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BEAVERHEAD NATIONAL FOREST FISHERIES:

SECOND ANNUAL REPORT

COVERING THE PERIOD JANUARY TO DECEMBER 1986

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A cooperative study between the Beaverhead National Forest and the Montana Department of Fish, Wildlife and Parks

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EXECUTIVE SUMMARY

This report documents the activities of the cooperative fisheries program between the Beaverhead National Forest (BNF) and the Montana Department of Fish, Wildlife and Parks (MDFWP) from 1985 through 1986. Data were collected on fish habitat, abundance, and spawning and overwinter movements.

Electrofishing catch per unit effort (standardized as the number of fish 3.0 inches and longer captured in one electrofishing pass per 1,000 feet of stream length) ranged from 1 to 33 for arctic grayling, 1 to 177 for cutthroat trout (based on external morphological characteristics, some were "pure" westslope, some were Yellowstone, and some were probably introgressed with rainbow trout), 2 to 35 for rainbow trout, and 3 to 660 for brook trout in sections where the above species were captured. Streams (Ranger District coded by BNF number) in which fluvial arctic grayling have been documented by this or any other MDFWP surveys are Big Lake (D-3), Deep (D-2), Fishtrap (D-2), Francis (D-3), Governor (D-3), LaMarche (D-2), Rock (D-3), Sandhollow (D-3), Steel (D-3), and Swamp (D-3) creeks, and the North Fork Big Hole River (D-3). Fluvial arctic grayling distribution appears to be limited to the Big Hole River and the lower portions of its tributaries within the main river valley bottom above Divide, Montana. Streams on the Dillon District which have been found to contain westslope cutthroat trout are Andrus, Brown's Canyon, Fox, Governor, Painter, Pole, Reservoir, and Thayer creeks. Streams on the Wise River Ranger District where westslope cutthroat trout have been found are Adson, Harriett Lou, Lacy, Meadow, Mono, and Wyman creeks. Only Doolittle and the South Fork Steel creeks have been found to support westslope cutthroat trout on the Wisdom District. Cutthroat trout distribution appeared to be limited to small headwater and/or high gradient tributaries. Frequently, cutthroat trout populations were found above a fish migration barrier.

Rainbow trout were found in reach 1 (R1) LaMarche and R2 Wyman creeks. The likely source of the Wyman Creek rainbow was past releases of hatchery rainbow into Lake of the Woods between 1941 and 1960. The source of rainbow in LaMarche Creek could be either hatchery releases made into LaMarche Creek between 1928 and 1954 or from fluvial Big Hole River populations.

Brook trout (charr) were the most commonly found trout species. High densities (at least 150 fish per 1,000 feet of stream length based on a population estimate) of brook trout 6.0 inches and longer have been documented in R2 Governor, R2 LaMarche, and R2 Wyman creeks. R2 Elk, R2 Joseph, R1 LaMarche, R2 Old Tim, R1 Steel, and R2 Trail creeks all had high densities (at least 180 fish per 1,000 feet of stream length based on a population estimate) of brook trout 3.0 to 5.9 inches in length. Extremely low densities of brook trout were observed in R1 Adson, R2 Cow Cabin, R2 Morrison, R2 Pole, R2 Ruby, R1 Sheep, R2 Steel, R1 Trail, and R1 Wyman creeks. All of these reaches except R1 Adson and R2 Pole creeks had received moderate to high livestock impacts. The streams in R2 Cow Cabin and R2 Morrison as well as the above two reaches were small headwater type streams and low fish densities are to be expected in these types of reaches.

Depletion-type estimators (two or more consecutive electrofishing passes) appeared to consistently underestimate fish numbers when compared to a mark-recapture estimator, and this bias seems to be high when probability of capture values are lower than 0.75. Underwater census techniques appear to have value in certain types of waters and may be able to provide good estimates when applied as the recapture technique using a mark-recapture estimator, provided an easily visible external mark or tag can be found.

A population estimate made in the Big Hole River immediately above Wisdom during late June yielded an estimate of 35 arctic grayling 8.5 inches and longer (Age II+) and 282 brook trout 9.0 inches and longe. This number of arctic grayling is much lower than a previous estimate obtained by Oswald (1984) of 105 per river mile and is cause for concern. Arctic grayling appear to be very suseptable to angling with easily recognizeable hooking scars observed on 15% of all captured grayling 10.0 inches and longer.

Rainbow trout redds were found in Jerry and Big Lake creeks, but not found in Bryant Creek. A large mature rainbow (19.0 inches long) was captured by an angler at the mouth of Steel Creek during the spawning season which may indicate Steel Creek is used for spawning.

An effort to document arctic grayling movement into or out of four Big Hole River tributaries (Big Lake, Sandhollow, Steel, and Swamp creeks) using fish traps and drift nets captured only three grayling moving downstream out of Swamp Creek. These three grayling were captured immediately after the opening of the 1986 fishing season and it is likely they were displaced due to the stress of being captured and released by anglers.

Seven arctic grayling were radioed by implanting radio transmitters during September. It was hoped that fall movements to overwinter habitat could be documented. Relocations were obtained for all but one fish. All subsequent relocations, but one, indicated the fish moved downriver. This downriver movement was either a slow staged movement from large pool to large pool or very fast active movement of up to six miles in eleven days. Unfortunately, no confirmed signals were received after October 21 even though the river from five miles above Wisdom down to Divide and lower Steel and Swamp creeks were searched.

Plastic coded tag return information indicated that tagged grayling and rainbow trout moved very little during the summer. The longest recorded movements were made by one juvenile grayling which moved 4.2 miles downstream out of Big Lake Creek into the Big Hole River between May 15 and September 4 and another juvenile grayling which moved approximately 2.8 miles up Steel Creek from the east channel of the Big Hole River between May 21 and August 27. Tag return rates were 8%, 24%, and 63% for juvenile grayling, adult grayling, and adult rainbow trout, respectively. Almost all of these tag returns were from fish captured during the course of this and other MDFWP studies indicating anglers are not a sufficient source of tag return information at present.

Habitat data were collected throughout study reaches and within each sample section. Pool habitat was abundant in R2 Mono and R2 Wyman creeks. Pools were sparse in R1 Wyman and moderately low in number in R2 Elk, R1 LaMarche, R2 Meadow, R1 Mono, and R1 and R2 Sheep creeks. A comparison between the percentages of pool and riffle habitat types estimated within the 400 to 1200 foot sample sections versus those estimated within the entire reach found no significant difference between the two methods ($P > 0.10$), however, in individual cases there were large differences. Habitat condition appeared to be related to livestock use, especially for those habitat parameters which were related to streambank condition and cover.

Streambed condition was assessed visually, by measuring embeddedness, and by sampling with a hollow core sampler. Embeddedness estimates found that R2 Sheep and R2 Elk creeks both had high embeddedness (more than 60% embedded). No difference was observed between embeddedness estimates in two different riffles within the same reach, especially when the two sites were located near each other. No significant difference ($P > 0.10$) was found between embeddedness estimated visually versus that estimated by measurements, however, individual pairs of estimates did appear to differ. Hollow core sampling found that few sampled sites contained less than 25% "fines" (material less than 0.25 inch) with most sites between 30 and 40 percent. Several sites (two in Trail Creek, one in Blacktail Creek, and one in Adson Creek) had more than 40% fine material which would indicate potential problems. It was believed the sampling biased the Adson samples by sampling in silts underneath the streambed gravels in seven of the ten samples. The distribution of fine sediment within the Trail Creek drainage on the Wisdom Distict is discussed. Linear regression between measured embeddedness and percentage of fine material in hollow cores found a moderately good correlation ($r^2 = 0.67$), but the spread of values at the higher levels of impact was disturbing.

Principle component analysis (PCA) was used to group habitat variables. The PCA function which explained the most variability in all habitat parameters measured at all sites weighted streambed variables most heavily.

The relationship between habitat variables and fish abundance was evaluated using Spearman rank correlations. There were significant positive correlations ($P < 0.10$) between the density of brook trout 6.0 inches and longer and the percentage of high class pools and between the density of cutthroat trout 6.0 inches and longer and the percentage of small gravel in the streambed. There were significant negative correlations between the percentage of low class pools ($P < 0.10$) and the density of brook trout 6.0 inches and longer, between the percentage of large gravel ($P < 0.05$), the amount of spawning habitat ($P < 0.10$), and channel sinuosity ($P < 0.10$) and the density of cutthroat trout 3.0 to 5.9 inches in length, and between the density of cutthroat trout 6.0 inches and longer and stream order ($P < 0.10$). For all cutthroat trout 3.0 inches and longer there was a highly significant negative correlation ($P < 0.05$) with stream order and channel sinuosity which suggests that cutthroat trout are more abundant in smaller, straighter stream channels which are usually associated with headwater portions of tributaries.

Stepwise multiple regressions between habitat variables and fish densities provided little insight into habitat variables which influenced brook trout densities (R^2 ranged between 0.31 and 0.36), but showed promise assessing the influence of habitat variables on cutthroat trout (R^2 ranging between 0.58 to 0.95). The habitat variables comprising this regression were percentage of the streambed in large gravel, bank angle, and channel sinuosity. Extremely small sample sizes presently limits the utility of these relationships, however, this area represents a fertile area for future development.

Evaluation of the COWFISH model found that the model appears to have limited utility when applied to streams supporting brook trout, but may have utility for streams containing cutthroat trout. The comment on sample size above is also pertinent here. Another finding was that it appears that, at least in the case of cutthroat trout, the COWFISH model underestimates the number of catchable (6.0 inches and longer) by a factor between 2.0 and 3.0.

INTRODUCTION

This report documents the activities of the cooperative fisheries program between the Beaverhead National Forest and the Montana Department of Fish, Wildlife and Parks for the period January 1, 1986 to December 31, 1986. This program was initiated during the late summer of 1985. During 1985 preliminary data collection was begun and data interpretation for that data is done in this report. This year, results have been separated into two reports. This report details the methodology and describes the statistical analyses used to describe relationships between fish abundance and habitat condition, test methodologies, and contrast differences between different stream reaches. A companion report entitled "Beaverhead National Forest Fisheries - Streams Surveyed During 1985-86" summarizes the fish and fish habitat information by stream reach. The objectives of this cooperative program are:

1. Collect baseline fisheries and hydrologic information in areas that are designated for intensive timber harvest activities.

2. Collect baseline fisheries information on various grazing allotments to evaluate grazing strategies and help calibrate the Forest Service's COWFISH model.

3. Determine fish populations in selected streams.

4. Determine the present condition of game fish habitat and identify factors which may be presently limiting game fish populations in streams draining Forest lands.

5. Identify tributary streams which provide spawning and/or rearing habitat for mainstem riverine fish populations.

6. Cooperatively work with the Forest Service Zone Fisheries Biologist to develop a positive fisheries program regarding habitat protection and enhancement opportunities.

Objective 2 was added to evaluate grazing impacts on fisheries resources (in addition to impacts from timber related activities) in response to the present updating of several allotment management plans and a desire to include fishery objectives in those plan updates.

STUDY AREA DESCRIPTION

The primary study area includes the Big Hole River drainage above Divide, Montana (Figure 1). The area includes the upper 100 miles of the 156 mile long Big Hole River drainage covering an area of approximately 1,635 square miles. The upper Big Hole River flows approximately 90 miles through a wide, high-altitude basin surrounded by the Beaverhead Mountains, Pioneer Mountains, and the Anaconda Range before entering a narrow canyon at Wise River which contains the river for the lower ten miles within the study area. The Big Hole River joins with the Beaverhead River near Twin Bridges, Montana to form the Jefferson River. The Jefferson River is a tributary to the Missouri River. Much of the following description is from Levings (1986).

DRAINAGE

Tributaries to the Big Hole River along the west and north sides of the study area generally contribute the majority of the water to the river with the exception of the Wise River drainage which joins the Big Hole River at Wise River. The U.S. Geologic Survey has gauging stations on the Big Hole River at Melrose, Montana (river mile 31.1 or approximately 24 miles below Divide, Montana) for which there is data from 1923 to the present and on Wise River near Wise River, Montana for which there is data from 1972 to the present. Peak flows generally occur in the late May to mid-June period with east- and north-side tributaries usually peaking slightly earlier than west- and south-side tributaries. For the water year 1985-86 the Big Hole River discharge at the Melrose gauging station recorded a total annual flow 95% of the average annual discharge for the period of record (USGS preliminary data, Helena, Montana) which made this year a near normal year.

Flood irrigation has been the accepted practice in the upper Big Hole valley for many generations. A large number of the tributaries to the Big Hole and Wise rivers are partially or entirely diverted near the valley sidewalls to provide water to hay and pasture lands. Portions of the Big Hole and Wise rivers are also diverted at various points along their lengths to provide irrigation water. Normally these diversions began diverting water to the fields at the onset of spring runoff and remain open until sometime in July. At that time the water is shut off to allow the hayfields time to dry before the hay is cut. Because of the relatively short growing season ranchers only cut hay once a year. After the harvest diversions are again opened and remain open until the late fall.

GEOLOGY

From the divide to the valley floor the upper west side of the basin (from Governor Creek north to Ruby Creek) is underlain by basement sedimentary rocks (primarily fine-grained impure quartzites). The west side of the basin from Trail Creek to Fishtrap Creek is underlain primarily by intrusive rocks with a few large isolated areas of glacial till. From Fishtrap Creek to Deep Creek the north side of the valley is underlain by a mixture of intrusives, Precambrian belt rocks, coarse valley fill, and alluvial deposits. From Deep Creek to Divide Creek the north side of the valley is underlain by intrusives, Precambrian belt rocks, alluvial deposits, volcanics, Precambrian quartzites,

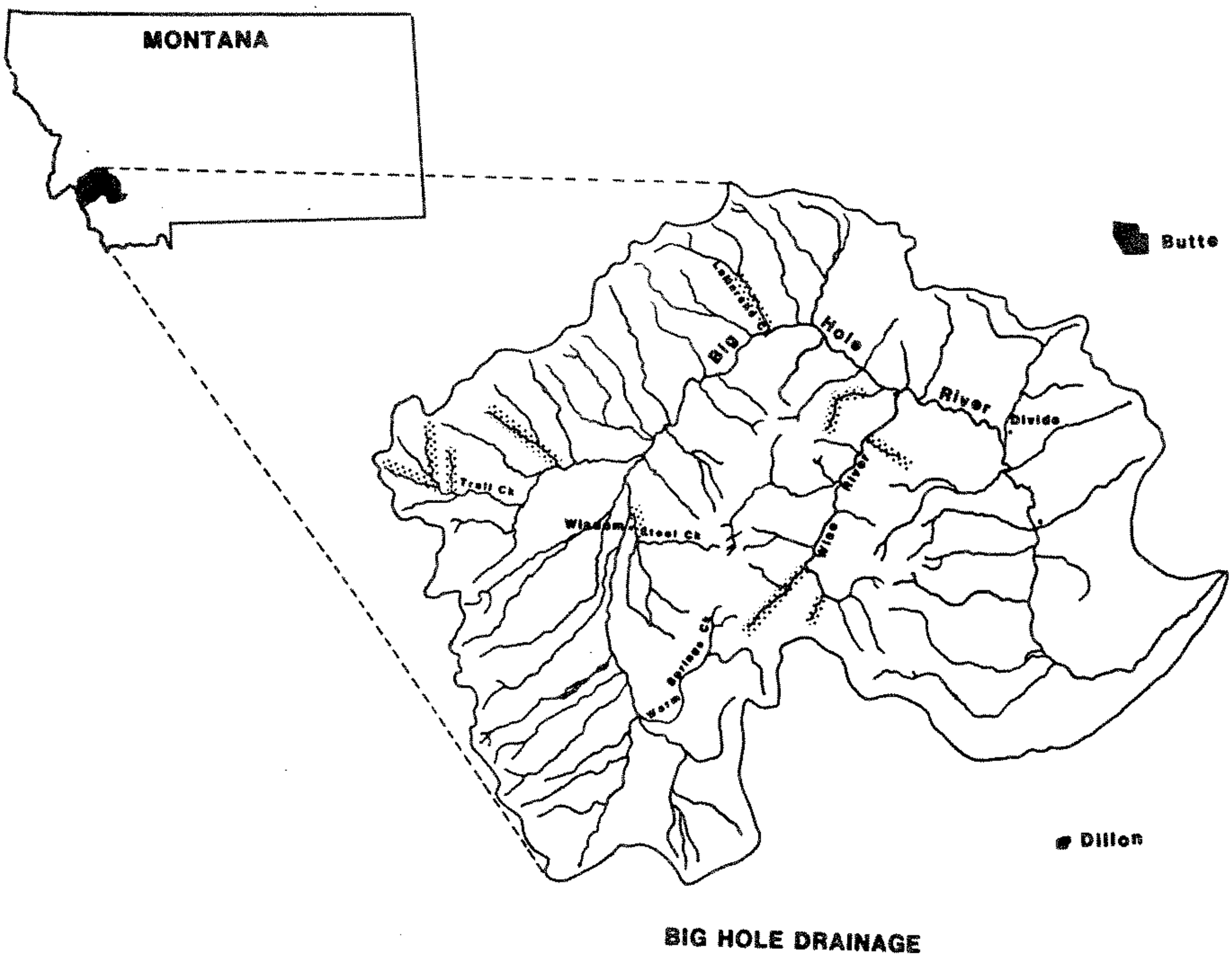

Figure 1. Map of the upper Big Hole River drainage showing study reaches (shaded areas) studied during 1986 as part of the cooperative fisheries study between the BNF and MDFWP.

siltites, and argillites, and shales, sandstones and limestones. The upper valley bottom, from the headwaters to Fishtrap Creek is filled with glacial and alluvial deposits. The lower valley bottom is dominated by alluvial deposits. The east side of the drainage from the headwaters to Wise River is underlain by intrusives, Precambrian quartzites, siltites, and argillites, coarse valley fill, and several large isolated areas of glacial till. The south side of the valley from Wise River to Divide Creek is underlain by intrusives, Precambrian quartzites, siltites, and argillites, and shales, sandstones and limestones.

The intrusives and glacial and alluvial deposits are generally the most erosive followed by the shales, sandstones, and limestones. Quartzites, siltites, and argillites generally are resistent to rapid erosion.

BIOTIC COMMUNITY

The upper Big Hole River drainage supports populations of arctic grayling (Thymallus arcticus), brown trout (Salmo trutta), burbot (Lota lota), rainbow trout (Salmo gairdneri), brook trout (Salvelinus fontinalis), westslope cutthroat trout (Salmo clarki lewisi), Yellowstone cutthroat trout (Salmo clarki bouvieri), mountain sucker (Catostomus platyrhynchus), white sucker (Catostomus commersoni), longnose sucker (Catostomus catostomus), longnose dace (Rhinichthys cataractae), and mottled sculpins (Cottus bairdi). Tailed frogs (Ascaphus truei) have been found in several tributaries.

METHODS

HABITAT

A total of ten streams were selected to inventory based on recommendations made by Forest Service personnel on the Wise River and Wisdom Districts. LaMarche Creek was selected as a control stream. Prior to the field season these streams were seggregated into relatively homogeneous reaches based on channel gradient, valley shape, and area drained using 1:24,000 USGS maps. This resulted in a total of 17 stream reaches in the ten streams. Reaches were numbered consecutively from the mouth upstream. The following data were recorded from these maps: stream order; reach length; channel gradient; acres drained by the reach; acres drained by the entire stream; lower and upper reach boundary landmarks; lower and upper reach boundary legal descriptions; lower and upper elevations of the channel; valley length; channel sinuosity; landtype association; and channel type according to methods described by the Fish Habitat Relationships System. Stream ordering was not done using the contour crenulation method. In addition, descriptive information for land use in the drainage will be obtained from the Beaverhead National Forest's database. This information was not all available at the time of this report, so it will be included next year. Detailed descriptions of each of these variables are provided in Appendix A.

Fish habitat was surveyed in 406 to 1184 foot long sample sections of 17 stream reaches where fish population data were collected to correlate fish numbers to quantity and quality of available habitat. These 17 reaches were located in Adson, LaMarche, Meadow, Mono, and Wyman creeks on the Wise River Ranger District, and Elk, Johnson, Joseph, Sheep, and Steel creeks on the Wisdom Ranger District (Table 1). In addition, entire reaches were surveyed in 14 of the above 17 reaches to further quantify available habitat. Entire reach surveys were not done in reaches 1 and 2 of Johnson Creek and reach 1 of Steel Creek.

Streambed samples were taken from potential spawning habitats in seven streams including Adson, Big Swamp, Jerry, Joseph, LaMarche, and Trail creeks and Wise River (Table 2).

Reach Surveys

Reach surveys were conducted by walking the entire length of each reach and tallying the occurence of the following habitat parameters: main habitat types (pools, riffles, runs, and pocketwaters), habitat sub-types (ie. for riffles - low gradient, rapids, and cascades), amount of spawning gravel (arbitrarly defined as areas larger than four square feet predominated by streambed material in the 0.5 to 3.0 inch category), accumulations of small (less than 6.0 inches in diameter) and large (6.0 inches and larger) organic debris (accumulations had to cover four square feet to be tallied), the number of these debris accumulations which crossed the entire wetted stream channel by size class, and the percentage of these debris considered to be stable (would not normally be moved in an average high flow year). In addition to tallying the above parameters various features within the reach were located including

Table 1. Description of stream reaches surveyed during 1986 including stream, reach, landmarks at lower and upper boundaries of each reach, legal descriptions of lower and upper boundaries of each reach, elevations (ft) at lower and upper boundaries of each reach, sample site legal description and length (ft), length of stream channel (mi), length of valley (mi), channel gradient (%), channel type (from Rosgen 1985), stream order, and channel sinuosity.

RANGER DISTRICT
Stream
Reach description

Channel length (mi)	Valley length (mi)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft)	Upper elevation (ft)

WISE RIVER DISTRICT

Adson Ck
Reach: 1
Lower landmark: MOUTH AT WISE RIVER
Lower legal description: T1S R11W SECTION19AB
Upper landmark: HEADWATERS
Upper legal description: T1S R11W SECTION33DB
Sample site legal description (length in feet): T 1SR11WSEC28BC (406)

3.3	3.1	5.1	A	3	1.06	5930	6810

LaMarche Ck
Reach: 1
Lower landmark: MOUTH AT BIG HOLE RIVER
Lower legal description: T2N R13W SECTION34DD
Upper landmark: FOREST SERVICE BOUNDARY
Upper legal description: T2N R13W SECTION21DA
Sample site legal description (length in feet): T 2NR13WSEC22CC (1,018)

2.9	2.5	4.4	B	4	1.16	5815	6050

Reach: 2
Lower landmark: FOREST SERVICE BOUNDARY
Lower legal description: T2N R13W SECTION21DA
Upper landmark: JUNCTION OF MIDDLE AND WEST FORKS
Upper legal description: T2N R13W SECTION6DA
Sample site legal description (length in feet): T 2NR13WSEC16BB (1,184)

4.5	3.6	0.8	C	3	1.26	6050	6235

Table 1. (continued)

RANGER DISTRICT
Stream
Reach description

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)

Meadow Ck

Reach: 2
Lower landmark: FOREST SERVICE BOUNDARY
Lower legal description: T1N R12W SECTION36AD
Upper landmark: HEADWATERS
Upper legal description: T1S R12W SECTION10CD
Sample site legal description (length in feet): T 1NR12WSEC36AC (500)

3.3	3.3	11.0	A	3	1.00	6040	7980

Mono Ck

Reach: 1
Lower landmark: MOUTH AT JUNCTION WITH JACOBSON CREEK
Lower legal description: T3S R12W SECTION33AA
Upper landmark: BRIDGE CROSSING OF F.S. ROAD NUMBER 484
Upper legal description: T4S R12W SECTION4BC
Sample site legal description (length in feet): T 4SR12WSEC 4BS (496)

1.5	1.4	8.3	A	2	1.03	6880	7525

Reach: 2
Lower landmark: BRIDGE CROSSING OF F.S. ROAD NUMBER 484
Lower legal description: T4S R12W SECTION4BC
Upper landmark: CULVERT CROSSING OF F.S. ROAD NUMBER 484
Upper legal description: T4S R12W SECTION8AB
Sample site legal description (length in feet): T 4SR12WSEC 5DA (700)

1.0	1.0	1.3	C	2	1.03	7525	7597

Table 1. (continued)

RANGER DISTRICT Stream Reach description							
Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)

Wyman Ck

Reach: 1
Lower landmark: MOUTH AT WISE RIVER
Lower legal description: T3S R12W SECTION17CA
Upper landmark: LOWER END OF LOWER ANDERSON MEADOWS (SM 1.88)
Upper legal description: T3S R13W SECTION24CA
Sample site legal description (length in feet): T 3SR13WSEC24DA (621)

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)
1.9	1.8	3.8	B	4	1.06	6715	7100

Reach: 2
Lower landmark: LOWER END OF LOWER ANDERSON MEADOWS (SM 1.88)
Lower legal description: T3S R13W SECTION24CA
Upper landmark: MOUTH OF DEER CREEK
Upper legal description: T4S R13W SECTION9AA
Sample site legal description (length in feet): T 3SR12WSEC17CC (500)

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)
5.2	4.0	0.9	C	4	1.29	7100	7350

WISDOM DISTRICT

Elk Ck

Reach: 1
Lower landmark: MOUTH OF ELK CK AT TRAIL CK
Lower legal description: T2S R18W SECTION9BD
Upper landmark: 1.52 MILES UPSTREAM FROM MOUTH
Upper legal description: T2S R18W SECTION33DA
Sample site legal description (length in feet): T 2SR18WSEC 4DB (571)

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)
1.5	1.5	1.7	B	3	1.02	6420	6560

Reach: 2
Lower landmark: 1.52 MILES UPSTREAM FROM MOUTH
Lower legal description: T2S R18W SECTION33DA
Upper landmark: HEADWATERS
Upper legal description: T1S R18W SECTION21BA
Sample site legal description (length in feet): T 1SR18WSEC33BD (528)

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)
3.4	2.9	2.7	B	3	1.15	6560	7060

Table 1. (continued)

RANGER DISTRICT
Stream
Reach description

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)

Johnson Ck
Reach: 1
Lower landmark: MOUTH AT NORTH FORK BIG HOLE RIVER
Lower legal description: T2S R16W SECTION4BC
Upper landmark: 10.3 MILES ABOVE MOUTH
Upper legal description: T1S R17W SECTION16AA
Sample site legal description (length in feet): T 1SR17WSEC25AA (597)

10.3	6.1	0.7	C	4	1.68	6085	6460

Reach: 2
Lower landmark: 10.3 MILES ABOVE THE MOUTH
Lower legal description: T1S R17W SECTION16AA
Upper landmark: HEADWATERS
Upper legal description: T1N R17W SECTION32AA
Sample site legal description (length in feet): T 1SR17WSEC 5CD (534)

3.9	2.8	4.4	A	3	1.35	6460	7360

Joseph Ck
Reach: 1
Lower landmark: MOUTH AT JUNCTION WITH TRAIL CREEK
Lower legal description: T2S R18W SECTION15BD
Upper landmark: MOUTH OF RICHARDSON CREEK
Upper legal description: T2S R18W SECTION7BC
Sample site legal description (length in feet): T 2SR18WSEC16BC (575)

3.7	3.4	0.8	C	3	1.08	6380	6540

Reach: 2
Lower landmark: JUNCTION OF RICHARDSON CREEK
Lower legal description: T2S R18W SECTION7BC
Upper landmark: HEADWATERS
Upper legal description: T2S R19W SECTION2CA
Sample site legal description (length in feet): T 2SR19WSEC12BC (592)

2.2	1.9	2.9	B	2	1.15	6540	6880

Table 1. (continued)

RANGER DISTRICT
Stream
Reach description

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)

Sheep Ck

Reach: 1
Lower landmark: MOUTH AT TRAIL CREEK
Lower legal description: T2S R18W SECTION14DC
Upper landmark: 1.08 MILES UPSTREAM FROM MOUTH
Upper legal description: T2S R18W SECTION11CD
Sample site legal description (length in feet): T 2SR18WSEC14BD (555)

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)
1.1	1.0	1.7	B	3	1.09	6340	6440

Reach: 2
Lower landmark: 1.08 MILES ABOVE MOUTH
Lower legal description: T2S R18W SECTION11CD
Upper landmark: HEADWATERS
Upper legal description: T1S R18W SECTION35
Sample site legal description (length in feet): T 2SR18WSEC11BB (534)

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)
2.8	2.6	4.0	B	3	1.11	6440	7040

Steel Ck

Reach: 1
Lower landmark: MOUTH AT BIG HOLE RIVER
Lower legal description: T2S R15W SECTION15BB
Upper landmark: MOUTH OF FRANCIS CREEK
Upper legal description: T2S R15W SECTION3CA
Sample site legal description (length in feet): T 2SR15WSEC34A (600)

Channel length (mi.)	Valley length (mi.)	Channel gradient (%)	Channel type	Stream order	Channel sinuosity	Lower elevation (ft.)	Upper elevation (ft.)
5.6	4.8	0.6	C	5	1.16	5990	6175

Table 2. Location (stream and legal description) and date sampled for hollow core sampling conducted in waters draining the Beaverhead National Forest during 1985-86.

Year Stream	Date	Legal Description
1985		
Doolittle Ck	11/04/85	T 1S R 14W SEC 28C
East Fork Ruby River	10/25/85	T 11S R 3W SEC 5B
Harriett Lou Ck	11/05/85	T 1N R 12W SEC 36D
Meadow Ck	10/31/85	T 1N R 12W SEC 36A
Mill Ck	10/23/85	T 2S R 4W SEC 23A
S Fk Blacktail Ck	10/24/85	T 12S R 5W SEC 30C
S Fk Willow Ck	10/30/85	T 3N R 3W SEC 13A
Trail Ck	11/07/85	T 2S R 18W SEC 13C
1986		
Adson Ck	11/13/86	T 1S R 11W SEC 20CA
Big Swamp Ck	10/29/86	T 5S R 16W SEC 16AA
Jerry Ck	11/17/86	T 1N R 11W SEC 36CD
Joseph Ck	10/22/86	T 2S R 18W SEC 16BA
LaMarche Ck	10/23/86	T 2N R 13W SEC 5CD
Trail Ck	10/20/86	T 2S R 18W SEC 15B
Wise River	11/07/86	T 3S R 12W SEC 21CA

any barriers to upstream fish movement, unique features (ie. eroding banks, livestock damage, bridges, etc.), irrigation withdrawals or returns, side channels, and areas of abundant high quality spawning habitat. All these features were located by pace. Side channels were further quantified by pacing from the point the side channel left the main channel to the point where the side channel returned to the main channel (this distance was paced along the main channel). For a more detailed description of these parameters and how they were measured consult Appendix B.

Reach surveys were conducted in Reach 1 (R1) of Adson, R1 and R2 of LaMarche, R2 of Meadow, R1 and R2 of Mono, and R1 and R2 of Wyman creeks on the Wise River District, and R1 and R2 of Elk, R1 and R2 of Joseph, and R1 and R2 of Sheep creeks on the Wisdom District. Due to extremely difficult access (downfall timber) or time constraints the entire length of R2 Sheep Creek, R2 Wyman Creek, R2 Meadow Creek, and R2 Joseph Creek were not surveyed.

Results of these surveys are reported as the frequency of occurence (number per mile) for debris accumulations, square feet per mile for spawning gravel, and percentage composition for both main and sub- habitat types. In addition, the locations of pertinent features were noted.

Detailed Habitat Surveys of Sample Sections

Detailed habitat surveys of 406 to 1184 foot long segments in each of the 17 reaches were conducted using techniques similar to Fish Habitat Relationships System methodology with the following exceptions: site selection was based on stream reach classification; secondary channel pools were not separated in pool classification (these would be included as side channels); channel gradient was calculated from USGS maps (scale 1:24,000), not in the field; the size classification for stream substrate materials was done using a modified Wentworth scale (Shepard 1986); canopy closure was not estimated; and canopy density was visually estimated as the percentage of the stream's surface overhung by canopy (tree) boughs.

Each study section was broken down into habitat types and classed into both main and sub-habitat types. Within each habitat type the following data were collected for the entire habitat type: length of type, length of undercut for both banks, canopy density (visually determined as the amount of overstory which actually overhung the wetted surface), instream cover (which was the total percentage of the water's surface area which had instream cover in the form of actual structure, ie. substrate or debris, water depth or disturbance, etc. - anything which prevented fish from being observed from above the water's surface was considered cover), low (one foot or less above the water's surface) and high (higher than one foot above the water's surface) overhead cover (percent of the water's surface covered), substrate composition (silt, sand, small gravel, large gravel, cobble, small boulder, large boulder), soil alteration rating (Platts et al. 1983), vegetation stability rating (Platts et al. 1983), and vegetation use by animals (Platts et al. 1983).

The following data were collected across at least one cross section per habitat type (cross sections were generally done at a frequency of one every ten to twenty feet of stream length): wetted width, channel width, average depth, thalweg depth (the deepest portion of each cross section), water depth at each shoreline averaged for the cross section, embeddednes classified visually, substrate score (modified from Crouse et al. 1981), D-90 (the diameter of a streambed particle which is larger than 90 percent of the remaining particles), depth of undercut bank (a horizontal measurement averaged for each cross section), and bank angle (also averaged for each cross section). Streamflow was measured at one uniform cross-section within each reach at the time of the above survey. Detailed descriptions of each of these variables and how they were measured can be found in Appendix C.

The above data were summarized by main habitat type and the averages and percentage composition are presented by habitat type and for the reach as a whole. Means and standard deviations were calculated for all variables. The amount of undercut bank was converted to a percentage using the formula:

$$\text{Percentage of Undercut} = \frac{\text{Total Length of Undercut (ft)}}{\text{(Total Length of Sample Section) X 2}} \text{ X 100}$$

Streambed Sampling

In 16 of the 17 sampled reaches embeddedness measurements were made following methodology described by Burns (1984). Reach 2 of Mono Creek was not sampled because its streambed was composed primarily of sand and was considered to be fully embedded. In R1 Steel Creek, R1 Adson Creek, and R2 LaMarche Creek two separate areas were sampled in an attempt to begin to assess the variability of embeddedness sampled within a reach.

Ten "hollow core" (McNeil and Ahnell 1964) samples were taken using the same methodology as in 1985 (Shepard 1986) in Adson, LaMarche and Jerry creeks and upper Wise River on the Wise River District and in upper Trail, Joseph and Big Swamp creeks on the Wisdom District. Embeddedness measurements (Burns 1984) were also made in each area where core samples were taken.

The core sampling was summarized by site and is presented along with estimated egg-to-fry survival values for cutthroat and rainbow trout from Irving and Bjornn (1984). I derived survival curves for brook trout using data from Witzel and McCrimmon (1983). Embeddedness values were summarized by site.

FISH ABUNDANCE ESTIMATES

Fish abundance was assessed using relative catch per unit effort (CPUE) and by making population estimates. Lengths of the sections censused ranged from 300 to 1184 feet. A Coffelt backpack electrofisher Model BP-1C was used in all sections. A total of 28 sections in 20 streams were electrofished. Abbreviations used for fish species throughout this report are: GR = arctic grayling; EBT = eastern brook trout (charr); RBXWCT = hybrid between westslope cutthroat and rainbow trout or unidentified _Salmo_ spp. (cutthroat trout, rainbow trout, or hybrids between the two); LING = burbot; MWF = mountain whitefish; RB = rainbow trout; WCT = westslope cutthroat trout.

Catch per Unit Effort (CPUE)

Electrofishing was conducted in section(s) of Adson, Butler, Fishtrap, LaMarche, Meadow, Mono, Swamp, and Wyman creeks on the Wise River District and Bender, Big Lake, Elk, Joseph, Johnson, Mussigbrod, Placer, Plimpton, Sheep, and Steel creeks and Salefsky and Goris gulches on the Wisdom District. The relative abundance of each species of fish for each of the above sampling sections was expressed as the number of fish for all fish 3.0 inches and longer captured in one electrofishing pass standardized to a 1,000 foot section of stream.

Tributary Population Estimates

Population estimates were made in 17 stream reaches using either depletion or mark-recapture estimators. Each sample section was electrofished from its upstream boundary downstream to its lowermost boundary. A block net was used at the downstream boundary of the section if there was no reasonable fish blocking feature naturally present in the stream channel. All captured fish were processed after the first pass to allow the section at least one to two hours of "rest" between electrofishings. The fish captured on the first pass were held in a livecar while the section was electrofished again in a downstream direction. All fish were marked with a fin clip. If the estimated probability of capture ($\hat{p}$) calculated using the formula:

$$\hat{p} = \frac{n_1 - n_2}{n_2}$$

(where n_1 and n_2 = number of fish captured in the first and second electrofishing passes, respectively)

was higher than 0.60 it was assumed that a reasonable population estimate could be obtained using a depletion estimator (personal communication, 1984, Tom Berggren, Bonneville Power Administration, Portland, Oregon). If the $\hat{p}$ value was less than 0.60, a recapture electrofishing was conducted from two to seven days later. The only exception to this general rule was in R2 of LaMarche Creek where the subsequent "recapture" was done using underwater observation by a diver snorkeling the stream in a mask and wet suit. Unfortunately, it was difficult for the diver to identify all fish with a clipped fin which designated marked fish (in this case an upper caudal clip).

Populations were estimated using the maximum liklihood technique in the MICROFISH software package (VanDeventer and Platts 1985) on a Zeinth AT microcomputer for depletion electrofishings and/or using Chapman's (1951) mark-recapture formula (cited in Ricker 1975) within a PRESENT query on the BNF's Data General computer system. For the estimate in Old Tim Creek (Dillon District) an equipment malfunction during the second electrofishing caused and incomplete second pass. An estimate of the total number of fish captured on the second pass was made (by dividing the actual number caught by the percentage of the sections sampled expressed as a decimal) and using this value within a two-pass estimator (Seber and LeCren 1967). Population estimates were made for fish in the 3.0 to 5.9 inch length class and for fish 6.0 inches and longer. No attempt was made to estimate the numbers of fish under 3.0 inches, however, the number of these small fish captured were used in constructing length frequency histograms.

Big Hole River Population Estimate

A 4.98 mile section of the Big Hole River above the Highway #43 bridge west of Wisdom was electrofished in the early summer to estimate the number of arctic grayling and brook trout inhabiting this section of river. Four marking runs were conducted between June 23 - 26 and three recapture runs were conducted between June 30 and July 2. In addition to length and weight data, the presence of obvious hooking scars were noted for all handled fish. The percentage of hook scared fish was estimated by species. This estimated percentage is likely an underestimate due to fact it is likely that some previously hooked fish may not have an obvious scar. The MDFWP mark-recapture computer program (which uses equations described by Vincent 1971 and 1974) was used to estimate the numbers of brook trout, rainbow trout, and arctic grayling in this section of river.

LENGTH, WEIGHT, AND CONDITION FACTOR

Length in inches to the nearest 0.1 inch was measured from all captured fish. Length frequency histograms were constructed by species for each stream reach where at least 25 fish of the same species were captured. Weight in pounds to the nearest 0.01 pound was obtained using a spring scale (weight range 0.00 to 5.00 pounds) for each fish captured, however, the scale became unreliable near the end of the field season and all unreliable weights were discarded. Condition factors were estimated for all salmonids using the formula (Anderson and Gutreuter 1983):

$$\text{Condition factor} = (\text{Weight}/\text{Length}^3) \times 10{,}000.$$

FISH MOVEMENT

Tributary Trapping During the Spring

Up and downstream box traps were installed in Big Lake, Steel, and Swamp creeks to monitor the movement of fish between the Big Hole River and these tributaries during the spring. Arctic grayling was the primary target species for this trapping effort. The upstream traps were constructed using a frame of 0.5 inch rebar covered with 0.5 inch mesh hardware cloth. A conical fyke was constucted at the downstream end to allow fish to move into the trap and prevent them from moving back out. The downstream traps were constructed using a wooden frame (2 by 4 inch stock) and plywood sides covered with 0.5 inch mesh hardware cloth at the upstream and downstream ends. A V-shaped entrance was constructed at the upstream end to allow fish moving downstream to enter the traps. These traps were placed on either side of the stream with a diagonal fence connecting them. This fence was constucted of steel fence posts supporting four foot high 0.5 inch mesh hardware cloth with a 0.5 foot portion of this hardware cloth buried into the streambed (Figure 2).

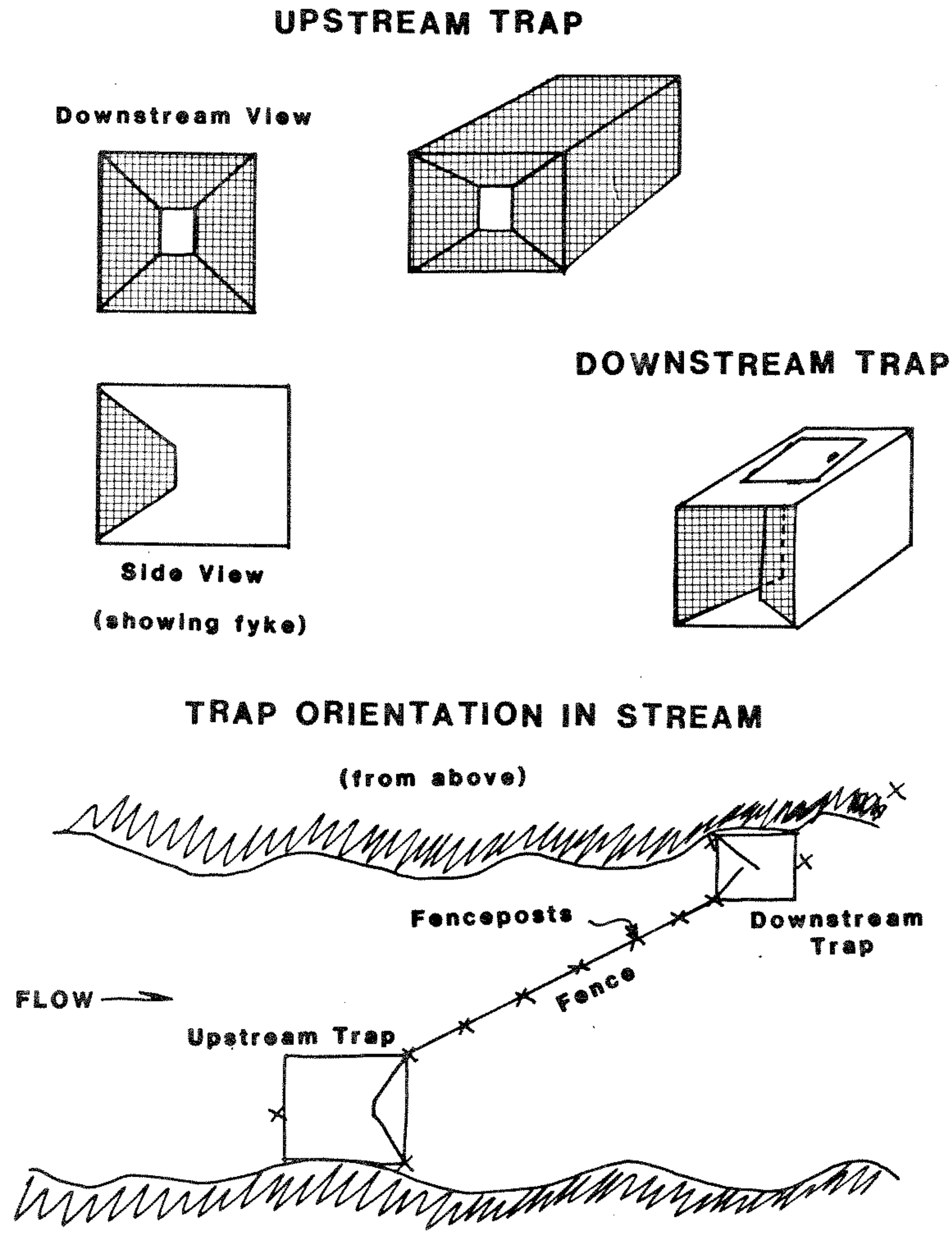

Figure 2. Schematic diagram of upstream and downstream fish traps and orientation of traps in the stream for trapping of migrating fish in the spring of 1986 as part of the cooperative fisheries study between the BNF and MDFWP.

The upstream and downstream traps were installed on April 7, 1986 in Steel Creek. Upstream traps were installed on April 7 in Big Lake Creek and on April 23 in Swamp Creek (Figure 3). The downstream traps were added on May 7 to the Big Lake and Swamp creek sites. These traps were checked at intervals ranging from every eight hours to every four days dependent upon flow conditions and the number of fish moving through the traps. The traps were difficult to maintain due to fluctuations in streamflow and the presence of drifting algae and debris. The Big Lake Creek trap site was moved upstream on May 22 because reduced flows from irrigation withdrawals dewatered the downstream trap. A mink predation problem was evident at the Swamp Creek trap site (partially eaten fish were found in the traps and on the bank adjacent to the traps) and may have occured at the other sites. During the major snowmelt event (from May 28 to June 19) the Big Lake and Steel creek traps were removed and the fence between the Swamp Creek traps was left down. The Swamp Creek trap was reinstalled on June 20 and the trap was operated until June 25 when it was removed.

Drift nets (1.0 by 1.5 foot rectangle openings with 80 openings per inch mesh nets, Wildco Supply number 158) were placed at three locations in Sandhollow Creek on the Wisdom District on May 20, 1986. These nets were checked twice daily until their removal on June 2.

Each time the traps and drift nets were checked all gamefish were measured to the nearest 0.1 inch and weighed to the nearest 0.01 pound, water temperature was measured, and condition of the traps, leads, and general observation of streamflow noted.

Rainbow Trout Redd Counts

Redd (trout spawning site) counts were conducted in Jerry and Bryant creeks draining the Wise River District to document the relative use of these two tributaries as spawning areas by rainbow trout. A portion of Jerry Creek from Forest Service Road #83 down to the mouth of Jerry Creek at the Big Hole River and a portion of Bryant Creek from immediately above the Forest Service boundary down to its mouth at the Big Hole River were surveyed on May 8, 1986. All observed disturbances in the streambed were classified into one of the following classes; sure redd, probable redd, and possible redd, based on criteria established by Shepard et al. (1982). Identified redds in Jerry Creek were further seggregated based on size in an attempt to quantify the number of redds constructed by fluvial Big Hole River adults.

Arctic Grayling Radiotelemetry

The movement of grayling within the Big Hole River system was evaluated using radio tags. Radio tags were implanted during the early summer (July 1 and 2) and during the early fall (September 22). The early summer work was done by Gould (1986). The fall work was conducted as part of this study.

On September 22, 1986 seven radio transmitters were surgically implanted into grayling which had been captured via electrofishing. The fish were captured and released in a segment of the river immediately above the town of Wisdom (between river miles 116 and 119). The radios weighed approximately 0.2

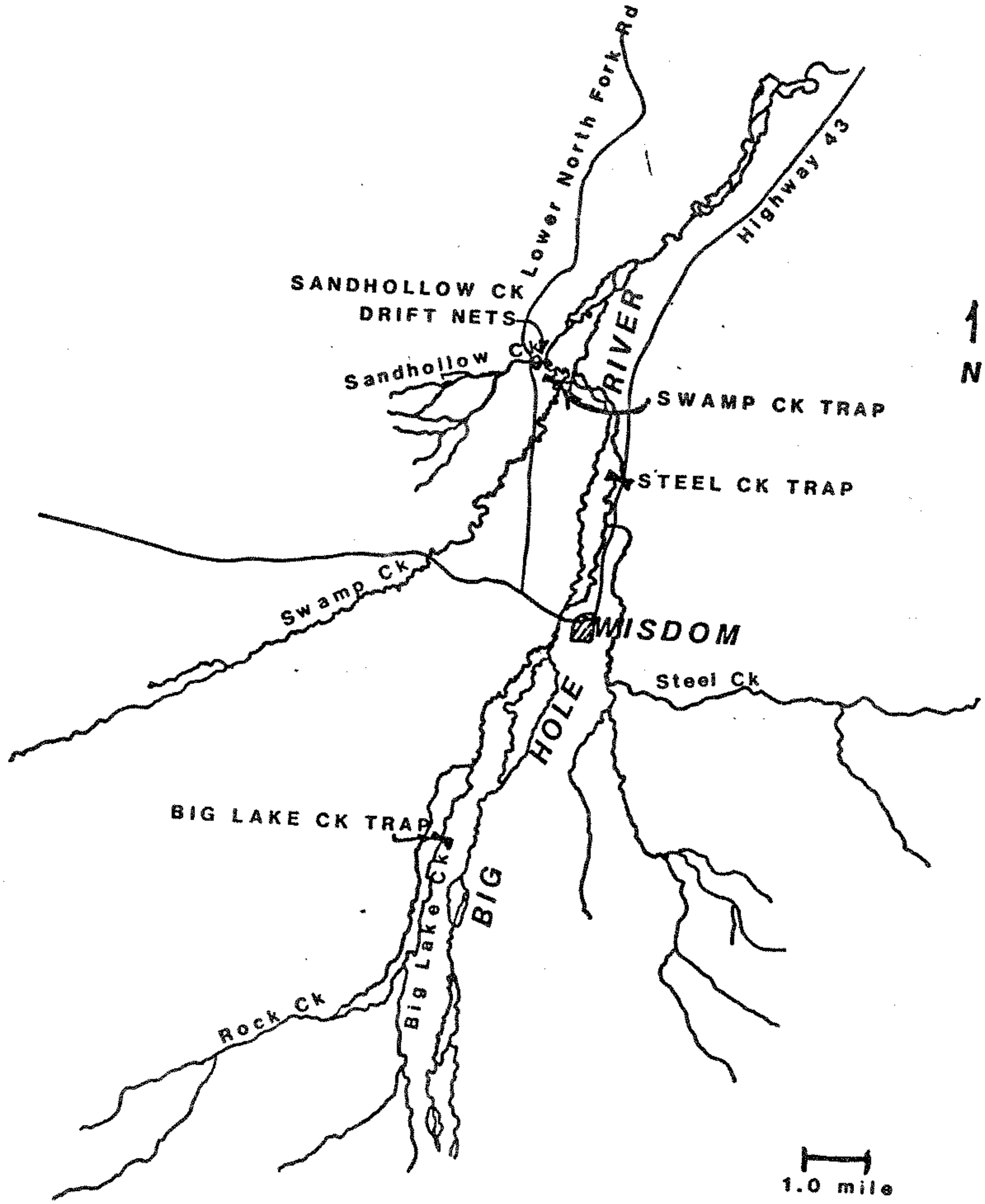

Figure 3. Location of fish trapping sites in the upper Big Hole River drainage in the vicinity of Wisdom, Montana which were operated during the spring of 1986. Sites in Big Lake, Steel, and Swamp creeks had up- and downstream traps (⧓), while the site in Sandhollow Creek had drift nets (o).

ounces (5 g) and were approximately 1.0 X 0.6 X 0.9 inches (26 X 16 X 24 mm) in size. These radios represented approximately 1.6 to 2.8 percent of the total body weight of the fish in which they were implanted. Hop (1985) found that grayling in Alaska were not impaired when radios weighed between 1.7 to 3.3 percent of total body weight. These radios had a rated life expectancy of 90 days. The 30 and 40 mHz bands were the receivers available from the Montana Cooperative Fisheries Research Unit, however, due to the moderately low water conductivity found in the Big Hole River (80-90 microsiemens: Levings 1986) higher bands may provide better results (Don Stoneburner, Custom Telemetry Consulting, Athens, Georgia; the source for the radios).

The surgical technique consisted of anesthesizing the fish in an approximately 1% solution of 2-phenoxy-ethanol. Fish were placed on an inclined V-shaped platform with their heads and gills within the anesthetic. A 0.5 to 1.0 inch (12.7 to 25.4 mm) incision was made between the pelvic fins and a transmitter which had been sterilized in an alcohol solution was inserted into the body cavity. The incision was sutured closed using Chromic 4-0 collagen gut suture material. The incision normally required three to four sutures to close.

Fish were relocated by floating the river or driving or walking the river bank at one week intervals. Relocation searches were done on sixteen separate days from September 23 to November 26. The search areas varied, but coverage included from river mile 55 up to river mile 121 and the lower portions of Swamp and Steel creeks (Table 3). During an extreme cold period from November 14 to November 19 many sections of the river froze completely over, especially in the Wisdom area. Most of the areas which froze over near Wise River opened up after a thaw around November 20 while much of the river in the Wisdom area remained frozen.

Plastic Coded Tagging

All arctic grayling and rainbow trout longer than 3.0 inches captured during the season were tagged with either a numbered juvenile dangler type (fish between 3.0 and 7.9 inches) or a numbered anchor type (fish 8.0 inches and longer) tag. Tag recoveries were made during the course of sampling and from anglers. These data are summarized by tag for all returns.

STATISTICAL ANAYLSES

Tests for Normality

The data were summarized using mean and standard deviations. Tests for normality were conducted for the habitat data collected within the fish abundance sample sections of R1 LaMarche Creek, R1 Adson Creek, R2 Joseph Creek, and R1 Sheep Creek using the micro-computer version of SAS's UNIVARIATE procedure (SAS 1985). This procedure uses the "W" statistic (Shapiro and Wilk 1965) to test for normality. The data was not normally distributed for most habitat variables. Nonparametric statistical procedures were utilized to overcome the problems associated with non-normal data analyses.

Principal components anaylsis (PCA) was used to transform these intercorrelated habitat values "to allocate the greatest possible variation to

Table 3. Areas searched for radio tagged arctic grayling in the upper Big Hole River drainage during the fall of 1986 including date of search, area searched, how search was conducted, water temperature (F, n.d. signifies no data), and general comments.

Date	Water temperature	Area searched	Method	General comments
9-22-86	48	Tags implanted		
9-23-86	n.d.	From RM[1/] 119.9 down to Highway 43 bridge (RM 116.0)	Float	Recap electro-fishing run
9-23-86	n.d.	Below bridge approximately 0.5 miles	On foot	
9-26-86	44	From RM 116.5 down to RM 116.0 (Highway 43 bridge)	On foot	
		From RM 116.0 down to RM 111.0 (below where Steel Creek enters east channel)	Float	Floated the west channel
10-3-86	41	From Highway 43 bridge down to below the mouth of Swamp Creek (RM 116.0 to RM 108.0)	Float	Floated the east channel
10-8-86	n.d.	From above the Highway 43 bridge (RM 116.8) down to bridge (RM 116.0)	On foot	Only had receiver to monitor 3 radios on 30mHz
10-14-86	40	From head of McDowell's irrigation diversion (RM 117.5) down to RM 111.0 (below where Steel Creek enters the east channel)	Float	Floated the east channel
10-21-86	39	From RM 120.9 (Rutledge Rd culvert) down to below the cemetary (RM 110.0)	Float	Floated the east channel
10-28-86	38	McDowell's diversion and area above Highway 43 bridge	On foot	Spot checked
		Floated from Highway 43 bridge (RM 116.0) down to below the cemetary (RM 110.0)	Float	Floated the west channel
11-3-86	35	From access below cemetary (RM 110.0) down to Daniel's ranch (Crane ranch at RM 104.2)	Float	Few channel splits

Table 3. continued.

Date	Water temperature	Area searched	Method	General comments
11-14-86	n.d.	From Highway 43 bridge near Wisdom (RM 116.0) to Highway 43 bridge near Divide (RM 55.7)	Drove	Only had receiver to monitor 3 radios on 30 mHz Lots of ice
11-17-86	n.d.	From Jerry Creek down to Highway 43 bridge near Divide (RM 55.7)	Drove	Only had receiver to monitor 3 radios on 30 mHz Lots of ice
11-19-86	n.d.	From Wisdom to Divide (RM 116.0 to RM 55.0)	Drove	Covered highway and dirt roads on both sides of river
11-20-86	n.d.	From McDowell's diversion (RM 117.5) down to below cemetary (RM 110.0) The lower 0.2 miles of Steel Creek	On foot	Searched the east channel. Still lots of ice
11-21-86	n.d.	From Daniel's ranch (Crane ranch at RM 104.2) down to below Wallace Christensen's house (RM 89.8)	On foot	Much of the river iced over
11-24-86	n.d.	From below Christensen's house (RM 89.9) down to Highway 43 bridge (RM 91.6)	On foot	Much of the river iced over
11-25-86	n.d.	From Jerry Creek down to Big Hole dam (RM 62.8 down to RM 57.8)	Float	River mostly free of ice in this section
11-26-86	n.d.	Swamp Creek from Northside Big Hole River Road bridge (CM 2/ 1.8) down the its mouth (CM 0.0)	On foot	Creek mostly iced over above spring (CM 1.5) and open below the spring

1/ RM indicates river mile from "River Mile Index of the Missouri River", Water Resources Division, Montana Department of Natural Resources and Conservartion, January 1979.

2/ CM indicates creek mile as measured from a USGS quad (scale: 1:24,000).

the fewest possible new uncorrelated variables" (Green 1979). These computed "variables" are actually linear additive functions which retain all the information in the "old" original data set for use in subsequent regression analyses against fish density information.

Comparisons Between Methodologies

Habitat Data

The Wilcoxon sign-ranked test (Daniel 1978) was used to compare the percentages of each of the two main habitat types (pools and riffles) estimated from the survey of the entire reach and the detailed survey of the fish abundance section in the 14 reaches where both surveys were conducted. This test was also used to compare the embeddedness values obtained from sampling using the Burns (1984) sample technique versus ocular estimation in the 17 reaches where both were done.

Fish Data

Estimates of fish populations derived from the two electrofishing estimators (depletion and mark-recapture) and from the underwater count and deplection estimator in R2 LaMarche Creek were compared.

The effect of radio implants on the condition of arctic grayling was assessed by comparing September condition factors of arctic grayling which had radios implanted in early July to those that did not using a two-sample t-test (Zar 1984).

Correlations Between Habitat Variables and Fish Densities

Fish population estimates were converted to fish densities by calculating the number of fish per surface acre in each sample section. Spearman's rank correlations were done between each habitat variable value and the corresponding fish density value.

PCA functions (see above) derived from habitat data were regressed against the corresponding fish densities (SAS 1985). These initial attempts at regressing these PCA functions against fish abundance data by species were inconclusive due to the small sample sizes.

Test of the COWFISH Model

Fish population estimates were conducted in sample sections of Browns Canyon, Cow Cabin, Morrison, Pass, and Painter creeks within the Dillon District where Range personnel had completed COWFISH habitat sampling (Lloyd 1986). In addition, the reaches surveyed in R1 Elk, R1 Joseph, R2 LaMarche, R2 Mono, R1 Sheep, R1 Steel, and R2 Wyman creeks during 1986 and R2 Governor, R2 Ruby, and R2 Steel creeks during 1985 all were within areas that had various levels of livestock grazing.

Data needed for the COWFISH habitat evaluation could be derived from habitat surveys directly except for the percent of streambank with overhanging vegetation. COWFISH estimates the linear percentage of streambank which has vegetation overhanging the water's surface, while the habitat surveys done during this study estimated the percentage of the water's surface covered by overhanging vegetation. I converted the percentage of water surface covered to the percentage of streambank with overhanging vegetation by adding the percentage of low and high coverage of the water's surface times the stream's average width divided by 8. This conversion assumes that much of the cover overhung the stream by 4.0 feet and usually resulted in an increase when converting from percentage coverage to percentage of streambank with cover.

Regressions were made between the estimated number of fish longer than 6.0 inches ("catchable") from electrofishing samples and both the predicted "optimum" and predicted "existing" numbers from the COWFISH model as well as between the electrofishing estimates and the total "parameter suitability index" for each stream using the "STATGRAPHICS" micro-computer statistcal software package. These regressions were run separately for stream sections which supported cutthroat trout and those which supported brook trout.

RESULTS

Fish and habitat information is presented in the report "Beaverhead National Forest Fisheries - Streams Surveyed During 1985-86" by stream with a brief discussion of habitat condition. This report will be used to contrast the condition of the aquatic resources between stream reaches which were surveyed during 1986 and to analyze relationships between habitat variables and between habitat variables and fish densities.

HABITAT

Reach Characteristics

Channel gradient, channel type, stream order, channel sinuosity, and lower and upper elevation of the stream channel within each stream reach were derived from contour maps. The results of surveys conducted throughout the "entire reach" describe the habitat composition, frequency of side channels, frequency of large and small woody debris, amount of available spawning habitat, and locations of potential fish passage barriers.

Map Derived Information

Information interpreted from maps is presented in Table 1. "A-type" channel reaches (R1 Adson, R2 Johnson, R2 Meadow, and R1 Mono creeks) are typified by relatively high channel gradient, narrow valley bottoms, and low channel sinuosity. "C-type" or typical "meadow" channel reaches (R1 Johnson, R1 Joseph, R2 LaMarche, R2 Mono, R1 Steel, and R2 Wyman creeks) are characterized by relatively low channel gradients, wide valley bottoms, and relatively high channel sinuosity. "B-type" channel reaches have channel and valley characteristics between "A" and "C" type channels.

Habitat Composition

Pool habitats dominated R2 Mono Creek and R2 Wyman Creek (Table 4). Pool habitats were noticeably sparse in R1 Wyman Creek and moderately low in R2 Elk, R1 LaMarche, R2 Meadow, R1 Mono, and R1 and R2 Sheep creeks. Riffle habitats were especially abundant in R1 Wyman, R2 Meadow, R1 Mono, and R1 Sheep creeks and scarce in R2 Mono Creek. Pocketwaters made up a moderately large percentage of the habitat in R2 Elk, R1 LaMarche, R2 Meadow, R1 Mono, R2 Sheep, and R1 Wyman creeks which reflects the relatively higher gradient in these reaches. Side channels were found along much of R1 and R2 of Joseph Creek. Moderate side channel development was found along R1 Elk, R2 Meadow, R2 Mono, and R1 Wyman creeks. Side channel development in Joseph, R1 Elk, and R2 Mono was caused by both beaver activity and livestock impacts. Side channel development in the other reaches listed above was primarily due to higher channel gradient associated with large debris which formed side channels during high streamflows.

Table 4. Percentage of each main habitat type within each reach of streams draining the Beaverhead National Forest surveyed during 1986.

RANGER DISTRICT Stream	Reach	Pools	Riffles	Runs	Pocket waters	Side channels
WISE RIVER DISTRICT						
Adson Ck						
	1	30	39	20	11	4
LaMarche Ck						
	1	23	32	26	19	5
	2	37	33	25	5	3
Meadow Ck						
	2	22	48	10	20	12
Mono Ck						
	1	27	45	7	22	3
	2	53	13	31	3	17
Wyman Ck						
	1	9	56	11	24	16
	2	43	24	28	5	1
WISDOM DISTRICT						
Elk Ck						
	1	35	29	25	10	10
	2	26	37	18	19	8
Johnson Ck 1/						
	1	17	38	21	25	-
	2	19	29	19	24	10
Joseph Ck						
	1	36	36	23	6	27
	2	34	35	21	10	35
Sheep Ck						
	1	23	44	30	2	1
	2	24	34	14	27	6
Steel Ck 1/						
	1	21	42	37	-	-

1/ Habitat compostion in reaches within these streams were based on habitat composition within the detailed sample section. See "Habitat Composition" section of "RESULTS" for a discussion of use of these data.

A comparison between habitat composition estimated within the sample sections and habitat composition for the reach as a whole was made by comparing the percentages of pools and riffles estimated within the sample section to counts made throughout the entire reach (Table 5). There was no significant difference between estimates for pools or riffles ($P > 0.10$). There were cases where relatively large differences between survey techniques were observed (ie. pools in R1 and R2 Joseph, R2 Meadow, and R1 Sheep; and riffles in R1 and R2 Wyman and R1 and R2 Elk). However, there was no consistent bias observed because in some cases higher percentages were estimated in the sample section and in other cases a higher percentage was found in the "entire reach" survey. This could present a problem in any attempt to expand fish population estimates derived using habitat composition data obtain from sample sections to the entire reach and suggests that any reasonable estimate of habitat composition should be based on a sample larger than a 300 to 1,000 foot sample section.

Pools were formed primarily by water plunging over debris and/or large streambed material and by lateral scouring of the stream's bank and bed at bends in the channel (Table 6). Lateral scouring was the predominant pool forming mechanism in lower gradient channels, while plunge pools predominated higher gradient reaches. Beaver dams were responsible for forming many pools in Elk and Joseph creeks. There were numerous high quality pools in LaMarche and Joseph creeks, while low quality pools dominated in Adson, Elk, Meadow, R1 Mono, R2 Sheep, and Wyman creeks.

Low gradient riffle types dominated riffles within low gradient reaches, while cascade riffle types dominated in high gradient reaches (Table 7).

Frequency of Debris and Spawning Habitat

The frequency of both large and small size classes of debris was relatively high in R2 Elk, R2 Meadow, and R2 Sheep creeks (Table 8). Debris frequencies were relatively low in R1 Joseph, R1 and R2 LaMarche, R1 and R2 Mono, R1 Sheep, and R2 Wyman creeks. More debris crossed narrow channels versus larger channels and large debris was more frequently observed across stream channels than small debris. Both these findings were expected and logical. Spawning habitat was extremely plentiful in R2 LaMarche Creek and probably adequate in all other stream reaches with the exceptions of R1 Mono and R1 Wyman creeks. It is likely that mature fish in R1 Wyman Creek and the upper 0.6 mile of R1 Mono Creek move upstream to spawn. R1 Mono Creek has a total barrier to upstream fish movement located near stream mile 0.4 which suggests that spawning habitat below this barrier may be limited.

Detailed Habitat Survey within Sample Sections

Detailed habitat surveys within sample sections documented the physical character of the stream channel, the amount and types of cover available to fish, and occular estimates of streambed composition and condition.

Physical Character of Stream Channel

Table 5. A comparison between the percentage of stream habitat in pools and riffles estimated by surveying the entire reach versus a 400 to 1200 foot sample section and the results of a Wilcoxon sign-ranked test (Daniel 1978) testing between the different surveys.

Stream	Percentage of pools				Percentage of riffles			
Reach	Section	Reach	D_i	Rank	Section	Reach	D_i	Rank
Adson Ck								
1	29	30	- 1	- 2.5	31	39	- 8	-10.0
Elk Ck								
1	44	35	9	8.0	40	29	11	11.5
2	37	26	11	9.0	26	37	-11	-11.5
Joseph Ck								
1	54	36	18	14.0	32	36	- 4	- 3.5
2	42	34	12	10.0	29	35	- 6	- 6.5
LaMarche Ck								
1	24	23	1	2.5	38	32	6	6.5
2	50	37	13	11.0	31	33	- 2	- 1.0
Meadow Ck								
2	7	22	-15	-12.0	55	48	7	8.5
Mono Ck								
1	24	27	- 3	- 5.0	41	45	- 4	- 3.5
2	54	53	1	2.5	20	13	7	8.5
Sheep Ck								
1	39	23	16	13.0	39	44	- 5	- 5.0
2	20	24	- 4	- 6.0	37	34	3	2.0
Wyman Ck								
1	8	9	- 1	- 2.5	42	56	-14	-13.5
2	38	43	- 5	- 7.0	38	24	14	13.5
Total positive and negative ranks				T+ = 70.0 T- = 35.0				T+ = 50.5 T- = 54.5

Ho: The median of the population of differences is zero
(ie. There is no difference between the two)
Ha: The median is not zero

Pools: T- = 35.0
P > 0.135

Riffles: T+ = 50.5
P > 0.445

Therefore, conclude that there is no significant difference between the methods

Table 7. Percentages of each type of riffle habitat for stream reaches draining the Beaverhead National Forest surveyd during 1986.

RANGER DISTRICT Stream	Reach	Low Gradient	Rapid	Cascade
WISE RIVER DISTRICT				
Adson Ck				
	1	13	48	39
LaMarche Ck				
	1	0	82	18
	2	69	27	3
Meadow Ck				
	2	3	42	56
Mono Ck				
	1	0	7	93
	2	61	17	23
Wyman Ck				
	1	6	50	44
	2	80	20	1
WISDOM DISTRICT				
Elk Ck				
	1	62	36	2
	2	39	51	10
Joseph Ck				
	1	70	29	0
	2	53	38	9
Sheep Ck				
	1	41	53	6
	2	27	51	22

Table 8. Frequency (number per mile) of large (six inches in diameter or larger) and small (less than six inches in diameter) debris, frequency which these large and small debris cross the wetted channel, and amount of spawning gravel observed (square feet of gravel per mile) by reach in streams draining the Beaverhead National Forest surveyed during 1986.

RANGER DISTRICT		Large debris		Small debris		
Stream	Reach	Total (#/mi)	Cross channel (#/mi)	Total (#/mi)	Cross channel (#/mi)	Spawning gravel (sq. ft/mi)
WISE RIVER DISTRICT						
Adson Ck						
	1	153.2	109.1	241.7	124.1	481
LaMarche Ck						
	1	30.6	3.3	23.0	0.0	1801
	2	27.0	2.6	46.7	0.0	24237
Meadow Ck						
	2	380.2	286.6	335.8	83.3	350
Mono Ck						
	1	49.6	36.1	52.9	0.0	21
	2	0.0	0.0	7.7	0.0	261
Wyman Ck						
	1	40.2	11.1	19.2	0.0	23
	2	2.8	1.1	3.9	0.0	223
WISDOM DISTRICT						
Elk Ck						
	1	145.1	62.8	110.5	0.0	333
	2	243.8	95.5	108.0	7.0	455
Joseph Ck						
	1	39.0	6.7	82.7	0.0	230
	2	101.7	19.4	106.5	0.6	258
Sheep Ck						
	1	38.1	9.5	26.2	0.0	508
	2	726.1	455.2	316.2	66.3	239

The physical characteristics of the stream channel in reaches surveyed during 1986 is presented in Table 9. A summary of physical characteristics stratified by main habitat type within each sample section is presented in Appendix D.

Cover

Mean estimates of cover parameters are presented in Table 10 and also segregated by main habitat type in Appendix E. Reaches which had relatively high percentages of undercut banks (greater than 50%) were R1 Adson, R2 Elk, R2 Joseph, R2 LaMarche, R2 Meadow, R2 Mono, and R1 and R2 Sheep creeks. The previous reaches with high percentages of undercut banks which also had relatively deep undercut banks (6.0 inches or deeper measured horizontally) were R2 Elk, R2 Joseph, R2 LaMarche, and R1 and R2 of Sheep creeks. R2 Mono Creek was obviously being impacted by livestock along its streambanks. R2 Meadow Creek was a high gradient stream with moderate livestock use occuring within the sample section. Stream reaches with a relatively low percentage of their streambanks undercut (less than 30 percent) were R1 LaMarche, R1 Mono, R1 Steel, and R1 Wyman creeks. The apparent cause of the low amount of undercut banks in R1 Steel Creek was livestock damage of the streambank within the private landholdings within the sample section. The relatively low percentage of undercutting in the other reaches was probably related to high peak streamflows coupled with the relatively narrow valley bottoms and boulder and cobble material along the streambanks. Livestock impacts to streambanks were observed in R1 Elk, R1 Johnson, R1 Joseph, R2 Mono, R1 Sheep, R1 Steel, and R2 Wyman creeks (Table 11).

Instream cover was abundant in R1 Mono Creek and was provided primarily by large streambed material (Table 10). Instream cover was noteably low in R1 Elk, R1 and R2 Joseph, R1 Sheep, and R1 Steel creeks. All of these reaches had moderate to high levels of livestock use with the possible exception of R2 Joseph Creek. Instream cover in the remaining reaches which were surveyed was considered moderate to high and consisted of instream debris, aquatic vegetation, streambed material, and surface disturbance.

Canopy coverage of the water's surface was obviously not found in reaches flowing through meadows dominated by grass/forb vegetation types and moderate in relatively small streams which flowed through dense forests. Relatively wide stream reaches such as R1 LaMarche had low canopy coverage even though it flowed through a forested canopy. R2 Johnson Creek had relatively low canopy coverage because the adjacent forested land on one side of the stream had been clearcut. R2 Joseph and R1 Wyman creeks flowed through open forests mixed with small stringer-type meadows. Low overhead cover was related to the amount of woody brush and grasses on the streambank, while high overhead cover was related to the amount of woody brush and low overhanging branches from trees.

Streambed Condition

The condition of the streambed was assessed by visually estimating the composition of the streambed; ranking the two predominant substrate types, the size of the material surrounding the two dominanat substrate types, and embeddedness of the dominant substrate types into a "substrate score"; visually

Table 9. Date of survey, temperature at time of survey (F), flow (cfs), total length of surveyed section (ft.), and mean estimated wetted width (ft), channel width (ft), average depth (in), thalweg depth (in), and average depth (in) at the streambank for stream reaches draining the Beaverhead National Forest surveyed during 1986. Standard deviations are in parentheses.

RANGER DISTRICT Stream Reach (n)	Date surveyed	Temp. (F)	Flow (cfs)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
WISE RIVER DISTRICT										
Adson Ck										
1 (38)	7/ 16/ 86		3.3	406.0	6.6 (1.5)	5.7 (2.1)	6.9 (2.7)	11.7	10.8 (3.2)	4.8 (3.0)
LaMarche Ck										
1 (21)	7/ 31/ 86	54	29.5	1018.0	39.6 (6.8)	31.8 (8.9)	10.0 (3.0)	41.4	19.5 (5.3)	3.1 (3.6)
2 (26)	7/ 31/ 86		29.5	1184.0	33.2 (5.7)	26.0 (5.0)	19.9 (9.9)	20.1	34.1 (14.4)	10.7 (6.7)
Meadow Ck										
2 (29)	7/ 29/ 86	46	3.1	493.0	10.8 (2.2)	9.0 (2.8)	5.1 (1.4)	22.3	10.4 (2.3)	2.5 (1.8)
Mono Ck										
1 (17)	7/ 14/ 86		3.0	495.6	13.5 (2.6)	12.8 (2.4)	6.3 (3.4)	28.9	14.5 (5.4)	4.3 (2.2)
2 (39)	7/ 9/ 86		2.6	669.9	5.5 (2.3)	4.7 (2.9)	13.5 (4.2)	4.7	20.9 (6.3)	8.0 (5.0)
Wyman Ck										
1 (24)	7/ 25/ 86	59	8.6	621.0	21.0 (2.8)	15.4 (4.9)	7.3 (2.3)	28.1	15.3 (3.5)	3.6 (2.6)
2 (24)	7/ 28/ 86	52	7.9	834.0	25.6 (6.3)	18.9 (7.4)	10.2 (5.8)	31.3	19.1 (9.6)	4.0 (3.4)

Table 9. (continued)

RANGER DISTRICT Stream Reach (n)	Date surveyed	Temp. (F)	Flow (cfs)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
WISDOM DISTRICT										
Elk Ck										
1 (25)	8/ 12/ 86	51	2.3	571.0	13.1 (2.6)	9.2 (3.2)	6.8 (3.6)	22.0	12.7 (6.1)	5.1 (3.7)
2 (27)	8/ 13/ 86	57	1.7	528.0	13.2 (1.7)	8.7 (3.9)	5.6 (3.0)	23.3	10.2 (4.6)	3.4 (2.5)
Johnson Ck										
1 (24)	10/ 7/ 86	45	7.5	597.0	24.4 (4.0)	20.4 (7.0)	7.9 (3.2)	35.9	14.7 (5.2)	2.7 (1.7)
2 (21)	8/ 20/ 86	46	2.2	534.0	27.3 (8.4)	18.0 (5.4)	4.7 (2.1)	57.2	11.0 (5.4)	1.5 (2.0)
Joseph Ck										
1 (22)	8/ 19/ 86	54	3.4	575.0	16.5 (3.4)	10.4 (3.7)	8.5 (4.1)	19.3	15.2 (7.0)	3.0 (3.2)
2 (38)	8/ 19/ 86	56	2.2	592.0	13.3 (2.4)	7.9 (3.7)	6.0 (3.4)	21.1	10.7 (5.5)	3.0 (2.3)
Sheep Ck										
1 (18)	8/ 7/ 86	43	1.9	555.0	12.2 (2.8)	7.9 (5.2)	8.9 (5.2)	15.6	14.1 (7.1)	6.9 (5.1)
2 (30)	8/ 6/ 86	48	1.9	534.0	15.2 (2.9)	11.9 (2.7)	4.7 (2.1)	35.0	9.1 (3.2)	2.7 (1.8)
Steel Ck										
1 (19)	9/ 11/ 86	50	6.7	855.0	32.9 (4.9)	25.9 (8.9)	7.0 (3.4)	57.8	11.7 (5.0)	1.9 (2.0)

Table 10. Mean estimates of cover availability including percentage undercut banks, canopy density over the water's surface (%), instream cover (%), low (1.0 foot or less above the water's surface) overhead cover (%), high (more than 1.0 foot above the water's surface) overhead cover (%), and depth of undercut banks (in) for stream reaches draining the Beaverhead National Forest surveyed during 1986. Standard deviations are in parentheses.

RANGER DISTRICT Stream Reach	n	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
WISE RIVER DISTRICT							
Adson							
1	38	56 (28)	4.8 (3.5)	2 (8)	30 (30)	13 (13)	22 (29)
LaMarche							
1	21	20 (16)	3.9 (4.3)	4 (6)	39 (24)	3 (2)	8 (4)
2	26	55 (14)	6.8 (3.1)	3 (10)	21 (11)	6 (5)	11 (8)
Meadow							
2	29	53 (24)	4.4 (3.2)	34 (34)	49 (25)	18 (19)	19 (17)
Mono							
1	17	11 (12)	3.6 (3.1)	10 (20)	87 (6)	8 (7)	9 (12)
2	39	51 (25)	4.8 (2.5)	0 (0)	17 (17)	8 (7)	0 (0)
Wyman							
1	24	27 (16)	2.7 (2.4)	2 (6)	50 (24)	7 (6)	17 (16)
2	24	33 (22)	3.2 (3.1)	0 (0)	30 (28)	5 (5)	4 (6)

Table 10. (continued).

RANGER DISTRICT Stream Reach	n	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
WISDOM DISTRICT							
Elk							
1	25	47 (24)	6.5 (4.1)	1 (2)	9 (6)	3 (5)	5 (6)
2	27	66 (18)	6.9 (4.5)	18 (21)	20 (18)	10 (9)	8 (10)
Johnson							
1	24	36 (19)	3.0 (2.6)	11 (19)	47 (19)	10 (9)	17 (15)
2	21	44 (30)	6.0 (7.7)	5 (9)	22 (25)	21 (25)	20 (22)
Joseph							
1	22	45 (29)	3.4 (3.2)	0 (0)	10 (7)	9 (8)	19 (14)
2	38	51 (26)	6.4 (5.1)	8 (19)	17 (15)	7 (7)	13 (14)
Sheep							
1	18	58 (27)	7.1 (5.3)	0 (0)	12 (8)	14 (13)	24 (24)
2	30	53 (26)	7.0 (5.6)	30 (31)	29 (18)	16 (15)	24 (21)
Steel							
1	19	22 (24)	2.1 (1.9)	0 (0)	14 (10)	1 (1)	2 (5)

Table 11. Mean estimates of percentage of streambank altered, streambank vegetation stability rating, percentage of streambank vegetation utilized, and bank angle (degrees) for stream reaches draining the Beaverhead National Forest surveyed during 1986. Standard deviations are in parentheses.

DISTRICT Stream Reach	n	Streambank altered (%)	Vegetation stability (rank)	Vegetation use (%)	Bank angle (degrees)
WISE RIVER DISTRICT					
Adson Ck					
1	38	15 (20)	4 (0)	6 (4)	68 (23)
LaMarche Ck					
1	21	9 (7)	4 (1)	0 (1)	54 (19)
2	26	12 (11)	4 (1)	10 (11)	68 (15)
Meadow Ck					
2	29	4 (4)	4 (0)	1 (1)	76 (18)
Mono Ck					
1	17	2 (3)	4 (0)	10 (1)	76 (14)
2	39	37 (23)	4 (1)	10 (2)	73 (18)
Wyman Ck					
1	24	28 (20)	3 (1)	60 (21)	54 (19)
2	24	44 (25)	2 (1)	60 (17)	57 (19)

Table 11. (continued)

DISTRICT Stream Reach	n	Streambank altered (%)	Vegetation stability (rank)	Vegetation use (%)	Bank angle (degrees)
WISDOM DISTRICT					
Elk Ck					
1	25	43 (22)	2 (1)	38 (19)	64 (21)
2	27	21 (18)	3 (1)	3 (2)	63 (16)
Johnson Ck					
1	24	18 (12)	3 (1)	69 (9)	73 (14)
2	21	10 (9)	4 (0)	16 (8)	75 (14)
Joseph Ck					
1	22	19 (17)	3 (1)	13 (16)	67 (14)
2	38	17 (16)	4 (1)	2 (2)	73 (12)
Sheep Ck					
1	18	15 (13)	4 (1)	10 (5)	70 (17)
2	30	6 (5)	4 (0)	1 (1)	65 (21)
Steel Ck					
1	19	50 (21)	1 (1)	67 (8)	66 (17)

estimating surficial embeddedness; measuring embeddedness; measuring the diameter of a streambed particle which was larger than 90% of all remaining streambed particles (D-90); and sampling the streambed with a "hollow core" sampler within known or suspected spawning areas to provide a more reliable estimate of streambed composition.

Occular Estimates

Occular estimates of streambed composition and condition including embeddedness, substrate score, and average D-90 are presented in Table 12 and Figure 4. Fine streambed material ("silts" and "sands") made up a relatively large percentage of the streambed (in decreasing order of percentage of fines) in R2 Mono, R2 Wyman, R1 Joseph, R1 Steel, R2 LaMarche, and R2 Joseph creeks. It should be noted that in Elk Creek R2 contains a higher proportion of "fine" material in the streambed than R1, probably an indication of erosive nature of the surrounding geology and inability of this portion of the stream to transport sediments out of its stream channel (Figure 4). Fine material was relatively low (in increasing order of percentage of fines) in R1 Mono, R1 LaMarche, R1 Wyman, R2 Meadow, and R2 Sheep creeks. The other stream reaches contained from 20 to 30 percent "fine" material.

In general, occular estimates of embeddedness reflected the percentage of "fine" sediments within the streambed with reaches having high percentages of "fines" also having relatively high embeddedness values. The exception to this general rule was R2 of Sheep Creek where the streambed appeared to be highly embedded even though surficial "fines" were estimated to make up only 13% of the streambed.

Substrate scores were inversely related to percentage of "fines" and embeddedness values which is due to the fact that both these measures are used to define substrate score (Table 12). Average D-90 values ranged from 0.6 to 29.4 inches.

Embeddedness Measurements

The majority of the sample sites had an average embeddedness of 40 to 50 percent (Table 13). The characteristics of each embeddedness sample site is presented in Appendix F. Those reaches with embeddedness averaging 30 to 40 percent were R1 Jerry, upper R2 LaMarche, R1 Steel, R2 Big Swamp, and lower R2 Trail creeks, and R3 Wise River. The only reaches with embeddedness values higher than 60 percent were R2 Elk and R2 Sheep creeks. Neither of these reaches have much land-use development, but both overlay erosive geological types. It should be noted that timber harvest activities are planned in lands adjoining these two reaches. The proposed timber harvest activities and scheduling of these activities have been addressed in the Trail Creek Area Analysis. The percentage of free matrix particles (those particles which were not embedded at all) ranged from zero to 30 percent.

Embeddedness Variation Within a Reach

A cursory examination of the difference between sampling in two separate riffles in R1 Steel and R1 Adson creeks found little difference between average

Table 12. Mean estimates of substrate composition (percent by size class), embeddedness (%), substrate score, and D-90 (in) for stream reaches draining the Beaverhead National Forest surveyed during 1986. Standard deviations are in parentheses.

RANGER DISTRICT Stream Reach	n	Substrate composition (%) Silt	Sand	Small gravel	Large gravel	Cobble	Small boulder	Large boulder	Embeddedness (%)	Substrate score	D-90 (in)
WISE RIVER DISTRICT											
Adson Ck											
1	38	10 (14)	12 (13)	17 (17)	34 (22)	21 (19)	6 (10)	0 (1)	74 (10)	13 (4)	6.0 (2.9)
LaMarche Ck											
1	21	1 (2)	5 (2)	9 (4)	16 (4)	28 (5)	25 (4)	16 (7)	25 (6)	21 (1)	28.7 (4.7)
2	26	9 (6)	23 (10)	17 (5)	44 (15)	6 (4)	1 (4)	0 (0)	62 (18)	12 (2)	3.9 (2.2)
Meadow Ck											
2	29	3 (3)	10 (6)	11 (6)	18 (6)	18 (6)	24 (12)	16 (12)	36 (18)	19 (3)	21.1 (5.5)
Mono Ck											
1	17	1 (2)	3 (3)	13 (9)	0 (0)	24 (11)	31 (9)	28 (23)	15 (6)	21 (0)	29.4 (7.4)
2	39	36 (29)	32 (21)	30 (29)	0 (1)	0 (0)	0 (0)	1 (6)	98 (7)	5 (1)	0.6 (2.8)
Wyman Ck											
1	24	7 (4)	5 (5)	2 (3)	12 (5)	41 (14)	22 (7)	10 (9)	48 (14)	19 (2)	16.9 (3.7)
2	24	18 (8)	20 (6)	17 (7)	30 (7)	12 (9)	2 (3)	2 (5)	65 (24)	13 (3)	6.4 (5.4)
WISDOM DISTRICT											
Elk Ck											
1	25	10 (5)	17 (6)	19 (8)	28 (9)	24 (9)	2 (3)	0 (0)	64 (16)	14 (2)	7.8 (1.4)
2	27	6 (7)	18 (5)	27 (7)	25 (9)	15 (4)	5 (5)	5 (7)	73 (11)	14 (3)	15.3 (7.4)

Table 12. (continued)

RANGER DISTRICT Stream Reach	n	Substrate composition (%) Silt	Sand	Small gravel	Large gravel	Cobble	Small boulder	Large boulder	Embeddedness (%)	Substrate score	D-90 (in)
Johnson Ck											
1	24	6 (3)	21 (7)	13 (4)	15 (3)	21 (4)	20 (6)	6 (4)	61 (18)	18 (3)	17.3 (4.3)
2	21	6 (4)	18 (8)	13 (4)	21 (9)	22 (10)	10 (5)	10 (12)	56 (16)	17 (3)	18.8 (9.7)
Joseph Ck											
1	22	14 (6)	23 (5)	17 (5)	25 (7)	21 (9)	0 (1)	0 (0)	67 (16)	14 (2)	6.1 (1.3)
2	38	11 (5)	19 (5)	15 (5)	21 (8)	22 (8)	9 (6)	2 (3)	55 (18)	16 (3)	9.2 (2.8)
Sheep Ck											
1	18	9 (9)	18 (9)	20 (6)	31 (13)	21 (10)	1 (2)	0 (0)	73 (20)	13 (3)	6.4 (2.0)
2	30	4 (2)	9 (4)	20 (7)	22 (12)	27 (9)	12 (8)	7 (7)	61 (11)	16 (3)	16.1 (7.5)
Steel Ck											
1	19	11 (5)	26 (5)	21 (3)	28 (6)	13 (4)	0 (0)	0 (0)	69 (15)	11 (1)	3.7 (0.8)

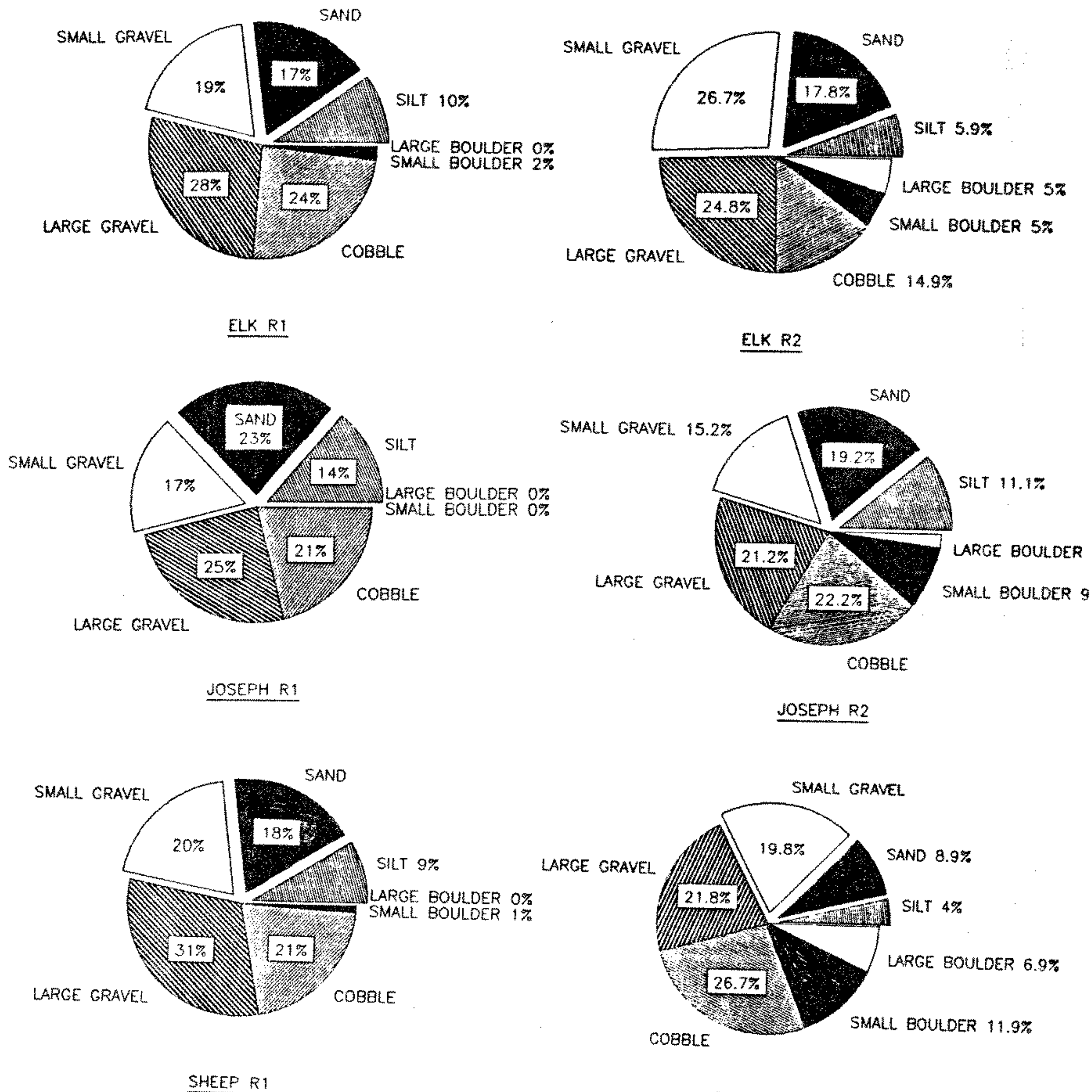

Figure 4. Pie chart diagrams of substrate composition which was estimated ocularly for two reaches in Elk, Joseph, and Sheep creeks which are all tributaries of Trail Creek. Percentages of fine material (less than 0.25 inch) are offset.

Table 13. Average percent embeddedness, "free matrix particles", and average size of particles measured (range in inches) from measurements made of streambed particles in riffle habitat types of stream reaches draining the Beaverhead National Forest surveyed during 1986.

Stream	Reach	n	Embeddedness	Percentage of "free matrix" particles	Average particle size (mm) (range)
Adson Creek	1A 1/	110	52	7	56 (24 - 113)
	1B 1/	107	47	10	54 (18 - 121)
Elk Creek	1	102	50	8	54 (28 - 190)
	2	100	63	3	72 (40 - 175)
Jerry Creek	1	72	34	14	64 (28 - 164)
Johnson Creek	2	146	43	17	66 (23 - 200)
Joseph Creek	1	115	42	10	41 (19 - 84)
	2	108	41	12	50 (20 - 135)
LaMarche Creek	1	105	33	23	71 (28 - 243)
	2A 2/	112	48	11	51 (24 - 111)
	2B 2/	105	33	14	59 (20 -225)
Meadow Creek	2	101	47	9	60 (27 - 144)
Mono Creek	1	101	50	11	67 (24 - 196)

Table 13. (cont.)

Stream	Reach	n	Embeddedness	Percentage of "free matrix" particles	Average particle size (mm) (range)
Sheep Creek	1	96	44	17	57 (27 - 137)
	2	106	69	0	63 (30 - 205)
Steel Creek	1A[3/]	95	39	29	39 (18 - 104)
	1B[3/]	99	38	19	39 (18 - 75)
Swamp Creek	2	95	35	11	60 (28 - 135)
Trail Creek	2	104	36	8	41 (16 - 74)
Wise River	3	94	37	16	57 (28 - 133)
Wyman Creek	1	101	40	18	85 (33 - 231)
	2	103	41	12	49 (29 - 80)

1/ Sample 1A was immediately above the sample section near stream mile 2.0. Sample 1B was in lower Adson Creek near stream mile 1.0.

2/ Sample 1A was within the sample section near stream mile 5.0 while sample 1B was near the hollow core site near stream mile 7.1. Sample 1A better typifies the reach's embeddedness.

3/ Sample 1A was in one riffle while sample 1B was in another riffle approximately 200 yards below the 1A site.

sampled embeddedness between the two riffle sites (Table 13). There was a relatively large difference between the two riffles sampled in R2 LaMarche Creek, however, it should be noted that the riffle sampled at 2A was located approximately two miles below the riffle sampled at 2B. Gradient differences existed between these two sites. Site 2B was in a higher gradient portion of the reach near its uppermost boundary, while site 2A was in a more "typical" area of R2 in a low gradient meadow.

Comparison Between Visual and Measured Embeddedness

A comparison between visual and measurement techniques for estimating embeddedness in riffles found that although there were differences between several pairs of estimates there was no significant difference between the two methods ($P > 0.10$; Table 14) using a Wilcoxon matched-pairs sign ranked test (Daniel 1978). Individual differences in R1 Adson, R2 Meadow, R1 Mono, and R2 Sheep creeks were due to sampling in different riffle sites which were spatially separated by distances of from 0.1 to 1.0 mile. Other large differences, for example R2 Wyman Creek, could not be explained by differences due to sampling in different locations.

Hollow Core Samples

Hollow core sampling conducted during 1985 and 1986 found that few sites contained less than 25% of material smaller than 0.25 inch (Table 15). Several sites contained more than 40% of material smaller 0.25 inch which indicates a potential sedimentation problem. Survival predictions for brook, cutthroat and rainbow trout embryos are presented to show relative health of the spawning gravels at these sites. It must be remembered that these survival predictions are based on laboratory data and field survival rates may be quite different dependent upon micro-habitat characteristics. The sites in East Fork Ruby River and Harriett Lou, Mill, South Fork Willow, Big Swamp, Jerry, and LaMarche creeks were not ideal spawning sites because these sample sites contained moderate to high amounts of cobble and/or boulder. Variability within sample sites (standard deviation divided by the mean expressed as a percentage) ranged from 15 to 47 percent and a higher variation was generally observed in sites which had higher percentages of material larger than 2.0 inches in diameter. The exception to this was in Adson Creek which had high variability between samples within the sample site, but had relatively low amounts of cobble within the streambed. A problem encountered in sampling Adson Creek was that the streambed material appeared to be "perched" on a layer of valley bottom silts which were encountered in seven samples at depths of approximately four to six inches. These silts were included in these samples and biased the samples with respect to the percentage of fine material. The inclusion of these valley bottom silts in the samples also inflated the amount of "fine" material estimated to occur in Adson Creek.

A separate discussion of the results obtained in the Trail Creek drainage is warranted because the Beaverhead Forest is presently in the process of completing an area anaylsis to help schedule timber harvest within the drainage. In 1985 ten hollow core samples were taken from Trail Creek downstream from the May Creek Campground. Those samples estimated that approximately 44% of the streambed material was comprised of material smaller than 0.25 inch (Table 15). The Beaverhead Forest's Management Team wanted to

Table 14. Comparison between visual and measurement estimates of embeddedness in riffles made during 1986 in streams draining the Beaverhead National Forest.

Stream Reach	Visual	Measured	D_i	Rank
Adson Ck				
1	66	52	14	9.0
Elk Ck				
1	51	50	1	2.0
2	63	63	0	
Johnson Ck				
2	55	43	12	7.5
Joseph Ck				
1	53	42	11	6.0
2	44	41	3	4.0
LaMarche Ck				
1	21	33	- 12	- 7.5
2	47	48	- 1	- 2.0
Meadow Ck				
2	27	47	- 20	- 12.0
Mono Ck				
1	12	50	- 38	- 14.0
2	53	38	15	10.5
Sheep Ck				
1	53	44	9	5.0
2	54	69	- 15	- 10.5
Steel Ck				
1	53	44	9	5.0
Wyman Ck				
1	39	40	- 1	- 2.0
2	63	41	22	13.0
Sum of positive and negative ranks			T+ = 57.0	T- = 48.0

Ho: Median of difference is zero (ie. There is no difference between methods)
Ha: Median of differences is not zero

P > 0.104

Therefore, conclude that there is no significant difference between methods.

Table 15. Average percentage of material (by dry weight) less than 0.37 inch (9.5 mm), 0.25 inch (6.34 mm) and less than 0.03 inch (0.85 mm) from hollow core samples taken from typical spawning areas during 1985-86 and predicted survivals of westslope cutthroat trout (WCT), rainbow trout (RB), and eastern brook trout (EBT) embryos from egg deposition to fry emergence based on laboratory studies conducted by Irving and Bjornn (1984) for WCT and RB and survival relationships developed by the author using data from Witzel and MacCrimmon (1985).

Year Stream (n)	Reach	Percentage less than			Predicted[1/] survival (%) of		
		9.5 mm	6.34 mm	0.85 mm	WCT	RB	EBT
1985							
Doolittle Creek (10)	1	37	32	10	19	29	49
E. Fork Ruby River (10)	1	30	24	7	31	45	59
Harriett Lou Creek (5)[2/]	1	27	27	15	27	15	56
Meadow Creek (10)[3/]	2	37	31	11	17	23	50
Mill Creek (10)	2	32	26	7	29	48	57
S. Fk. Blacktail Ck (10)	1	58	48	24	50	3	28
S. Fk. Willow Creek (10)	2	29	24	5	42	61	60
Trail Creek (10)	1	49	44	15	9	4	33
1986							
Adson Creek (9)	1	48	40	19	0	2	42
Big Swamp Creek (10)	2	27	22	6	40	56	63
Jerry Creek (10)	1	30	25	7	33	48	59
Joseph Creek (10)	1	41	36	12	12	16	43
LaMarche Creek (10)	2	40	27	7	32	8	56
Trail Creek (10)	2	64	56	18	8	0	17
Wise River (10)	3	34	30	8	25	39	52

Table 15. (continued - footnotes)

1/ Many of these streams do not support populations of cutthroat or rainbow trout; however, these relative survival values are presented to indicate the relative condition of the spawning habitat.

2/ Harriett Lou Creek contained a streambed composed of large angular boulder and cobble surrounded by fine material. A cursory of the lower portion of the stream did not locate any spawning habitat; therefore, streambed sampling was done in a boulder/cobble habitat which was extremely difficult to sample. These data are of questionable value.

3/ The best spawning site, and therefore sample site, in Meadow Creek was was located immediately downstream from an old bridge site. This area may have contained an abnormally high level of fine sediment and may not accurately reflect the streambed condition of the entire stream.

further investigate the possible source of this fine sediment to document whether it originated from highway construction, livestock and timber activities within the Forest, or mining activity. While it is not possible to accurately determine the source of sediment from hollow core sampling, it was hoped that sampling two additional sites (one near the mouth of Joseph Creek and one in Trail Creek immediately above the mouth of Joseph Creek) would shed some light on where this sediment originated. It can be seen that the Joseph Creek sample contained an estimated 36% material smaller than 0.25 inch, while upper Trail Creek contained an estimated 56% material smaller than 0.25 inch. These data suggest that past management activities within the upper Trail Creek drainage (most noteably past livestock damage to streambanks) probably were the primary sources of fine sediment seen in the lower drainage. This sediment appears to be slowly "migrating" down the stream channel with the main "pulse" of sedimentation presently located near the mouth of Joseph Creek. Further sampling in upper Trail Creek near the mouth of Sunshine Creek during 1987 should help quantify any possible sediment "recovery" of the upper channel. It is likely that since Trail Creek has a relatively low gradient and numerous beaver ponds throughout its length, making its ability to transport sediment relatively low, and presently has large quantities of fine sediment "stored" within the streambed "flushing" of these fine sediments from the streambed will take a long time.

Comparison Between Measured Embeddedness and Hollow Core "Fines"

Simple linear regression as used to compare average measured embeddedness estimates with percentage of material less than 6.34 mm (0.25 inch) estimated from hollow core samples taken at or near the same locations (Figure 5). The regression was calculated using both the untransformed data and after transforming both the embeddedness and hollow core percentages using the arcsin square root transformation recommended by Zar (1984). Figure 5 shows the correlation obtained using the untransformed data. The transformed data also yielded an "r" = 0.82. While this correlation shows promise, the increasing scatter of data points from the predictive line at the higher levels of embeddedness and percent fines would present a problem if one were trying to predict results from one measure using the other. Further testing of correlations between these two methods needs to be done to ensure that results obtained using one technique could be compared to results from the other.

Principle Component Analysis (PCA)

PCA was used in an attempt to consolidate all the measured habitat variables into several functions which could then be regressed against fish abundance variables. The habitat surveys conducted during 1986 resulted in 442 separate observations for each of the 25 variables in 17 sample sections. All 11,050 observations (442 observations times 25 variables) were used in the PCA. The five factors which explained most of the variance observed within stream habitat are listed in Table 16 along with the coeffecients assigned to each individual variable. The variables are segregated into overhead cover, streambed, streambank, channel shape, and instream cover classes. Coeffecients larger than 0.5 are highlighted in bold type. It can be seen that Factor 1 explained approximately 33% of the variation in habitat and this factor relied heavily on streambed related variables. This suggests that the streambed component is an important component in explaining stream habitat and any

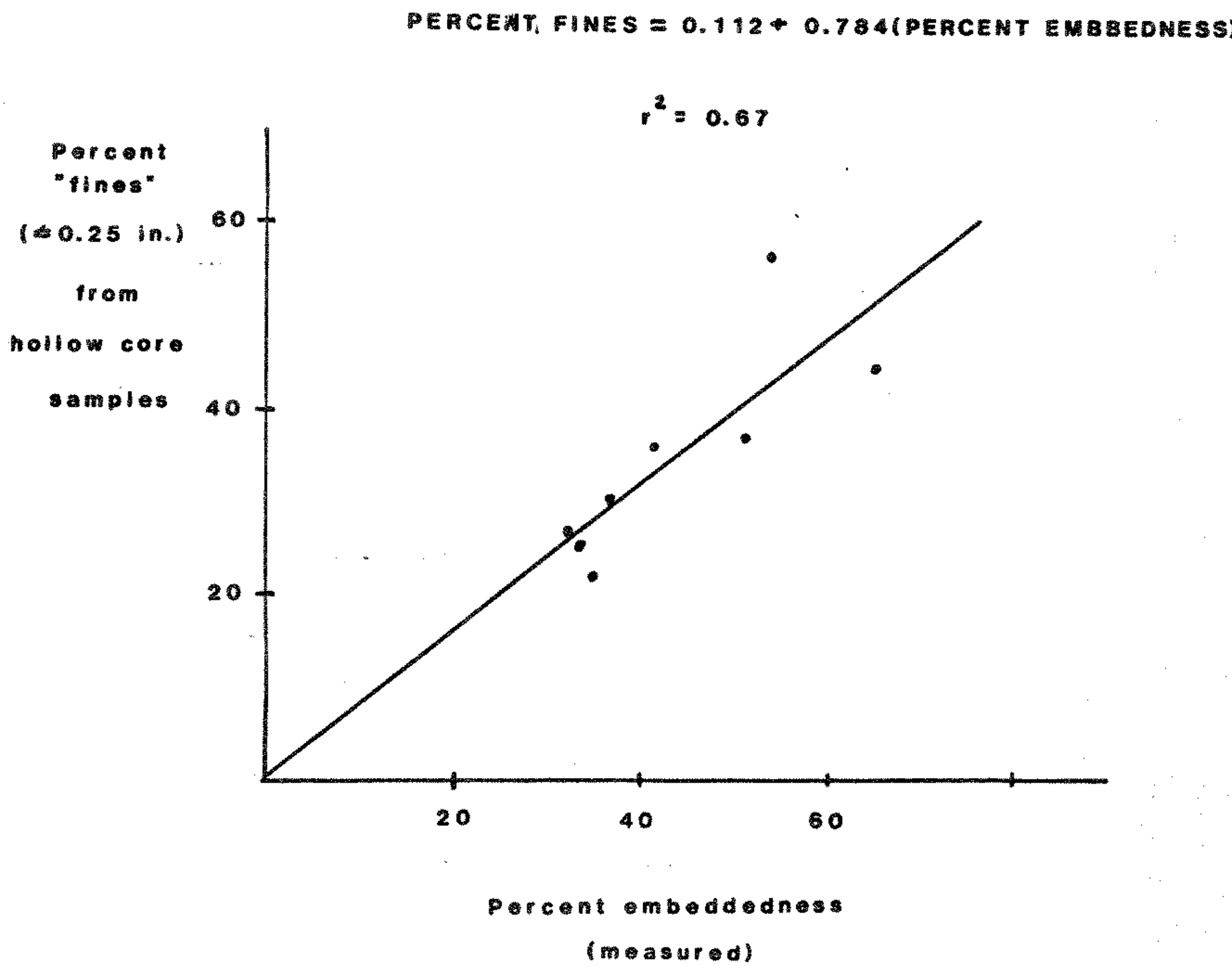

Figure 5. Relationship between "percent fines" (material less than 0.25 inch) sampled by hollow core sampling and percent embeddedness sampled by measuring at least 100 individual particles at the same sample site.

Table 16. Principal components analysis for habitat variables measured in the "detailed habitat survey section" across 442 measured transects in 17 stream sections surveyed during 1986.

Habitat variable	Factors 1	2	3	4	5
Overhead cover					
Canopy density	0.28388	0.33354	- 0.10441	0.09041	0.06647
Low overhead veg.	0.14411	**0.51195**	- 0.04891	0.24565	**0.54523**
High overhead veg.	0.23471	0.44501	- 0.05166	0.45111	**0.51418**
Streambed					
Silt	**- 0.58286**	0.06916	0.13728	- 0.40189	0.31313
Sand	**- 0.67058**	0.04448	0.08234	- 0.12119	0.07420
Small gravel	- 0.45222	0.12519	- 0.27031	- 0.04549	- 0.37720
Large gravel	- 0.12440	- 0.22720	- 0.18430	**0.78116**	- 0.09747
Cobble	**0.60574**	- 0.18535	- 0.13294	0.20525	0.13543
Small boulder	**0.81873**	0.09928	0.23210	- 0.25801	- 0.01038
Large boulder	**0.66566**	0.15138	0.23966	- 0.37264	- 0.05586
Embeddedness	**- 0.83389**	0.12326	- 0.08600	- 0.08596	0.14915
Substrate score	**0.90698**	- 0.07155	0.10452	0.10908	- 0.00045
D-90	**0.84089**	0.07645	0.22507	- 0.17867	- 0.11697
Streambank					
Bank alteration	- 0.39872	**- 0.64645**	- 0.05388	- 0.21547	0.30242
Vegetation stability	0.15998	**0.74646**	- 0.04219	- 0.03573	- 0.30741
Vegetation use	- 0.04498	**- 0.63240**	0.18284	- 0.03537	0.43132
Undercut bank	- 0.20902	0.24272	0.38943	0.37868	- 0.05433
Depth of undercut	- 0.12364	**0.53517**	0.10685	0.26850	0.05923
Bank angle	- 0.06250	**0.59962**	0.05413	- 0.02066	- 0.00557
Channel shape					
Wetted width	0.17611	- 0.44377	**0.68149**	0.25651	- 0.12203
Channel width	0.17155	**- 0.58290**	**0.57898**	0.32008	- 0.11917
Average depth	**- 0.51367**	0.20537	**0.74773**	- 0.00872	- 0.03926
Thalweg depth	- 0.39467	0.11409	**0.81920**	- 0.02870	- 0.02533
Near shore depth	- 0.46507	0.43989	0.46484	0.06105	- 0.04970
Instream cover	**0.55808**	0.25300	0.37591	- 0.26785	0.34344
VARIANCE EXPLAINED	6.128	3.668	2.938	1.869	1.409

FINAL COMMUNALITY ESTIMATES: TOTAL = 18.371

changes in streambed resulting from management activities could change stream habitat. It is unclear at this time what effect changes in habitat has on fish populations from the data collected to date. A discussion of these results will be presented later. Factors 2, 3, 4, and 5 relied heavily on streambank, channel shape, large gravel (related to spawning gravel), and overhead cover variables, respectively. These factors explained approximately 20, 16, 10, and 8 percent of the variability observed in stream habitat, respectively.

FISH ABUNDANCE

Catch per Unit Effort (CPUE)

Catch of fish 3.0 inches and longer by species made in a single electrofishing pass standardized to 1,000 feet of stream length are presented in Tables 17 through 19. CPUE ranged from 3 to 660 fish per 1,000 feet for brook trout in sections where brook trout were captured, 1 to 177 fish per 1,000 feet for cutthroat trout in sections where cutthroat trout were captured, 2 to 35 fish per 1,000 feet for rainbow trout in sections where rainbow trout were captured, and 1 to 33 fish per 1,000 feet for arctic grayling in sections where grayling were captured.

Tributary Population Estimates

Population estimates made for tributary reaches electrofished during 1985 and 1986 are presented in Table 20. R2 Governor, R2 LaMarche, and R2 Wyman creeks had the highest densities of brook trout 6.0 inches and longer, while R2 Elk, R2 Joseph, R1 LaMarche, R2 Old Tim, R1 Steel, and R2 Trail creeks all had relatively high densities of brook trout 3.0 to 5.9 inches long. Reaches which had extremely low densities of brook trout were R1 Adson, R2 Cow Cabin, R2 Morrison, R2 Pole, R2 Ruby, R1 Sheep, R2 Steel, R1 Trail, and R1 Wyman creeks. R1 Adson, R2 Cow Cabin, R2 Morrison, and R2 Pole are all reaches where the streams are very small and the low density of brook trout was to be expected. R2 Ruby, R1 Sheep, and R2 Steel appeared to be impacted by livestock grazing. R1 Trail appeared to be impacted by high levels of fine sediment (see above for a discussion of the source of this sediment).

Densities of westslope cutthroat trout (identified using external morphological characteristics - see below for a discussion of genetic analysis conducted on some of these populations) were high for R2 Brown's Canyon, R2 Painter, and R2 Reservoir creeks. Streams within the Wise River District generally had lower densities of cutthroat. It appears that dewatering near the mouths of tributaries to Horse Praire Creek and Grasshopper Creek limited rainbow and/or brook trout from entering these tributaries and competing and/or introgressing with the cutthroat trout populations native to these tributaries. In general, cutthroat trout populations are limited to small headwater and high gradient tributaries or are above some type of fish passage barrier.

Rainbow trout were found in R1 LaMarche and R2 Wyman creeks. The rainbow in LaMarche Creek could have orginated from either releases of hatchery rainbow trout between 1928 and 1954 or from fluvial Big Hole River rainbow populations.

Table 17. Relative fish abundance by species for fish 3.0 inches and longer in streams draining the Beaverhead National Forest within the Dillon Ranger District derived from single pass electrofishing catches using a Coffelt BP-1C backpack electrofisher during 1985 and 1986.

Stream	Legal description	Year	Section length (ft.)	Number per 1,000 feet					
				EBT [1/]	WCT	RB	GR	LING	OTHER
Andrus Ck	T 7SR14WSec 5CB	85	565	183	4	-	-	2	-
Browns Canyon	T 8SR13WSec30AA	86	300	-	177	-	-	-	-
Cow Cabin Ck	T 6SR14WSec24BC	86	300	30	-	-	-	-	-
Fox Ck	T 7SR14WSec12AC	85	550	171	13	-	-	-	-
	T 6SR14WSec33DC	85	450	129	-	-	-	-	-
Governor Ck	T 6SR14WSec 6BA	85	500	84	-	2	-	32	40 MWF
	T 7SR14WSec 6DA	85	1,375	168	5	-	-	3	-
	T 7SR14WSec32BA	85	325	123	28	-	-	-	-
Morrison Ck	T13SR12WSec15CC	86	300	14	-	-	-	-	-
	T13SR12WSec10DC	86	300	No fish captured except 2 sculps.					
Old Tim Ck	T 4SR13WSec33DD	86	300	220	-	-	-	-	-
Painter Ck	T 8SR14WSec25AB	86	300	-	120	-	-	-	-
Pass Ck	T12SR12WSec33CC	86	300	144	-	-	-	-	-
Pole Ck	T 5SR13WSec34AD	86	300	24	4	-	-	-	-
Reservoir Ck	T 8SR13WSec16AB	86	300	-	97	-	-	-	-
Saginaw Ck	T 7SR15WSec10		Not sampled - flows very little water						
Thayer Ck	T 7SR14WSec26BB	85	320	225	4	-	-	-	-

[1/] Abreviations for species are: EBT = eastern brook trout; WCT = westslope cutthroat trout; RB = rainbow trout; GR = arctic grayling; LING = burbot; and under the other - HB = hybrids between EB and WCT; MWF = mountain whitefish.

Table 18. Relative fish abundance by species for fish 3.0 inches and longer in streams draining the Beaverhead National Forest within the Wise River Ranger District derived from single pass electrofishing catches using a Coffelt BP-1C backpack electrofisher during 1985 and 1986.

Stream	Legal description	Year	Section length (ft.)	Number per 1,000 feet: EBT [1/]	WCT	RB	GR	LING	OTHER
Adson Ck	T 1SR11WSec28BC	86	406	5	12	-	-	-	-
	T 1SR11WSec28CB	86	275	11	4	-	-	-	-
Bryant Ck	T 1NR12WSec 8AD	85	500	150	-	-	-	-	-
	T 1NR13WSec25AB	85	200	145	-	-	-	-	-
Butler Ck	T 1SR11WSec30CD	86	200	No fish captured					
California Ck	T 3NR11WSec30DB	85	580	61	-	35	-	-	-
Fishtrap Ck	T 2NR13WSec32DD	86	200	660	-	15	5	10	-
Harriet Lou	T 1SR12WSec12BB	85	300	-	3	-	-	-	-
	T 1SR12WSec 1AC	85	250	No fish observed					
Lacy Ck	T 2SR12WSec 6DA	85	250	76	4	-	-	20	-
	T 3SR12WSec 2AD	85	500	42	36	-	-	-	-
LaMarche Ck	T 2NR13WSec22CC	86	1,018	131	-	22	-[2/]	-	-
	T 2NR13WSec16BB	86	1,184	82	-	-	-	-	1 MWF
Meadow Ck	T 1NR12WSec36AC	85	500	-	28	-	-	-	-
	T 1NR12WSec36BA	86	493	-	14	-	-	-	-
Mono Ck	T 4SR12WSec 4BA	86	496	-	34	-	-	-	-
	T 4SR12WSec 5DA	86	700	-	24	-	-	-	-
	T 4SR12WSec 8AB	86	300	-	9	-	-	-	-
O'Dell Ck	T 3SR13WSec25AC	85	500	88	-	-	-	-	18 HB
Sevenmile Ck	T 3NR12WSec23AC	85	400	245	-	-	-	-	-
Wyman Ck	T 3SR13WSec24DA	86	621	40	-	-	-	6	8 HB
	T 3SR12WSec17CC	86	834	155	7	7	1	-	2 HB

1/ Abreviations for species are: EBT = eastern brook trout; WCT = westslope cutthroat trout; RB = rainbow trout; GR = arctic grayling; LING = burbot; and under the other - HB = hybrids between RB and WCT; MWF = mountain whitefish.

2/ Arctic grayling were observed and angled from the lower segment of LaMarche Creek.

Table 19. Relative fish abundance by species for fish 3.0 inches and longer in streams draining the Beaverhead National Forest within the Wisdom Ranger District derived from single pass electrofishing catches using a Coffelt BP-1C backpack electrofisher during 1985 and 1986.

				Number per 1,000 feet					
Stream	Legal description	Year	Section length (ft.)	EBT [1/]	WCT	RB	GR	LING	OTHER
Bender Ck	T 1SR17WSec12CB	86	700[2/]	8	-	-	-	-	-
Big Lake Ck	T 3SR15WSec18DD	86	1,550	10	-	-	2	2	17 MWF
	T 3SR15WSec19DC	85	1,000	11	-	-	-	20	-
	T 4SR16WSec32AA	85	350	146	-	-	-	-	-
Doolittle Ck	T 1SR14WSec28CD	85	640	50	2	-	-	-	-
Elk Ck	T 2SR18WSec 4DB	86	571	96	-	-	-	-	-
	T 1SR18WSec33BD	86	528	208	-	-	-	-	-
Goris Gulch	T 1SR14WSec 8AA	86	-	Very little flow - no fish					
Johnson Ck	T 1SR17WSec25AA	86	597	103	-	-	-	39	-
	T 1SR17WSec 5CD	86	534	110	-	-	-	-	-
Joseph Ck	T 2SR18WSec16BC	86	575	113	-	-	-	2	-
	T 2SR19WSec12BC	86	592	381	-	-	-	-	-
	T 2SR19WSec11AA	86	150	153	-	-	-	-	-
Mussigbrod Ck	T 1SR16WSec 9BA	86	700[2/]	3	-	-	-	-	-
Placer Ck	T 2SR17WSec16DA	86	650[2/]	17	-	-	-	-	-
Plimpton Ck	T 1SR15WSec22BD	86	300[3/]	87	-	-	-	-	-
Rock Ck	T 3SR15WSec19CC	85	400	35	-	-	33	-	-
Ruby Ck	T 3SR18WSec25AD	85	1,000	10	-	-	-	-	-
	T 3SR17WSec30BC	85	350	23	-	-	-	-	-
Salesfsky G	T 1SR14WSec 8CA	86	500	No fish captured					
Sheep Ck	T 2SR18WSec14BD	86	555	43	-	-	-	9	-
	T 2SR18WSec11BB	86	534	60	-	-	-	-	-
Squaw Ck	T 1NR14WSec27DC	85	500	70	-	-	-	10	-
Steel Ck MWF	T 2SR15WSec15BD	86	1,400[4/]	7	-	-	5	1	27
	T 2SR15WSec34AB	86	855	180	-	-	2	5	17 MWF
	T 2SR15WSec34AB	85	600	149	-	-	3	2	18 MWF
	T 3SR14WSec 5CB	85	880	30	1	-	-	6	2 HB

Table 19. (continued)

Stream	Legal description	Year	Section length (ft.)	Number per 1,000 feet EBT 1/	WCT	RB	GR	LING	OTHER
Swamp Ck	T 2SR15WSec16CA	85	500	90	-	-	4	22	4 MWF
Tie Ck	T 2SR17WSec 2BC	85	500	56	-	-	-	10	-
	T 1SR17WSec34CA	85	350	146	-	-	-	3	-
Trail Ck	T 1SR18WSec31AB	85	1,000	184	-	-	-	17	-
	T 2SR17WSec22D	85	500	12	-	-	-	14	4 MWF

1/ Abreviations for species are: EBT = eastern brook trout; WCT = westslope cutthroat trout; RB = rainbow trout; GR = arctic grayling; LING = burbot; and under the other - HB = hybrids between RB and WCT; MWF = mountain whitefish.

2/ These streams were electrofished early in the spring when water temperatures were near 35° to 40° F. These values should be considered low due to the low efficiency.

3/ An additional 1,000 feet were electrofished in an effort to capture grayling, but no grayling were found. A local resident claimed to have angled grayling out of the creek in the recent past.

4/ This portion of Steel Creek was within a channel of the Big Hole River which captured the lower 3.0 miles of Steel Creek. Several burbot were electrofished, but not netted.

Table 20. Estimated fish populations in streams surveyed on the Beaverhead National Forest during 1985 and 1986. Population estimates calculated using a two-pass estimator (2P) (Seber and LeCren 1967), maximum-liklihood estimator (ML) (Van Deventer and Platts 1985), mark-recapture (MR) (Ricker 1975), and snorkel counts (SNORK).

Stream Reach	Estimator (Section length ft)	Species	Size range (inches)	Estimated population	80 % C.I.	Number per 1,000 ft	Number per acre
DILLON DISTRICT							
Browns Canyon							
2	ML	WCT 1/	3.0 - 5.9	41	40-44	137	850
	(300)		6.0 +	23	23-24	77	477
Cow Cabin							
2	ML	EBT	3.0 - 5.9	5	5-6	17	186
	(300)		6.0 +	6	6-7	20	223
Governor							
2	ML	EBT	3.0 - 5.9	73	66-80	53	196
	(1,375)		6.0 +	213	209-217	155	572
Morrison							
2	2P	EBT	3.0 - 5.9	-	- 2/	-	-
	(300)		6.0 +	4	-	13	87
Old Tim 3/							
2	2P	EBT	3.0 - 5.9	64	62-67	213	1387
	(300)		6.0 +	16	15-18	53	347
Painter							
2	ML	WCT	3.0 - 5.9	26	26-27	87	353
	(300)		6.0 +	14	14-15	47	190
Pass							
2	ML	EBT	3.0 - 5.9	33	33-34	110	622
	(300)		6.0 +	14	- 2/	47	264
Pole							
2	ML	EBT	3.0 - 5.9	7	7-9	23	141
	(300)		6.0 +	3	3-4	10	61
		WCT	3.0 - 5.9	-	-	-	-
			6.0 +	2	2-4	7	40
Reservoir							
2	ML	WCT	3.0 - 5.9	12	- 2/	40	379
	(300)		6.0 +	17	- 2/	57	537

Table 20. (continued)

Stream Reach	Estimator (Section length ft)	Species	Size range (inches)	Estimated population	80 % C.I.	Number per 1,000 ft	Number per acre
WISDOM DISTRICT							
Elk							
1	ML	EBT	3.0 - 5.9	48	47-50[2/]	84	398
	(571)		6.0 +	15	-	26	124
2	ML	EBT	3.0 - 5.9	99	98-101	188	939
	(528)		6.0 +	22	22-23	42	209
Doolittle							
2	MR	EBT	3.0 - 5.9	76	49-103	119	450
			6.0 +	21	14-29	33	124
Johnson							
1	ML	EBT	3.0 - 5.9	41	41-43	69	147
	(597)		6.0 +	31	31-33	52	111
2	ML	EBT	3.0 - 5.9	69	63-76	129	313
	(534)		6.0 +	14	14-15	26	63
Joseph							
1	ML	EBT	3.0 - 5.9	44	41-49	88	381
	(575)		6.0 +	39	38-41	78	336
2	ML	EBT	3.0 - 5.9	229	224-234	458	2660
	(592)		6.0 +	35	35-36	71	407
Ruby							
2	ML	EBT	3.0 - 5.9	12	6-18	12	31
	(1,000)		6.0 +	6	6-7	6	16
Sheep							
1	MR	EBT	3.0 - 5.9	15	15	27	149
	(555)		6.0 +	12	12	22	119
2	MR	EBT	3.0 - 5.9	38	30-46	71	260
	(534)		6.0 +	10	8-13	19	69

Table 20. (continued)

Stream Reach	Estimator (Section length ft)	Species	Size range (inches)	Estimated population	80 % C.I.	Number per 1,000 ft	Number per acre
Steel							
1	ML	EBT	3.0 - 5.9	270	201-339	316	531
	(855)		6.0 +	62	61-66	73	122
2	ML	EBT	3.0 - 5.9	33	28-41	38	172
	(880)		6.0 +	12	11-15	14	63
Trail							
1	SNORK	EBT	3.0 - 5.9	11	-	22	34
	(500)		6.0 +	14	-	28	43
2	ML	EBT	3.0 - 5.9	193	174-212	193	701
	(1,000)		6.0 +	83	82-85	83	301
WISE RIVER DISTRICT							
Adson							
1	ML	WCT	3.0 - 5.9	-	-	-	-
	(406)		6.0 +	7	7-13	17	132
		EBT	3.0 - 5.9	3	3-4	7	56
			6.0 +	-	-	-	-
LaMarche							
1	MR	EBT	3.0 - 5.9	207	171-243	203	279
	(1,018)		6.0 +	84	68-97	83	113
		RB	3.0 - 5.9	50	29-71	49	67
			6.0 +	6	6	6	8
2	SNORK	EBT	3.0 - 5.9	222	-	188	314
	(1,184)		6.0 +	189	-	160	267
Meadow							
2	MR	WCT	3.0 - 5.9	8	7-9 2/	16	79
	(493)		6.0 +	1	-	2	10

Table 20. (continued)

Stream Reach	Estimator (Section length ft)	Species	Size range (inches)	Estimated population	80 % C.I.	Number per 1,000 ft	Number per acre
Mono							
1	MR	WCT	3.0 - 5.9	31	20-42 2/	63	213
	(496)		6.0 +	6	-	12	41
2	ML	WCT	3.0 - 5.9	13	12-15	21	302
			6.0 +	10	8-13	17	238
Wyman							
1	MR	EBT	3.0 - 5.9	24	22-27	39	109
	(621)		6.0 +	18	17-20	29	82
		RBXWCT	3.0 - 5.9	7	6-9	11	32
			6.0 +	2	2	3	9
2	MR	EBT	3.0 - 5.9	226	174-278	271	625
	(834)		6.0 +	157	140-174	188	434

1/ Species codes are: WCT = westslope cutthroat trout; EBT = eastern brook trout; RB = rainbow trout; and RBXWCT = unidentifiable westslope cutthroat, rainbow trout and/or hybrids between these two species.

2/ All captured fish were captured on the first pass making a confidence estimate impossible.

3/ A complete second pass was not completed in Old Tim Creek. The catch in the second pass was estimated based on the length of stream fished versus the total section length.

I believe the rainbow trout in R2 Wyman Creek originated from past releases of hatchery rainbow trout made into Lake of the Woods between 1941 and 1960.

Evaluation of Different Estimation Techniques

A comparison between depletion type (two or more consecutive electofishing passes) and mark-recapture estimators found that depletion type estimates were lower than mark-recapture estimates, especially when capture probabilities ($\hat{p}$) were less than 0.75 (Table 21). This result suggests that two-pass estimates may be underestimates and underestimation is more likely to increase as probability of capture decreases. All two-pass probability of capture estimates reported in Table 20 were 0.75 or higher except for brook trout 3.0 to 5.9 inches in R2 Governor Creek (0.68), cutthroat trout 6.0 inches and longer in R2 Pole Creek (0.67), brook trout 3.0 to 5.9 inches in R2 Johnson Creek (0.69), brook trout 3.0 to 5.9 inches in R2 Ruby Creek (0.55), brook trout 3.0 to 5.9 inches in R1 Steel Creek (0.38), brook trout 3.0 to 5.9 inches and 6.0 inches and longer in R2 Steel Creek (0.59 and 0.65, respectively), brook trout 3.0 to 5.9 inches in R2 Trail Creek (0.59), and cutthroat trout 3.0 to 5.9 inches and 6.0 inches and longer in R2 Mono Creek (0.55 and 0.57, respectively). It is likely that severe underestimates were made in any case where these probability of capture values were less than 0.60.

A comparison between the depletion estimate and a snorkel count in R2 LaMarche Creek found that the snorkel count observed more fish than estimates made using the depletion estimator (222 versus 143 for brook trout 3.0 to 5.9 inches long and 189 versus 132 for brook trout 6.0 inches and longer). The capture probabilities for the depletion estimator were low ($\hat{p}$ = 0.25 and 0.47 for brook trout 3.0 to 5.9 inches long and 6.0 inches and longer, respectively) making the depletion estimate less reliable. An attempt was also made to mark fish using electrofishing and conduct the recapture data using snorkel observation. It was difficult to observe the mark (a clipped dorsal lobe of the caudal fin) underwater, however, this type of approach appears to hold promise providing a tag or other mark which is easily applied and identifiable underwater can be found.

Presence of "Sensitive Species" by District

Tables 22 through 25 highlight the streams where westslope cutthroat trout and arctic grayling have been documented. Both these species have been classified as "sensitive species" by the Forest Service and are "species of special concern" within the state of Montana. Further quantification of the genetic status of suspected "pure" westslope cutthroat trout populations in five tributaries (Brown's Canyon, Reservoir, South Fork Steel, and Mono creeks) was made by sending seven to eleven fish to the University of Montana's Genetics Laboratory for electrophoretic analyses. From these analyses it appears that the cutthroat trout in both Brown's Canyon and Reservoir creeks are "pure" westslope cutthroat trout (letter dated September 1, 1986 from Robb Leary, Genetics Laboratory, University of Montana to Brad Shepard, MDFWP). The cutthroat from Mono and Fox creeks were certainly introgressed cutthroat-rainbow trout populations. Introgression within the South Fork Steel Creek population was less clear and more sampling from this stream would be necessary to verify if this population has been introgressed with rainbow trout.

Table 21. Comparison of depletion (two or more consecutive electrofishing catches) and mark-recapture estimates and their associated efficiencies (probability of capture for depletion = p; and number of recaptures divided by the total number marked for mark-recapture) from estimates made during 1985 and 1986 in streams draining the Beaverhead National Forest.

Stream Reach	Species Size class (inches)	Estimate Depletion	Estimate Mark-recap	Depletion (p)	Mark-recap (R/M)
Doolittle Ck					
1	EBT[1/]				
	3.0 - 5.9	-[2/]	76	-	.33
	6.0 +	15	21	.79	.30
LaMarche Ck					
1	EBT				
	3.0 - 5.9	130	207	.45	.37
	6.0 +	76	84	.67	.52
	RB				
	3.0 - 5.9	26	50	.46	.25
	6.0 +	6	6	-[3/]	.50
Meadow Ck					
2	WCT				
	3.0 - 5.9	7	8	.87	.67
	6.0 +	1	1	-[3/]	1.00
Sheep Ck					
1	EBT				
	3.0 - 5.9	15	15	.88	.53
	6.0 +	12	12	.92	.58
2	EBT				
	3.0 - 5.9	32	38	.79	.44
	6.0 +	8	10	.89	.29
Wyman Ck					
1	EBT				
	3.0 - 5.9	23	24	.61	.60
	6.0 +	17	18	.74	.50
	RBXWCT				
	3.0 - 5.9	6	7	.60	.60
	6.0 +	2	2	-[3/]	1.00
2[4/]	EBT				
	3.0 - 5.9	203	226	.24	.20
	6.0 +	130	163	.60	.30

Table 21. (continued - footnotes)

1/ Species abbreviations are: EBT = eastern brook trout; WCT = westslope cutthroat trout; RBXWCT = westslope cutthroat, rainbow trout, and hybrids between the two species.

2/ No estimate was possible because the same number of fish were captured in the first and second electrofishings.

3/ No estimate of $\hat{p}$ possible because all captured fish were captured on the first electrofishing.

4/ More than two electrofishing passes were made for the depletion estimate.

Table 22. Relative numbers and population estimates (where available) of westslope cutthroat trout (identified from external morphological characteristics) ranked from highest to lowest catch per unit effort (CPUE from one electrofishing pass with a Coffelt BP-1C backpack electrofisher) in streams draining the Dillon District, Beaverhead National Forest surveyed during 1985-86.

Stream (reach)	Year	CPUE per 1,000 feet Cutthroat trout	Other salmonids	Section length (ft)	Population estimate (80% CI)	Number per 1,000
Browns Canyon Creek	86	177	-	300	64 (4)	214
Painter Creek	86	120	-	300	40 (2)	134
Reservoir Creek	86	97	-	300	29 (0)	97
Governor Creek (3)	85	28	123	325	-	-
Fox Creek (1)	85	13	171	550	-	-
Governor Creek (2)	85	5	168	1375	8 (2)	6
Thayer Creek	85	4	225	320	-	-
Andrus Creek	85	4	183	565	-	-
Pole Creek	86	4	24	300	2 (1)	7

Table 23. Relative numbers and population estimates (where available) of westslope cutthroat trout (identified from external morphological characteristics) ranked from highest to lowest catch per unit effort (CPUE from one electrofishing pass with a Coffelt BP-1C backpack electrofisher) in streams draining the Wise River District, Beaverhead National Forest surveyed during 1985-86.

		CPUE per 1,000 feet				
Stream (reach)	Year	Cutthroat trout	Other salmonids	Section length (ft)	Population estimate (80% CI)	Number per 1,000
Lacy Creek (2)	85	36	42	500	-	-
Mono Creek (1)	86	34	-	496	21 (1)	42
Meadow Creek (2)	85	28	-	500	-	-
	86	14	-	493	9 (2)	18
Mono Creek (2)	86	24	-	700	28 (4)	40
	86	9	-	300	-	-
Adson Creek (1)	86	12	5	406	7 (2)	18
	86	4	11	275	-	-
Wyman Creek (2)	86	7[1/]	163	834	-	-
Harriett Lou Creek	85	3	-	300	-	-

1/ It is probable that these cutthroat have hybridized to some extent with rainbow present in the Wyman Creek drainage.

Table 24. Relative numbers and population estimates (where available) of westslope cutthroat trout (identified from external morphological characteristics) ranked from highest to lowest catch per unit effort (CPUE from one electrofishing pass with a Coffelt BP-1C backpack electrofisher) in streams draining the Wisdom District, Beaverhead National Forest surveyed during 1985-86.

		CPUE per 1,000 feet				
Stream (reach)	Year	Cutthroat trout	Other salmonids	Section length (ft)	Population estimate (80% CI)	Number per 1,000 '
Doolittle Creek (1)	85	2	50	640	-	-
Steel Creek (2)	85	1[1/]	32	880	-	-

[1/] It is probable that the cutthroat in Steel Creek had hybridized to some extent with the rainbow in the drainage.

Table 25. Relative numbers and population estimates (where available) of arctic grayling ranked from highest to lowest catch per unit effort (CPUE from one electrofishing pass with a Coffelt BP-1C backpack electrofisher) in streams draining the Beaverhead National Forest surveyed during 1985-86.

Stream (reach)	Year	CPUE per 1,000 feet: Arctic grayling	CPUE per 1,000 feet: Other salmonids	Section length (ft)	Population estimate (80% CI)	Number per 1,000
Rock Creek (1)	85	33	35	400	-	-
Steel Creek (1)	86	5 1/	34	1400	-	-
	85	3	149	600	-	-
	86	2	197	855	3 (2)	4
Fishtrap Creek (1)	86	5	675	200	-	-
Swamp Creek (1)	85	4	94	500	-	-
Big Lake Creek (1)	86	2	27	1550	-	-
Wyman Creek (2)	86	1 2/	171	834	-	-
LaMarche Creek (1)	86	- 3/	153	1018	-	-

1/ The channel electrofished was in lower Steel Creek where the Big Hole River has presently cut a side channel which has captured this lower portion of Steel Creek.

2/ It is believed that the grayling captured in reach 2 of Wyman Creek originated from Lake Odell stock.

3/ No grayling were electrofished from the sample section in reach 1 of LaMarche Creek, however, several grayling were observed and angled from the lower 0.5 mile of the creek.

Big Hole River Population Estimate

The total number of arctic grayling 8.5 inches and longer during late June was estimated to be approximately 35 fish per river mile in a 4.9 mile long sample section of the Big Hole River located immediately above the Highway 43 bridge at Wisdom (Table 26). This segment of the population represents all fish age 2 and older. An estimate of all fish 6.0 inches and longer yielded an estimate of 71 fish per mile. Only one fish larger than 13.0 inches was captured. Grayling appeared to be very susceptable to anglers. The incidence of easily recognizeable hooking scars was 10% for all grayling handled and increased to 15% for grayling longer than 10.0 inches. Approximately 6.7% of the rainbow trout handled and 1.5% of the brook trout handled had recognizeable hooking scars.

It appears that the population of grayling in this portion of the river has declined since 1983 when Oswald (1984) estimated approximately 105 age 2 grayling per mile. Oswald (personal communication) estimated grayling numbers in the same section of the river during the fall of 1986. He had difficulty obtaining reliable estimates due to the initiation of fall downstream movements between his marking and recapture electrofishings, however, using two estimation techniques, he estimated that this section contained somewhere between 51 and 98 grayling 6.0 inches and longer per mile. One noteworthy finding of Oswald's sampling during the fall was the presence of numerous age 0 grayling in several side channel areas which may indicate that the 1986 year class had better than average survival since in previous sampling very few age 0 grayling had been captured.

The number of eastern brook trout 9.0 inches and longer was estimated to be 282 fish per river mile in this same sample section, while the number of brook trout under 9.0 inches was estimated to be 152 per river mile (Table 22).

LENGTH, WEIGHT, AND CONDITION FACTOR

Average lengths, weights (where reliable weight information was available), and condition factors are presented in Appendix G.

Length Frequencies

Length frequency data suggest that the upper reaches of tributaries are important spawning and rearing areas while the lower reaches support a higher percentage of adult and "catchable" size fish (Figures 6 through 8). The exceptions to this general rule appear in data for brook trout in LaMarche Creek and cutthroat trout in Mono Creek (Figure 7). The large number of brook trout less than 3.0 inches in Johnson Creek (30) probably occurred because this reach was sampled late in the year (August 27) after the young of the year were suseptable to the electrofishing. R2 of Wyman Creek supported a higher number of larger fish than R1, probably because of the presence of more high quality pool habitats in R2. Adult cutthroat trout in Mono Creek appeared to spawn and spend the early summer in R2, while the juveniles seemed to prefer the higher gradient and large substrate found in R1. More brook trout in all length classes 6.5 inches and less were found in R2 of Joseph versus R1. R1 appeared

Table 26. Estimated populations of arctic grayling and eastern brook trout in the McDowell section of the Big Hole River above Wisdom, Montana in late June, 1986 using a mark-recapture estimator.

Species	Length class	Estimated number (80% CI)	Number per mile
Arctic grayling	8.5 - 10.4	75 (39 - 111)	16
	10.5 +	93 (62 - 124)	19
	8.5 +	168	35
	6.0 +	348	70
Eastern brook	less than 9.0	741 (593 - 889)	152
	9.0 - 11.9	1,170 (1,056 - 1,284)	239
	12.0 +	209 (146 - 272)	43
	9.0 +	1,379	282

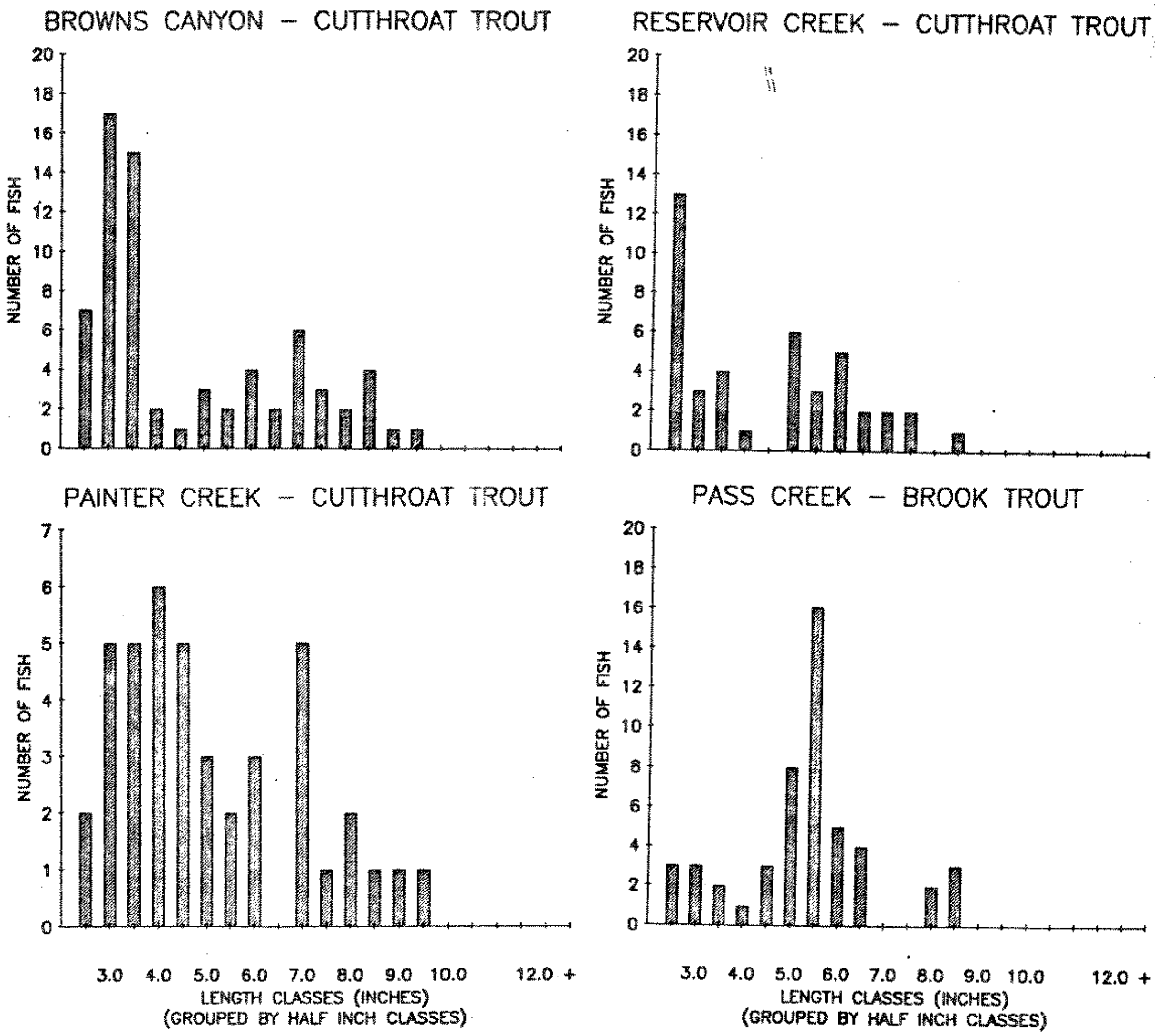

Figure 6. Length frequency histograms for fish captured in streams on the Dillon District during 1986.

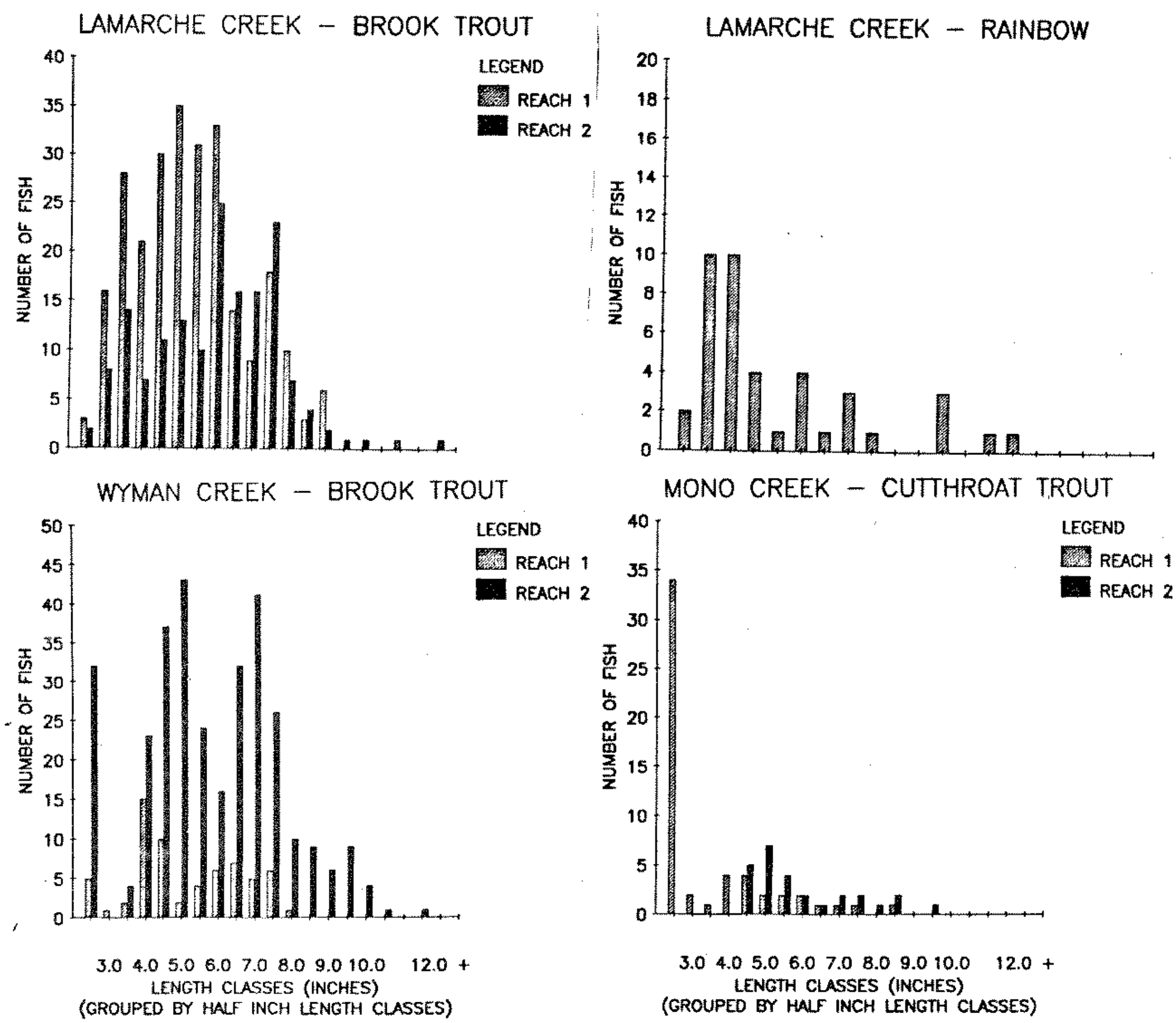

Figure 7. Length frequency histograms for fish captured in stream reaches sampled on the Wise River District during 1986.

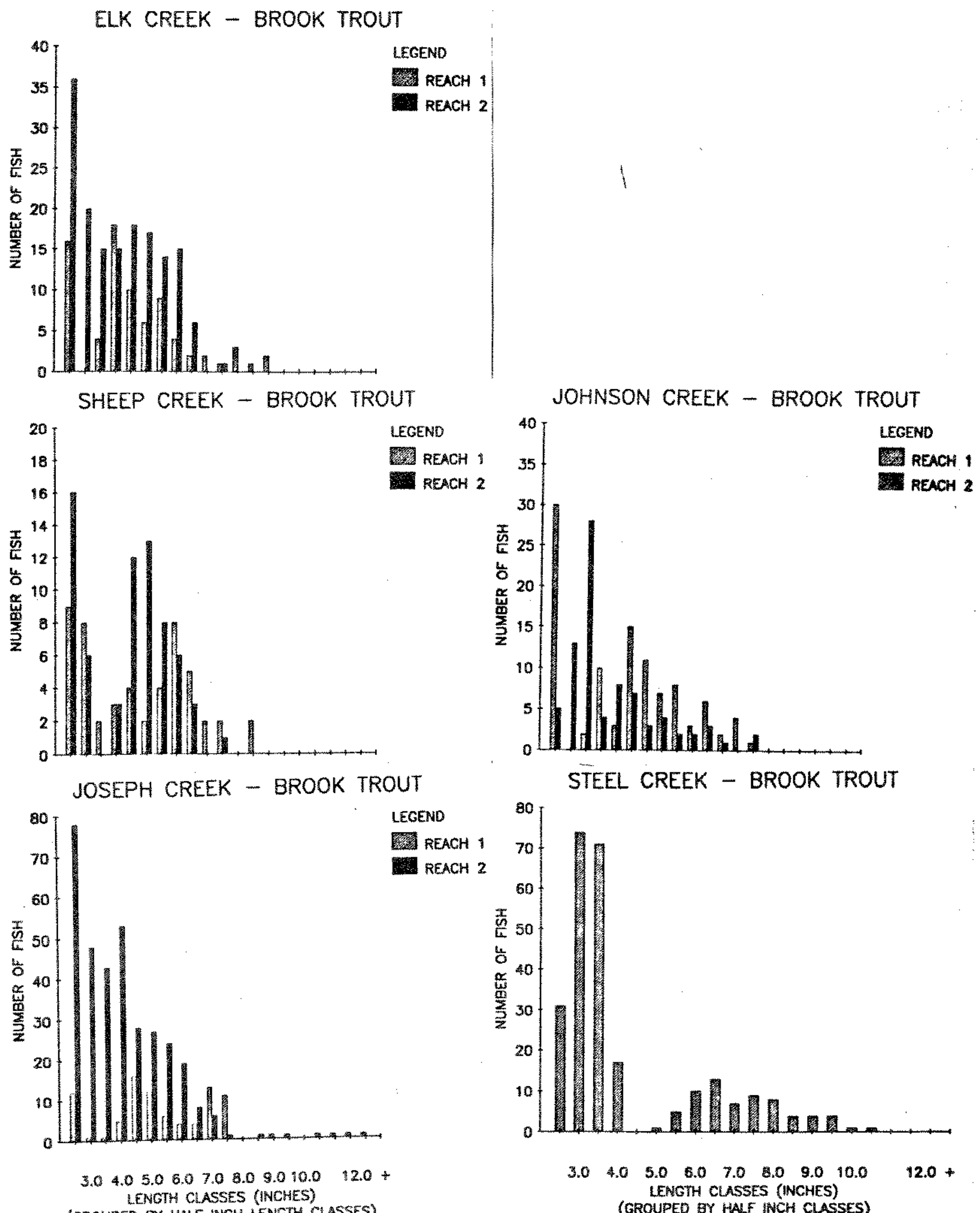

Figure 8. Length frequency histograms for fish captured in stream reaches sampled on the Wisdom District during 1986.

to be much more impacted by livestock than R2, however, R1 had more high class pools than R2 and that was reflected in the numbers of captured fish larger than 6.5 inches.

Length-Weight Relationships

Regressions on log transformations of both length and weight values yielded length-weight predictive equations for grayling and rainbow trout from the Big Hole River and brook trout and cutthroat trout from all tributaries combined (Table 27). In general the predictive ability of these equations was good, however, use of the GM regression technique recommended by Ricker (1975) yielded somewhat better predictive capability, particularly for smaller fish (Table 28).

FISH MOVEMENT

Rainbow Trout Redd Surveys

A preliminary survey of Big Lake, Bryant, and Jerry creeks were made during May, 1986 to document the presence of rainbow trout redds (spawning sites). Redds were observed in Big Lake and Jerry creeks (Table 29). No redds were observed in lower Bryant Creek. An angler captured a 19.0 inch rainbow at the mouth of Steel Creek on May 20, 1986 which may indicate Steel Creek is used for spawning. Further survey work is needed to confirm this possibility.

Spring Trapping

The spring trapping effort captured only three arctic grayling (Table 30). All of these grayling were captured in the downstream trap located in Swamp Creek. Two were captured on May 18 and one was captured on May 21. The general fishing season opened on May 16 and it is likely these fish may have been caught and released by anglers fishing the opening weekend and moved downstream after their release. These fish ranged in length from 9.3 to 13.4 inches and all appeared to be males. None of these fish were obviously spent (spawned recently), however, the sexual condition of grayling is notoriously difficult to determine from external examination. One fish had died in the leads (it was believed a victim of angler catch and release) and internal examination found that it was a male with one half of the testes in a mature, but not ripe, stage. Below is a summary by creek.

Big Lake Creek

The upstream trap captured nine fish in 53 days of operation from April 4 to May 30 during which the leads remained up only 11 days. No game fish were included in the catch. The catch consisted of eight longnose dace (*Rhinichthys cataractae*), one white sucker (*Catostomus commersoni*), and one mountain sucker (*Catostomus platyrhynchus*).

Table 27. Regression equations for log transformations of fish length versus fish weight by species and water from data collected during 1986 in waters draining the Beaverhead National Forest.

Species	Water	Equation	r^2
GR[1/]	Big Hole River	Log(weight) = 2.78*Log(length)-3.21	0.97
RB	Big Hole River	Log(weight) = 2.66*Log(length)-3.05	0.99
EBT	Big Hole River	Log(weight) = 2.79*Log(length)-3.16	0.95
EBT	Big Hole tribs	Log(weight) = 2.34*Log(length)-2.91	0.90
WCT	Big Hole tribs	Log(weight) = 2.12*Log(length)-2.79	0.90

1/ Species abbreviations are: GR = arctic grayling; RB = rainbow trout; EBT = brook trout (charr); and WCT = westslope cutthroat trout.

Table 28. GM regression equations (Ricker 1975) for log transformations of fish length versus weight by species and water from data collected during 1986 in waters draining the Beaverhead National Forest.

Species	Water	Equation
GR[1/]	Big Hole River	Log(weight) = 2.82*Log(length) - 3.21
RB	Big Hole River	Log(weight) = 2.68*Log(length) - 3.05
EBT	Big Hole River	Log(weight) = 2.86*Log(length) - 3.16
EBT	Big Hole tribs	Log(weight) = 2.46*Log(length) - 2.91
WCT	Big Hole tribs	Log(weight) = 2.23*Log(length) - 2.79

1/ Species abbreviations are: GR = arctic grayling; RB = rainbow trout; EBT = brook trout (charr); and WCT = westslope cutthroat trout.

Table 29. Redd surveys conducted during the spring of 1986 by stream, type of survey, date of survey, and number of redds located.

Stream	Type of survey	Date of survey	Location	Number of redds by size: Small	Number of redds by size: Large
Big Lake Creek	Cursory	5-8-86	CM 4.5	Noted a few redds	
Bryant Creek	Detailed	5-8-86	CM 0-1.0	No redds found	
Jerry Creek	Detailed	5-8-86	CM 0-1.7	21	7
Steel Creek				One 19.0 inch rainbow was caught by angler 5-20-86	

Table 30. Summary of results of up- and downstream traps located in Swamp, Steel, and Big Lake creeks and fry drift nets located in Sandhollow Creek during the spring of 1986.

Parameters	Streams: Big Lake	Steel	Swamp	Sandhollow
UPSTREAM TRAPS				
Date in	4-7-86	4-7-86	4-23-86	
Date removed	5-30-86	5-30-86	6-25-86	
Number days trapped	53	53	64	
Number of days the leads were down 1/	32	25	52	
Total catch				
- Artic grayling	0	0	0	
- Brook trout	0	2	0	
- Mountain whitefish	0	1	2	
- Other 2/	10	15 3/	6	
DOWNSTREAM TRAPS				
Date in	5-6-86	4-7-86	5-7-86	5-20-86
Date removed	5-30-86	5-30-86	6-25-86	6-2-86
Number days trapped	24	53	49	13
Number of days the leads were down 1/	9	25	42	0
Total catch				
- Artic grayling	0	0	3	0
- Brook trout	10	1	2	1 4/
- Mountain whitefish	8	1	1	0
- Other 2/	43	15	11	34

1/ A day was considered to have had the leads down if the leads were found down during any time of the day.

2/ Other species included mountain suckers, white suckers, longnose dace and burbot.

3/ Also found numerous additional fry.

4/ One brook trout 5.2 inches long was captured.

The downstream trap captured 61 fish in 24 days of operation from May 6 to May 30 during which the leads remained up 15 days. The catch included ten brook trout ranging in length from 4.1 to 14.0 inches, eight mountain whitefish ranging in length from 4.5 to 12.1 inches, seven burbot, four longnose dace, 20 mountain suckers, and 12 white suckers. Mink predation was believed to be a problem at the trap site. Much of the downstream movement observed appeared to be a response to decreasing streamflows associated with the initiation of irrigation withdrawals.

Sandhollow Creek

The drift nets placed in this small intermittent stream captured 34 fry and one 5.2 inch brook trout during 13 days of operation from May 20 to June 2. One fry captured on May 27, 1986 appeared to be a recently emerged burbot fry which was approximately 0.6 inches long. The remaining fry were sucker fry.

Steel Creek

The upstream trap in Steel Creek (actually an east channel of the Big Hole River near Steel Creek) was operated for 53 days from April 7 to May 30, but the leads were down during 25 days of that operation. This trap captured two brook trout, 15 white suckers, two mountain suckers, two longnose dace, one mountain whitefish, two burbot, and 34 sucker fry. Several burbot were found in the leads. One large rainbow trout (19.0 inches) was measured from an anglers catch made on May 20, 1986. This rainbow trout was captured in the pool immediately below where Steel Creek and the east channel of the Big Hole River converge.

The downstream trap operated for 49 days from April 7 to May 30 during which the leads were down 25 days. This downstream trap captured one brook trout, seven white suckers, two mountain suckers, 10 burbot, and one sucker fry.

Swamp Creek

The upstream trap in Swamp Creek was operated for 64 days from April 23 to June 25 during which the leads were down 52 days. The trap and leads had to be removed for 20 days (June 1 to 20) due to the extremely high spring streamflows. This trap captured two mountain whitefish, three mountain suckers, and three longnose dace. Two burbot were found stuck in the leads.

The downstream trap was operated for 49 days from May 7 to June 25, but the leads were down 42 of these days (see explaination above for 20 of the days). This trap captured three arctic grayling, two brook trout, one mountain whitefish, two white suckers, nine mountain suckers, and one fry. A discussion of the grayling catch was presented above. Predation (probably by mink) was a problem at this trap site as partially eaten fish were found in the traps and against the leads.

Arctic Grayling Radiotelemetry

Eight arctic grayling larger than 12.0 inches, two which had been radio tagged in early July, were captured during September electrofishing. Condition factors which indicate length to weight relationship were compared between radioed and non-radioed fish to explore the possibility that the radio tags interferred with a fish's growth during the summer. These data suggest that condition factors for radioed fish were lower than non-radioed fish (Table 31). While this difference was significant ($P < 0.05$), the extremely small sample size may have influenced the findings.

Of the seven grayling radiotagged on September 22, 1986, six were subsequently relocated. Five of these six relocations indicated the fish had moved in a downriver direction with the sixth fish moving 0.1 miles upriver. All relocated fish were found in deep pools or backwaters. The longest recorded movement was approximately 6.0 miles downriver in 11 days. None of the fish were positively relocated after October 21 even though the river was searched from five miles above the release sites to 61 miles below the release sites. The lower portions of two tributaries were also searched with no positive relocations. There was a problem with the reception of a good strong signal at all times. Often a single signal would be received with no subsequent signals. The telemetry history of each individual is fish is described below.

Grayling number 1 (a female 13.2 inches long) was relocated one day after being tagged in the same pool she was released into. From September 23 to October 21 the areas searched with the receivers were all downstream from her location. She was relocated again on October 21 approximately 200 yards upstream from her release site in a large deep pool. She was not relocated again after October 21 even though the area upstream and downstream of that same pool were searched on October 28 and several searches were made from her last relocation downriver. The total documented movement for this grayling was approximately 0.1 miles upstream in 29 days.

Grayling number 2 (a female 10.7 inches long) was recaptured via electrofishing one day after being tagged in the same pool she was released into. At that time she appeared healthy and behaved normally. On September 26 (four days after tagging) she was relocated approximately 350 yards downstream of her release site in a backwater off the main channel. She was relocated again in this backwater on October 8. She was not relocated again in this backwater in a search of this area on October 21. On November 20 received several signals on this channel at a deep hole immediately above Highway 43 bridge near Wisdom (approximately 200 yards below the last relocation). I could not confirm that this was grayling number 2 because even with repeated searching, I did not receive any more signals in this area. The confirmed movement of this grayling was approximately 0.2 miles downstream in 16 days.

Grayling number 3 (a male 10.6 inches long) was never relocated after its release.

Grayling number 4 (a female 10.4 inches long) was relocated on October 14 (22 days after being tagged) approximately 350 yards below her release site in a pool in the main river channel. She was relocated again in this same pool on October 21, but was not relocated again after that time even with repeated

Table 31. Comparison between the condition factors of two radio tagged arctic grayling versus six non-radio tagged arctic grayling approximately two months (July and August) after radio implants.

Radio vs. Non-radio Fish number (sex)	Length (in)	Weight (lb)	Condition	Mean condition	Sum of Squares
Radio					
1 (♂)	12.3	0.59	31.71		
2 (♀)	13.4	0.66	27.43		
				29.57	9.16
Non-radio					
1 (♂)	12.9	0.69	32.14		
2 (♀)	12.4	0.62	32.52		
3 (♀)	12.5	0.66	33.79		
4 (♀)	13.1	0.67	29.80		
5 (♂)	12.8	0.67	31.95		
6 (♀)	12.2	0.65	35.80		
				32.67	20.11

Ho: Radioed grayling had equal or higher condition factors than unradioed grayling

Ha: Radioed grayling had poorer condition factors than unradioed grayling

$s^2_p = (20.11 + 9.16)/8 = 3.66$

$s_{(\text{mean difference})} = 3.66/6 + 3.66/2 = 1.56$

$t_{(\text{sample})} = (32.67 - 29.57)/1.56 = 1.99$

$t_{(\text{tabled})} = 1.860$

Therefore, reject the Ho and say that condition factor of radioed fish is poorer than non-radioed fish ($0.025 < P < 0.05$).

searching of the area around the pool of her last relocation and areas up- and downstream. The total documented movement of this grayling was 0.2 miles downriver in 29 days.

Grayling number 5 (a male 12.8 inches long) was relocated in a deep pool approximately 150 yards downstream from where he was released the day after being released. He had moved approximately 200 yards further downstream on September 26 (four days after his release) and was found at the tail of another deep pool in or near a submerged accumulation of organic debris. On October 3 he was again relocated approximately another 200 yards downstream in another pool where two channels of the river came back together. This fish was not relocated again even though repeated searches of the area above and below his last relocation were conducted. On one subsequent search up- and downstream of this area (made on November 20) a single signal was received several times in areas downstream from the last confirmed relocation on October 3, but none of these signals could be confirmed as this fish's channel. The confirmed movement of this male was approximately 0.3 miles downstream in 11 days. He apparently moved in several stages downriver from pool to pool.

Grayling number 6 (a female 11.9 inches long) was relocated in a pool immediately downstream from the pool she was released in the day after her release. She was relocated again at the head of this same pool on October 3 (11 days after her release) and at the tail of this same pool on October 14 (22 days after her release). She was not relocated afterwards even though repeated searches were made in this area. The same discussion of the single signals received on November 20 under grayling number 5 would also apply to this grayling. The confirmed movement of grayling number 6 was only 100 yards downstream over 22 days.

Grayling number 7 (a female 11.3 inches long) was not relocated immediately after her release. She was only relocated once (on October 3, 11 days after her release) in a pool at the mouth of Steel Creek approximately six miles below her release site. She was not relocated again after that time even after repeated searches of the river and one search of lower Steel Creek. The total documented movement of this fish was approximately 6.0 miles downriver in 11 days.

One final note: During a search of lower Swamp Creek (which enters the Big Hole River at river mile 108.9 or approximately eight miles below the release sites) on November 26, 1986 a series of signals were received approximately one mile upstream from its confluence with the river on the receiver set up for receiving grayling numbers 4 through 7. No confirmation of channel (and therefore individual fish) could be made even after repeated attempts to receive subsequent signals to document which channel was transmitting. This area was searched for approximately 20 minutes with no further signals being received.

Plastic Tag Returns

Tag return information indicated that grayling and rainbow trout moved very little during the course of the summer in 1986 (Table 32). The longest recorded movements were made by juvenile grayling. One moved 4.2 miles downstream out of Big Lake Creek into the Big Hole River between May 15 and

Table 32. Tag return information for fish tagged during 1985 and 1986 and recaptured during 1986 from waters in the upper Big Hole River drainage.

Species (life stage) Tag number	Tagging information Date	Length	Location	Recapture information Date	Length	Location	Net Movement
Grayling (juveniles)							
RD 427	7-1-86	8.7	BHR(116)	9-22-86	9.0	BHR(116)	0
RD 437	5-21-86	7.9	Steel(0.8)	8-27-86	8.7	Steel(3.6)	+ 2.8
RD 483	5-15-86	8.1	B.Lake(4)	9-4-86	9.2	BHR(116)	- 4.2
	TOTAL TAGGED = 37			TOTAL RECAPPED = 3		8% RETURN	
Grayling (adults)							
WF 8653	6-25-86	11.4	BHR(119)	9-3-86	11.6	BHR(118)	- 1.0
WF 8658	6-25-86	11.7	BHR(118)	9-3-86	11.9	BHR(118)	0
WF 8672	6-26-86	9.5	BHR(116)	9-3-86	10.2	BHR(116)	0
WF 8679	6-30-86	9.4	BHR(117)	9-3-86	9.5	BHR(117)	0
WF 8680	7-1-86	12.0	BHR(121)	9-22-86	12.2	BHR(121)	0
WF 8683	7-1-86	13.0	BHR(120)	9-22-86	13.1	BHR(120)	0
WF 8684	7-1-86	12.2	BHR(119)	9-3-86	12.3	BHR(120)	+ 1.0
WF 8686	7-1-86	9.5	BHR(118)	9-22-86	9.8	BHR(117)	- 1.0
WF 8691	7-2-86	10.1	BHR(119)	9-3-86	10.4	BHR(120)	+ 1.0
WF 8693	7-2-86	9.1	BHR(116)	9-3-86	9.8	BHR(117)	+ 1.0
	TOTAL TAGGED = 42			TOTAL RECAPPED = 10		24% RETURN	
Rainbow trout (adults)							
WF 8668	6-24-86	14.7	BHR(119)	9-4-86	14.9	BHR(121)	+ 2.0
WF 8674	6-30-86	13.0	BHR(121)	9-4-86	13.2	BHR(121)	0
WF 8675	6-30-86	17.2	BHR(121)	9-22-86	17.3	BHR(121)	0
WF 8677	6-30-86	11.9	BHR(116)	9-22-86	11.9	BHR(116)	0
WF 8681	7-2-86	13.0	BHR(120)	9-4-86	12.6	BHR(118)	- 2.0
	TOTAL TAGGED = 8			TOTAL RECAPPED = 5		63% RETURN	

September 4. Another moved approximately 2.8 miles upstream from the east channel of the Big Hole River below Steel Creek up into Steel Creek between May 21 and August 27. Tag return rates for juvenile grayling, adult grayling, and adult rainbow trout tagged during the spring and early summer of 1986 and recaptured within the same year were 8%, 24%, and 63%, respectively.

RELATIONSHIPS BETWEEN HABITAT VARIABLES AND FISH DENSITIES

Spearman Rank Correlations

Spearman rank correlations between habitat variables and brook trout densities indicated significant ($P < 0.10$) positive correlations between the density of brook trout 6.0 inches and longer and the percentage of high class pools and negative correlations between percentage of low class pools and frequency of small debris crossing the stream channel (Table 33). For stream reaches containing cutthroat trout significant negative correlations between the density of cutthroat trout 3.0 to 5.9 inches long and the percentage of large gravel ($P < 0.05$), amount of spawning habitat ($P < 0.10$), and channel sinuosity ($P < 0.10$) (Table 34). The negative correlations between small cutthroat and spawning gravel variables is somewhat interesting and suggests that cutthroat rear in areas other than where they were spawned. A significant positive correlation ($P < 0.10$) was found between cutthroat 6.0 inches and longer and the percentage of small gravel and a negative correlation ($P < 0.10$) between these large cutthroat and stream order. For all cutthroat 3.0 inches and longer a significant negative correlation ($P < 0.05$) was found for both stream order and channel sinuosity. This suggests that cutthroat are more abundant in smaller, less sinuous (straighter) stream reaches higher in the drainages.

Untransformed Habitat Variables versus Fish Densities

Stepwise multiple regression was used to determine if habitat variables could be used to predict fish density. Results from this type of analysis can be used to help determine which habitat variables are important to fish density and to provide an equation whereby fish density could be predicted using habitat variables. This type of analysis will help in predicting impacts that land management activities might have on fish populations through changes in aquatic habitat. It must be remembered that the sample sizes are presently very low, eleven stream reaches for brook trout and six stream reaches for cutthroat trout. These small sample sizes make this type of analysis difficult and of questionable value at the present time. These results are being included to inform the readers of the study direction and illustrate how these data will be used to aid in the land management decision making process. Seperate regressions were conducted for each species by length class (3.0 to 5.9 inches, 6.0 inches and longer, and 3.0 inches and longer). In each analysis only the five variables which had the highest spearman rank correlation coefficients were regressed against fish densities. The exception to this rule was when two or more variables were obviously related to each other (ie. percentage high quality and percentage low quality pools), then one of those variables was dropped and the variable with the next higher spearman rank correlation coefficient was added. The results for brook trout were

Table 33. Spearman rank correlation coefficients between habitat variables and the number of eastern brook trout per acre by length class. Significance levels are P < 0.05 (**) and P < 0.10 (*). Nineteen stream sections were sampled. The five highest correlations are in boldface type.

	Number of eastern brook trout per acre		
Habitat variables	3.0 - 5.9 inches	6.0 + inches	3.0 + inches
<u>Channel characteristics</u>			
Wetted width	- 0.1343	- 0.0913	- 0.0860
Channel width	- 0.1272	- 0.0860	- 0.0649
Average depth	**- 0.2783**	- 0.0751	- 0.2713
Thalweg depth	- 0.1842	- 0.0658	- 0.2351
Instream cover	**- 0.3881**	- 0.2020	- 0.2502
<u>Bank characteristics</u>			
Near shore depth	- 0.0985	0.0660	- 0.1336
Bank angle	- 0.0816	- 0.1389	- 0.1036
Soil alteration	0.1493	0.1462	0.0939
Percentage undercut bank	0.2098	0.1300	0.1694
Depth of undercut bank	0.2344	0.0316	0.1172
Vegetation stability	- 0.2262	- 0.1499	- 0.1305
Vegetation use	- 0.0595	0.0463	- 0.1189
Low overhead cover	- 0.2525	**- 0.3684**	- 0.2948
High overhead cover	- 0.2084	- 0.2797	- 0.2848
Canopy density	- 0.0489	- 0.3137	- 0.0512
<u>Streambed characteristics</u>			
% Silt	- 0.0739	0.1285	0.0097
% Sand	0.1279	0.0578	0.0988
% Small gravel	0.0221	0.0331	0.0909
% Large gravel	0.1407	0.3127	0.2233
% Cobble	- 0.0485	0.0534	0.0115
% Small boulder	- 0.0855	- 0.1684	- 0.1154
% Large boulder	- 0.1995	**- 0.3898**	- 0.1926
Embeddedness	0.0035	- 0.1635	- 0.0879
Substrate score	**- 0.2886**	- 0.3663	**- 0.2975**
D-90	0.1308	0.0518	0.1088
<u>Habitat composition</u>			
% Pools	0.1551	0.1252	0.0678
% Class V	0.2779	**0.5695 ***	**0.3872**
% Class IV	- 0.0366	0.2975	0.0961
% Class III	- 0.2636	**- 0.5818 ***	**- 0.3909**
% Riffles	- 0.1214	0.1461	0.0699
% Runs	- 0.1116	0.1248	0.0220
% Pocketwaters	0.0449	- 0.1942	- 0.0968
% Side channels	- 0.2068	- 0.3508	**- 0.3088**
<u>Organic debris</u>			
Large debris frequency	0.2471	- 0.1088	0.0765
Freq. cross channel debris	0.1319	- 0.1437	0.0163
Small debris frequency	**0.2840**	- 0.1898	0.0530
Freq. cross channel debris	- 0.1217	**- 0.4630 ***	- 0.1960
Amount of spawning habitat	- 0.1324	- 0.3000	- 0.2176
Stream order	**- 0.3016**	- 0.3552	**- 0.3627**
Channel gradient	0.0800	- 0.0480	0.0589
Channel sinuosity	- 0.2452	- 0.1675	- 0.1169

Table 34. Spearman rank correlation coefficients between habitat variables and the number of westslope cutthroat trout per acre by length class. Significance levels are P < 0.05 (**) and P < 0.10 (*). Eight stream sections were sampled. The five highest correlations are in boldface type.

Habitat variable	Number of westslope cutthroat trout per acre		
	3.0 - 5.9 inches	6.0 + inches	3.0 + inches
Channel characteristics			
Wetted width	0.0476	- 0.4048	- 0.4524
Channel width	- 0.0952	- 0.4524	**- 0.5714**
Average depth	0.0476	0.1429	0.0238
Thalweg depth	0.3333	0.1905	0.1667
Instream cover	0.3234	- 0.2395	0.0838
Bank characteristics			
Near shore depth	- 0.0476	0.2619	0.1429
Bank angle	**0.6667**	0.3189	**0.6088**
Soil alteration	- 0.1905	0.0476	- 0.2143
Vegetation stability	0.1650	**0.5086**	**0.5911**
Vegetation use	- 0.0883	- 0.2648	- 0.4414
Percent undercut bank	- 0.5238	- 0.1429	- 0.2381
Depth of undercut bank	- 0.0247	0.1482	0.2224
Low overhead cover	- 0.2771	- 0.1928	- 0.0723
High overhead cover	- 0.2143	- 0.2143	0.0952
Canopy density	0.2942	- 0.4119	0.0588
Streambed characteristics			
% Silt	- 0.2857	0.1190	- 0.2381
% Sand	- 0.3810	0.0476	- 0.2857
% Small gravel	- 0.2755	**0.6228** *	0.1078
% Large gravel	**- 0.8264** **	- 0.0240	- 0.4192
% Cobble	- 0.1429	- 0.2381	- 0.1190
% Small boulder	0.3353	- 0.0359	0.3234
% Large boulder	**0.6571**	**- 0.5429**	- 0.0857
Embeddedness	- 0.2143	0.1667	0.0476
Substrate score	0.3825	**- 0.5885**	- 0.1471
D-90	0.3810	- 0.2381	0.0714
Habitat composition			
% Pools	0.0952	0.5000	0.2381
% Class V	0.3714	0.0286	0.0857
% Class IV	0.6000	0.4286	0.5429
% Class III	- 0.6000	- 0.4286	- 0.5429
% Riffles	0.0719	- 0.5030	- 0.1078
% Runs	- 0.5714	- 0.0952	- 0.5476
% Pocketwaters	0.4671	0.0120	0.4671
% Side channels	0.2143	- 0.2619	0.0952
Organic debris			
Large debris frequency	0.0719	0.0599	0.3234
Freq. of cross channel	0.1464	0.0732	0.3904
Small debris frequency	0.0000	- 0.1905	0.1905
Freq. of cross channel	- 0.4364	- 0.1091	- 0.0273
Amount of spawning habitat	**- 0.6429** *	- 0.2381	- 0.3810
Stream order	- 0.4914	**- 0.7307** *	**- 0.7937** **
Channel gradient	0.3095	0.1667	0.5238
Channel sinuosity	**- 0.6547** *	- 0.2667	**- 0.7516** **
Channel type	- 0.2087	- 0.1304	- 0.4956

Table 35. Stepwise multiple regession results for regressions of habitat variables against density of eastern brook trout by size class from data collected in drainages draining the Beaverhead National Forest during 1985 and 1986.

Size class (inches) Independent variable	Coefficient	Standard error	t-value	Signif. level
6.0 +				
Constant	519.88	189.32	2.746	0.025
Small debris cross channel	- 2.10	0.85	- 2.479	0.038
Substrate score	- 19.79	12.23	- 1.619	0.144
R^2 (adjusted) = 0.36				
3.0 +				
Constant	297.34	237.84	1.250	0.243
Percent side channel	37.42	15.90	2.353	0.043
R^2 (adjusted) = 0.31				

disappointing. No clear predictive capability appeared between the habitat variables and fish density (Table 35). The results for cutthroat trout were more promising, but the small sample size presently limits the utility of these results (Table 36). Stream order and bank angle were the two variables selected as best predictors of total cutthroat trout (3.0 inches and longer) density. Percentage of large gravel, bank angle, and channel sinuosity were the three variables selected as best predictors of small (3.0 to 5.9 inches long) cutthroat trout density.

Test of COWFISH Model

The COWFISH model was tested by comparing estimated number of catchable fish (fish 6.0 inches and longer) per 1,000 feet of stream for both brook and cutthroat trout with predicted existing and optimum number of catchable fish (fish 6.0 inches and longer) per 1,000 feet of stream and mean parameter suitability index (PSI) generated by the COWFISH model using habitat data collected at the same sample site. These comparisons were done using simple linear regression. The discussion above concerning the small sample sizes used in these analyses and limitations regarding these small sample sizes applies to these tests as well. Fifteen and four sample sites were tested for brook and cutthroat trout, respectively. It appears that the COWFISH model might have some utility when applied to streams containing cutthroat trout, but its applicability to streams containing brook trout appears limited (Figures 9 and 10). The highest r^2 value for cutthroat (0.96) was obtained by using the predicted existing number of catchable fish per 1,000 feet of stream generated by the COWFISH data which is an encouraging result. One important factor to note is that the coefficient for the existing number of catchable fish per 1,000 feet of stream generated by the COWFISH model (or slope of the line) is 2.53 in the regression between estimated numbers of catchables and predicted existing numbers of catchables. This result indicates that the numbers of catchable fish predicted by the COWFISH model underestimates actual numbers by at least a factor of 2.

Table 36. Stepwise multiple regession results for regressions of habitat variables against density of westslope cutthroat trout by size class from data collected in drainages draining the Beaverhead National Forest during 1985 and 1986.

Size class (inches) Independent variable	Coefficient	Standard error	t-value	Signif. level
3.0 - 5.9				
Constant	- 485.81	207.02	- 2.347	0.143
Percent large gravel	- 5.78	0.82	- 7.080	0.019
Bank angle	5.28	1.36	3.878	0.060
Channel sinuosity	289.17	133.40	2.168	0.163
R^2 (adjusted) = 0.95				
6.0 +				
Constant	- 24.77	35.71	- 0.694	0.526
Percent small gravel	5.83	2.08	2.805	0.049
R^2 (adjusted) = 0.58				
3.0 +				
Constant	1431.54	373.66	3.831	0.031
Stream order	- 222.92	41.57	- 5.363	0.013
Bank angle	- 9.04	3.84	- 2.352	0.100
R^2 (adjusted) = 0.91				

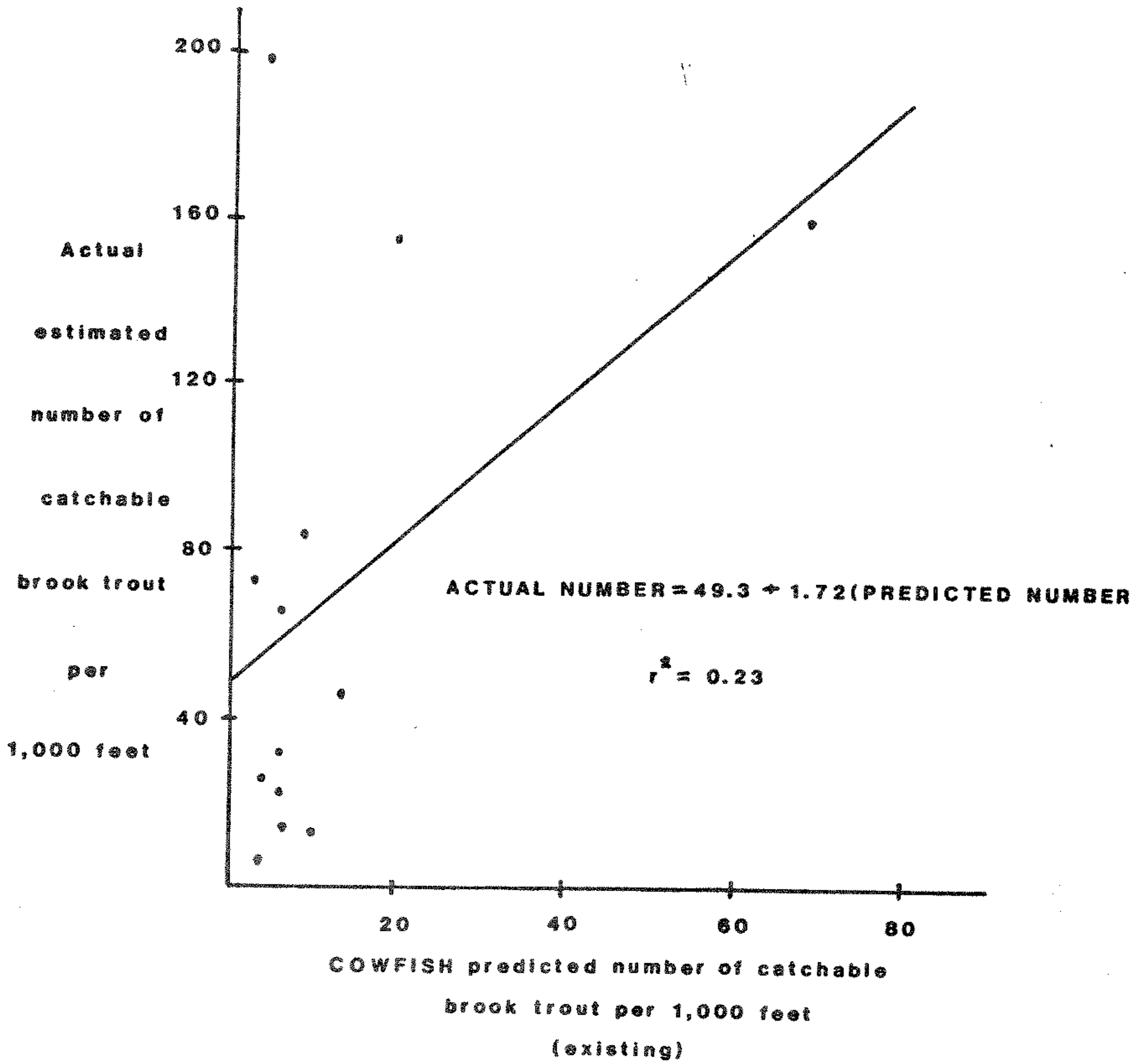

Figure 9. Relationship between the actual number of fish estimated and the existing number of fish predicted by the COWFISH habitat model at 13 sites sampled during 1986 which contained brook trout.

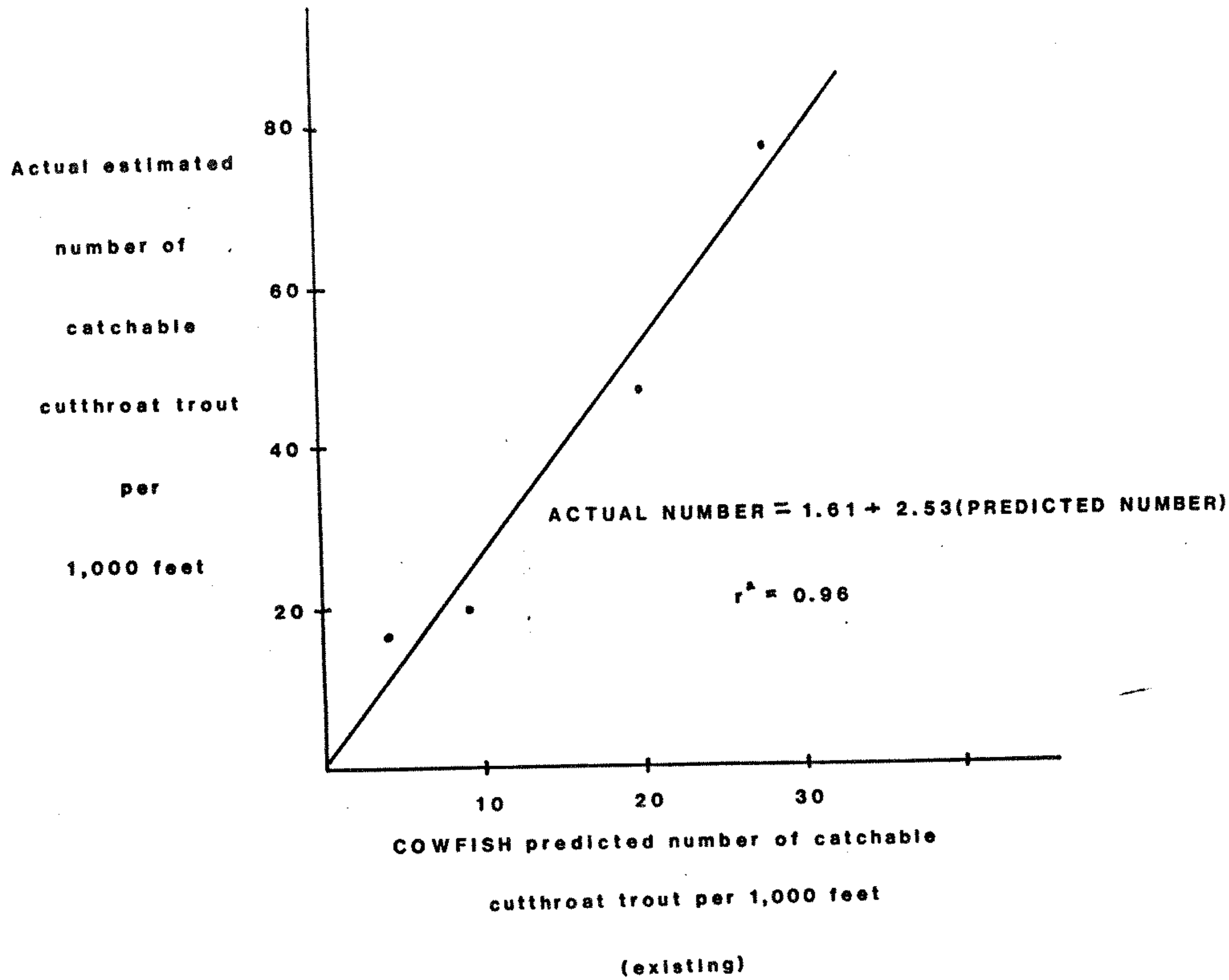

Figure 10. Relationship between the actual number of fish estimated and the existing number of fish predicted by the COWFISH model at four sites sampled during 1986 which contained cutthroat trout.

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MDFWP WATER CODES AND KEYWORDS

WATER CODES

Stream	Water code	Stream	Water code
Adson Creek	02-0050	Morrison Creek	01-5120
Andrus Creek	02-0125	Mussigbrod Creek	02-4150
Bender Creek	02-0375	N Fk Big Hole River	02-4275
Big Hole River	02-0475	O'Dell Creek	02-4375
Big Lake Creek	02-0500	Old Tim Creek	02-4400
Big Swamp Creek	02-0550	Painter Creek	01-5640
Browns Canyon Creek	N.A.	Pass Creek	01-5700
Bryant Creek	02-0800	Placer Creek	02-4625
Butler Creek	02-0925	Plimpton Creek	02-4650
California Creek	02-0950	Pole Creek	01-5940
Cow Cabin Creek	02-1400	Reservoir Creek	01-6200
Deep Creek	02-1625	Rock Creek	02-4900
Doolittle Creek	02-1750	Ruby Creek	02-5000
East Fork Ruby River	01-2520	S Fk Blacktail Creek	01-7220
Elk Creek	02-2075	S Fk Steel Creek	02-5825
Fishtrap Creek	02-2200	S Willow Creek	10-6880
Fox Creek	02-2275	Saginaw Creek	N.A.
Francis Creek	02-2325	Salesfsky Gulch	02-5075
Goris Gulch	N.A.	Sandhollow Creek	02-5128
Governor Creek	02-2525	Sevenmile Creek	02-5275
Harriett Lou Creek	02-2650	Sheep Creek	02-5400
Jerry Creek	02-2950	Squaw Creek	02-5900
Johnson Creek (D-2)	02-2975	Steel Creek	02-5950
Johnson Creek (D-3)	02-3000	Swamp Creek	02-6175
Joseph Creek	02-3025	Thayer Creek	02-6287
Lacy Creek	02-3150	Tie Creek	02-6350
LaMarche Creek	02-3175	Trail Creek	02-6450
Meadow Creek	02-3800	Wise River	02-7025
Mill Creek	01-5020	Wyman Creek	02-7075
Mono Creek	02-4000		

KEYWORDS

arctic grayling, eastern brook trout, grazing, habitat, logging, rainbow trout, sediment, spawning, westslope cutthroat trout.

Table 6. Percentage of each type and class of pools (class V is the highest quality pool) within each reach of streams draining the Beaverhead National Forest surveyed during 1986.

RANGER DISTRICT		Types of pools					Classes of pools		
Stream	Reach	Plunge	Dammed	Beaver	Trench	Lateral scour	V	IV	III
WISE RIVER DISTRICT									
Adson Ck									
	1	56	11	0	2	32	1	25	74
LaMarche Ck									
	1	49	5	0	0	46	29	27	44
	2	25	4	.3	7	62	65	29	6
Meadow Ck									
	2	69	22	0	1	8	3	15	82
Mono Ck									
	1	98	2	0	0	0	9	40	51
	2	12	8	0	4	76	16	54	30
Wyman Ck									
	1	89	6	0	4	0	15	28	57
	2	16	2	2	8	72	10	27	63
WISDOM DISTRICT									
Elk Ck									
	1	21	5	10	8	56	9	20	71
	2	45	10	10	2	34	7	29	65
Joseph Ck									
	1	24	5	15	3	52	39	38	24
	2	34	5	22	3	36	55	25	20
Sheep Ck									
	1	19	5	3	18	55	24	39	37
	2	68	10	0	0	22	1	6	93

F-01-3

APPENDICES

FOR

BEAVERHEAD NATIONAL FOREST FISHERIES:

SECOND ANNUAL REPORT

COVERING THE PERIOD JANUARY TO DECEMBER 1986

Bradley B. Shepard
Montana Department of Fish, Wildlife and Parks
c/o Beaverhead National Forest
610 North Montana Street
Dillon, Montana 59725

A cooperative study between the Beaverhead National Forest and the Montana Department of Fish, Wildlife and Parks

April, 1987

APPENDICES

Appendix A. Description and explaination of information obtained from USGS maps (scale: 1:24,000).

Appendix B. Description and explaination of information collected during habitat surveys conducted by walking the entire reach (or a minimum of one mile).

Appendix C. Description and explaination of information collected during detailed habitat surveys conducted within the sample section of each reach.

Appendix D. Mean estimates of temperature (F), streamflow (cfs), length of each habitat unit (ft), wetted width (ft), channel width (ft), average depth (in), thalweg depth (in), and average depth at each bank (in) for streams draining the Beaverhead National Forest surveyed during 1986. Standard deviations are in parentheses.

Appendix E. Mean estimates of cover availability including percentage undercut banks, canopy density over the water's surface (%), instream cover (%), low (1.0 foot or less above the water's surface) overhead cover (%), high (more than 1.0 foot above the water's surface) overhead cover (%), and depth of undercut banks (in.) by habitat type for waters draining the Beaverhead National Forest surveyed during 1986.

Appendix F. Embeddedness data by sample (hoop) and stream reach for streams sampled during 1986.

Appendix G. Mean lengths and weights, condition factors and sample sizes by stream, reach, and species for all fish captured in streams draining the Beaverhead National Forest surveyed during 1986.

Appendix A.

Description and explaination of information obtained from USGS maps (scale: 1:24,000).

EXPLANATION OF HOW TO ENTER DATA FROM MAPS ONTO MAPS DATA FORM

This document explains how to enter data from maps onto the "FORM TO ENTER DATA DERIVED FROM MAPS" data form. It is recommended that topographic maps of a scale of 1:24,000 be used to do reach delineation and calculations for areas. If it is necessary to use maps of other scales to obtain land-use and miles of road information convert that data to a scale of 1:24,000 if that was the scale used to obtain the other reach information. Be sure that all the data entered onto this form is taken or converted to the scale recorded on the form.

EXPLANATION OF VARIABLES

SERIAL - Serial numbers are alpha-numeric codes assigned by the MDFWP to uniquely identify each reach. It is a three (3) integer variable that is unitless.

STREAM - Name of the stream for the reach of interest. Name recorded from the map.

REACH - Number of the reach delineated from the map. Reaches are assigned numbers in ascending order from the stream mouth upstream. Reach numbers must start over again at 1 whenever a stream changes name. Reach numbers are unitless.

DATE - Date the map data is completed in the form of mm/dd/yy.

QUAD NAME - Name of the USGS quad or quads used to obtain the reach data.

SCALE - Scale of the map used to delineate reaches. All data entered onto this form must be converted to the scale listed in this space.

STREAM - ORDER Stream order is defined in this context as the number assigned any stream course delineated on a 1:24,000 USGS quad. Stream orders are assigned starting with the upstream most unbranched stream courses which are assigned as stream order 1. When two stream courses assigned as 1's come together the resulting stream course is assigned as stream order 2. To have a stream order of 4 two stream courses assigned as 3's must come together, the junction of a stream order 3 and 2 do not form a 4. Stream order is unitless.

REACH - LENGTH Reach length is the length of the reach from the lower to the upper boundary in miles to the nearest tenth of a mile.

GRADIENT - Gradient of the reach is estimated from the map by calculating the change in elevation (in feet) and dividing that by the length of the reach (also in feet). Gradient is reported in percent to the nearest tenth (0.1) of a percent.

AREA DRAINED BY ENTIRE STREAM - The area drained by the entire stream is estimated by digitizing the area within the drainage boundary from the mouth of the stream. This area is estimated in acres to the nearest tenth of an acre.

AREA DRAINED BY REACH - The area drained by the reach is estimated as above, however, the drainage area is subdivided into reaches by extending drainage boundaries to the lower bound of each reach following topography. This area is reported in acres to the nearest tenth of an acre.

LOWER AND UPPER REACH LANDMARKS - The lower reach landmark is a description of the lower reach boundary based on easily recognized landmarks from the map or on the ground. Bridges, entering tributaries, etc. all make good landmarks. If a good landmark doesn't exist, express the reach landmark as the number of miles (to the nearest tenth of a mile) to the nearest good landmark.

LOWER AND UPPER REACH LEGAL BOUND - The legal description to the quarter quarter section which locates the reach boundaries. Includes township, range, section and alphabetic code described by MDFWP for quarter quarter section.

LOWER AND UPPER REACH ELEVATION - The elevation of the stream channel at the lower and upper bound of the reach as estimated from USGS quads. It is reported in feet to the nearest foot. Accuracy is usually to the nearest 10 feet.

VALLEY LENGTH - Valley length is the straight line length of the valley bottom in miles to the nearest tenth of a mile.

CHANNEL SINUOSITY - Channel sinuosity is the ratio of the length of the valley (in miles) to the length of the stream channel (in miles). Channel sinuosity is a unitless measure.

LANDTYPE ASSOCIATION - Landtype association is the landtype association as determined by Dan Svoboda, the Forest Soils Scientist, for the reach.

CHANNEL TYPE - Channel type as defined by Rosgen (1985). Types are based on gradient, valley shape, flow character and other variables. Recorded as a letter A, B, C or D.

LAND USE - Land use in the drainage will be estimate from forest land type maps. Land use will be broken down into the following categories:

- Timbered land
- Timber harvested (equivalent clearcut acres)
- Range land
- Type of range management
- Estimated AUM's per acre
- Irrigated cropland
- Nonirrigated cropland
- Mining disturbance
- Miles of road (to tenths of mile) by type:
  - Main artery
  - Collector
  - Spur

Land use will be expressed as acres to the tenths of an acre for the major land activities. Roads will be expressed in miles to the nearest tenth of a mile.

Appendix B

Description and explaination of information collected during habitat surveys conducted by walking the entire reach (or a minimum of one mile).

EXPLANATION OF DATA ENTRY ONTO THE "ENTIRE REACH" FORM

This document explains how to enter data collected in the field for a survey of an entire reach onto the "FIELD FORM FOR SURVEYING ENTIRE REACH". Most of the data collected during the survey of the entire reach will be tallied on the form and then summed for computer entry. Other data will be based on locating certain aquatic habitat components within the reach by the surveyor's pace and later transfering these data to maps. The field survey will also allow the surveyor to verify map data and modify certain variables assigned using the maps if map information was inaccurate.

<u>EXPLANATION OF VARIABLES</u>

SERIAL - The serial number is an alpha-numeric code assigned by the MDFWP which uniquely identifies the stream reach. This code is three (3) characters long and is unitless.

STREAM - Name of the stream from USGS quad map.

REACH - Number of the reach assigned from map. Reaches are assigned in ascending order from the mouth of the stream upstream.

DATE: - Date of the survey in the format mm/dd/yy.

STAGE: - Relative stage of the stream at the time of the survey. Coded as L = low, M = moderate, and H = high.

BEGINNING OR ENDING LANDMARK - A landmark from the map or on the ground which identifies the lower (or upper) reach boundary. The surveyor may relocate the reach boundaries if the field conditions warrant a change. Any change must be clearly noted.

WETTED WIDTH - The wetted width at the upper and lower reach boundaries will be measured in feet to the nearest tenth of a foot.

PACE LENGTH - The length of the surveyor's pace in feet to the nearest tenth of a foot. The surveyor is responsible for keeping track of paces as he walks the reach. It is important to do this so important habitat features can be relocated on maps.

<u>Data to be Tallied</u>

HABITAT TYPE - The number of each habitat type will be counted for the entire reach and tallied as the surveyor walks the stream. Main habitat types will be pools, riffles, runs, pocketwaters, and side channels. Side channels are defined as channels carrying 25 % or less of the flow. Pool habitats will be classified into: 1) trench pools; 2) plunge pools; 3) dammed pools; and 4) beaver ponds. Riffles will be classified into: 1) low gradient riffles; 2) rapids; and 3) cascades. Pools within pocketwater types will be classified into: 1) backwater pools; 2) lateral scour pools; and 3) secondary channel pools. Main channel pools will also be rated based on width, depth and cover criteria. Habitat type classification and pool rating will be done according to methods described by FHR.

SPAWNING GRAVEL - The amount of spawning gravel within the entire reach will be estimated by summing visual estimates tallied throughout the reach. Spawning gravel will be arbitrarly defined as areas larger than four (4) square feet predominated by streambed material in the 0.5 to 3.0 inch size category. Spawning gravel will be measured in square feet to the nearest whole square foot.

LOCATION OF HIGH QUALITY SPAWNING HABITAT - If an extensive area of spawning habitat is located within a reach, the surveyor will record the pace number at the beginning and end of the high quality spawning area so that it can be identified and recorded on a map.

SMALL AND LARGE CHANNEL DEBRIS - A tally will be kept of accumulations of small (less than 6.0 inches) and large (6.0 inches and larger) organic (woody) debris within the stream channel. For the purpose of these surveys, accumulations must cover at least four (4) square feet to be included.

PERCENT OF STABLE DEBRIS - The estimated percentage of large and small channel debris which will not be moved by a normal spring (high flow) event. Estimated seperately for large and small debris.

Variables Located within the Reach by Pace

BARRIER - All potential barriers to fish movement are to be located within the reach by pace. At each potential barrier the surveyor will record the type of barrier: 1) culvert; 2) debris jam; 3) diversion structure; 4) beaver dam; 5) falls; 6) cascade; or 7) other by name. The surveyor will also measure the depth (in inches to the nearest inch) of the water immediately below the barrier (to determine if it has adequate depth to serve as a jump pool),the water immediately above the barrier (to determine if it has adequate depth to serve as a catch pool), and the length of the barrier (in feet to the nearest tenth of a foot). The height of the barrier will be measured in feet to the nearest tenth of a foot. Comments should be made regarding the barrier to allow for assessing if passage is possible, probable, or impossible.

FEATURE - The feature variable is to be used to enter location information for any landmark or significant habitat variable the surveyor encounters within the reach. Examples of what should be included as features are: culverts; slumped banks; all road crossings; junctions with tributaries; areas impacted due to land-use activities; sediment sources; debris accumulations; swamps; beaver activity; etc. Record the location by pace or range of paces.

IRRIGATION WITHDRAWAL OR RETURN - The location of any irrigation water withdrawal or return must be noted by pace. The surveyor should estimate the flow (in cfs) or percentage of the stream's flow which is withdrawn or returned. Note whether the withdrawal or return is on the left right bank (looking downstream) and the type of diversion structure (if any).

SITE FOR FISH AND HABITAT WORK - During the reach survey try to select a representative site to conduct fish population estimates and detailed habitat surveys. Try to select a section which is near to an access point. Record pace location and landmarks. If it is near a road try to find the road and leave flagging on the road to mark the section.

CHANNEL TYPE - Type the channel according to criteria presented by Rosgen. A, B or C with the associated numbers.

GENERAL COMMENTS - Write down any general comment regarding the reach's capacity to support fish. Results of angling, evidence of past angling, the condition of the habitat, the condition of the riparian area, presence of macroinvertebrates, etc.

Appendix C

Description and explaination of information collected during detailed habitat surveys conducted within the sample section of each reach.

DOCUMENTATION OF DATA ENTRY INTO FIELD HABITAT TRANSECT FORM

This document explains how to enter data onto the field form "FIELD FORM FOR ENTERING HABITAT TRANSECT DATA BY REACH AND TYPE". This document will explain each variable, how it is measured, the units of measure, and the number of significant digits. Habitat data will be measured by habitat type. Analysis will be stratified based on habitat type. Each habitat type surveyed will have a unique transect number within each reach. Cross sections will be measured across each habitat unit with the number of cross sections dependent upon the length and uniformity of the habitat unit. Several parameters will be estimated for the entire habitat unit. A streamflow measurement must be completed for each reach surveyed near the habitat survey section. Use the standard USGS streamflow form and methodology. Be sure that no more than 10% of the flow is measured in any one cell measured.

PARAMETER EXPLANATIONS

Header Information

SERIAL - Unique serial number assigned by Montana Department of Fish, Wildlife and Parks. An alpha-numeric variable which is unitless.

STREAM - Name of the stream from USGS quad map.

REACH - Reach number of the stream reach surveyed. Reaches are assigned for each named tributary increasing in value from the mouth upstream. Reaches are generally uniform with respect to channel gradient, channel type, valley configuration, and volume of flow.

DATE - Date the survey is completed in the format of mm/dd/yy.

TEMPERATURE - Temperature of the water in the section surveyed in degrees Farenheit to the nearest whole degree.

FLOW - The measured streamflow in cubic feet per second (cfs) to the nearest tenth.

Information Collected for Whole Habitat Unit

TRANSECT NUMBER - Unique transect number for the specific habitat unit surveyed by stream and reach.

HABITAT TYPE - Main and secondary habitat type which the habitat unit is classified. Main types are pools, riffles, runs (glides), pocketwaters, and side channels. Side channels are defined as channels which flow 25% or less of the entire streamflow. Where more than one channel exists and each channel carries more than 25% of the flow, each channel is typed into units. Secondary habitat types are classified according to criteria presented in the FHR handbook.

LENGTH OF TYPE - Length of the habitat unit in feet to the nearest tenth of a foot.

LENGTH OF UNDERCUT - Total length of undercut banks on both sides of the channel within the habitat unit sampled. Length is measured in feet to the nearest tenth of a foot and can total more than the length of the habitat unit. Done for entire habitat unit.

POOL CLASS - Pool class is rated based on criteria of size, depth, and cover. Only classes with ratings of 5, 4 and 3 will generally be used because pools with ratings of 1 and 2 are defined as being less than the average stream width by 10% or more and these will usually be classed in the pocketwater habitat type.

CANOPY DENSITY - Estimated percentage of the stream channel having canopy covering the channel. Underbrush and willow growth are not considered as canopy cover.

INSTREAM COVER - Instream cover is estimated for the entire habitat unit as the percent of the wetted area where cover within the water is available. Instream cover can be provided by depth, substrate, debris, turbulence, and aquatic vegetation. To qualify as instream cover the surveyor must determine what percentage of the wetted area has the ability to hide fish.

LOW OH COVER - Low overhead cover is defined as cover one foot or less above the water's surface hanging over the water's surface. It is estimated for the entire habitat unit in percent of the wetted area covered by overhanging material less than or equal to one foot above the water's surface. This type of cover can be provided by grasses, forbes, shrubs, trees, debris, or man-made structures.

HIGH OH COVER - High overhead cover is cover as defined above which is higher than one foot above the water's surface.

SUBSTRATE - Substrate composition is estimated for the entire habitat unit sampled by estimating the percentage of each size class which makes up the streambed. Size classes are defined as follows:

- Silt - less than 0.83 mm (usually organic material)
- Sand - 0.83 to 2.0 mm
- Small gravel - 2.1 to 6.34 mm
- Large gravel - 6.35 to 76.0 mm
- Cobble - 76.1 to 256.0 mm
- Small boulder - 256.1 to 609.0 mm
- Large boulder - Larger than 609.0 mm

SOIL ALT RATING - The soil alteration rating is the degree to which the streambank has been altered from its optimum condition according to criteria developed by Platts et al. (1983). The alteration can occur by the presence of animals (code with an A), logging (L), roads (R), high streamflows (S), or other (O). Soil alteration is recorded as percent altered to the nearest percent followed by the letter code for the expected reason for the alteration.

VEG STAB RATING - The vegetative stability rating is the ability of the vegetation on the streambank to resist erosion. Rating criteria for this parameter were also developed by Platts et al. (1983) in the form of a ranking system with "4" being excellent and "1" being poor. The rated portion of the streambank includes only that area from the stream to the top of the bank.

VEG USE BY - The vegetation use by animals is rated as a percentage use based on criteria established by Platts et al. (1983).

<u>Variables Measured Across Cross Sections Within Sampled Habitat Unit</u>

WET WIDTH - Width of the wetted stream channel in feet to the nearest tenth of a foot. The edge of the water is determined to be where any material is not completely surrounded by water. Any items protruding above the waters surface are included in the wetted width measurement except islands of inorganic sediment wider than one foot. The width of these islands are deducted from the total width to obtain wetted width.

CHANNEL WIDTH - Width of the stream channel at the "bankfull" stage as determined by rooted terestrial vegetation or water marks. Width is measured in feet to the nearest tenth of a foot. Multiple channels are summed to obtain total channel width.

AVE DEPTH - Average depth of the stream in inches to the nearest tenth of an inch. To calculate average depth, the depth is measured at five locations across the stream channel: at the two margins, and one-fourth, one-half, and three-fourths of the width across the habitat unit. These five measurements are then averaged to obtain average depth.

THAL DEPTH - Thalweg depth of each cross section is measured at the deepest point of the cross section in inches to the nearest tenth of an inch.

SHORE DEPTH - Shore depth is the water's depth adjacent to the shoreline. It is measured in inches to the nearest tenth of an inch. In cases where the streambank gradually slopes up, shore depth is "0". In cases where an overhanging or undercut bank exists, shore depth is measured from the top edge of the bank which overhangs the stream.

EMBEDDEDNESS	Level to which the large dominant particles within the streambed are surrounded by fine silts, sands and small gravels. This level is estimated as percent of the height of the dominant particle which is surrounded by these fine materials. This value may be best estimated by removing several large particles from the stream bottom and observing where there is no periphyton growth. (NOTE: The method of Burns (1984) will be tested on several stream reaches and may be adopted for all reaches to better quantify embeddedness.)
SUBSTRATE - SCORE	Substrate score was first proposed by Sandine (1974) and modified by Crouse et al. (1981). It is calculated by adding four ranked values: 1) the size class of the dominant particle within the streambed; 2) the size class of the second most abundant dominant particle; 3) the size class of the material surrounding these dominant particles; and 4) the level of embeddedness. At each habitat unit cross section, one point of streambed is to be randomly selected and a substrate score value will be calculated for that cross section based on that random point. An effort must be made to sample areas near shore, mid-channel, heads of units, middle of units, and tails of units.
D-90 -	D-90 is a symbol for the diameter of a particle within the streambed which is larger than 90 percent of the material comprising the streambed. D-90 measurements are taken across an intermediate axis (not the longest axis) in inches to the nearest tenth of an inch.
DEPTH OF - UNDERCUT BANK	Depth of the undercut bank measured in inches to the nearest tenth of an inch. Measured by holding a yard stick parallel to the water's surface and pushing the yard stick under the undercut bank until the verticle streambank immediately adjacent to the water's surface is encountered. The measurement is then read to the edge of the overhanging bank.
BANK ANGLE -	Bank angle is the angle of the downward sloping streambank as it meets the streambottom. If the streambank is undercut the bank angle is always less than 90 degrees. Bank angle is measured by placing a clinometer on a rod placed with one end at the water's edge and then lain on the streambank or to the top edge of an undercut bank. Bank angle is reported in degrees to the nearest degree.

Appendix D.

Mean estimates of temperature (F), streamflow (cfs), length of each habitat unit (ft), wetted width (ft), channel width (ft), average depth (in), thalweg depth (in), and average depth at each bank (in) for streams draining the Beaverhead National Forest surveyed during 1986.

Table D1. Mean estimates of temperature (F), streamflow (cfs),length of each habitat unit (ft) wetted width (ft), channel width (ft), average depth (in), thalweg depth (in), and average dept at each bank (in) for streams draining the Beaverhead National Forest surveyed during 1986. Standard deviations are in parentheses.

Stream Reach	Habitat type (n)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
ADSON CK								
1								
	Pools (11)	8.4	6.6	6.0	9.7	8.1	14.2	7.5
		(2.5)	(1.8)	(1.6)	(2.4)		(2.3)	(3.0
	Riffles (12)	12.8	7.3	6.1	5.4	15.0	9.1	3.0
		(7.2)	(2.6)	(1.8)	(1.5)		(1.9)	(2.0
	Runs (11)	10.4	5.8	5.4	5.9	12.5	9.3	4.3
		(2.2)	(1.2)	(1.0)	(1.8)		(2.2)	(2.1
	Pockets (3)	12.3	8.0	5.6	5.6	12.4	9.5	2.5
		(2.5)	(2.4)	(0.3)	(1.0)		(2.3)	(1.3
	Side C. (1)	10.0	2.5	2.5	10.7	2.8	15.8	7.0
		(0.0)	(0.0)	(0.0)	(0.0)		(0.0)	(0.0
	Reach summary (38)	406.0	6.6	5.7	6.9	11.7	10.8	4.8
			(2.1)	(1.5)	(2.7)		(3.2)	(3.0
ELK CK								
1								
	Pools (11)	23.5	12.9	9.5	9.8	11.9	18.4	7.6
		(7.5)	(3.5)	(3.0)	(2.6)		(3.7)	(3.4
	Riffles (10)	22.2	13.9	9.4	3.3	36.7	6.6	2.4
		(16.0)	(3.1)	(2.4)	(1.1)		(1.4)	(2.1)
	Runs (4)	22.5	11.5	7.5	7.3	13.1	12.3	5.0
		(15.5)	(2.7)	(1.5)	(2.1)		(1.3)	(2.7)
	Reach summary (25)	571.0	13.1	9.2	6.8	22.0	12.7	5.1
			(3.2)	(2.6)	(3.6)		(6.1)	(3.7)
2								
	Pools (10)	13.2	13.8	9.1	9.0	12.8	15.1	5.6
		(5.6)	(5.6)	(1.8)	(2.0)		(4.0)	(2.4)
	Riffles (7)	16.6	12.8	8.8	2.8	38.1	6.4	1.4
		(12.5)	(1.4)	(1.9)	(0.7)		(1.8)	(1.3)
	Runs (3)	14.3	12.7	7.4	4.7	19.7	7.9	2.5
		(7.6)	(5.9)	(1.9)	(0.8)		(0.8)	(2.3)
	Pockets (7)	33.9	13.0	8.3	4.0	25.0	8.0	2.7
		(19.1)	(1.8)	(1.2)	(0.6)		(1.3)	(0.7)
	Reach summary (27)	528.0	13.2	8.7	5.6	23.3	10.2	3.4
			(3.9)	(1.7)	(3.0)		(4.6)	(2.5)

Table D1. (continued).

Stream Reach	Habitat type (n)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
JOHNSON CK								
1								
	Pools (4)	34.3	33.8	24.8	12.8	23.9	23.7	3.5
		(22.8)	(5.5)	(2.8)	(3.1)		(5.8)	(2.7
	Riffles (9)	18.6	23.4	21.2	5.1	53.0	10.4	2.3
		(9.4)	(6.4)	(4.5)	(1.0)		(1.1)	(1.6
	Runs (5)	25.8	23.5	18.8	8.9	26.2	15.9	2.6
		(11.4)	(7.1)	(3.2)	(1.4)		(1.2)	(0.7
	Pockets (6)	27.3	20.4	17.6	8.3	26.3	14.3	2.9
		(9.5)	(2.3)	(1.4)	(1.5)		(1.6)	(2.1
	Reach summary (24)	597.0	24.4	20.4	7.9	35.9	14.7	2.7
			(7.0)	(4.0)	(3.2)		(5.2)	(1.7
2								
	Pools (4)	21.8	26.8	17.7	7.4	29.7	18.3	1.4
		(2.9)	(4.8)	(8.8)	(1.4)		(3.7)	(2.1)
	Riffles (6)	17.2	27.6	18.7	2.5	98.4	6.0	0.6
		(4.8)	(4.8)	(9.0)	(0.5)		(1.0)	(1.2)
	Runs (4)	20.8	25.1	12.2	4.8	30.0	9.5	0.4
		(5.3)	(8.2)	(4.3)	(1.0)		(1.0)	(0.5)
	Pockets (5)	41.6	29.6	24.4	4.8	62.4	12.9	2.6
		(10.7)	(6.0)	(8.5)	(1.3)		(5.4)	(1.8)
	Side C. (2)	26.5	26.6	11.9	5.5	29.7	9.9	3.8
		(6.4)	(2.8)	(4.2)	(3.7)		(5.5)	(4.6)
	Reach summary (21)	534.0	27.3	18.0	4.7	57.2	11.0	1.5
			(5.4)	(8.4)	(2.1)		(5.4)	(2.0)
JOSEPH CK								
1								
	Pools (12)	29.1	16.8	10.5	11.6	11.1	20.6	4.2
		(10.6)	(3.1)	(3.6)	(2.6)		(4.1)	(3.6)
	Riffles (7)	18.7	17.4	10.4	4.0	34.3	7.0	1.3
		(7.8)	(4.9)	(3.4)	(1.1)		(1.6)	(1.7)
	Runs (3)	31.7	13.2	10.1	7.0	17.1	12.6	2.2
		(28.9)	(0.9)	(4.5)	(0.5)		(0.7)	(2.6)
	Reach summary (22)	575.0	16.5	10.4	8.5	19.3	15.2	3.0
			(3.7)	(3.4)	(4.1)		(7.0)	(3.2)

Table D1. (continued).

Stream Reach	Habitat type (n)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
JOSEPH CK (continued)								
2								
	Pools (16)	16.1 (8.8)	13.2 (4.4)	9.5 (2.5)	9.3 (2.4)	13.4	15.9 (4.1)	4.5 (2.4
	Riffles (11)	6.8 (1.9)	13.5 (3.3)	6.6 (1.9)	2.7 (0.8)	32.6	5.2 (1.5)	1.5 (1.4
	Runs (4)	20.3 (8.7)	14.2 (3.0)	6.3 (1.5)	5.1 (0.8)	15.0	9.7 (1.4)	3.1 (1.4
	Pockets (7)	25.4 (15.2)	12.6 (3.3)	7.4 (1.3)	4.1 (1.1)	24.1	8.2 (2.0)	1.7 (1.0
	Reach summary (38)	592.0	13.3 (3.7)	7.9 (2.4)	6.0 (3.4)	21.1	10.7 (5.5)	3.0 (2.3
LAMARCHE CK								
1								
	Pools (5)	19.4 (2.8)	36.4 (10.1)	31.5 (9.9)	13.1 (4.3)	34.5	26.4 (5.8)	6.4 (5.9
	Riffles (8)	44.0 (21.1)	38.6 (9.4)	30.5 (5.2)	9.0 (2.2)	42.1	16.8 (2.7)	2.3 (2.0
	Runs (1)	39.0 (0.0)	35.6 (0.0)	24.4 (0.0)	10.8 (0.0)	27.1	23.2 (0.0)	0.0 (0.0
	Pockets (7)	75.7 (35.9)	43.6 (8.0)	34.8 (5.8)	8.8 (0.8)	47.4	17.2 (2.4)	2.0 (1.1
	Reach summary (21)	1018.0	39.6 (8.9)	31.8 (6.8)	10.0 (3.0)	41.4	19.5 (5.3)	3.1 (3.6
2								
	Pools (13)	50.8 (16.2)	33.6 (6.4)	25.9 (6.0)	26.5 (8.8)	12.3	45.3 (9.8)	13.0 (7.0
	Riffles (8)	28.1 (23.4)	33.4 (2.5)	25.3 (5.0)	9.6 (2.6)	34.2	18.4 (5.6)	5.5 (4.7)
	Runs (5)	59.6 (40.7)	31.8 (4.2)	27.1 (7.1)	19.2 (3.3)	17.5	30.0 (6.3)	12.8 (4.3)
	Reach summary (26)	1184.0	33.2 (5.0)	26.0 (5.7)	19.9 (9.9)	20.1	34.1 (14.4)	10.7 (6.7)

Table D1. (continued).

Stream Reach	Habitat type (n)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
MEADOW CK								
2								
	Pools (2)	8.5 (2.1)	10.8 (0.1)	10.1 (0.5)	7.0 (0.1)	17.2	14.0 (4.0)	3.5 (1.4)
	Riffles (16)	17.6 (9.5)	10.2 (2.4)	8.6 (2.4)	4.5 (0.6)	23.3	10.0 (2.1)	2.0 (1.2)
	Runs (2)	12.0 (1.4)	10.3 (0.6)	8.7 (0.8)	8.3 (1.6)	12.7	14.0 (2.3)	6.8 (3.9)
	Pockets (9)	19.0 (4.9)	12.1 (3.6)	9.4 (2.0)	5.0 (1.1)	23.6	9.6 (0.6)	2.1 (1.4)
	Reach summary (29)	493.0	10.8 (2.8)	9.0 (2.2)	5.1 (1.4)	22.3	10.4 (2.3)	2.5 (1.8)
MONO CK								
1								
	Pools (4)	12.2 (3.0)	14.1 (2.5)	13.0 (3.4)	10.1 (5.5)	19.2	20.1 (7.8)	5.1 (3.5)
	Riffles (7)	32.1 (25.6)	13.5 (1.8)	12.8 (2.3)	4.6 (1.0)	35.1	12.5 (2.3)	3.1 (1.0)
	Runs (1)	31.0 (0.0)	12.1 (0.0)	12.1 (0.0)	8.6 (0.0)	16.9	15.2 (0.0)	7.0 (0.0)
	Pockets (5)	38.2 (11.0)	13.2 (3.6)	12.9 (3.2)	5.1 (0.5)	30.2	12.8 (4.7)	4.6 (1.8)
	Reach summary (17)	495.6	13.5 (2.4)	12.8 (2.6)	6.3 (3.4)	28.9	14.5 (5.4)	4.3 (2.2)
2								
	Pools (21)	19.0 (27.7)	6.4 (3.5)	5.6 (2.6)	15.5 (3.7)	4.8	24.3 (4.8)	9.2 (5.3)
	Riffles (8)	11.0 (5.0)	4.2 (1.2)	3.7 (1.2)	8.4 (1.2)	5.4	12.7 (2.8)	5.9 (3.3)
	Runs (10)	18.3 (7.5)	4.5 (1.9)	3.8 (1.8)	13.4 (3.2)	3.7	20.3 (4.8)	7.3 (5.4)
	Reach summary (39)	669.9	5.5 (2.9)	4.7 (2.3)	13.5 (4.2)	4.7	20.9 (6.3)	8.0 (5.0)

Table D1. (continued).

Stream Reach	Habitat type (n)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
SHEEP CK								
1								
	Pools (7)	17.6 (6.9)	12.5 (3.4)	9.0 (2.1)	12.9 (5.0)	9.1	20.6 (5.9)	9.2 (5.8
	Riffles (7)	27.0 (14.9)	14.7 (6.2)	7.3 (3.5)	4.1 (1.5)	26.5	7.4 (1.9)	2.7 (2.1
	Runs (4)	60.8 (38.1)	7.2 (2.5)	6.9 (2.2)	10.4 (1.8)	8.0	14.6 (2.3)	10.1 (1.5
	Reach summary (18)	555.0	12.2 (5.2)	7.9 (2.8)	8.9 (5.2)	15.6	14.1 (7.1)	6.9 (5.1
2								
	Pools (6)	9.8 (3.8)	14.2 (2.2)	12.0 (3.5)	8.1 (1.4)	17.8	14.3 (2.7)	4.8 (2.0
	Riffles (11)	17.1 (5.1)	14.7 (2.9)	10.5 (2.3)	3.4 (0.9)	40.2	7.2 (1.3)	2.1 (1.2
	Runs (3)	13.7 (3.1)	17.9 (3.1)	11.7 (1.8)	5.0 (1.0)	28.4	10.4 (1.8)	1.5 (1.8
	Pockets (10)	24.6 (8.8)	15.4 (2.5)	13.3 (2.9)	4.0 (1.2)	41.6	7.7 (1.5)	2.4 (1.4
	Reach summary (30)	534.0	15.2 (2.7)	11.9 (2.9)	4.7 (2.1)	35.0	9.1 (3.2)	2.7 (1.8
STEEL CK								
1								
	Pools (4)	50.8 (22.5)	35.4 (4.6)	27.1 (3.1)	11.2 (3.0)	30.4	19.0 (3.6)	2.0 (2.3
	Riffles (8)	33.0 (19.1)	35.6 (11.4)	26.4 (5.9)	4.1 (1.2)	86.3	7.3 (1.4)	1.0 (1.5
	Runs (7)	55.4 (17.4)	28.4 (6.0)	24.6 (4.8)	7.8 (2.0)	40.8	12.5 (2.2)	2.8 (2.3
	Reach summary (19)	855.0	32.9 (8.9)	25.9 (4.9)	7.0 (3.4)	57.8	11.7 (5.0)	1.9 (2.0

Table D1. (continued).

Stream Reach	Habitat type (n)	Length (ft)	Channel width (ft)	Wetted width (ft)	Average depth (in)	Width to depth ratio	Thalweg depth (in)	Bank depth (in)
WYMAN CK								
1								
	Pools (2)	14.5	18.9	12.8	12.3	13.1	23.3	6.3
		(3.5)	(6.2)	(3.7)	(2.5)		(3.9)	(8.8
	Riffles (10)	24.5	21.7	15.9	6.8	30.2	14.2	3.4
		(19.6)	(6.4)	(2.2)	(1.7)		(2.5)	(1.9
	Runs (6)	23.3	19.9	14.6	7.9	22.9	16.5	3.7
		(10.4)	(4.6)	(3.6)	(2.0)		(1.3)	(1.6
	Pockets (6)	34.5	21.8	16.2	5.8	34.6	13.2	2.8
		(17.1)	(1.7)	(2.7)	(1.0)		(2.7)	(1.4
	Reach summary (24)	621.0	21.0	15.4	7.3	28.1	15.3	3.6
			(4.9)	(2.8)	(2.3)		(3.5)	(2.6
2								
	Pools (9)	38.4	24.6	19.4	16.3	14.7	29.9	5.8
		(8.3)	(9.2)	(8.2)	(4.1)		(4.8)	(3.8
	Riffles (9)	20.9	26.6	18.3	4.9	50.7	9.8	2.8
		(11.8)	(7.6)	(5.6)	(1.4)		(2.2)	(3.1
	Runs (3)	65.3	25.4	21.9	9.9	27.9	18.1	2.3
		(33.7)	(1.5)	(1.9)	(2.6)		(3.5)	(3.3
	Pockets (3)	34.7	26.2	15.9	8.2	25.8	15.4	3.6
		(24.7)	(6.8)	(4.2)	(2.2)		(1.4)	(1.0
	Reach summary (24)	834.0	25.7	18.9	10.2	31.3	19.1	4.0
			(7.4)	(6.3)	(5.8)		(9.6)	(3.4

Appendix E

Mean estimates of cover availability including percentage undercut banks, canopy density over the water's surface (%), instream cover (%), low (1.0 foot or less above the water's surface) overhead cover (%), high (more than 1.0 foot above the water's surface) overhead cover (%), and depth of undercut banks (in.) by habitat type for waters draining the Beaverhead National Forest surveyed during 1986.

Table E1. Mean estimates of cover availability including percentage undercut banks, canopy density over the water's surface (%), instream cover (%), low (1.0 foot or less above the water's surface) overhead cover (%), high (more than 1.0 foot above the water's surface) overhead cover (%), and depth of undercut banks (in.) by habitat type for waters draining the Beaverhead National Forest surveyed during 1986. Standard deviations are in parentheses.

Stream Reach	Habitat type (n)	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
Adson							
1							
	Pools (11)	65	7.3	4	41	14	24
		(26)	(3.4)	(9)	(31)	(12)	(34)
	Riffles (12)	54	3.3	3	35	10	23
		(34)	(3.5)	(12)	(34)	(11)	(32)
	Runs (11)	52	4.4	0	10	9	22
		(26)	(2.9)	(1)	(7)	(6)	(28)
	Pockets (3)	36	2.3	3	23	12	15
		(3)	(2.0)	(6)	(16)	(15)	(17)
	Side C. (1)	90	5.5	0	85	60	20
		(0)	(0.0)	(0)	(0)	(0)	(0)
	Average (38)	56	4.8	2	30	13	22
		(28)	(3.5)	(8)	(30)	(13)	(29)
Elk							
1							
	Pools (11)	54	8.0	0	11	3	5
		(20)	(4.1)	(0)	(7)	(3)	(4)
	Riffles (10)	37	5.3	1	7	2	3
		(24)	(3.9)	(3)	(5)	(2)	(3)
	Runs (4)	54	5.2	1	6	7	9
		(29)	(4.2)	(1)	(3)	(12)	(14)
	Average (25)	47	6.5	1	9	3	5
		(24)	(4.1)	(2)	(6)	(5)	(6)

Table E1. (continued)

Stream Reach	Habitat type (n)	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
Elk (cont.)							
2							
	Pools (10)	77	8.2	19	20	10	8
		(21)	(6.5)	(17)	(19)	(10)	(11)
	Riffles (7)	62	5.9	19	20	9	7
		(18)	(3.2)	(26)	(18)	(10)	(9)
	Runs (3)	56	6.4	0	5	7	5
		(6)	(2.6)	(0)	(5)	(6)	(5)
	Pockets (7)	61	6.3	24	27	12	11
		(14)	(2.5)	(25)	(17)	(7)	(10)
	Average (27)	66	6.9	18	20	10	8
		(18)	(4.5)	(21)	(18)	(9)	(10)
Johnson							
1							
	Pools (4)	41	4.1	7	39	11	16
		(32)	(3.7)	(6)	(22)	(13)	(14)
	Riffles (9)	34	1.6	6	44	7	13
		(19)	(1.5)	(7)	(20)	(5)	(6)
	Runs (5)	32	3.8	9	45	10	15
		(15)	(1.6)	(17)	(18)	(12)	(15)
	Pockets (6)	38	3.6	23	57	14	26
		(16)	(3.4)	(32)	(16)	(10)	(24)
	Average (24)	36	3.0	11	47	10	17
		(19)	(2.6)	(19)	(19)	(9)	(15)
2							
	Pools (4)	46	3.5	2	13	9	13
		(19)	(3.6)	(1)	(9)	(5)	(5)
	Riffles (6)	36	4.8	1	11	12	11
		(39)	(7.1)	(2)	(9)	(11)	(15)
	Runs (4)	20	2.1	3	16	16	14
		(18)	(3.1)	(3)	(9)	(12)	(6)
	Pockets (5)	59	8.3	6	54	49	45
		(22)	(6.6)	(7)	(34)	(40)	(34)
	Side C. (2)	78	16.5	20	11	13	19
		(15)	(18.4)	(28)	(13)	(11)	(16)
	Average (21)	44	6.0	5	22	21	20
		(30)	(7.7)	(9)	(25)	(25)	(22)

Table E1. (continued)

Stream Reach	Habitat type (n)	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
Joseph							
1							
	Pools (12)	42	4.4	0	12	10	18
		(19)	(3.8)	(0)	(8)	(8)	(12)
	Riffles (7)	40	1.8	0	6	8	16
		(36)	(1.8)	(0)	(5)	(9)	(19)
	Runs (3)	68	3.4	0	10	7	28
		(45)	(1.7)	(0)	(5)	(5)	(10)
	Average (22)	45	3.4	0	10	9	19
		(29)	(3.2)	(0)	(7)	(8)	(14)
2							
	Pools (16)	63	7.9	13	18	7	14
		(19)	(3.2)	(24)	(12)	(9)	(14)
	Riffles (11)	37	5.5	6	10	5	8
		(32)	(7.3)	(18)	(11)	(4)	(7)
	Runs (4)	51	4.9	7	14	7	11
		(28)	(1.3)	(12)	(15)	(9)	(13)
	Pockets (7)	46	5.4	0	27	8	20
		(22)	(5.9)	(0)	(21)	(5)	(20)
	Average (38)	51	6.4	8	17	7	13
		(26)	(5.1)	(19)	(15)	(7)	(14)
LaMarche							
1							
	Pools (5)	28	5.9	7	39	2	10
		(20)	(6.9)	(10)	(14)	(2)	(4)
	Riffles (8)	15	3.3	3	55	3	7
		(11)	(3.1)	(3)	(30)	(2)	(5)
	Runs (1)	13	0.0	0	20	2	5
		(0)	(0.0)	(0)	(0)	(0)	(0)
	Pockets (7)	21	3.6	2	24	5	7
		(18)	(3.5)	(2)	(8)	(1)	(3)
	Average (21)	20	3.9	4	39	3	8
		(16)	(4.3)	(6)	(24)	(2)	(4)

Table E1. (continued)

Stream Reach	Habitat type (n)	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
LaMarche (cont.) 2							
	Pools (13)	51	7.7	4	28	5	10
		(12)	(2.5)	(14)	(10)	(3)	(7)
	Riffles (8)	58	5.3	3	13	7	12
		(15)	(4.0)	(7)	(8)	(7)	(11)
	Runs (5)	60	6.7	0	16	7	12
		(15)	(2.6)	(1)	(9)	(5)	(7)
	Average (26)	55	6.8	3	21	6	11
		(14)	(3.1)	(10)	(11)	(5)	(8)
Meadow 2							
	Pools (2)	45	5.8	55	40	4	7
		(7)	(3.9)	(49)	(28)	(2)	(5)
	Riffles (16)	51	4.5	30	57	21	21
		(28)	(3.5)	(32)	(25)	(23)	(18)
	Runs (2)	78	4.5	58	15	15	20
		(20)	(6.4)	(46)	(0)	(7)	(7)
	Pockets (9)	55	3.9	30	43	16	18
		(16)	(2.3)	(35)	(21)	(13)	(19)
	Average (29)	53	4.4	34	49	18	19
		(24)	(3.2)	(34)	(25)	(19)	(17)
Mono 1							
	Pools (4)	19	4.3	15	83	10	9
		(22)	(3.6)	(24)	(10)	(4)	(8)
	Riffles (7)	5	2.7	14	89	7	10
		(5)	(2.9)	(26)	(3)	(8)	(18)
	Runs (1)	6	2.0	2	80	5	10
		(0)	(0.0)	(0)	(0)	(0)	(0)
	Pockets (5)	13	4.6	2	88	8	6
		(6)	(3.4)	(2)	(4)	(7)	(9)
	Average (17)	11	3.6	10	87	8	9
		(12)	(3.1)	(20)	(6)	(7)	(12)

Table E1. (continued)

Stream Reach	Habitat type (n)	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
Mono (cont.)							
2							
	Pools (21)	50	5.5	0	18	8	0
		(22)	(2.5)	(0)	(19)	(6)	(0)
	Riffles (8)	34	2.9	0	8	5	0
		(27)	(1.9)	(0)	(6)	(1)	(0)
	Runs (10)	65	4.8	0	19	13	0
		(22)	(2.1)	(0)	(18)	(9)	(0)
	Average (39)	51	4.8	0	17	8	0
		(25)	(2.5)	(0)	(17)	(7)	(0)
Sheep							
1							
	Pools (7)	61	8.6	0	16	8	14
		(13)	(5.4)	(0)	(11)	(8)	(10)
	Riffles (7)	37	3.1	0	10	15	19
		(25)	(2.8)	(0)	(3)	(15)	(20)
	Runs (4)	90	11.5	0	9	25	50
		(13)	(3.8)	(0)	(3)	(12)	(34)
	Average (18)	58	7.1	0	12	14	24
		(27)	(5.3)	(0)	(8)	(13)	(24)
2							
	Pools (6)	60	7.8	31	38	31	42
		(31)	(7.2)	(48)	(14)	(14)	(26)
	Riffles (11)	45	7.9	33	33	12	23
		(26)	(6.6)	(31)	(25)	(12)	(19)
	Runs (3)	54	2.3	32	18	8	15
		(21)	(2.1)	(35)	(3)	(11)	(22)
	Pockets (10)	58	6.8	24	23	13	17
		(26)	(4.0)	(23)	(13)	(15)	(17)
	Average (30)	53	7.0	30	29	16	24
		(26)	(5.6)	(31)	(18)	(15)	(21)

Table E1. (continued)

Stream Reach	Habitat type (n)	Percent undercut bank	Depth undercut bank	Canopy density (%)	Instream cover (%)	Overhead cover Low (%)	Overhead cover High (%)
Steel 1							
	Pools (4)	14 (9)	1.2 (1.2)	0 (0)	21 (11)	1 (1)	1 (1)
	Riffles (8)	22 (32)	2.2 (2.0)	0 (0)	9 (10)	1 (0)	1 (1)
	Runs (7)	26 (21)	2.6 (2.3)	0 (0)	16 (8)	2 (2)	5 (9)
	Average (19)	22 (24)	2.1 (1.9)	0 (0)	14 (10)	1 (1)	2 (6)
Wyman 1							
	Pools (2)	24 (1)	1.5 (2.1)	5 (7)	43 (39)	15 (7)	50 (42)
	Riffles (10)	30 (19)	3.1 (2.3)	3 (9)	70 (13)	6 (6)	14 (10)
	Runs (6)	23 (16)	1.6 (2.7)	0 (0)	32 (21)	7 (3)	16 (12)
	Pockets (6)	26 (17)	3.5 (2.5)	0 (0)	39 (19)	8 (6)	12 (8)
	Average (24)	27 (16)	2.7 (2.4)	2 (6)	50 (24)	7 (6)	17 (16)
2							
	Pools (9)	46 (16)	3.3 (2.2)	0 (0)	44 (29)	7 (7)	7 (9)
	Riffles (9)	20 (24)	3.1 (4.5)	0 (0)	9 (8)	3 (3)	2 (4)
	Runs (3)	31 (17)	4.1 (2.0)	0 (0)	13 (3)	3 (2)	3 (4)
	Pockets (3)	35 (20)	2.3 (1.5)	0 (0)	66 (7)	5 (3)	2 (1)
	Average (24)	33 (22)	3.2 (3.1)	0 (0)	30 (28)	5 (5)	4 (6)

Appendix F

Embeddedness data by sample (hoop) and stream reach for streams sampled during 1986.

Table F1. Embeddedness data by sample (hoop) and stream reach for streams sampled during 19

Stream	Reach	Hoop	Depth	Velocity	n	Embeddedness	Average particle size (mm) (range)
WISE RIVER DISTRICT							
Adson							
	1A	1	6.4	1.3	31	49	62.3
	1A	2	5.9	1.1	42	49	52.7
	1A	3	4.7	1.7	37	58	54.2
		AVERAGE FOR THE SITE			110	52	55.9 (24.0 - 113.0)
	1B	1	5.0	1.8	39	42	51.7
	1B	2	5.6	1.7	23	52	51.0
	1B	3	4.8	1.2	26	47	58.8
	1B	4	5.1	1.4	19	54	56.4
		AVERAGE FOR THE SITE			107	47	54.1 (18.0 - 121.0)
Jerry							
	1B	1	5.5	1.7	26	43	69.2
	1B	2	6.5	1.5	29	24	60.6
	1B	3	6.0	1.0	17	36	60.0
		AVERAGE FOR THE SITE			72	34	63.5 (28.0 - 164.0)
LaMarche							
	1	1	7.5	1.2	35	31	67.6
	1	2	9.5	1.8	33	33	78.9
	1	3	8.5	1.0	37	35	66.4
		AVERAGE FOR THE SITE			105	33	70.7 (28.0 - 243.0)
	2	1	11.0	2.0	34	46	50.6
	2	2	11.4	1.2	43	53	51.6
	2	3	11.0	1.5	35	45	51.4
		AVERAGE FOR THE SITE			112	48	51.3 (24.0 - 111.0)
	2B	1	6.5	1.3	39	34	62.4
	2B	2	8.0	1.8	41	30	53.4
	2B	3	5.5	1.2	25	37	61.5
		AVERAGE FOR THE SITE			105	33	58.7 (20.0 - 225.0)

Table F1. (continued)

Stream	Reach	Hoop	Depth	Velocity	n	Embeddedness	Average particle size (mm) (range)
Meadow							
	2	1	4.3	1.1	31	40	57.0
	2	2	4.3	0.9	28	50	55.8
	2	3	5.9	1.1	42	51	66.1
		AVERAGE FOR THE SITE			101	47	60.4 (27.0 - 144.0)
Mono							
	1	1	4.9	1.0	32	45	74.3
	1	2	5.8	1.0	34	54	65.3
	1	3	5.2	1.1	35	50	62.7
		AVERAGE FOR THE SITE			101	50	67.3 (24.0 - 196.0)
Wise River							
	3B	1	6.5	1.7	57	43	55.9
	3B	2	8.5	1.8	37	29	59.9
		AVERAGE FOR THE SITE			94	37	57.5 (28.0 - 133.0)
Wyman							
	1	1	7.3	1.4	29	48	88.0
	1	2	7.9	1.8	26	40	85.3
	1	3	9.6	2.0	29	31	79.2
	1	4	14.2	1.7	17	43	88.8
		AVERAGE FOR THE SITE			101	40	84.9 (33.0 - 231.0)
	2	1	7.1	1.1	41	38	51.2
	2	2	5.9	1.1	62	43	47.4
		AVERAGE FOR THE SITE			103	41	48.9 (29.0 - 80.0)
WISDOM DISTRICT							
Big Swamp							
	2B	1	6.5	1.3	33	35	57.7
	2B	2	7.0	1.3	22	29	64.0
	2B	3	7.5	1.5	21	43	58.8
	2B	4	6.5	2.0	19	35	60.8
		AVERAGE FOR THE SITE			95	35	60.0 (28.0 - 135.0)

Table F1. (continued)

Stream	Reach	Hoop	Depth	Velocity	n	Embeddedness	Average particle size (mm) (range)
Elk							
	1	1	6.3	1.3	38	47	50.7
	1	2	6.0	1.7	30	47	57.9
	1	3	4.7	1.8	34	56	55.1
		AVERAGE FOR THE SITE			102	50	54.3 (28.0 - 190.0)
	2	1	5.0	1.3	6	59	98.5
	2	2	5.0	0.8	13	56	78.8
	2	3	1.4	0.8	18	65	69.2
	2	4	2.0	1.3	13	55	69.0
	2	5	4.3	1.0	21	67	54.2
	2	6	4.4	1.0	13	75	77.5
	2	7	6.1	0.8	16	62	81.2
		AVERAGE FOR THE SITE			100	63	72.0 (40.0 - 175.0)
Johnson							
	2	1	4.7	1.3	13	33	50.0
	2	2	7.5	1.1	46	47	62.6
	2	3	4.3	1.3	33	54	65.0
	2	4	5.9	1.3	54	35	73.0
		AVERAGE FOR THE SITE			146	43	65.9 (23.0 - 200.0)
Joseph							
	1	1	4.3	2.0	60	37	41.2
	1	2	4.3	1.7	55	46	40.1
		AVERAGE FOR THE SITE			115	42	40.7 (19.0 - 84.0)
	2	1	5.9	1.5	36	38	50.5
	2	2	3.1	1.7	35	42	49.1
	2	3	6.3	1.1	37	43	51.2
		AVERAGE FOR THE SITE			108	41	50.3 (20.0 - 135.0)

Table F1. (continued)

Stream	Reach	Hoop	Depth	Velocity	n	Embeddedness	Average particle size (mm) (range)
Sheep							
	1	1	4.7	2.0	31	42	50.6
	1	2	5.5	1.7	36	50	64.3
	1	3	5.9	1.3	29	40	55.3
		AVERAGE FOR THE SITE			96	44	57.2 (27.0 - 137.0)
	2	1	5.9	1.0	8	74	68.3
	2	2	4.7	1.0	5	62	63.0
	2	3	5.9	1.1	17	62	60.4
	2	4	4.3	1.3	12	69	51.2
	2	5	5.5	0.9	11	75	80.6
	2	6	6.7	1.0	19	64	61.1
	2	7	4.9	1.8	20	72	64.7
	2	8	7.1	2.0	14	72	61.6
		AVERAGE FOR THE SITE			106	69	63.3 (30.0 - 205.0)
Steel							
	1A	1	2.6	1.3	95	39	38.6
		AVERAGE FOR THE SITE			95	39	38.6 (18.0 - 104.0)
	1B	1	5.1	1.1	99	38	38.6
		AVERAGE FOR THE SITE			99	38	38.6 (18.0 - 75.0)
Trail							
	2	1	9.0	1.1	29	30	39.6
	2	2	9.0	1.0	48	43	44.0
	2	3	8.0	0.9	27	28	38.1
		AVERAGE FOR THE SITE			104	36	41.2 (16.0 - 74.0)

Appendix G

Mean lengths and weights, condition factors and sample sizes by stream, reach, and species for all fish captured in streams draining the Beaverhead National Forest surveyed during 1986.

Table G1. Mean lengths and weights, condition factors and sample sizes by stream, reach, and species for all fish captured in streams draining the Beaverhead National Forest surveyed during 1986.

DISTRICT Stream	Reach	Species	n	Length (range) (in.)	Weight (range) (lbs.)	Condition
DILLON DISTRICT						
Browns Canyon Ck	2	WCT	70[1/]	4.8 (1.3 - 9.8)	-	-
Cow Cabin Ck	2	EBT	11	6.2 (3.3 - 9.3)	-	-
Morrison Ck	2	EBT	6	5.3 (2.6 - 7.5)	-	-
Painter Ck	2	WCT	42	5.3 (2.8 - 9.7)	-	-
Pass Ck	2	EBT	50	5.5 (2.8 - 8.8)	-	-
Pole Ck	2	EBT	14	4.7 (2.6 - 7.7)	-	-
		WCT	2	7.3 (6.3 - 8.2)	-	-
Reservoir Ck	2	WCT	42	4.3 (1.5 - 8.7)	0.06 (0.01 - 0.25)	88.5
WISE RIVER DISTRICT						
Adson Ck	1	EBT	3	4.8 (4.3 - 5.5)	0.06 (0.05 - 0.08)	58.9
		WCT	7	7.3 (6.8 - 7.8)	0.16 (0.12 - 0.18)	40.2

Table Gl. (continued)

DISTRICT Stream	Reach	Species	n	Length (range) (in.)	Weight (range) (lbs.)	Condition
LaMarche Ck	1	RB	34	4.5 (2.7 - 9.5)	0.06 (0.01 - 0.39)	40.7
		EBT	201	5.4 (1.6 - 11.1)	0.08 (0.01 - 0.74)	40.9
	2	EBT	161	6.1 (1.4 - 13.3)	0.11 (0.01 - 0.98)	43.9
		WSUCK	1	9.6	0.36	40.7
		MWF	1	14.0	1.06	38.6
Meadow Ck	2	WCT	9	4.2 (1.7 - 6.4)	0.03 (0.01 - 0.07)	57.8
Mono Ck	1	WCT	70	3.6 (2.0 - 8.9)	0.03 (0.01 - 0.24)	49.4
	2	WCT	32	6.4 (4.6 - 11.3)	0.12 (0.05 - 0.32)	36.7
Wyman Ck	1	EBT	42	5.3 (2.1 - 8.2)	0.08 (0.01 - 0.21)	43.9
		RBXWCT	10	4.1 (2.3 - 6.2)	0.03 (0.01 - 0.08)	47.2
		LING	5	9.2 (7.9 - 11.7)	0.14 (0.08 - 0.22)	-
	2	EBT	268	5.8 (1.8 - 11.5)	0.10 (0.01 - 0.54)	42.1
		GR	1	9.1 (9.1 - 9.1)	0.22 (0.22 - 0.22)	29.2
		RBXWCT	13	7.3 (4.2 - 11.3)	0.18 (0.02 - 0.56)	34.9

Table G1. (continued)

DISTRICT Stream	Reach	Species	n	Length (range) (in.)	Weight (range) (lbs.)	Condition
WISDOM DISTRICT						
Elk Ck	1	EBT	78	4.7 (1.6 - 9.2)	0.07 (0.01 - 0.36)	57.0
	2	EBT	157	4.2 (1.4 - 7.5)	0.04 (0.01 - 0.18)	52.8
Johnson Ck	1	EBT	102	4.9 (2.0 - 9.2)	-	-
		LING	23	8.9 (6.7 - 10.2)	-	-
	2	EBT	82	4.4 (1.5 - 9.0)	-	-
Joseph Ck	1	EBT	91	5.8 (2.2 - 12.9)	0.37 (0.10 - 0.86)	39.8
		LING	2	8.6 (8.4 - 8.8)	-	-
	2	EBT	336	4.1 (1.3 - 8.8)	0.04 (0.01 - 0.30)	58.4
Sheep Ck	1	EBT	36	4.6 (1.6 - 8.8)	0.07 (0.01 - 0.31)	74.4
		LING	5	9.2 (8.3 - 10.2)	-	-
	2	EBT	52	4.5 (1.2 - 7.9)	0.05 (0.01 - 0.21)	61.9
Steel Ck	1	EBT	260	4.4 (2.5 - 10.5)	-	-
		GR	3	5.9 (4.0 - 8.7)	-	-
		LING	4	8.3 (5.7 - 10.3)	-	-

Table G1. (continued - footnote))

1/ Species abbreviations are: EBT = brook trout; GR = arctic grayling; LING = burbot; RB = rainbow trout; RBXWCT = undetermined rainbow or cutthroat trout or hybrids between the two; WCT = cutthroat trout.