270
		280	250		08271
		250	125		08272
		267	270		08276
	5-14-80	237	180		08284
	5-30-80	464	260		08289
	6-4-80	240	180	Male	07526
	6-7-80	225	150		08293
	6-13-80	176	70		
	5-6-81	312	110		
	5-11-81	184	80		
		193	100		
		217	120		08725
		231	150		08650
	5-15-81	222	110		08649
	5-22-81	252	180		08648
	5-23-81	211	150		
	6-5-81	342	550	Female	08687
		415	1020	Female	
	6-9-81	233	180		
		380	860		08690
		286	300	Male	08691
	6-16-81	438	830		08693
		258	260		08694
		259	240		08695
Rock bass	6-4-80	145	85		
	6-13-80	187	150		
	5-22-81	196	110		
	5-25-81	173	40		
		210	60		
	6-16-80	166	110		
		179	130		
Sauger	6-2-80	335	300		08288
	6-5-81	487	990		
Walleye	6-4-80	524	1380		08290
	6-16-81	334	330	Female	
		339	310		
Saugeye	5-13-80	380	550		08275

Appendix L . Information collected on sport fish, mouth of Otter Creek, 1980-1981.

Species	Date	Length (mm)	Weight (g)	Sex	Tag Number
Smallmouth bass	4-28-80	224	140		
	4-29-80	394	820		
	5-1-80	349	620		08265
		239	170		
	5-9-80	256	200		08266
		209	110		
	5-13-80	255	210		08273
	5-14-80	271	240		08277
		259	210		08278
		310	360		08279
		247	150		08280
		287	270		08281
		269	260		08282
		279	240		08283
		195	90		
		237	180		08284
		271	280		08285
		242	200		08286
	6-4-80	285	300		08291
	6-7-80	239	170		08292
	6-11-80	413	860		08187
		397	870		08294
		411	930	Male	08295
		285	300	Female	08296
	6-13-80	380	730		08297
		277	225		
	6-18-80	331	450	Female	08299
		261	260		08301
		218	110		08302
		241	220		08303
	4-16-81	395	840		08721
	5-11-81	320	450		08724
	5-27-81	390	760		08685
	5-28-81	450	1140		08686
	6-8-81	404	900		08689
	6-18-81	364	630		08696
		382	780		08698
		290	320		08697
		151	50		
	6-22-81	231	150		08699
Rock bass	4-25-80	199	160		
	4-29-80	172	110		
		206	170		
	5-13-80	217	225		
	6-16-80	205	160		
		185	130		
		230	120		
		159	90		
		170	100		
	6-18-80	230	245		

Appendix L . Continued.

Species	Date	Length (mm)	Weight (g)	Sex	Tag Number
		178	130		
		172	120		
		165	90		
	6-20-80	184	110		
		151	70		
	5-13-81	170	110		
		188	150		
		182	145		
		245	150		
	5-25-81	150	80		
	6-8-81	167	100		
Walleye	5-13-80	215	90		