MONTANA DEPARTMENT OF FISH WILDLIFE AND PARKS
FISHERIES DIVISION
JOB COMPLETION REPORT

State: Montana Title: Statewide Fisheries Investigations
Project: F-46-R-4 Title: Bitterroot Forest Inventory
Job: Ij
Period Covered: July 1, 1990 to June 30, 1991

ABSTRACT

Population estimates were collected on the study streams on the Bitterroot National Forest for the second consecutive year. Overall, populations appeared to increase slightly and the consistency between years indicate that electrofishing may be an effective monitoring tool. Bull trout appear to be incompatible with brook trout in Bitterroot National Forest streams. The two species do not co-exist in large numbers and brook trout appear to be replacing bull trout in at least one stream. Electrophoretic analysis indicates that pure strain westslope cutthroat trout exist in most of the samples taken. A discussion of fish populations and habitat by specific stream in Bitterroot National Forest districts is included. Daly Creek fish populations do not appear to be responding to the fishing closure.

Bitterroot River fish populations are discussed. Special regulations in the Darby area appear to have been moderately successful. Rainbow trout populations in the dewatered section of the Bitterroot River are very low. Redd counts in Bitterroot River tributaries indicate that westside streams are heavily used by spawning rainbow trout from the Bitterroot River. Fry trapping of these streams indicate that dewatering and diversion of water for irrigation are impacting the survival of young-of-the-year rainbow and brown trout.

BACKGROUND

Recently, public interest in land management activities on public lands has increased and more emphasis is being placed on protection of fish and wildlife. At the same time, demand for information concerning outdoor activities on private land continues to increase.

To meet the demand for more information on the fisheries of the Bitterroot drainage on public and private land, the Bitterroot National Forest (BNF) and the Montana Department of Fish, Wildlife and Parks entered into a cooperative agreement to study fisheries issues. They agreed to fund a fisheries biologist position that would work with both agencies to work on fisheries issues of importance.

Presently, the project has been focused on the following issues:

1. Trout and habitat relationships on the BNF, with emphasis on the effects of land management activities on sedimentation of streams and it's effect on BNF fisheries.

2. Building a long term monitoring program for the fisheries of the BNF.

3. Studying the trout populations of the Bitterroot River and assessing the effects of fishing regulations.

4. Studying the early life history of rainbow trout populations in the Bitterroot River.

The Bitterroot National Forest (BNF) encompasses 1.6 million acres, 71% of which lies in Montana. Three mountain ranges, the Bitterroots to the west, the Sapphires to the east and the Anaconda-Pintlars to the southeast comprise the BNF. Water flowing within the BNF is excellent in quality. Most of the water draining the BNF is considered soft, a result of basin geology. Streams originating from the Bitterroot Mountains are unusually low in hardness and dissolved solids because of the resistant igneous and metamorphic rocks. The streams draining the Sapphire range tend to have higher dissolved solids because of slightly less resistant and more soluble background geology (Garn and Malmgren 1973). Within Montana, the BNF contains streams which are the headwaters of the Bitterroot River.

The Bitterroot River flows in a northerly direction from the confluence of the East and West Forks near Conner, Montana. It flows 84 miles through irrigated crop and pastureland to it's confluence with the Clark Fork River near Missoula, Montana. Five major diversions and numerous smaller canals remove substantial quantities of water from the river during the irrigation season (Spoon 1987). In addition, many of the tributaries which originate on the BNF are diverted for irrigation during the summer months and contribute little streamflow to the river during that time. Therefore, many tributaries and the mainstem of the Bitterroot River are chronically dewatered during the irrigation season.

Streamflow characteristics vary along the Bitterroot River with the most critically dewatered reach between Hamilton and Stevensville (Spoon 1987). To help alleviate the mainstem dewatering the Montana Department of Fish, Wildlife and Parks annually supervises the release of 15,000 acre-feet of water from Painted Rocks Reservoir on the West Fork of the Bitterroot River.

Since the waters of the Bitterroot National Forest are so important to the Bitterroot River, this project was initiated to study fisheries throughout the drainage without regard to administrative boundary.

Fisheries information within the Bitterroot valley is available from a variety of sources. The Bitterroot River has been studied in relation to dewatering and the impacts of releases of Painted Rocks Reservoir water (Spoon 1987). Some midvalley tributaries that have dewatering problems and spawning runs by Bitterroot River fish have been studied (Good 1985, Good et al 1984).

Most of the work has been on or near to the Bitterroot National Forest. Fish populations at the forest boundary, relationships between salmonids and sedimentation, and woody debris counts have all been addressed to some degree (Hoth 1979, Odell 1985, Munther 1986, Peters 1987, 1988, Vadeboncouer et al 1989).

The relationship between trout and different habitat components has been studied extensively. Sediment, particularly sand, can be detrimental to salmonid fisheries (Alexander and Hansen 1983, 1986, Bianchi 1963, Bjornn et al 1977, Crouse et al 1981, Irving and Bjornn 1984, Klamt 1976, Reiser and White 1983, Saunders and Smith 1965, Sowden and Power 1985, Stowell et al 1983, Tappel and Bjornn 1983, Young 1989). Most of the sediment that is introduced from human related activities is introduced as a result of roadbuilding and to a lesser degree by logging practices (Bilby et al 1989, Burns 1972, Duncan and Ward 1985, Johnson et al 1986, Megahan and Kidd 1972, Moring 1982, Yee and Roelofs 1980). In recent years more work is being done to control erosion from these sources (Burroughs and King 1989, Yee and Roelofs 1980). While the negative relationship between fine sediment and salmonid populations is generally accepted, disagreements about the amounts, timing and the methods of measurement are common (Chapman 1988, Chapman and McLeod 1987, Everest et al 1986, Harvey 1989, Levinski 1986, Lotspeich and Everest 1981, Platts et al 1979, Vadeboncouer et al 1989).

Large woody debris (LWD) is recognized as a benefit to salmonid populations in many areas (Cardinal 19??, Dolloff 1986, Elliott 1986, Heifetz et al 1986, Lestelle 1978, Lisle 1986, Marston 1982, Sedell et al 1988). Overhead cover has also been positively correlated with salmonid populations (Wesche et al 1987a, 1987b).

This study will attempt to define the relationships of salmonids and their habitat on the BNF, and understand the relationship between recruitment, fishing regulations and trout populations on the Bitterroot River. The studies began during June of 1989, and the report covers the 1989 and 1990 field seasons.

OBJECTIVES AND DEGREE OF ATTAINMENT

1. To develop a fish habitat monitoring program related to land management activities on the Bitterroot National Forest. Data included in this report

2. To develop a fish population monitoring program which will measure the fit of existing fish-habitat model and provide a means of updating model parameters. Data collected and will be included in a future report.

3. To interpret fish population and fish habitat information to Bitterroot National Forest project staff. Data included in this report.

METHODS

Bitterroot National Forest

Streams for monitoring were selected based on several factors. Basin geology and degree of human development were considered so that fish populations could be studied under many different scenarios (Figure 1). Several streams were selected from an earlier study and were included in this study (Peters 1987, 1988, Munther 1986).

Before any fieldwork was completed the stream gradient and order were mapped from USGS 1:24,000 contour maps. Based on gradient, the general area of study was selected and approximately a 1 mile reach of this area was surveyed in the field. This primary survey consisted of counting habitat types and woody debris. Based on this survey, an 800 or 1000 foot section was selected for further intensive fish population and habitat measurements. All surveys were completed between July 15 and September 15.

When the final survey sections were selected, fish populations were enumerated on sections either 800 or 1000 feet in length. Electrofishing was conducted on most streams with a Coffelt Mark-10 backpack electrofisher or a bank electrofishing unit on larger streams. A mark-recapture method was used, with the recapture run occurring within 7-14 days following marking.
Mark-recapture was selected as the population estimator since it generally is more accurate than the removal method and we were unable to capture a large percentage of the population in our first sample (Peterson and Cederholm 1984). Individual fish were measured, weighed and marked, and larger fish were tagged with individually numbered dart tags.

Population estimates were calculated using the Mark-Recapture program which is based on the Chapman modification of the Petersen

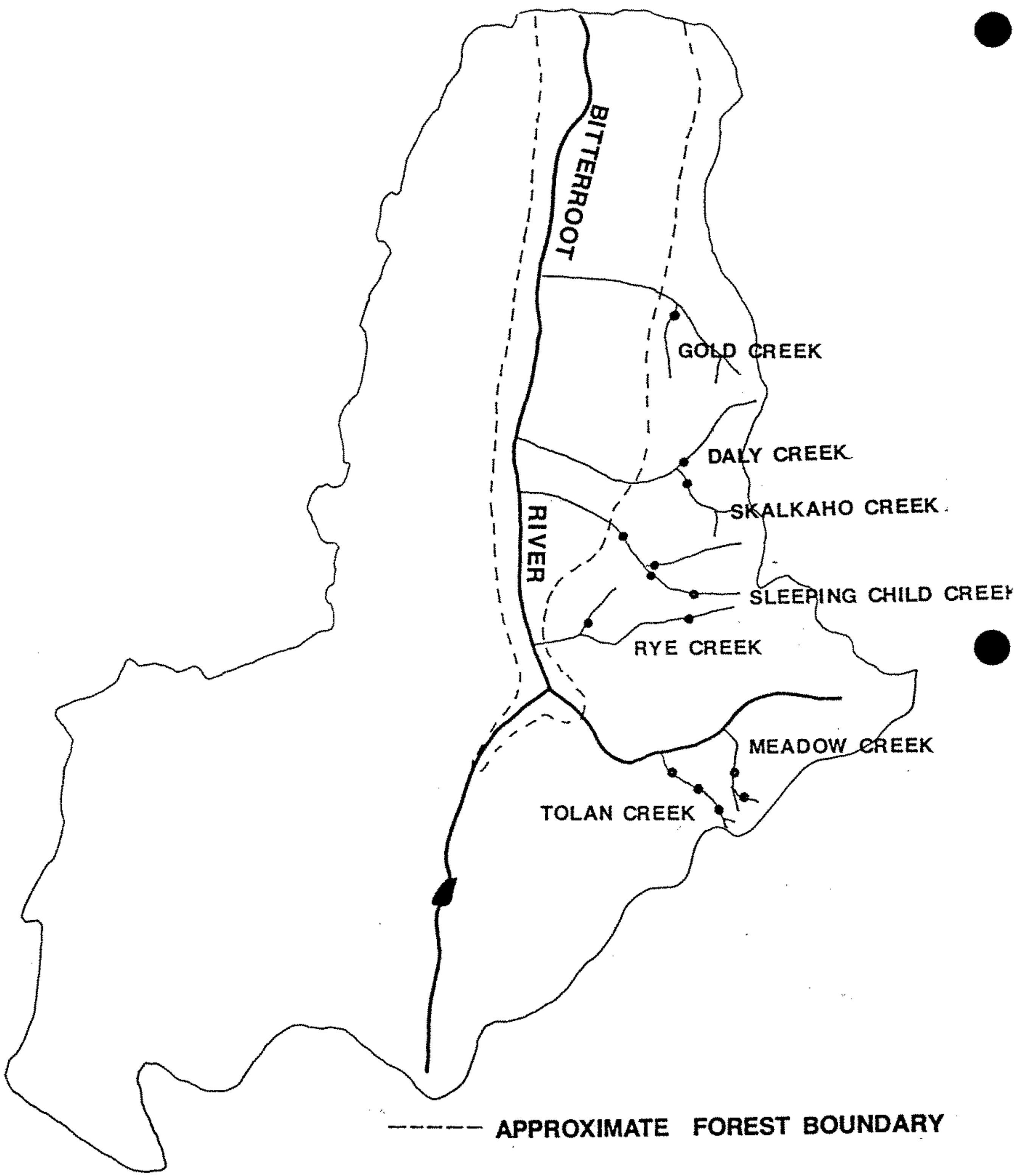


FIGURE 1 - Study Sections on the Bitterroot National Forest.

estimate (Ricker 1975).

General habitat features were measured by a method similar to that used on the Beaverhead National Forest (Shepard 1987 Platts et al 1983, 1987). Specific habitat types were classified according to generally accepted methods (American Fisheries Society 1985). In addition to the overhead cover measurements taken in the standard survey, a second method was devised. At each cross section in the transects, the mean distance of overhang from the streambank for a distance of 1 yard upstream and downstream of the tape was measured for low and high overhead cover. Also the quality, or shading potential of the overhead cover was ranked. The ranking was on a numeric basis of 1 through 4 based on the density of the cover. Number 1 was sparse, up to 25% of the water under the cover would be shaded and number 4 was dense, with over 75% of the water under the cover being shaded. Numbers 2 and 3 were intermediate. Individual woody debris pieces were counted and estimates of their length were recorded. The sizes of woody debris were separated into three diameter classes (0-6", 6-12", and over 12") and two location classes (in water or out of water). While ocular measures of sediment are included in the general habitat measurements, two other methods are being used.

Whitlock-Vibert boxes filled with marbles were placed in areas that appeared to be similar habitat to westslope cutthroat spawning areas (Reiser et al 1987, Shepard et al. 1984, Wesche et al 1989). Artificial redds were built and the boxes were placed in pits that were excavated by plunging with a bathroom plunger. They were buried flush with the streambottom, and covered with material that was excavated immediately upstream by plunging. The plunger was used to simulate redd building activity of cutthroat trout. Boxes were placed in the stream during early June and collected during late August, which is considered to be the incubation period of westslope cutthroat on the BNF.

Upon removal from the stream, the W-V boxes were emptied of their contents, the marbles were separated from the sediments and a volumetric measure of sediment was calculated with Imhoff cones. The sediment was then placed in double ziploc bags and kept for further analysis. A special study site was setup on Reimel Creek to test the sediment collecting characteristics of the W-V boxes. A riffle that was composed of fairly uniform depths, velocities and gravels was selected. Twenty-five boxes in 5 rows and 5 columns were placed in the riffle on 6/12/90 and each column was removed beginning on 6/12 at two week intervals. Immediately after the contents of the boxes were collected, the boxes were placed back into the stream at their original site. On the day of the removal of the last column of boxes, all boxes were removed and their contents collected.

McNeil hollow core samples were collected on selected streams (McNeil and Ahnell 1964). On most of the streams which were easily accessible, samples were collected adjacent to a W-V sample which was considered to be a good set. Hollow core samples were collected at the same time that W-V boxes were removed. A total of 41 hollow core samples were collected. Sediment samples from the W-V boxes and McNeil cores were dried at 130 degrees F, sieved and weighed. Due to large amounts of organic matter and clay in the W-V samples they were washed before drying. The size of sieves used with the W-V boxes was standard sieve sizes number 10, 20, 40, 100, 200 and pan. In addition to these sizes the McNeil core samples were sieved through standard sieve sizes 3 inch, 2 inch, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch and 1/4 inch. After sieving, the sample retained in each sieve was weighed to the nearest gram. All of the smaller fractions from the McNeil cores were subsampled because the entire sample was too large for analysis.

Westslope cutthroat and bull trout were collected for electrophoretic analysis on some streams. All fish were sent to the University of Montana for analysis.

The Bitterroot National Forest Plan recommends monitoring 6 streams annually to meet the Forest objectives (USDA 1987). We have set a goal of monitoring trout populations for at least 3 years in each stream we select to serve as a baseline for future population studies.

Bitterroot River

Fish populations on the Bitterroot River were collected on four reaches (Figure 2). Study reaches were selected based on historical data, flow patterns and fishing regulations. The reaches are 3.6 - 5.1 miles in length. Electrofishing was conducted from a 14-foot long steel drift boat fitted with a boom shocking system. The Petersen mark-recapture method was used to calculate population estimates (Ricker 1975). Several mark and recapture runs were required to obtain sufficient sample size to estimate fish populations.

Rainbow trout redd counts were made on 12 streams during the Spring of 1990 (Table 1). Starting at the mouth of the stream, redds in the lowest one mile were counted and measured once a week. All of the disturbed area of the redd was measured including the pit and tailspill. A painted rock was placed at the upstream edge of each redd so that each redd was counted only once. Areas where several redds were present or were reworked between counts presented a problem. If a large area was disturbed the counter judged how many redds were present. Any new area of disturbance between weeks was considered a new redd. Counts occurred between March and May, when spring runoff precluded further studies.

Emerging fry were trapped in 9 of the streams with downstream drift traps (Table 1). The trap opening was a 9 square foot frame composed of reinforcing bar 3 ft in length on each side, and it funnelled down into a catch basin constructed of PVC pipe and net material. The main body of the trap was constructed of 1/4" and 1/8" mesh hardware cloth. The 1/4" mesh cloth encompassed the upstream half of the cone and the 1/8" mesh cloth encompassed the cod end of the trap. Trapping began in late May and proceeded until mid-July when most of the downstream drift had ended.

Trout fry were counted and a subsample was measured each day.

We attempted to calculate the trap efficiency by three methods. First, we measured streamflow in each stream and streamflow through the trap to calculate the percentage of flow passing through the trap. Second, we sprinkled 1" long pieces of 1/8" dowel into the stream 100-200 feet upstream of the trap and

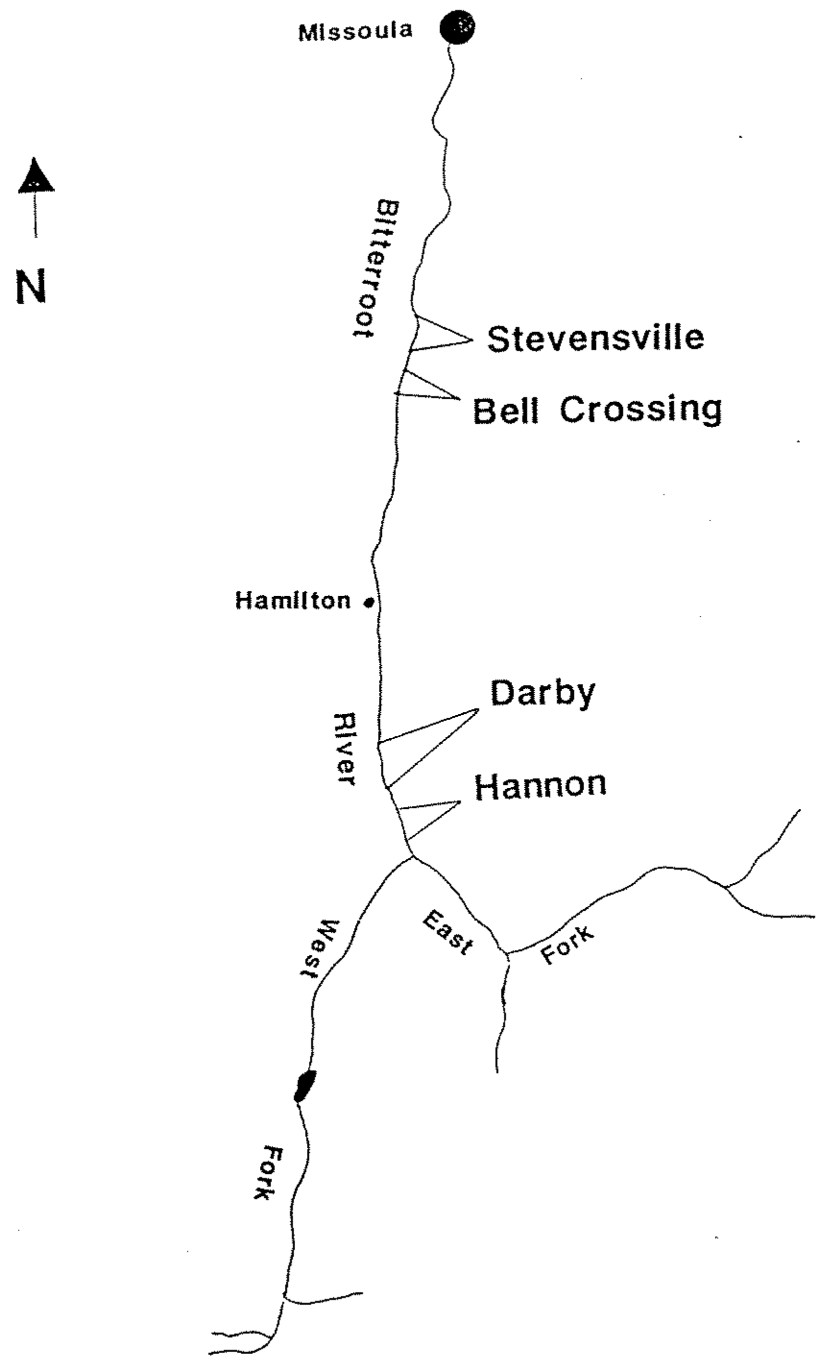


FIGURE 2 - Study Sections on the Bitterroot River.

observed the percentage of dowels retained by the trap. The third method we used was to stain rainbow trout fry with bismark brown and release them upstream of the trap (Ward and Verhoeven 1963). Subsequent trapping gave us an idea of the percentage of fish being captured in the trap. The fish were captured and classified to species (Martinez 1984).

All data was compiled and analyzed on PC compatible computers. The software we used was DBase III+, Mark-Recapture, Harvard Graphics 2.1, WordPerfect 5.0 and Statgraphics 2.1.

Table 1. Streams where Spring redd counts and Summer fry trapping occurred in 1990.

Redd counts	Fry trapping
Kootenai Creek	Kootenai Creek
Big Creek	Big Creek
Sweathouse Creek	Sweathouse Creek
Bear North Channel	Bear North Channel
Bear South Channel	Bear South Channel
Mill Creek	Mill Creek
Blodgett Creek	Blodgett Creek
Tincup Creek	Tincup Creek
Fern Creek	Fern Creek
Skalkaho Creek	
Warm Springs Creek	
Tolan Creek	

RESULTS AND DISCUSSION

Bitterroot National Forest trout populations

Population estimates of westslope cutthroat trout increased slightly between 1989 and 1990 (Figure 3). North Rye and Meadow Creek 02 were the only streams where population estimates of westslope cutthroat were not consistent between years. The overall consistency of population estimates between years indicate that the mark-recapture procedure is probably an appropriate enumeration method. Bull trout population estimates are more difficult to collect (Figure 4). Annual fluctuations in populations of salmonids has brought into question the validity of population estimates as monitoring tools (Platts 1988). However, the paper does not present enough detailed information to assess the findings. For monitoring purposes, we will collect population estimates for a minimum of three years at each site.

In general, in these streams the predominant species is the westslope cutthroat trout, with lesser numbers of bull trout. Of the streams we sampled, Skalkaho Creek supports the highest number of westslope cutthroat trout and Daly Creek supports the highest number of bull trout (Figures 3,4).

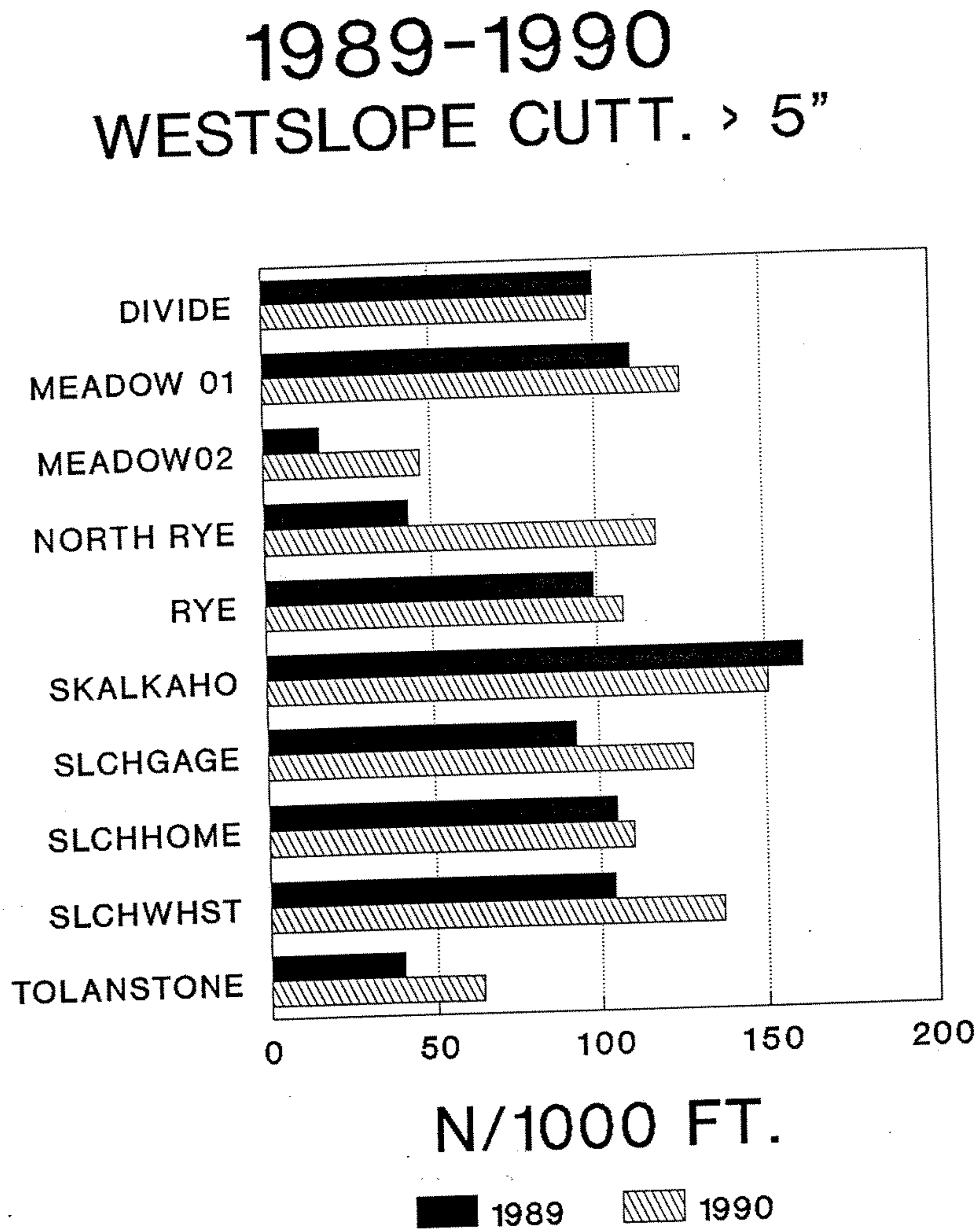


FIGURE 3 - Westslope Cutthroat Trout per 1000 feet of stream during 1989 and 1990.

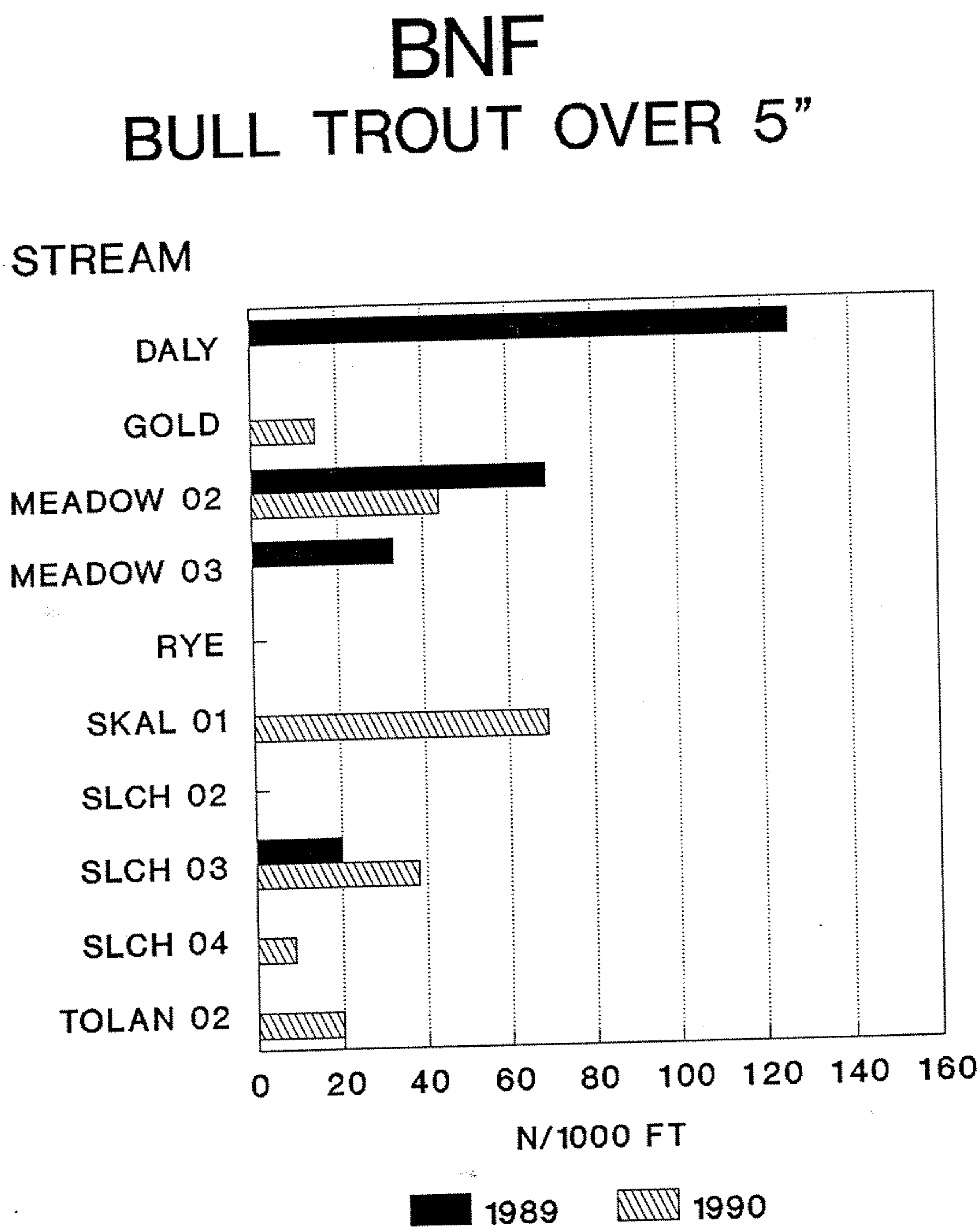


FIGURE 4 - Bull Trout per 1000 feet during 1989 and 1990.

The discussion of individual streams is included later in the report under Forest Service Districts and a discussion of fish and habitat relationships is discussed in a separate section of the report.

Bull trout-brook trout interactions

While bull trout are native to the Bitterroot drainage, brook trout are not. Little work has been done to assess interactions between the two species, but they are known to hybridize and produce a non fertile offspring (Leary et al 1983). Data collection on the BNF indicates that brook trout may be replacing bull trout populations in some streams. Analysis of historic fisheries data on the Bitterroot National Forest indicates that the two species seldom coexist together and never in large numbers. Of 35 streams sampled on the BNF no streams supported estimatable populations of both species and only 5 contained individuals of both species (Table 2). A majority of streams contain one species and not the other. This data also illustrate the fact that the dominant species of trout on the BNF is the westslope cutthroat as estimatable populations are usually present in all of the streams.

Tolan Creek is the only stream that contains historic and present data that reflect recent interactions of the two species. Three sections of Tolan Creek have been sampled recently (Figure 15). All three sections are dominated by westslope cutthroat trout with lesser numbers of bull or brook trout (Table 2). In 1989 and 1990, the two upstream sections supported only westslope cutthroat and bull trout while the downstream section supported only westslope cutthroat and brook trout. The lower section supported a bull trout population as recently as 1986 (Peters 1987). Brook trout appear to have replaced bull trout in the lower section of Tolan Creek.

Table 2. Population status of the three species of fish collected in the following streams near or on the Bitterroot National Forest during sampling from past years.

Stream	Westslope cutthroat	Bull trout	Brook trout
Bass	Pop*	0*	Pop
Bertie Lord	Pop	1*	Pop
Cameron	Pop	0	Pop
Chaffin-L	Pop	1	Pop
Chaffin-U	Pop	0	1
Coal	Pop	0	0
Daly	Pop	Pop	0
Divide 01	Pop	1	0
Divide 02	Pop	Pop	0
Gold	Pop	Pop	0
Laird	Pop	0	Pop
Lick	Pop	0	Pop
Martin	Pop	1	0
Meadow 01	Pop	Pop	0
Meadow 02	Pop	Pop	0
Meadow 03	Pop	Pop	0
Meadow 04	Pop	Pop	0
Moose	Pop	Pop	0
Piquett	Pop	1	Pop
Reimel 01	Pop	0	Pop
Reimel 02	Pop	0	Pop
Reimel 03	Pop	0	Pop
Rye	Pop	1	0
Rye N.Fk.	Pop	0	Pop
Skalkaho	Pop	Pop	0
Sl.Child 02	Pop	1	1
Sl.Child 03	Pop	Pop	1
Sl.Child 04	Pop	Pop	0
Threemile	1	0	Pop
Tolan 01	Pop	0	Pop
Tolan 02	Pop	Pop	0
Tolan 03	Pop	Pop	0
Warm Sp.	Pop	1	0
Waugh	Pop	0	Pop

*Pop indicates enough fish available for a population estimate, 1 indicates that the species is present usually in small numbers, 0 indicates the species is not present.

Genetic testing

Trout from several streams have been tested for genetic purity at the University of Montana. This testing will continue into the future as we attempt to identify the locations of pure strain populations of westslope cutthroat and bull trout. Overall, most of the populations that have been tested have been pure strain westslope cutthroat trout, however the samples from several of the streams was too small (Table 3). More populations and larger sample sizes will be collected during 1991.

Table 3. Results of electrophoretic testing of trout populations in selected BNF streams.

Stream	Sample Size	Year	Status
	Westslope cutthroat		
Meadow Creek	21	1989	Pure
Sleeping Child Creek	42	1985, 1989	Pure
Gold Creek	26	1985	Pure
Gold Creek	4	1990	Pure
North Rye Creek	8	1990	Pure*
Willow Creek	5	1990	Pure*
Warm Springs Creek	5	1990	Hybridized -Rainbow trout
Martin Creek	25	1985	Pure
Moose Creek	25	1985	Pure
Tincup Creek	50	1982	Hybridized -Rainbow trout
Bass Creek	11	1984	Hybridized -Yell. cutt.
Bluejoint Creek	5	1987	Pure*
	Bull trout		
Meadow Creek		1989	Pure*

* Sample size too small for statistical validity

BITTERROOT NATIONAL FOREST DISTRICTS

The habitat variables that are most commonly associated with trout populations were measured on 14 reaches of 10 streams (Table 5,6, and 7). Refer to Table 4 for trout population estimates and Tables 5-7 for the habitat discussion in this section. Stream gradient and mapping by stream order are on file for each of these streams in the Supervisors Office in Hamilton.

The following discussion pertains to individual streams on the four districts. It should give a general idea of the character of the fishery and the habitat. A discussion of overall habitat and trout relationships on the BNF is presented later in the report.

Stevensville district

Trout population estimates were collected on Bass, Willow, and Gold Creeks within the Stevensville district. Sediment data was collected on Willow, Gold, Big, Kootenai, and Mill Creeks on the District.

Gold Creek:

A fish population study section was established near the confluence with Burnt Fork (Peters 1987). The downstream boundary of the section is located approximately 1/4 mile upstream of the Burnt Fork mainstem crossing (Figures 5,6). The lower boundary is marked by a steel fencepost and the upper boundary is 800 feet upstream marked by round 1 1/2" aluminum tabs nailed into trees adjacent to the creek. The upper boundary of the section ends about 50 feet upstream of a large talus slope.

The fish population is composed of westslope cutthroat and bull trout (Table 4). Gold Creek is small and when compared to other study streams on a fish per acre basis it has fewer than average westslope cutthroat and average number of bull trout.

Other than width, Gold Creek is average in channel characteristics and habitat types. Sediment measurements indicate that Gold Creek is within the middle ranges of the streams measured.

Kootenai Creek:

No fish population work has been completed during this study however, the population of fish is considered excellent, composed mostly of westslope cutthroat, rainbow-cutthroat hybrids, mountain whitefish and brook trout, in decreasing order of abundance (O'Dell, 1985). W-V boxes were planted in Kootenai Creek during 1990 and the average weight of sediment collected in the boxes was 303 grams which is above the average for the study streams. However, due to the large size of Kootenai Creek, only 4 boxes were considered good sets so our sample size is small.

Big Creek:

No fish population work has been completed during this study however Big Creek is considered to have lower than average numbers of trout when compared to other westside streams (O'Dell, 1985). Trout populations near the Forest boundary are composed mostly of westslope cutthroat, rainbow trout and their hybrids. Mountain whitefish, brook and brown trout are present in lesser numbers. W-V boxes were planted during the Summer of 1990, and the average weight of sediment collected in the boxes was 214 grams which is below the average for the study streams.

Mill Creek:

No Fish population work has been completed during this study, however Mill Creek is considered to have average numbers of trout when compared to other westside streams (O'Dell, 1985). Trout populations near the National Forest boundary are composed mostly of westslope cutthroat, rainbow trout and their hybrids, with lesser numbers of brook and bull trout. W-V boxes were planted during the summer of 1990, and the average weight of sediment collected in the boxes was 212 grams which is below the average for the study streams. It is also very close to the amount collected in Big Creek which has similar drainage characteristics.

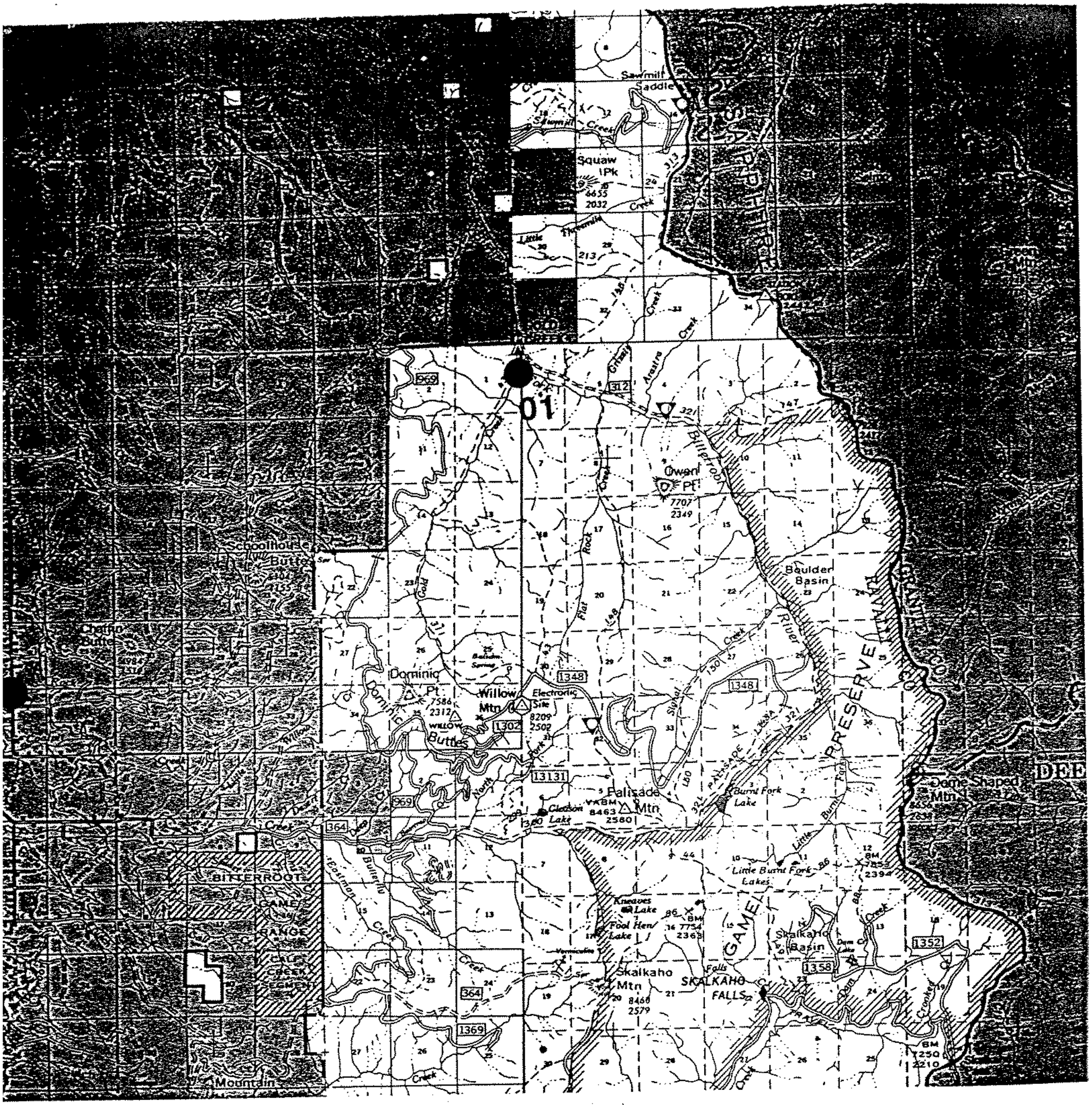


FIGURE 5 - Location Map of Gold Creek Study Section.

FIGURE 6 - Gold Creek Study Section.

Willow Creek:

A fish population study section was established on the Forest Service portion of Section 10 downstream of the confluence of Butterfly Creek. A population estimate of 55 + 9 westslope cutthroat > 5" per 1000 feet of stream was collected on 4/27/90. Bull trout up to 8" were also collected and brook trout were present. The population of westslope cutthroat is slightly below average when compared to other streams in the study.

A 300 foot reach of Butterfly Creek from the mouth upstream was electrofished to establish if a fishery was present. Westslope cutthroat up to 3.8 inches and bull trout up to 5.6 inches were present.

Due to the unusually high streamflows in Willow Creek during the Summer, we were unable to collect further population estimates. Since the streamflows appear to be altered, this stream will not be included in the trout-habitat relationships study.

W-V boxes and McNeil hollow core samples were used to measure sediment in the stream. The W-V boxes indicated that Willow Creek may be carrying more sediment than the average of the other study streams. The average in Willow Creek was 298 grams. The McNeil core samples were average when compared to the other streams sampled.

Bass Creek:

Fish population estimates were collected on Bass Creek during the Fall of 1989 at the Charles Waters Memorial Campground. Two study sections were sampled, immediately upstream and downstream of the irrigation diversion structure in the campground. The two pass removal method was used due to the late season and fear of ice up before a recapture could be completed. The population estimate upstream of the diversion on a 550 ft long section was 56 cutthroat trout and 93 brook trout. Downstream of the diversion the population estimate on a 540 ft long section was 9 cutthroat trout and the brook trout estimate was invalid.

The population of both species was much lower downstream of the diversion, indicating that diversion activities are impacting the fishery.

We also electrofished within the ditch and captured 24 brook trout and 3 cutthroat trout in 275 feet of ditch, indicating that fish do swim into the diversion.

A fish screen device, consisting of a perforated pipe buried in the streambotton is being tested at this diversion and this data should serve as a baseline for the analysis of it's effectiveness.

Darby district

Trout population estimates were collected on Daly, Divide, North Rye, Rye, Sleeping Child (3) and Skalkaho Creeks on the Darby district (Figure 7). Sediment data was collected on all of these sections also.

Sleeping Child and Divide Creeks:

Study sections were established on 3 sections of Sleeping Child Creek and 1 section of Divide Creek (Figure 8). Sleeping Child site 04 lies upstream of the proposed White Stallion timber sale and site 02 is immediately downstream of the sale area. The Divide Creek section serves as a control site. The populations of westslope and bull trout in Sleeping Child and Divide Creeks compares well with other streams in the study (Figures 3,4). The streams support between 215 and 296 westslope cutthroat over 5" per acre of stream (Table 4). Overall the stream is characterized by a cobble gravel substrate, average amounts of woody debris, and average overhead cover. The W-V boxes collected more sediment than average when compared to the other streams in the study in all sections. McNeil hollow core samples were not collected at these sites.

Skalkaho Creek:

A study section was established just upstream of the confluence of Daly Creek (Figure 9). The lower end of the section is 0.75 road miles above the bridge crossing of Daly Creek. This section of stream supports an above average number of westslope cutthroat trout, particularly in the larger sizes over 8 inches (Figure 3). The bull trout population is also above average in this reach (Figure 4).

Skalkaho Creek is one of the larger streams studied to date and receives more fishing pressure than most of the study streams. The substrate is composed of more large material than the other streams and also has lower sediment measurements than the other streams. It has low amounts of woody debris in the channel, likely a result of the large amount of energy within the channel during high water periods. Overhead cover from the streambank is above average.

Daly Creek:

The study section on Daly Creek was established in 1984 when the stream was closed to fishing. It lies upstream of the confluence with Skalkaho Creek (Figure 9). The lower end of the study section is 0.65 miles road miles upstream of the bridge crossing of Daly Creek. Trout population estimates have been collected on this reach for several years and although the stream has been closed to fishing for several years, the trout population does not appear to have increased (Figure 10). This may be due to the fact that it was not overfished to begin with or that fishing has continued even though it was illegal. Signing of the closure was not easily evident and this may have caused confusion among fishermen. Fish with hookscars were evident during sampling,

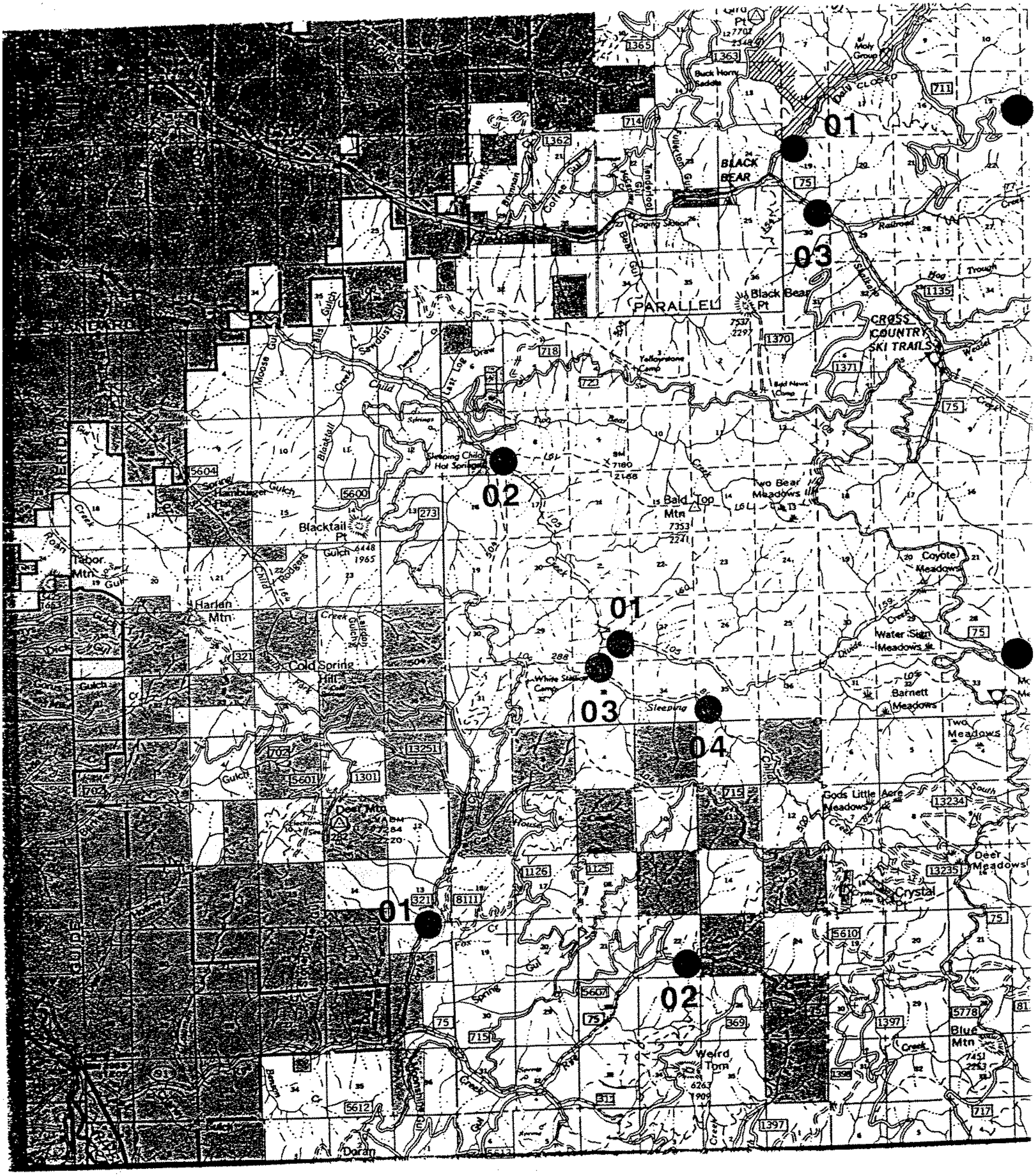


FIGURE 7 - Darby District Study Section Location Map.

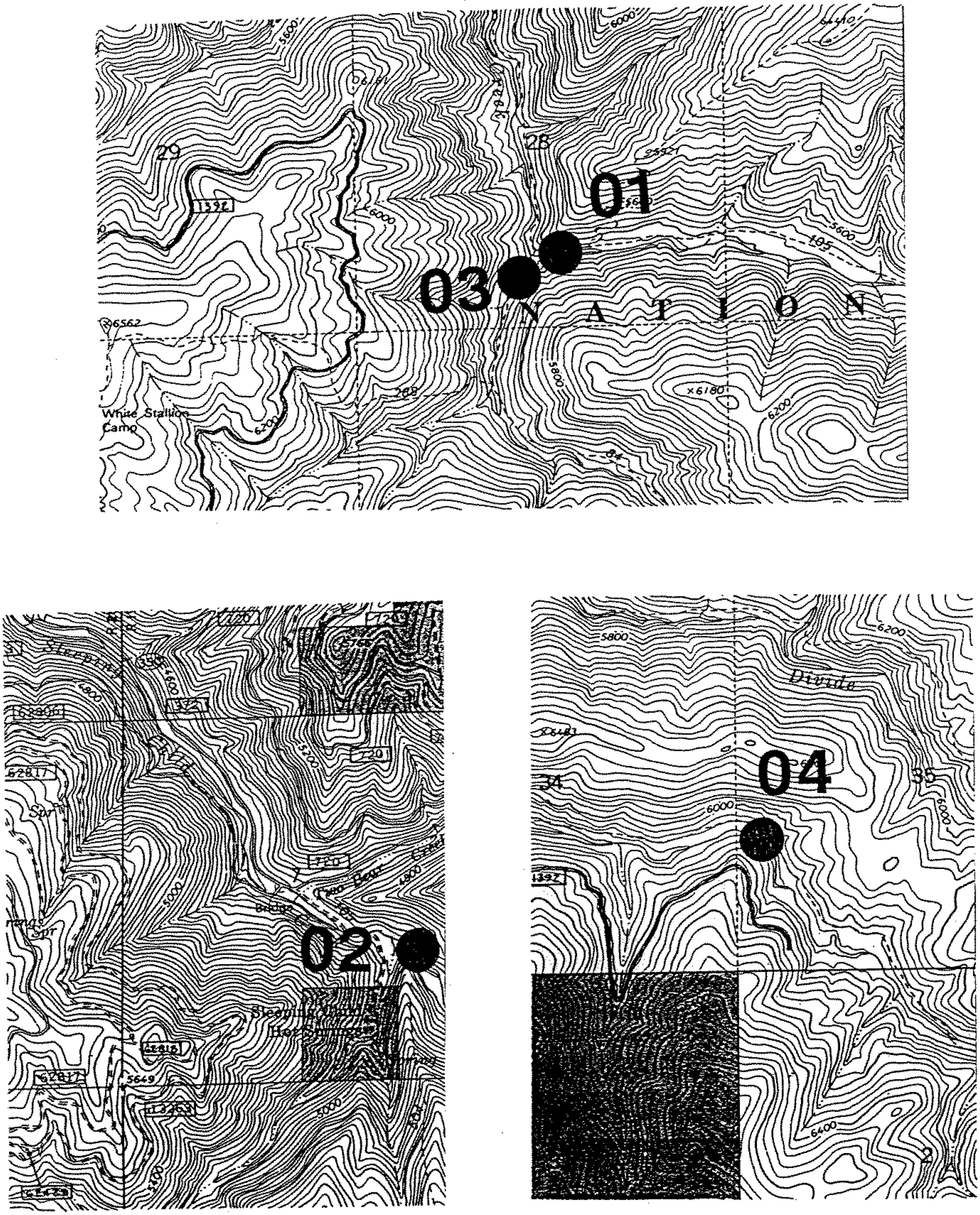
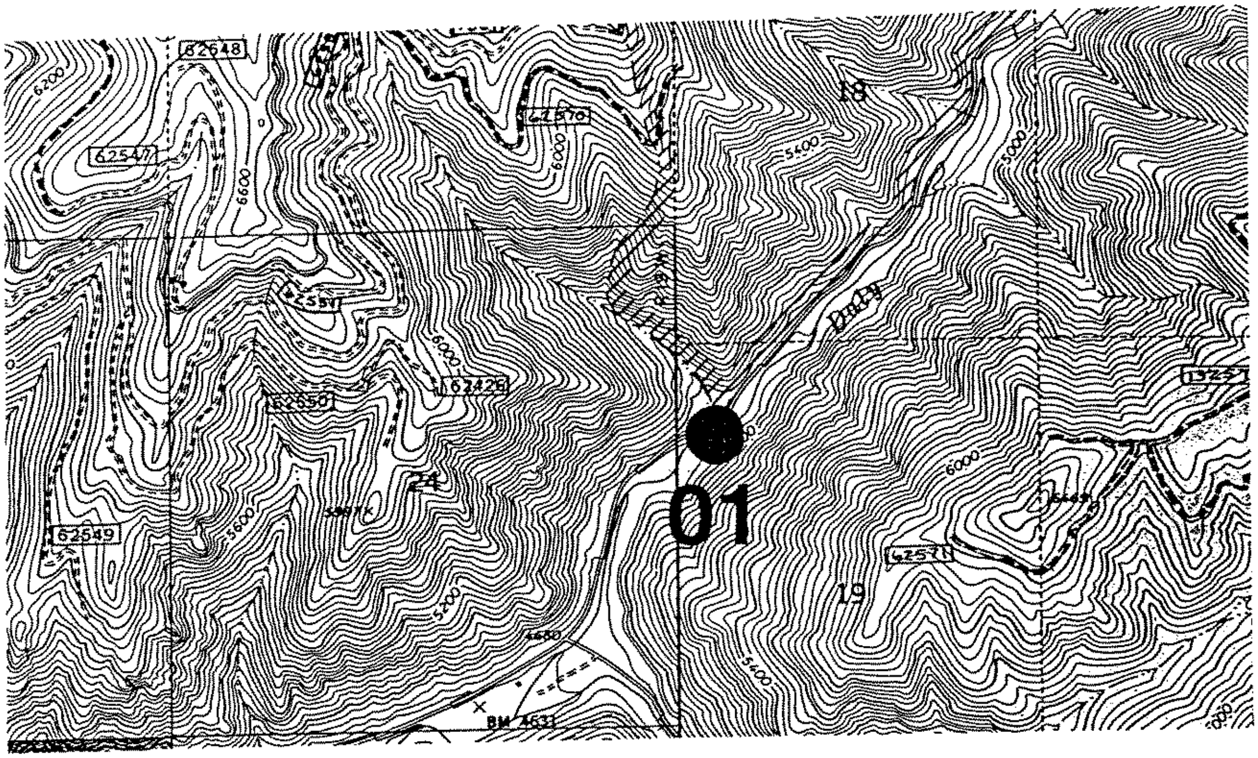


FIGURE 8 - Study Sections on Sleeping Child and Divide Creek.



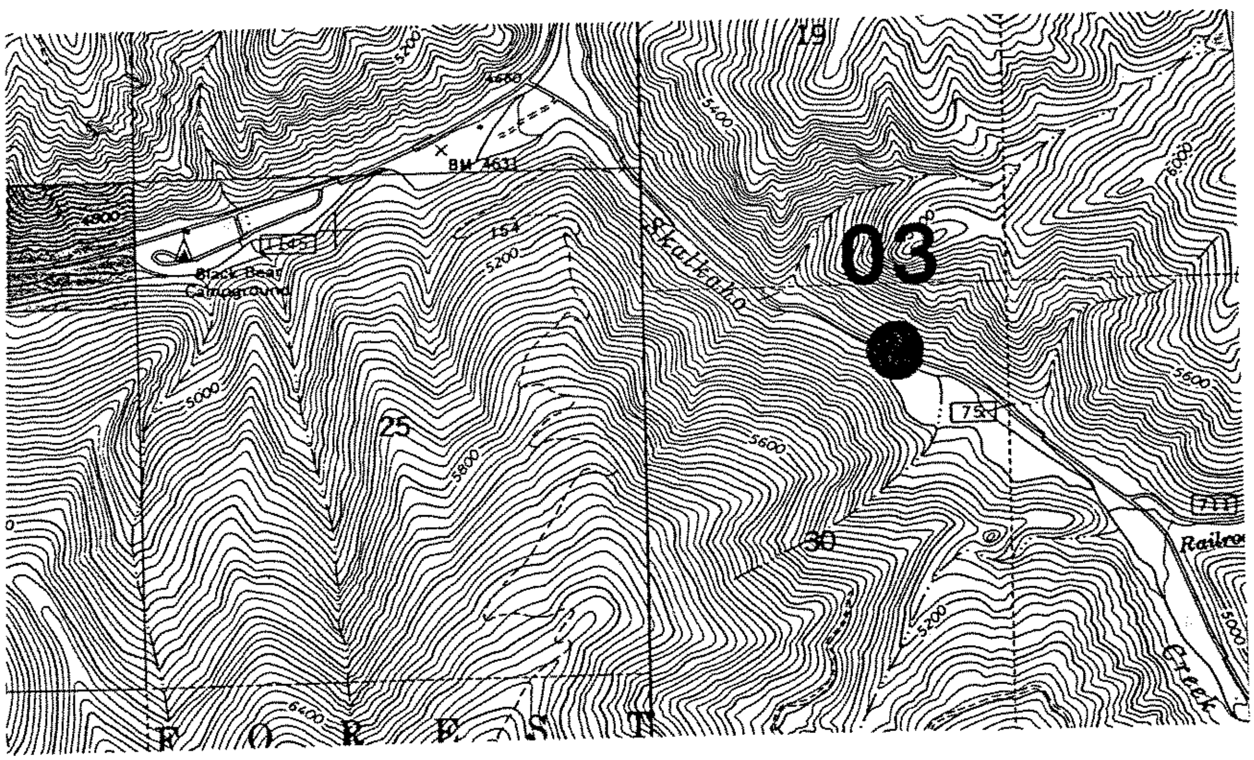


FIGURE 9 - Study Sections on Skalkaho and Daly Creeks.

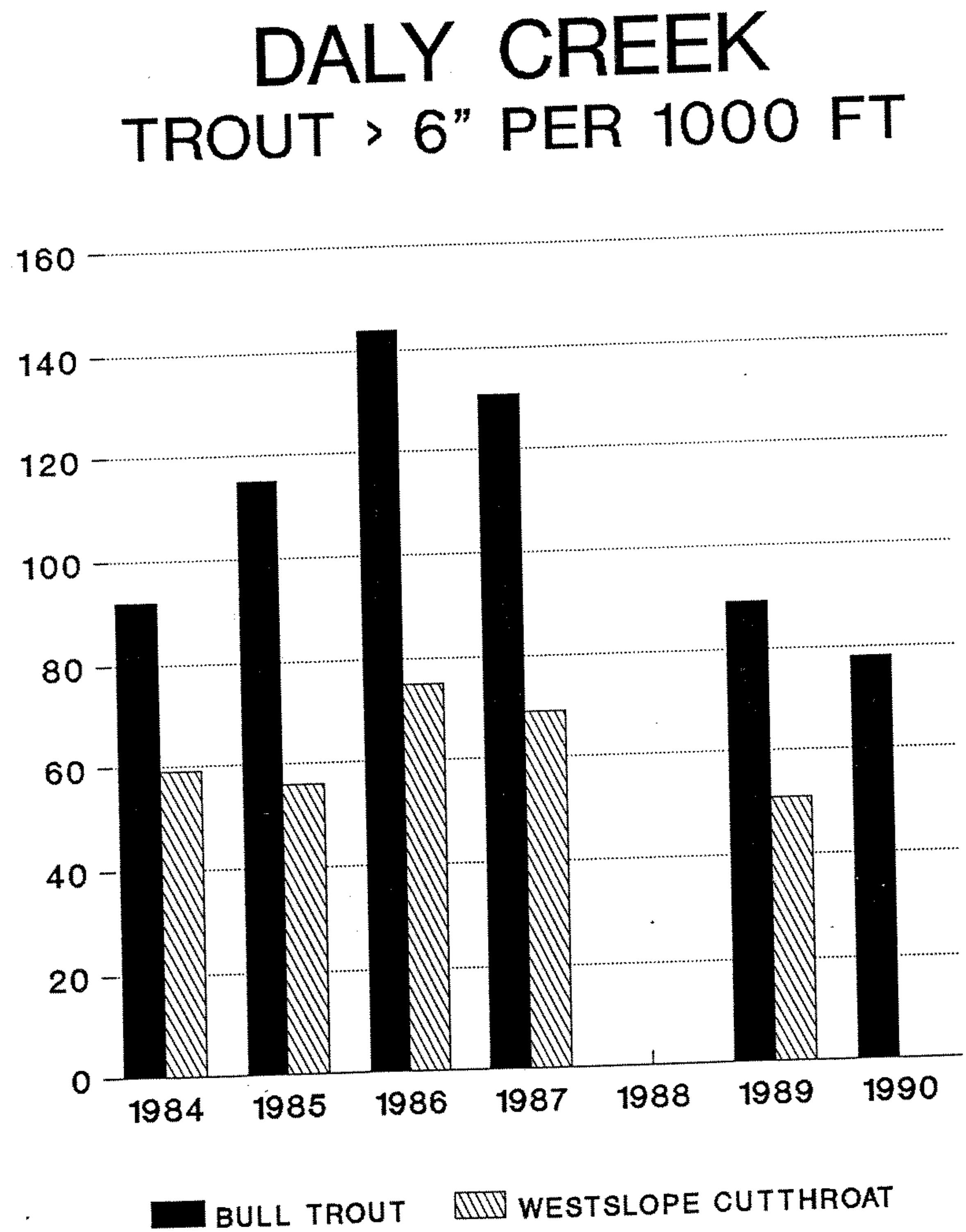


FIGURE 10 - Trout Population Estimates on Daly Creek during the years indicated.

indicating that fishing continued to some degree during the closure.

Daly Creek supports an average population of westslope cutthroat trout when compared to other study streams, although the average size tends to be large. The bull trout population in Daly Creek is the largest encountered to date on the Bitterroot National Forest (Figure 4).

Sediment measurements in Daly Creek conflict. The W-V boxes collected much higher than average amounts of sediment and the McNeil core samples had an average amount of sediment when compared to other streams in the study.

Rye Creek:

One section of Rye Creek was sampled during 1989 and 1990 (Figure 11). The lower boundary of the study section begins immediately upstream of the bridge crossing in Section 22. This section of stream supports an above average number of westslope cutthroat trout when compared to other study streams (Figure 3). Bull trout are present but in very small numbers.

The Rye Creek study section is characterized by very few pools and is small in size. It has larger amounts of woody debris present but less overhead cover. It tends to have higher sediment measurements than the other streams by most measures except the W-V boxes which have a lower measurement than the other streams.

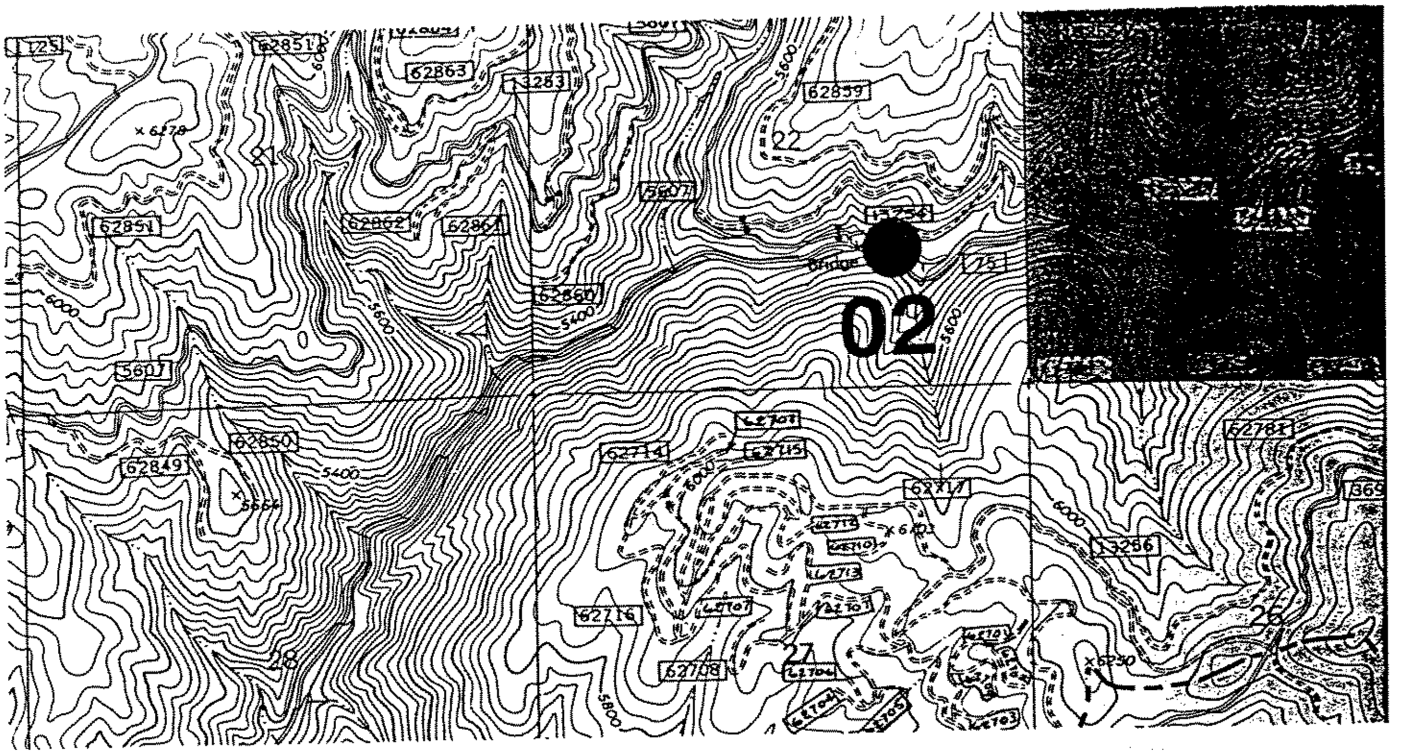
In 1985, Rye Creek downstream near the confluence with the North Fork supported a very high population of trout when compared to other Eastside streams (O'Dell, 1985). The population of trout is composed primarily of westslope cutthroat and rainbow trout hybrids, with lesser numbers of brook and brown trout and mountain whitefish in that reach.

North Rye Creek:

During 1989 and 1990 the North Fork of Rye Creek was sampled (Figure 11). The study section lower boundary is 1.7 road miles from the intersection of the North Fork road and the main Rye Creek road. The population estimates varied significantly between years, with 1990 supporting a higher population of westslope cutthroat than 1989. Brook trout are also present in the creek in lesser numbers than westslope cutthroat. The 1989 and 1990 population estimates were 10 and 50 brook trout longer than 5.0 inches per 1000 feet. The 1990 population estimate of brook trout is likely an overestimate as spawning brook trout were encountered during electrofishing, therefore, movement of fish was possible during the sampling period.

North Rye Creek is small when compared to the other streams and has a higher gradient likely the result of channelization caused by the road immediately adjacent to it. It carries little large woody debris, also likely a result of the road.

By all measures, North Rye Creek is carrying a higher sediment load than the average streams in the study.



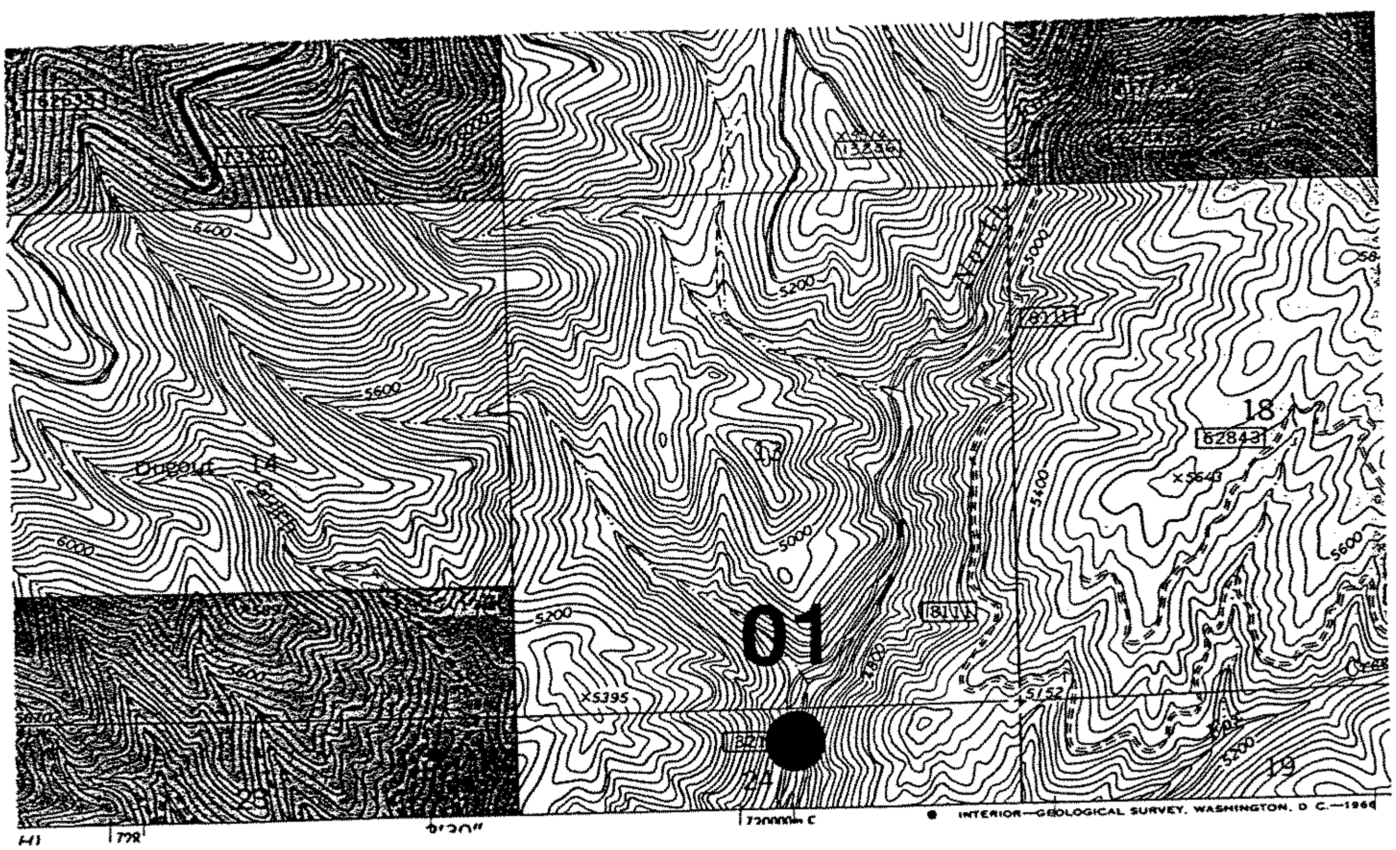


FIGURE 11 - Study Sections on North Rye and Rye Creeks.

Sula district

Trout population estimates were collected on Meadow (2), Reimel and Tolan Creeks (3) on the Sula district (Figure 12). Sediment data was collected on all of these sections.

Meadow Creek:

Two sections of Meadow Creek were sampled during 1989 and 1990 (Figure 13). Meadow Creek supports populations of westslope cutthroat and bull trout in the sections we sampled (Figures 3,4). Section 02 supports higher populations of both species than Section 03. Section 03 appears to have low numbers of fish less than 5.0 inches in length.

Previous information on Meadow Creek indicates that it supports higher numbers of fish than other streams in the area (O'dell 1985).

Meadow Creek is dominated by gravel and cobble substrate with very few boulders and larger materials. Sediment measurements indicate that the upper section (03) carries more fine sediment than the lower section (02). This may explain why the upper section has lower numbers of fish.

Both of the sections contain large amounts of large woody debris.

Tolan Creek:

Three sections of Tolan Creek were sampled during 1989 and 1990 (Figure 14). All three sections support westslope cutthroat in lower than average numbers when compared to other study stream. Section 01 contains brook trout and the two upstream sections support bull trout. In 1985 bull trout were found in Section 01 (Peters 1986). They were not present in 1990. Brook trout are probably replacing bull trout in the lower reaches of Tolan Creek.

At the present time we have been unable to obtain a population estimate for bull trout in section 01. The bull trout population that is present in section 02 is lower than other study streams.

Tolan Creek is characterized by cobble gravel substrates with few boulders or larger substrates. Visual estimates of fine materials in the substrate indicate that section 02 has very high amounts and sections 01 and 03 have lesser amounts. Hollow core samples were taken only at section 01 where % fines were high. The W-V boxes indicated an increasing trend in fines in a downstream direction, but all sections were lower in fines than the average stream in the study.

Woody debris occurrence in the stream varies by section. section 01 has very little, section 02 has very large amount and section 03 has yet to be measured, but it appears to be high.

Reimel Creek:

A population estimate was collected on Reimel Creek during 1990 in the meadow . The estimate on 6/12/90 was 82 westslope cutthroat and 47 brook trout over 5" per 1000 feet of stream.

The W-V box test on Reimel Creek indicate that a large portion

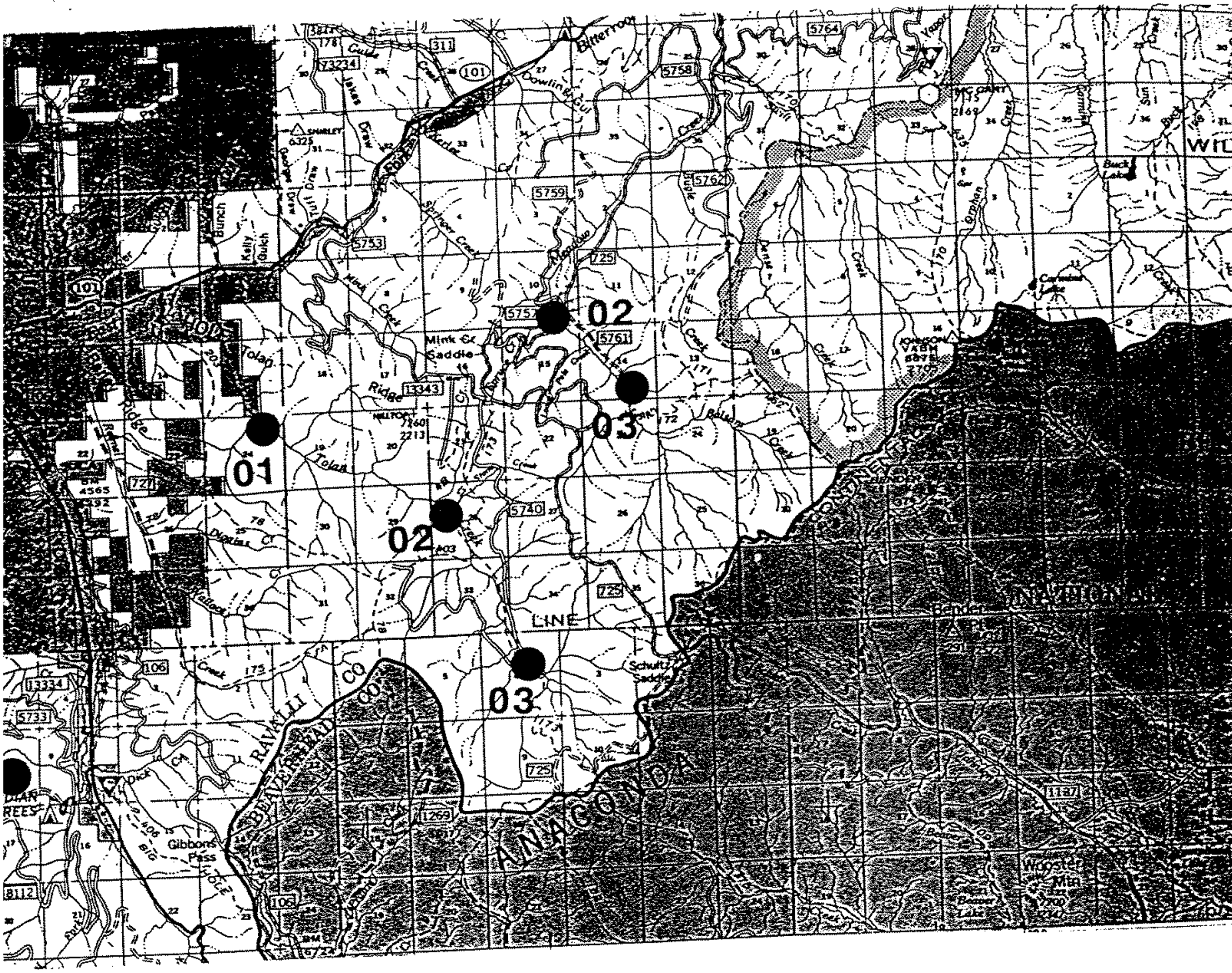


FIGURE 12 - Study Section Locations on Sula District.

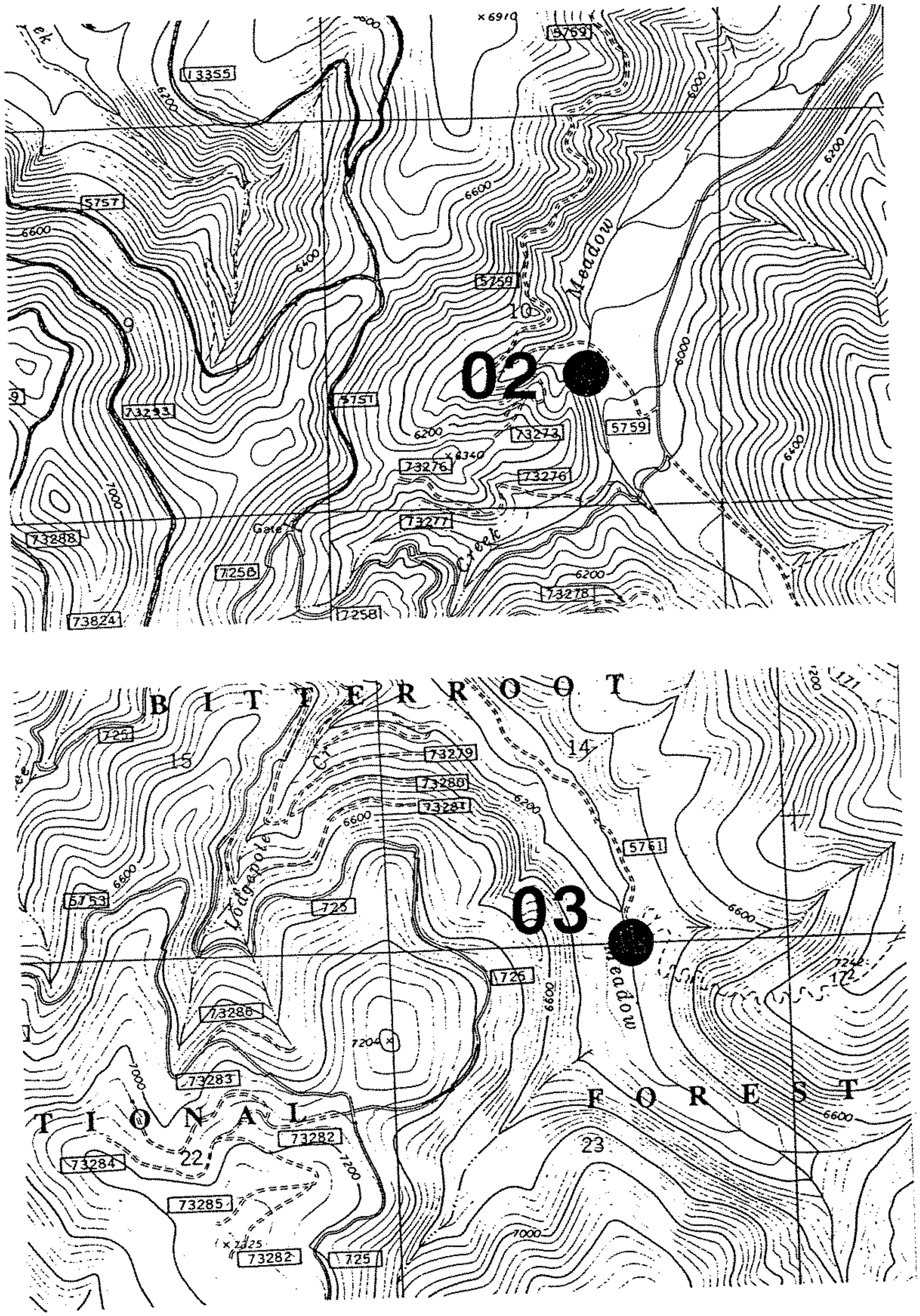


FIGURE 13 - Study Sections on Meadow Creek.

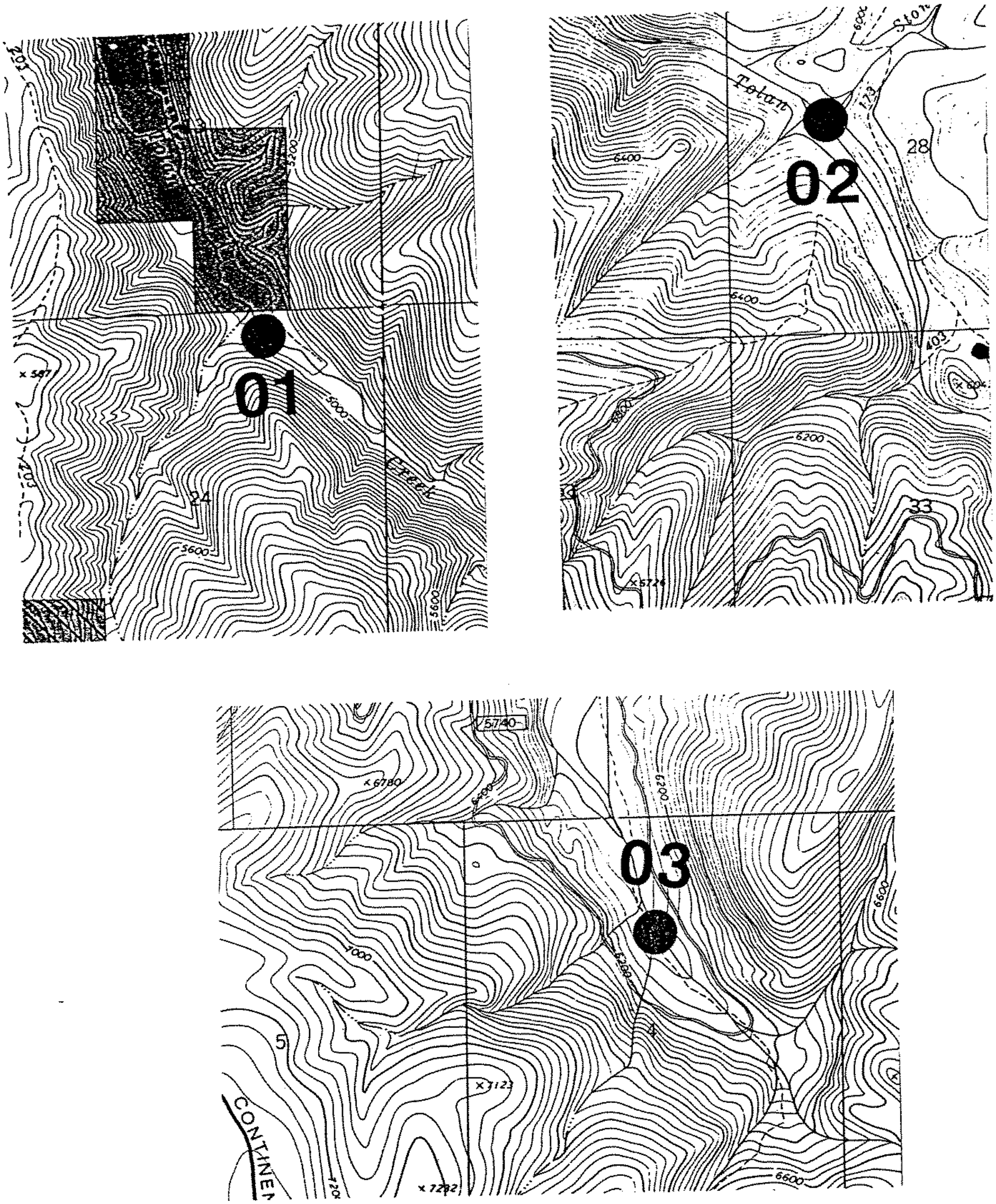


FIGURE 14 - Study Sections on Tolan Creek.

of the inorganic fines were collected in the boxes at the time of placement into the stream, but that significant amounts entered the boxes later during the incubation period (Figure 15). Since we were attempting to simulate cutthroat trout spawning behavior when the boxes were placed, it indicates that the eggs in the gravel probably must tolerate high amounts of sediment immediately upon being laid in the gravel. Late in the incubation period the amount of accumulating sediment decreased probably a result of decreased streamflow and bedload transport.

As the boxes were removed in two week intervals, they were immediately replaced and allowed to accumulate sediment until the end of the study period. At the date of the removal of the last column of boxes the other boxes that had been replaced were also removed and their contents analyzed. These modified samples indicate the same conditions as the original samples, that the sediment accumulated mostly in the early time period and declined later in the summer (Figure 15).

West Fork district

No streams on the West Fork District have been sampled as part of this study. We will likely begin sampling during 1991 on a limited number of streams on the District and begin a much larger program by 1992. The streams we have identified in this report will be sampled for 3 consecutive years which will end in 1991. After that we will most likely begin work on a different set of streams which will include West Fork district streams.

TROUT-HABITAT RELATIONSHIPS

This data will be included in a later report.

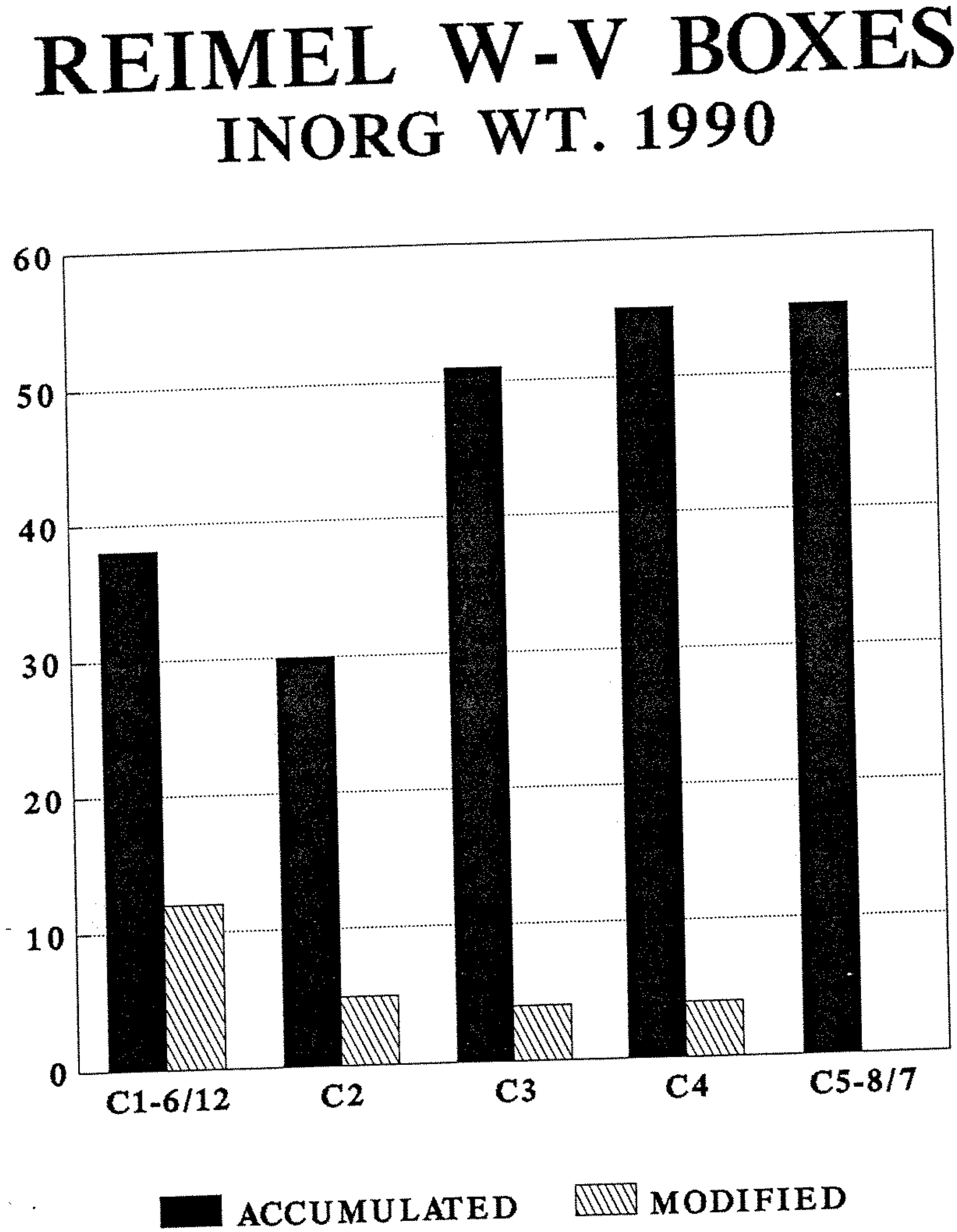


FIGURE 15 - Accumulated Sediment in Reimel Creek.

Table 4. Average number (lbs. in parenthesis) of westslope cutthroat, bull trout and brook trout, over 5 inches, per acre in the study sections during 1989 and 1990.

Stream	westslope cutthroat	bull trout	brook trout
Daly	115 (26)	203 (30)	0
Divide	215 (27)	*	0
Gold	147 (14)	65 (4)	0
Meadow 01	350 (39)	167 (17)	0
Meadow 02	98 (22)	22 ( )	0
N. Rye	384 (45)	0	143 (13)
Rye	431 (31)	**	0
Skalkaho	276 (47)	124 (20)	0
SlChild01	219 (30)	32 (4)	**
SlChild02	247 (32)	67 (6)	0
SlChild03	296 (29)	22 (2)	0
Tolan 01	235 (25)	0	106 (9)
Tolan 02	165 (18)	63 (3)	0
Tolan 03	97 (7)	*	0
Average	234 (28)	70 (8)	125 (11)

*present in significant numbers but population estimates are not valid
**present but in very small numbers

Table 5. Physical habitat variables for the sections of the study streams. Elevation, channel width and wet width are in feet, average depth and thalweg depth are in inches, and gradient, pools and riffle are in percent.

Stream	Elev	Grad	Chanwid	Wetwid	Pool	Rif	Avdep	Thaldep
Daly Cr.	4750	1.5	37	27	16	8	11	18
Divide Cr.	5280	2.3	26	20	18	27	10	14
Gold Cr.	4920	2.8	11	10	16	28	8	11
Meadow 01	5925	2.2	23	15	18	25	7	11
Meadow 02	6200	2.6	20	14	24	15	7	11
N. Rye	4520	3.9	13	9	17	14	6	9
Rye Cr.	5325	3.1	14	10	4	39	5	8
Skalkaho03	4755	1.0	32	25	13	15	11	16
Sl Ch 01	4530		30	22	16	32	9	15
Sl Ch 02	5280	2.7	26	19	3	9	8	13
Sl Ch 03	5840	1.3	23	18	27	17	10	15
Tolan 01	4875	3.6	16	14	3	44	6	10
Tolan 02	5680	1.7	19	14	31	36	8	12
Tolan 03	6070	3.4	17	13	18	59	7	10
Average	5282	2.5	22	16	19	26	8	12

Table 6. Streambottom substrate variables in the study streams.

Stream	Ocfines*	%Boulders	Score**	Core***	WV****
Daly	14	28	17	44	316
Divide	36	19	14		273
Gold	34	3	13	50	176
Meadow 01	24	9	12	39	160
Meadow 02	31	10	14	48	198
N.Rye	39	21	12	51	251
Rye	53	6	11	52	228
Skalkaho	16	23	15	38	184
SlChild 01	24	18	15		407
SlChild 02	22	36	16		254
SlChild 03	41	12	13		295
Tolan 01	27	12	13	45	172
Tolan 02	56	1	11		138
Tolan 03	20	2	14		97
Average	31	14	14	46	225

* A visual measure of all material < 1/4" in diameter expressed as a percent of total streambottom

** A calculated score based on the size of particles on the streambottom. Smaller numbers indicate more fine material, larger numbers indicate larger cobbles and boulders

*** A measured percentage by weight of material <1/4" in diameter in McNeil hollow core samples. Five samples were taken on listed streams except Gold Creek where 3 samples were taken.

**** Average weight of inorganic fine material collected in W-V boxes that were judged to be effective sets.

Table 7. Overhead cover and woody debris measurements in the study sections. All Measurements are in feet unless otherwise noted.

Stream	LowOh	HiOh	Underlen	Instco(%)	MedLargeWDeb
Daly	1.6	2.9	360	22	734
Divide	2.5	4.1	367	37	1399
Gold	0.7	2.1	676	21	518
Meadow 01	-	-	671	32	2141
Meadow 02	1.7	2.6	863	27	3592
N. Rye	1.6	2.9	267	18	570
Rye	1.2	2.4	382	19	1620
Skalkaho	2.5	4.4	388	22	465
SlChld01	2.4	3.2	343	27	788
SlChld02	1.5	2.6	99	25	644
SlChld03	1.2	2.4	530	38	761
Tolan 01	1.3	2.0	110	23	270
Tolan 02	3.3	3.7	794	24	2794
Tolan 03	-	-	536	31	-
Average	1.8	2.9	456	26	1253

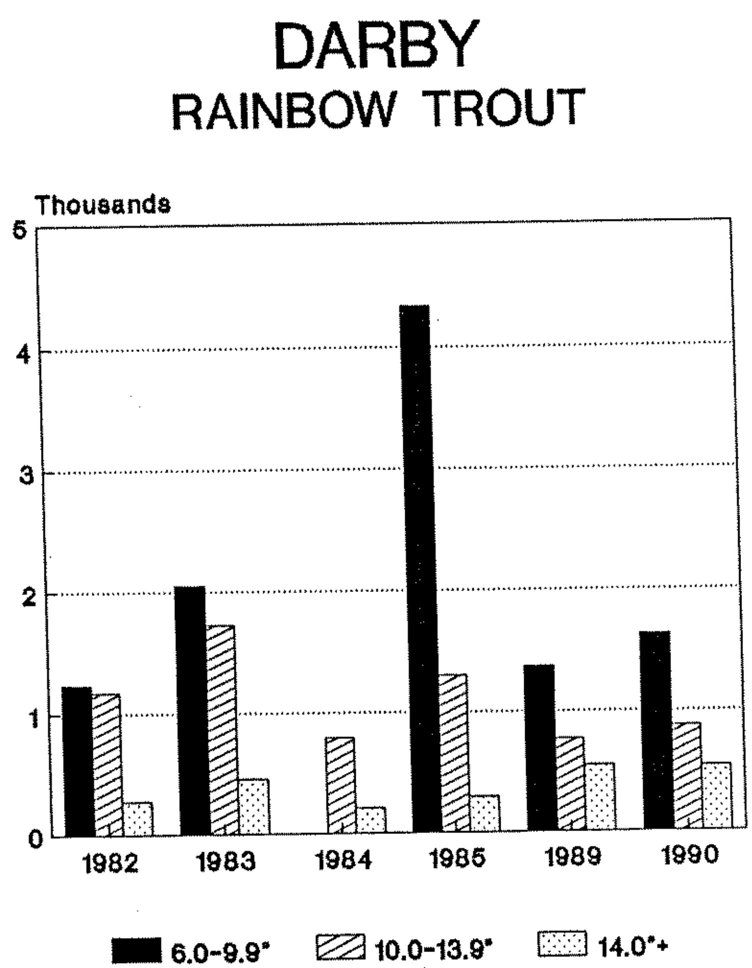
Bitterroot River Fish Populations

During the past two years, trout population estimates have been collected on four study sections (Figure 2). The Darby and Hannon Memorial study sections were analyzed to assess the impacts of different fishing regulations on the trout populations. The Bell Crossing and Stevensville sections were analyzed to assess the effects of dewatering on the trout populations, although this comparison is confounded by differing fishing regulations on these sections.

The Darby section has been under a restrictive limit since 1982. The limit is 5 fish of which 4 may be under 12 inches and 1 over 20 inches or all five may be under 12 inches. Also, only artificial flies and lures may be used. The regulation protects all fish between 12 and 20 inches. The population of both brown and rainbow trout over 14" has increased since the regulation took effect (Figure 16). While this data would indicate that the regulation may be having a positive impact, the streamflows in this section have also changed since the regulation took effect. Beginning in 1983, approximately 15000 acre-feet of water has been released annually into the Bitterroot River system at Painted Rocks Reservoir. The water supplements the flows in the Bitterroot River during midsummer. Since the fishing regulations and streamflows changed at nearly the same time, assessing the impacts of each on the fish population is difficult. For this reason, a study section immediately adjacent to the Darby section was selected for comparison. The Hannon section is similar in nature and flow regime to the Darby section and should be comparable to the Darby section. The Hannon section has remained under the standard 5 fish limit, with the use of natural baits allowed. During 1989 and 1990, brown trout populations have been higher on the Darby section (Figure 17). The 1989 data indicates that rainbow trout are also more numerous on the Darby section, but the 1990 data indicates the opposite. I feel that the 1990 rainbow trout population estimate at Hannon is not valid, as our recapture percentage was very small, indicating a sampling problem. The 1989 comparison is probably the only valid comparison for rainbow trout.

The results of the data from the Darby and Hannon sections indicate that the restrictive regulations have been moderately effective in protecting larger rainbow and brown trout.

The Bell Crossing and Stevensville sections have also been sampled during 1989 and 1990. Bell Crossing is within the area of river that is described as critically dewatered (Spoon 1987). The Stevensville section lies downstream of this reach below several irrigation returns which replenish the streamflows to some degree. Another difference between the two sections is the fishing regulations. Similar to the Darby section, the Stevensville section has been under the slot limit and an artificial fly and lure



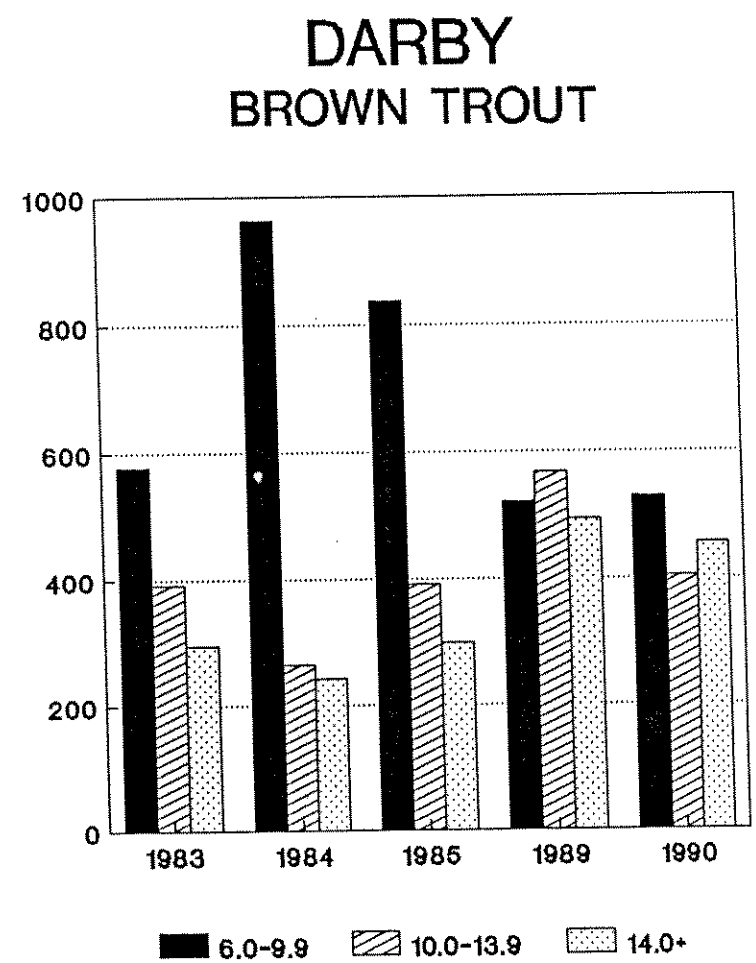
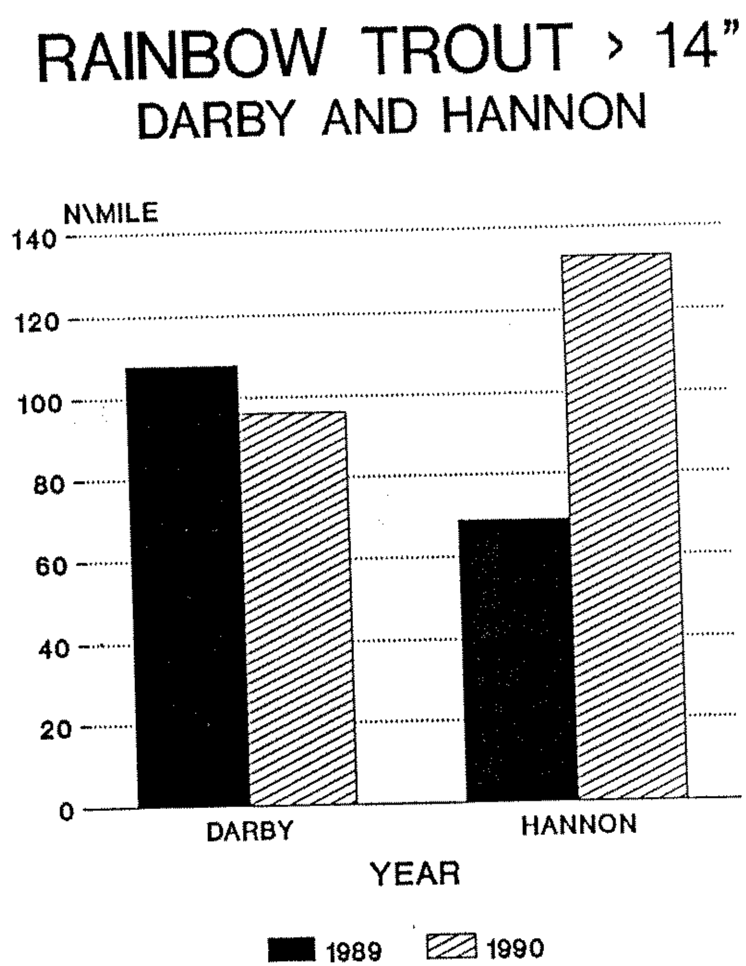


FIGURE 16 - Trout Populations on the Darby Section during the years indicated.



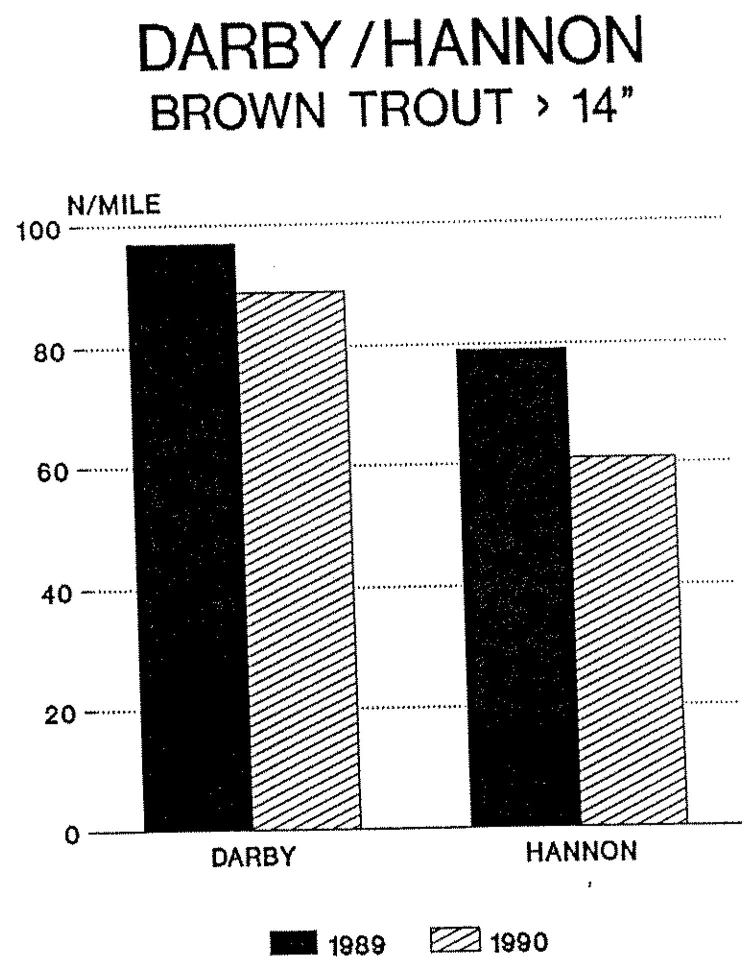


FIGURE 17 - Trout Population Estimates on the Darby and Hannon Sections of the Bitterroot River.

regulation since 1982. The Bell Crossing section has been under the standard 5-fish limit without bait restrictions.

The Stevensville section supports higher numbers of rainbow trout than the Bell Crossing section (Figure 18). While fishing regulations are more restrictive in the Stevensville section and may be contributing to the difference, the Bell Crossing section supports low numbers of yearling rainbow trout (Figure 19, data from Spoon 1987). This lack of young fish is probably responsible for the low population numbers of larger rainbow trout in the Bell Crossing section.

Brown trout were more numerous on the Bell Crossing section than Stevensville section during 1989. This is not well understood, although it appears to fit into a pattern of declining brown trout numbers in a downstream direction.

Bitterroot River tributaries

In an attempt to better understand the early life history of rainbow trout in the Bitterroot drainage, a study to assess the relative importance of Bitterroot River tributaries to the mainstem was initiated. During March, April and May of 1990 and 1991, we walked the lower 1 mile of 12 tributaries of the Bitterroot River once a week (Table 1). Kootenai, Big, Sweathouse, Mill and Tincup Creeks supported the highest number of redds of the streams studied (Figure 20). Skalkaho Creek supported a few redds but none were found in Tolan Creek. Spawning was initiated in early March, peaked in mid-April in most streams, and was generally tapering off by mid May.

Spawning in higher elevation streams such as Tincup and Fern Creek was later than in the other streams. Big and Kootenai Creeks have been documented as important spawning tributaries previously (Good et al 1984). They also found that Rye Creek supports very little rainbow trout spawning and in Sleeping Child Creek none was documented.

Once the spawning ended, incubation of the eggs takes place. Emergence and downstream drift of young-of-year (YOY) rainbow trout began in late June and most was completed by mid-July. Enumeration of drifting YOY is difficult. Three methods were used to attempt to derive the overall numbers of YOY drifting out of each tributary (Table 8). Confidence in these figures in not high.

The drift of YOY was almost entirely at night. Trapsets during the daylight period did not tend to result in capture of any YOY. On the evening of 7/11 traps were checked every hour between 2100 and 0700 on 7/12 on Big and North Bear Creeks. The drift patterns of YOY was similar between the two streams (Figure 21). Little drift occurred until 2300 and most of it occurred between 2400 and 0200. The night was moonlit and once the moon had risen, downstream drift declined.

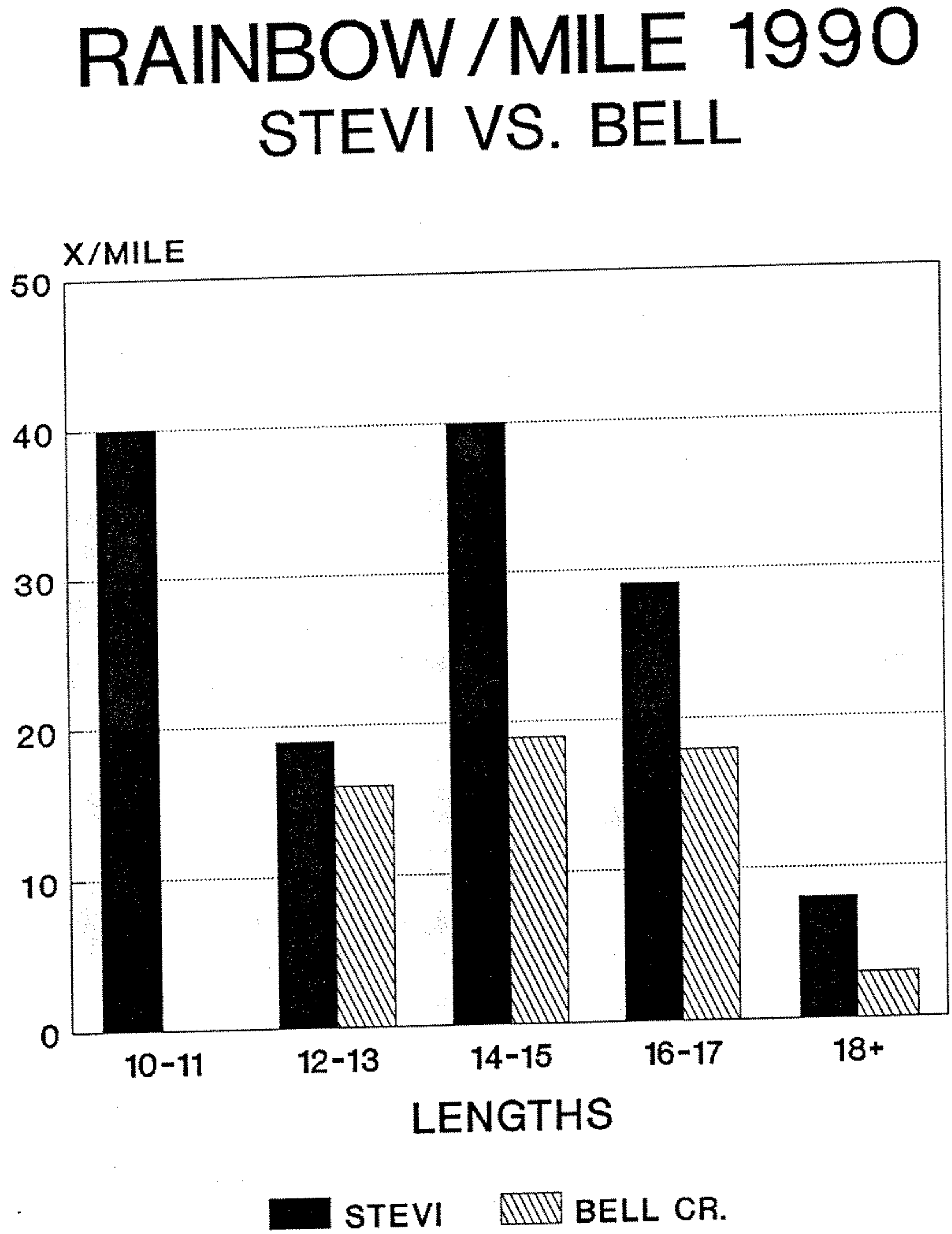


FIGURE 18 - Rainbow Trout Populations on the Stevensville and Bell Crossing Sections.

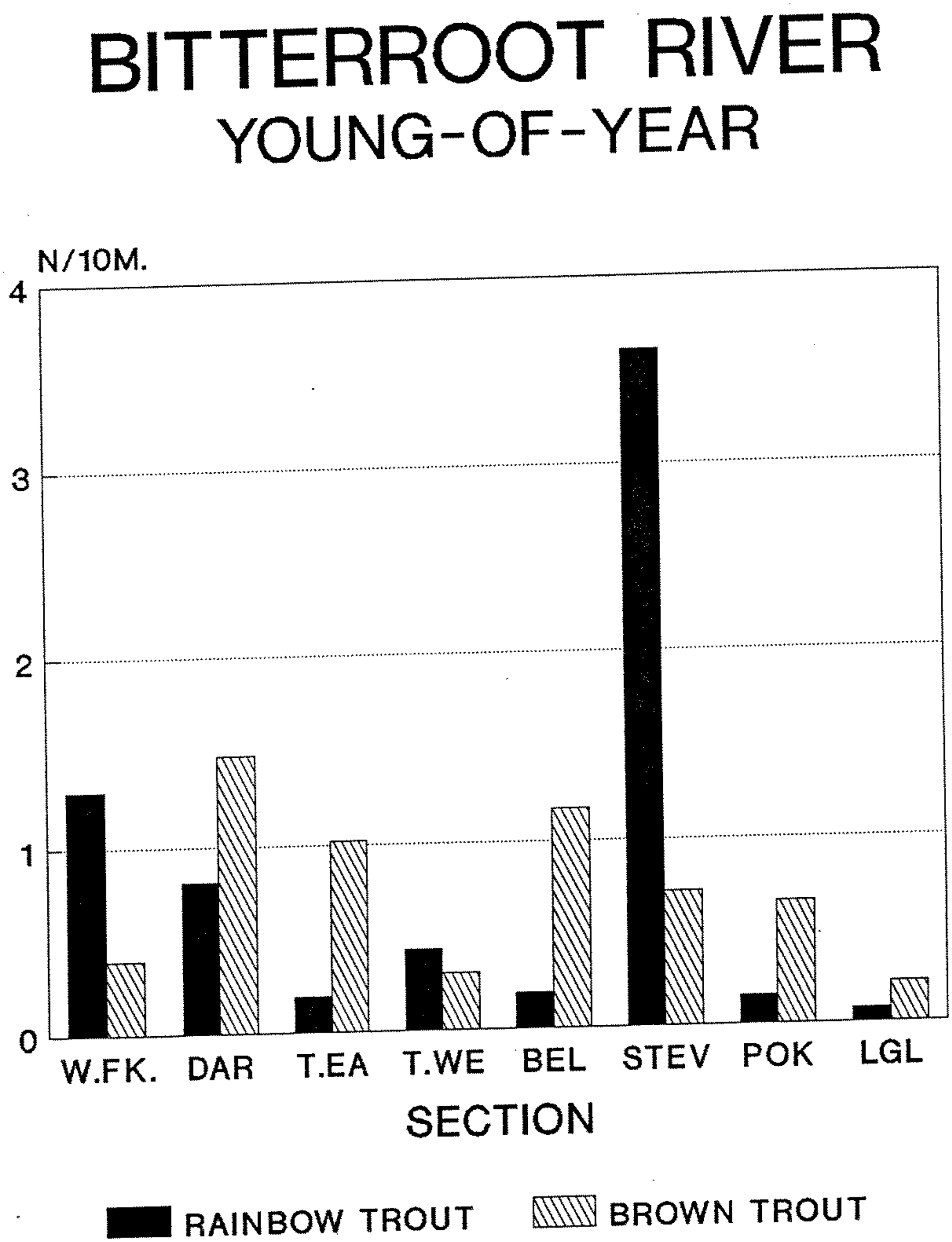


FIGURE 19 - Young of the Year Electrofishing Index in various sections of the Bitterroot River during 1984. (Data from Spoon 1987)

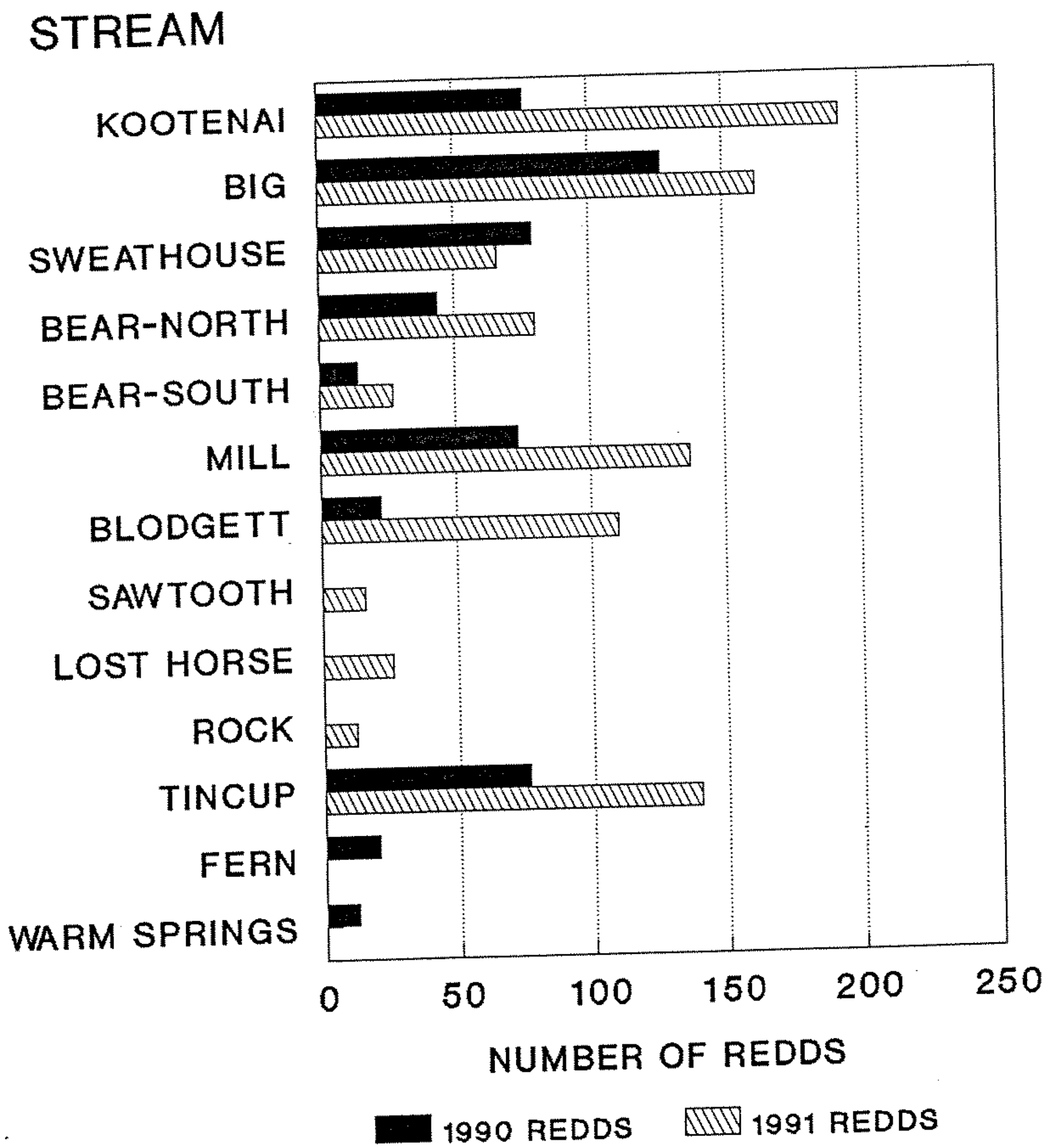


FIGURE 20 - Rainbow Trout Redds in reaches of streams during 1990 and 1991.

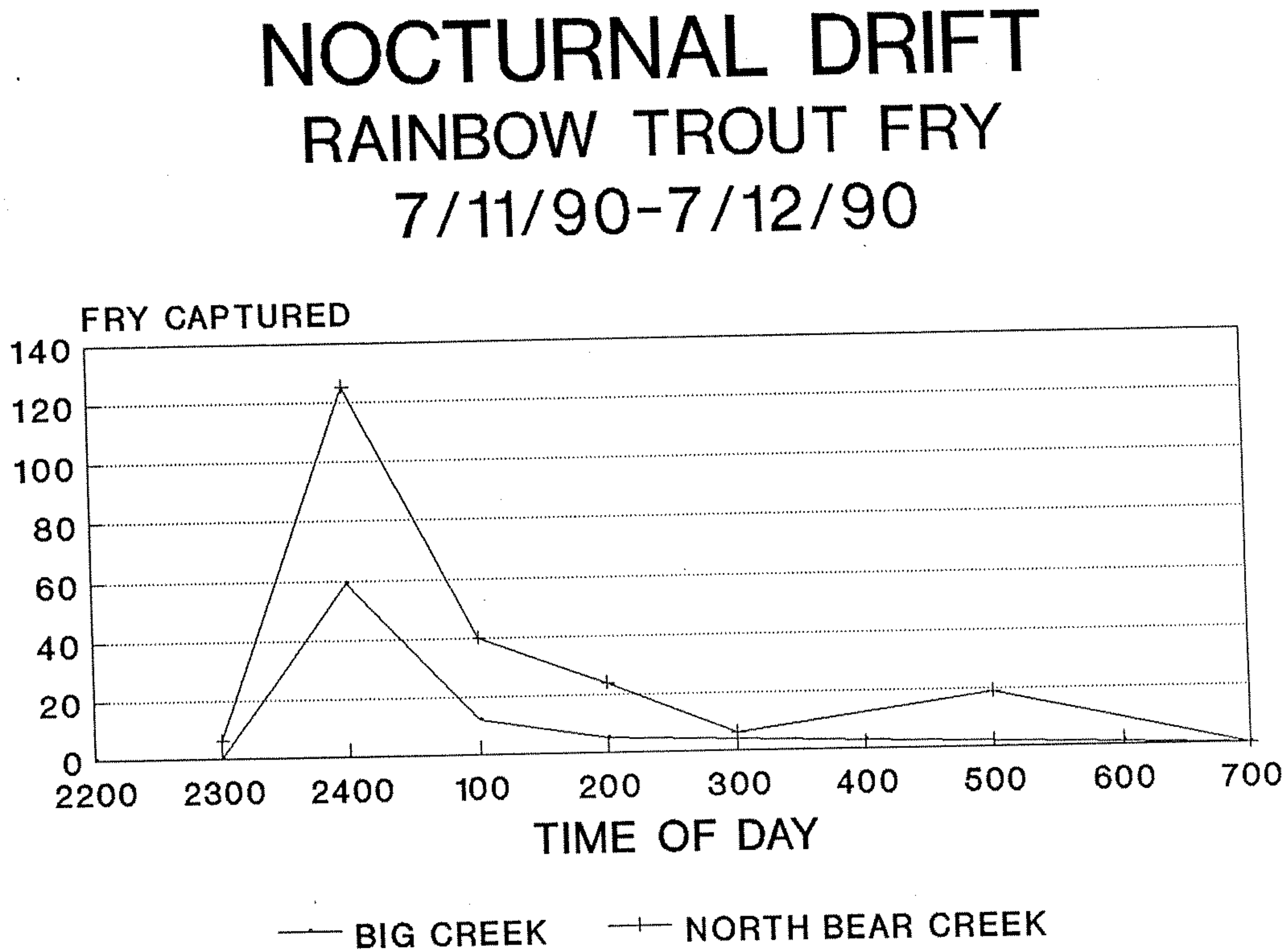


FIGURE 21 - Overnight drift of Rainbow Trout Fry in Big Creek and North Bear Creek during July 1990.

Table 8. Efficiency of traps using three different methods of assessment and the resulting estimate of drifting rainbow trout fry based on an average of the three methods, the number of trap nights and the number of fry captured per night*.

	Efficiencies (%)				
Stream	Float	Discharge	Fry dye	Average	Estimated number
Kootenai	7	9	6	7	13702
Big	9	11	10	10	6825
Sweathouse	7	20	-	14	468
North Bear	23	20	7	17	8538
South Bear	3	21	17	14	4822
Mill	13	14	-	14	522
Blodgett	14	13	-	14	3152
Tincup	-	-	-	14**	8821
Fern	-	-	-	17**	453

*These estimates are not statistically valid. They are strictly for comparison purposes and should be considered best guesses and not absolute figures.

**No efficiency tests were made on Tincup and Fern Creeks. The efficiencies were estimates based on experience from the other streams. Very few nights of trapping data are available for calculating these estimates.

Kootenai is a very important spawning tributary of the Bitterroot River for rainbow trout. It was still producing a large number of fry when the trap was removed. Tincup, North Bear, Big, South Bear and Blodgett Creeks also contribute large numbers of recruitment to the Bitterroot River. Sweathouse and Mill Creeks both supported large numbers of redds but we did not capture large numbers of YOY rainbow trout in either of them. It is unclear why more fish were not captured in these streams. A linear simple regression was run between the number of redds counted in these streams and the estimated YOY that were produced by these streams and it was not a significant relationship (r =7.9). The redd counts are probably fairly consistent between streams but the estimates of YOY numbers could be inaccurate. Compounding the inaccuracy of the YOY estimates with biological factors that may affect survival to the swimup stage makes a relationship between redd numbers and fry numbers difficult to assess.

Loss of YOY trout is considered to be a major problem in the Bitterroot River (Spoon 1987). Dewatering of the mainstem by irrigation withdrawals is suspected as a problem for survival of young trout in the River. South Bear, North Bear, Sweathouse, and

Big Creeks all contribute large numbers of YOY rainbow trout to the dewatered section of the Bitterroot River, yet adult populations in the Bell Crossing area are very low. Additional data collection is necessary to understand this relationship. Also, understanding the effect of irrigation withdrawals within the tributaries and the resultant loss of young trout is necessary.

LITERATURE CITED

Alexander, G.R. and E.A. Hansen. 1983. Sand sediment in a Michigan trout stream, Part II. Effects of reducing sand bedload on a trout population. N. Am. J. Fish. Mgmt. 3:365-372.

Alexander, G.R. and E.A. Hansen. 1986. Sand bed load in a brook trout stream. North American Journal of Fisheries Management 6(1):9-23.

American Fisheries Society, Western Division. 1985. Glossary of Stream Habitat Terms. Habitat Inventory Committee, William T. Helms, Editor.

Bianchi, D.R. 1963. The effects of sedimentation on egg survival of rainbow trout and cutthroat trout. M.S. thesis, Montana State University, Bozeman.

Bilby,R.E., K. Sullivan, and S.H. Duncan. 1989. The generation and fate of road-surface sediment in forested watersheds in southwestern Washington. Forest Science 35:453-468.

Bjornn, T.C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, stream flow, cover, and population density. Trans. Am. Fish. Soc. 100(3):423-438.

Burns, J.W. 1972. Some effects of logging and associated road construction on northern California streams. Trans. Am. Fish. Soc. 101(1):1-17.

Burroughs, E.R. and J.G. King. 1989. Reduction of soil erosion on forest roads. USDA Forest Service. Intermountain Research Station Technical Report INT-264. Ogden.

Cardinal, P.J. Habitat and juvenile salmonid population in streams in logged and unlogged areas of southeastern Alaska. M.S. thesis, Montana State University, Bozeman.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Trans. Am. Fish. Soc. 117:1-21.

Chapman, D.W. and K.P. Mcleod. 1987. Development of criteria for fine sediment in the northern rockies ecoregion. U.S. EPA. Final Report EPA910/9-87-162.

Crouse, M.R., C.A. Callahan, K.W. Malueg, and S.E. Dominguez. 1981. Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Trans. Am. Fish. Soc. 110:281-286.

Dolloff, C.A. 1986. Effects of stream cleaning on juvenile coho salmon and Dolly Varden in southeast Alaska. Tran. Am. Fish. Soc. 115:743-755.

Duncan, S.H. and J.W. Ward. 1985. The influence of watershed geology and forest roads on the composition of salmon spawning gravel. Northwest Science 59(3):204-212.

Everest, F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1986. Fine sediment and salmonid production--a paradox. 1987. Pages 98-142 in E. Salo and T. Cundy, editors. Streamside management and forestry and fishery interactions, University of Washington, College of Forest Resources, Contribution 57, Seattle.

Elliott, S.T. 1986. Reduction of a Dolly Varden population and macrobenthos after removal of logging debris. Trans. Am. Fish. Soc. 115:392-400.

Garn, H.S. and R.C. Malmgren. 1973. Soil and water resources of the Bitterroot National Forest, Montana. Part I. USDA Forest Service. Bitterroot National Forest.

Good, W., C. Kronberg, and D. O'dell. 1984. Bitterroot tributary study, phases 1, 2 and 3. Trout Unlimited, Hamilton, MT.

Good, W.R. 1985. Bitterroot tributary study, phase 4. Trout Unlimited, Hamilton, MT.

Harvey, G.W. 1989. Technical review of sediment criteria. Idaho Department of Health and Welfare, Water Quality Bureau. Boise.

Heifetz, J., M.L. Murphy, and K.V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaska streams. North American Journal of Fisheries Management 6(1):52-58.

Hoth, D. 1979. Summary: Magruder corridor intragravel environment. USDA Forest Service, Bitterroot National Forest, final report. Hamilton.

Irving, J.S. and T.C. Bjornn. 1984. Effects of substrate size composition on survival of kokanee and cutthroat and rainbow trout embryos. Completion Report. Idaho Cooperative Fishery Research Unit. University of Idaho, Moscow.

Johnson, S.W., J. Heifetz, and K.V. Koski. 1986. Effects of logging on the abundance and seasonal distribution of juvenile steelhead in some southeastern Alaska Streams. North American Journal of Fisheries Management 6(4):532-537.

Klamt, R.R. 1976. The effects of coarse granitic sediment on the distribution and abundance of salmonids in the central Idaho batholith. M.S. thesis. University of Idaho. Moscow.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1983. Consistently high meristic counts in natural hybrids between brook trout and bull trout. Systematic Zoology 32(4):369-376.

Lestelle, L.C. 1978. The effects of forest debris removal on a population of resident cutthroat trout in a small headwater stream. M.S. thesis, University of Washington, ??????

Levinski, C.L. 1986. Technical Assessment of alternative techniques for evaluating the impacts of stream sedimentation of fish habitat. Idaho Dept. of Health and Welfare, Water Quality Bureau Report. Boise.

Lisle, T.E. 1986. Effects of woody debris on anadromous salmonid habitat, Prince of Wales Island, Southeast Alaska. North American Journal of Fisheries Management 6(4):538-550.

Lotspeich, F.B. and F.H. Everest. 1981. A new method for reporting and interpreting textural composition of spawning gravel. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station Research Note PNW-369. Corvallis.

Marston, R.A. 1982. The geomorphic significance of log steps in forest streams. Annals of the Association of American Geographers 72(1):99-108.

Martinez, A.M. 1984. Identification of brook, brown, rainbow and cutthroat trout larvae. Trans. Am. Fish. Soc. 113:252-259.

Mcneil, W.J. and W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. U.S. Fish and Wildlife Service Spec. Sci. Rep.--Fish. 469.

Megahan, W.F. and W.J Kidd. 1972. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. Journal of Forestry March 1972:136-141.

Michael, J.H. 1983. Contribution of cutthroat trout in headwater streams to the sea-run population. California Fish and Game 69(2):68-76.

Moring, J.R. 1982. Decrease in stream gravel permeability after clear cut logging: an indication of intragravel conditions for developing salmonid eggs and alevins. Hydrobiologia 88:295-298.

Munther, G. 1986. Aquatic environment and fisheries habitat 1986 monitoring report. Bitterroot, Deerlodge and Lolo National Forests. Missoula

Odell, D. 1985. A fishery study of potential hydropower sites on Bitterroot River tributary streams. National Trout Unlimited, Trout and Salmon Foundation, Montana Dept. of Fish, Wildlife and Parks, Anglers Afloat Guide Service, Al Engle, Bitterroot Chapter of Trout Unlimited.

Peters, D. 1987. Second year evaluation of sediment and fish populations in selected tributaries in Rock Creek and the Bitterroot River drainage. Montana Dept. of Fish, Wildlife and Parks, Missoula.

Peters, D. 1988. Third year evaluation of sediment and fish populations in selected tributaries in Rock Creek and the Bitterroot River drainage. Montana Dept. of Fish, Wildlife and Parks, Missoula.

Peterson, N.P. and C.J. Cederholm. 1984. A comparison of the removal and mark-recapture methods of population estimation for juvenile coho salmon in a small stream. North American Journal of Fisheries Management 4(1):99-102.

Platts, W.S. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8(3):333-345.

Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. U.S. Forest Service, Intermountain Research Station, General Technical Report INT-221.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian and biotic conditions. U.S. Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-138.

Platts, W.S., M.A. Shirazi and D.H. Lewis. 1979. Sediment particle sizes used by salmon for spawning with methods for evaluation.

Corvallis Environmental Research Laboratory, EPA Report No. EPA-600/3-79-043.

Reiser, D.W., J.M. Peters, and S.K. Running. 1987. Development and application of an intergravel sampling device for quantifying sediments in streams. Pacific Gas and Electric Co. Final Report.

Reiser, D.W. and R.G. White. 1988. Effects of two sediment size classes on survival of steelhead and chinook salmon eggs. North Am. Jour. of Fish. Manage. 8:432-437.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Fisheries Research of Canada Bulletin 191.

Saunders, J.W. and M.W. Smith. 1965. Changes in a stream population of trout associated with increased silt. J. Fish. Res. Bd. Can. 22(2):395-404.

Sedell, J.R., P.A. Bisson, F.J. Swanson and S.V. Gregory. 1988. What we know about large trees that fall into streams and rivers. In: Maser, C., R.F. Tarrant, J.M. Trappe and J.F. Franklin editors, USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-229. Portland.

Shepard, B.B. 1987. Beaverhead National Forest Fisheries: Second Annual Report. Beaverhead National Forest, Dillon, Montana.

Shepard, B.B., K.L. Pratt, and P.J. Graham. 1984. Life histories of westslope cutthroat and bull trout in the upper Flathead River Basin, Montana. Montana Department of Fish, Wildlife and Parks. Environmental Protection Agency Contract No. R008224-01-5

Sowden, T.K. and G. Power. 1985. Prediction of rainbow trout embryo survival in relation to groundwater seepage and particle size of spawning substrates. Trans. Am. Fish. Soc. 114:804-812.

Spoon, R.L. 1987. Evaluation of management of water releases for Painted Rocks Reservoir, Bitterroot River, Montana. Final Report. Montana Department of Fish, Wildlife and Parks. Bonneville Power Administration, contract report. Project 83-463, contract number DE-A179-83BP13076.

Stowell, R.A., A. Espinosa, T.C. Bjornn, W.S. Platts, D.C. Burns, and J.S. Irving. 1983. A guide for predicting salmonid response to sediment yields in Idaho batholith watersheds. Unpub. Rept. R1/R4, USDA-FS.

Tappel, P.D. and T.C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North Am. Jour. of Fish. Manage. 3:123-135.

USDA Forest Service. 1987. Forest Plan. Bitterroot National Forest. Northern Region.

Vadeboncouer, Y., S. Luchessa, and R.P. Kramer. 1989. Fisheries habitat and aquatic environment monitoring report, Bitterroot, Deerlodge and Lolo National Forests. Missoula.

Ward, F.J. and L.A. Verhoeven. 1963. Two biological stains as markers for sockeye salmon fry. Trans. Am. Fish. Soc. 92:379-383.

Wesche, T.A., C.M. Goertler, and C.B. Frye. 1987. Contribution of riparian vegetation to trout cover in small streams. North American Journal of Fisheries Management 7(1):151-153.

Wesche, T.A., C.M. Goertler, and W.A. Hubert. 1987. Modified habitat suitability index model for brown trout in Southeastern Wyoming. North American Journal of Fisheries Management 7(2): 232-237.

Wesche, T.A., D.W. Reiser, V.R. Hasfurther, W.A. Hubert and Q.D. Skinner. 1989. New technique for measuring fine sediment in streams. North American Journal of Fisheries Management 9(2):234-238.

Yee, C.S. and T.D. Roelofs. 1980. Planning forest roads to protect salmonid habitat. USDA Forest Service. Pacific Northwest Forest and Range Experiment Station General Technical Report PNW-109. Portland.

Young, M.K. 1989. Effect of substrate composition on the survival to emergence of Colorado River cutthroat trout and brown trout. Ph D. Dissertation, Univ. of Wyoming, Laramie.

Prepared by Christopher G. Clancy
Date: August 1991

Stream	Code Number	Key Words
Bitterroot River drainage	2-03-8865	Trout populations Trout habitat Sediment Dewatering Fishing regulations