Water Quality Status Report No. 108

SQUAW CREEK
Beneficial Use Assessment
Gem County, Idaho
1991 – 1992

Idaho Department of Health and Welfare
Division of Environmental Quality
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ABSTRACT

Squaw Creek, Gem County, Idaho is a designated "Stream Segment of Concern" in Idaho's Antidegradation Program. A Local Working Committee, formed as part of the Antidegradation Program for Squaw Creek, felt that forest practices and grazing over the years had lead to increased sediment production, which in turn had reduced habitat, aquatic insects and fish populations. The Idaho Division of Environmental Quality (DEQ) noted in their 1988 Water Quality Assessment Report that all beneficial uses in Squaw Creek were supported, but threatened due to forest practices and range management. Sediment was the identified pollutant of concern according to DEQ. A cooperative monitoring project between the Boise National Forest and DEQ was implemented in 1991 to: (1) assess beneficial uses status and (2) determine if problems truly existed. A series of physical and biological parameters were monitored in an attempt to answer these two objectives.

Physical habitat monitoring revealed higher percent fines, lower substrate permeability, sorting and porosity in Third Fork Squaw Creek than main Squaw Creek. Third Fork is also the more intensely used system of the two based on timber harvest and road density. Both systems exhibited high width to depth ratios, some pools of poor quality and low riparian vegetative cover. Main Squaw Creek had lower density and a more clumped distribution of large woody debris than did Third Fork. Main Squaw Creek warmed faster and to a higher degree in summer than did Third Fork, while Third Fork cooled more quickly and to a lower degree in the fall than did Squaw Creek. Macroinvertebrate diversity and %EPT tax were very similar between the two streams; however, Third Fork had a lower interstitial space index and higher macroinvertebrate pollution tolerance than did main Squaw Creek. The macroinvertebrate (benthic) communities between the two systems were more dissimilar than similar based on Jaccard's coefficient of similarly. Brachyentrus, a sediment intolerant species, was found in main Squaw Creek, but not in Third Fork. Despite having inadequate physical habitat and more pollution tolerant macroinvertebrates, Third Fork had the highest number, densities and recruitment of trout than did main Squaw Creek. It would appear based on the data that Third Fork is exhibing cumulative impacts from the combined activities of timber harvest and grazing. However, despite the apparent degradation in physical habitat, Third Fork continues to support wild trout recruitment.

INTRODUCTION

BACKGROUND

The 1987 Clean Water Act required each state to adopt an "antidegradation policy" to address nonpoint source (NPS) water pollution. In response to this mandate the "Idaho Antidegradation Agreement" was drafted in 1988. The Agreement was implemented by Executive Order No. 88-23 in November 1988. A key part of the antidegradation policy was public participation in discussion of nonpoint source water pollution issues. Public participation came through the Basin Area Meetings held during the summer of 1989. As a result of input from these meetings, particular streams were designated for special monitoring to prevent the degradation of their water quality. These are now known as Stream Segments of Concern (Dunn 1990). Squaw Creek was and is one of these Stream Segments of Concern (SSOC), specifically from the headwaters to the mouth, including Second Fork (Figure 1).

A special provision of Idaho's Antidegradation Program is the formation of Local Working Committees (LWC) on SSOC where timber harvest is identified as a major nonpoint source activity. Squaw Creek was one such stream, and a local working committee was formed with the goals of drafting specific Best Management Practices to address NPS pollution associated with timber harvest activities. Best Management Practices are intended to better control nonpoint source pollution and protect existing instream beneficial uses. Designated beneficial uses in Squaw Creek include agricultural water supply, cold water biota, salmonid spawning and primary and secondary contact recreation (IDHW 1992). Comments from the LWC indicated that sediment was the primary pollutant of concern in Squaw Creek. It was felt that sediment from timber harvest activities were adversely affecting the beneficial uses of salmonid spawning and cold water biota in Squaw Creek (Roberts 1991). The LWC felt increased sediment from timber harvest could be affecting temperature, instream fish habitat and macroinvertebrates. It was felt that timber harvest and to a certain extent grazing were causing elevated water temperatures, decreasing quality and quantity of instream habitat, as well as reducing macroinvertebrate populations (Roberts 1991). The public was not alone, in this perception, because in 1988 the Idaho Division of Environmental Quality (DEQ) indicated salmonid spawning and cold water biota were at risk in their 1988 Water Quality Assessment Report. The Boise National Forest showed these same uses to be partially supported in their 1990 Land Management Plan. Both assessments identified timber harvest and grazing as primary activities affecting water quality in Squaw Creek.

Allen and Jazdzewski (1986) (in The Pacific Northwest Rivers Study) indicated that Squaw Creek had high habitat quality and high fish species significance, in assigning a 1 value class, for outstanding resident fish resource. In 1990, the Idaho Department of Fish and Game changed their fisheries management from put and take to a wild trout fishery, acknowledging the importance of Squaw Creek for natural trout production. According to Boise National Forest (1990) fish habitat in Squaw Creek is 69 and scheduled to be increased to 75 (90 being optium), while Third Fork is rated 80 (100 being optium) and scheduled to remain at this habitat condition value. Salmonid species present in Squaw Creek include Rainbow trout (red band variety) (Oncorhynochus mykiss), Redband trout (Oncorhynochus sp.), Bull trout (Salvenlinus confluentus), Mountain whitefish (Prosopium williamsoni) and assorted non-game species including Northern squawfish (Ptychocheilus oregonensis), Speckled dace (Rhinichtys osculus), Redside shiner (Richardsonius balteatus), Mottled sculpin (Cottus bairdi) and Torrent sculpin (Cottus rhotheus) (Simpson and Wallace 1982). Redband trout and Bull trout are listed as "species of special concern" by the Idaho Department of Fish and Game and an important "indicator species" by the Boise National Forest (BNF).

OBJECTIVES

Due to the interest the public expressed in Squaw Creek through the antidegradation program and because of its importance as a fishery, according to both the Boise National Forest and Idaho Department of Fish and Game, DEQ entered into a cooperative water quality monitoring effort with the Boise National Forest in 1991. There were three monitoring objectives to this agreement:

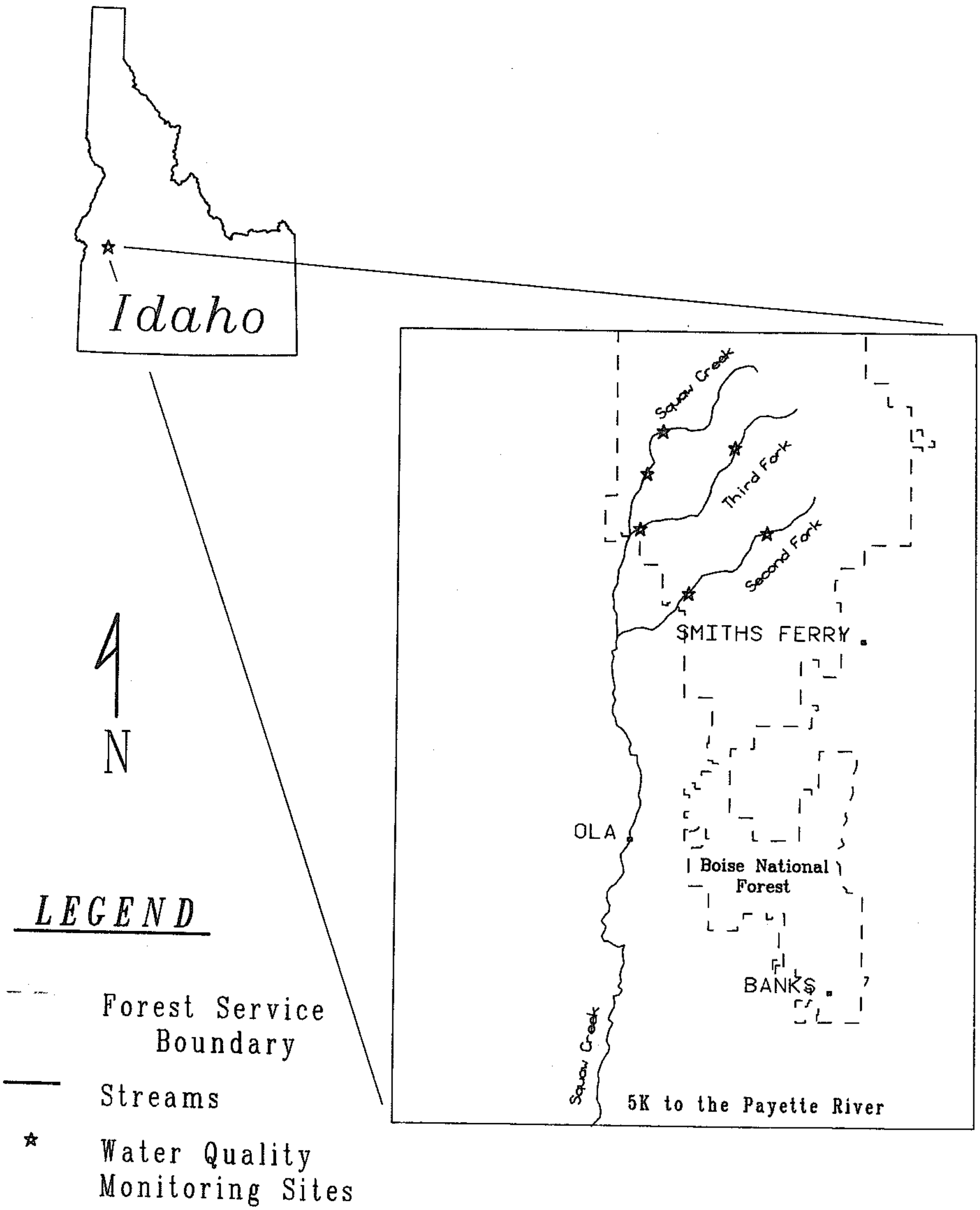
1. Formulate a cooperative monitoring plan to assess benefical uses in Squaw Creek, sharing resources and expertise.

2. Monitor physical habitat structure and biological components of benefical uses.

3. Based on results of monitoring, determine if benefical uses are impacted.

The Boise National Forest was to concentrate on riparian conditions, while DEQ was to focus on in-stream conditions. In June 1991, the Boise National Forest established a riparian demonstration area in upper Main Squaw Creek, above Third Fork. This demonstration area became the monitoring site for what will be referred to as Main Squaw Creek in the rest of this report. This monitoring site along with the Third Fork site (Figure 1) are the two locations from which data was collected.

Figure 1. Squaw Creek Study Area



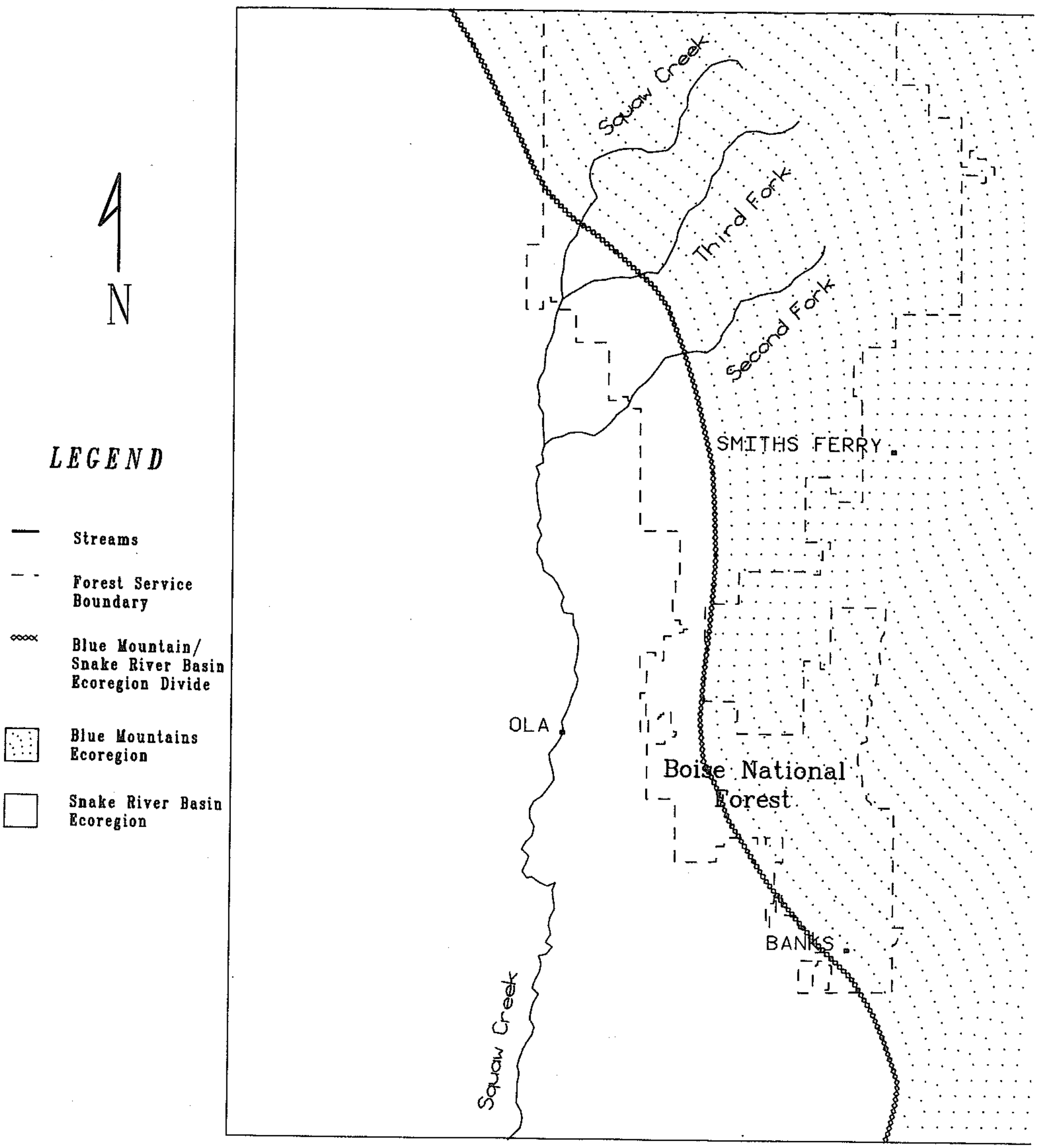
MATERIALS AND METHODS

STUDY AREA

Main Squaw Creek lies in the Blue Mountain Ecoregion (Figure 2), while lower Squaw Creek lies in the Snake River Basin Ecoregion (Omernik and Gallant 1986). The Blue Mountain Ecoregion as delineated by Omerinik and Gallant (1986) also lies within the boundaries of the Boise National Forest. Hence the forested portions of Squaw Creek are included in the Blue Mountain Ecoregion as well. Annually, this region is characterized as averaging 10 to 20 inches of precipitation in the valley and greater than 40 inches in the mountains annually (Boise National Forest 1990). Numerous springs are scattered throughout the region. Several springs are located in the Main Squaw Creek watershed. Soils in the upper elevations have been formed under forest cover from volcanic ash parent material. The dominate vegetative cover in the mountains is forests of grand fir, Douglas fir, ponderosa pine and Englemann spruce/grand fir (Boise National Forest 1990). Lower elevations support sagebrush/wheatgrass steppe and wheatgrass/bluegrass grasslands. According to Boise National Forest (1990) slopes in the Squaw Creek area are moderately steep to steep, with elevations varying from 4,000 to 8,500 feet and soil erosion potential rated moderate to high. The lower portion of Squaw Creek, from Second Fork to the confluence with Black Canyon Dam, lies in the Snake River Basin Ecoregion (Figure 2). This portion of Squaw Creek receives between 8 to 12 inches of precipitation a year. Soils are formed from lacustrine lava deposits under shrub and sagebrush vegetation. Sagebrush/wheatgrass is the predominate vegetation type in lower Squaw Creek (Omernik and Gallant 1986).

Nearly 90 percent of Main Squaw Creek lies in the Boise National Forest, Emmett Ranger District. While lower Squaw Creek was first homesteaded and developed in the late 1890s, Main Squaw Creek has been managed by the U.S. Forest Service. Grazing by domestic livestock commenced in the late 1800s in Squaw Creek, with up to 100,000 sheep and 1,500 cattle on two allotments within the Squaw Creek watershed. The Forest Service began "managing" the allotment in 1925, in response to the heavy use and damage from previous grazing. Since 1925 sheep have only been allowed to trail through Squaw Creek and cattle numbers have varied between 480 to 1250 at any one time (Emmett Ranger District 1992). Currently there are approximately 4,500 animal unit months between the two grazing allotments in Main Squaw Creek. A Forest Service study in 1976 concluded Main Squaw Creek (Third Fork up) was suffering from excessive fines, shortage of pools of good quality and riparian habitat impacted by grazing. In response to this study, grazing pressure was reduced 28% in 1976. A subsequent study by the Forest Service in 1986 revealed no significant changes as a result of the grazing management change, despite 12 years of reduced grazing pressure (Corley 1986).

Figure 2. Squaw Creek in relation to the Boise National Forest and the Blue Mountain Ecoregion.



Some early logging occurred in Main Squaw Creek in the 1920s and 1930s in support of local homesteads and ranches, however serious timber extraction did not occur in Squaw Creek until after World War II, and particularly since the 1960s. Main Squaw Creek lies in management area 48, Sagehen, in the Boise National Forest Plan. According to this plan, area 48 is scheduled to remove 48 million board feet (mmbf) of timber in eight sales over ten years (Boise National Forest 1990). This has changed somewhat given the recent insect infestation and drought, now over 48 mmbf will come out of this unit in the 10 years. Table 1 displays the past level of timber activity in the drainage. It offers some perspective into the number of acres disturbed, vegetation converted and miles of roads constructed in the last 40 years associated with timber management in Squaw Creek.

Table 1. Stream and watershed information for the three tributaries of Squaw Creek. All three systems are third order streams. Metric equivalents are in ( ).

Stream	Drainage area (ac)	Miles of road	Road Density (mi/mi^2)	Percent harvest	Stream length (mi)
Squaw Creek above Third Fork	22,431 (9,062)	81.6 (130.6)	2.3	17	17 (27.2)
Third Fork Squaw	13,807 (5,578)	56.1 (89.8)	2.6	23	12 (19.2)
Second Fork Squaw	21,473 (8,875)	120.5 (192.8)	3.6	32	14 (22.4)

METHODS

Water quality concerns expressed by the Squaw Creek Local Working Committee were temperature, sediment and aquatic insects (Roberts 1991). The objectives of this study then were to address those concerns by monitoring/assessing the physical habitat structure and biology found in the main portions of Squaw Creek. Several methods were employed to assess whether or not sediment was impacting physical habitat structure in Squaw Creek by looking at the structural characteristics of instream habitat from the viewpoint of the benefical uses, that is, looking at the suitability of the physical habitat for fish and macroinvertebrates. Below are the methods and protocols used in collection of data and information.

Physical Habitat:

Burton, T. 1991.

Burton, T. and G. Harvey. 1990.

Wolman, M. G. 1954.

Platts, et al. 1987.

Cowley, E. C. 1991.

Pebble counts and cobble embeddedness measurements were taken at each of 10 cross stations, spaced approximately 34 m apart at each site. Large woody debris was any woody material greater than 10 cm in length, lying within the bankfull zone of influence. Solarpathfinder and densiometer measurements were taken at each station (n=10). Temperature measurements were made from July 21 through November 18, 1992 with Omni datapods.

Macroinvertebrates:

Clark, W. H. and T. R. Maret. 1991.

Five macroinvertebrate samples were collected at each site per year. One hundred organisms were identified via a "random pick" from each sample. Insect identification was performed by the Idaho State Laboratory in Boise Idaho. Collections were made the first week of October 1991 and 1992. A surber sampler (.1 m^2 sample area) with a 500 μm mesh net was used to collect macroinvertebrates. Samples were collected from five different riffle habitats at each site per year. Each sample was placed in a whirl-pac, labeled and preserved with 70% alcohol until processing at the laboratory.

Fish:

Maret, T. R., G. L. Chandler and D.W. Zaroban. 1991.

A Coffelt model BP-6 backpack electroshocker was employed for collecting fish. Lengths were recorded to the nearest 1 mm for salmonids only and weights were not measured. A one pass removal method was employed for estimating populations. Two electroshocking efforts (50 m total) were conducted on the second order tributary to Third Fork, 4 separate efforts (100 m total) on Third Fork, and 8 efforts (184 m) on Main Squaw Creek. Main Squaw Creek was electroshocked by fisheries personnel from the Boise National Forest in August 1991. The electroshocking in the two Third Fork systems was conducted by DEQ with assistance from Idaho Department of Fish and Game in August 1992.

QUALITY ASSURANCE/CONTROL

Quality Control was maintained by collecting and measuring field parameters according to the methods noted above. All field notes were rechecked by the field supervisor for completeness and accuracy. Questionable, incomplete or inaccurate recordings were addressed while in the field by the individual having made the recording. Each crew person was responsible for a set of measurements or collections, insuring continuity and expertise in that area. Temperature readings by the Omni datapod were periodically checked against a hand held thermometer to verify measurement accuracy.

RESULTS AND DISCUSSION

PHYSICAL HABITAT

Results of the physical habitat monitoring are displayed in Table 2. Data from a 1974 U.S. Forest Service survey was also used in the same location for comparison and trends. Average stream width has increased in main Squaw from 5.8 m in 1974 to 7 m in 1992. This represents a 21 percent increase in stream width in 18 years. Third Fork, while a smaller drainage over all, (Table 1) is even wider than main Squaw Creek at 7.8 m. Average depth decreased in main Squaw Creek along with increasing width since 1974. Stream discharge and sediment capacity are major determinants of its width and depth, and the ratio of width to depth (W/D) can be used to judge its condition. Both main Squaw Creek and Third Fork rated were classified as a C-3 stream type according to the Rosgen Stream Classification System (Rosgen 1992). According to this classification scheme, C-3 type streams have a mean W/D ratio of 22, so main Squaw Creek at 48 and Third Fork at 90 are much wider than would be expected. Both systems appear to be out of "dynamic equilibrium" or balance with one or more of the parameters affecting steam processes: width, depth, slope, roughness of bed and bank, discharge, form, sediment concentration and size (Leopold et al. 1964).

The percentage of pools relative to riffles (P/R) is an indication of the amount and quality of habitat for salmonids (Table 2). A ratio of 1 or 50:50 would be considered optimum. The P/R ratio for Main Squaw Creek was 0.22 (1:5) and for Third Fork was 0.24 (1:4). It should be noted that of the 8 pools observed in Main Squaw Creek 6 were man-made, while all 10 on Third Fork were naturally formed. Sullivan et al. (1987) has suggested that pool frequency generally occurs at intervals between 3 to 5 channel widths (mean of 4.2 channel widths). Main Squaw Creek would then be expected to have approximately 10 pools in the 304 m of stream inventoried, it had only 2 naturally formed pools in this stretch. Third Fork would be expected to have approximately 10 pools in 304 m, which it did. The average depth of pools in Third Fork was very shallow relative to their width and length, even compared to those in Main Squaw Creek where average depths were much higher.

Cobble embeddedness (EMB) measurements were very similar among the stream sites, 34.0 in Main Squaw Creek and 34.4 in Third Fork (Table 2). A Mann Whitney U test of EMB measurements ($n=30$) in the two systems showed no significant difference ($p<0.10$). Looking at percent fines less than 6.3 mm, fine particles in main Squaw Creek increased from 4.1 percent in 1974 to 8 percent in 1992, and Third Fork were highest at 10.1 in percent. Figure 3 is a graphical interpretation of substrate data, which shows that Third Fork has a higher percentage of fines less than 6.3 mm than does main Squaw Creek. It also indicates that the range of substrate occurring in Third Fork is smaller, but more evenly distributed than main Squaw Creek. The d16, d25, d50, d75 and d84 particle sizes in Table 3 illustrates the fact that Third Fork has a smaller substrate than main Squaw Creek, despite having a higher channel gradient.

Interstitial space index (ISI) or living space is another way of looking at the available habitat within stream substrate. Main Squaw Creek has 7.4 m/m^2, while Third Fork had 6.0 m/m^2.

Table 2. Results of physical habitat monitoring for Squaw Creek. W/D=width to depth ratio, P/R=pool riffle ratio, EMB=cobble embeddedness, Q=flow. Habitat measurements taken during low flow periods for 1974, 1991 and 1992.

Parameter	Squaw Creek (1974)	Squaw Creek	Third Fork
Width (m)	5.8	7.0	7.8
Depth (m)	0.23	0.15	0.10
W/D Ratio	-	46.7	90
Slope (%)	-	1.0	1.6
P/R Ratio	-	0.22	0.24
# Pools/304 (m)	-	8	10
EMB (%)	-	34.0	34.4
% Fines (<6.3mm)	4.1	10.1	8.0
Q (m^3/s)	-	0.56	0.09

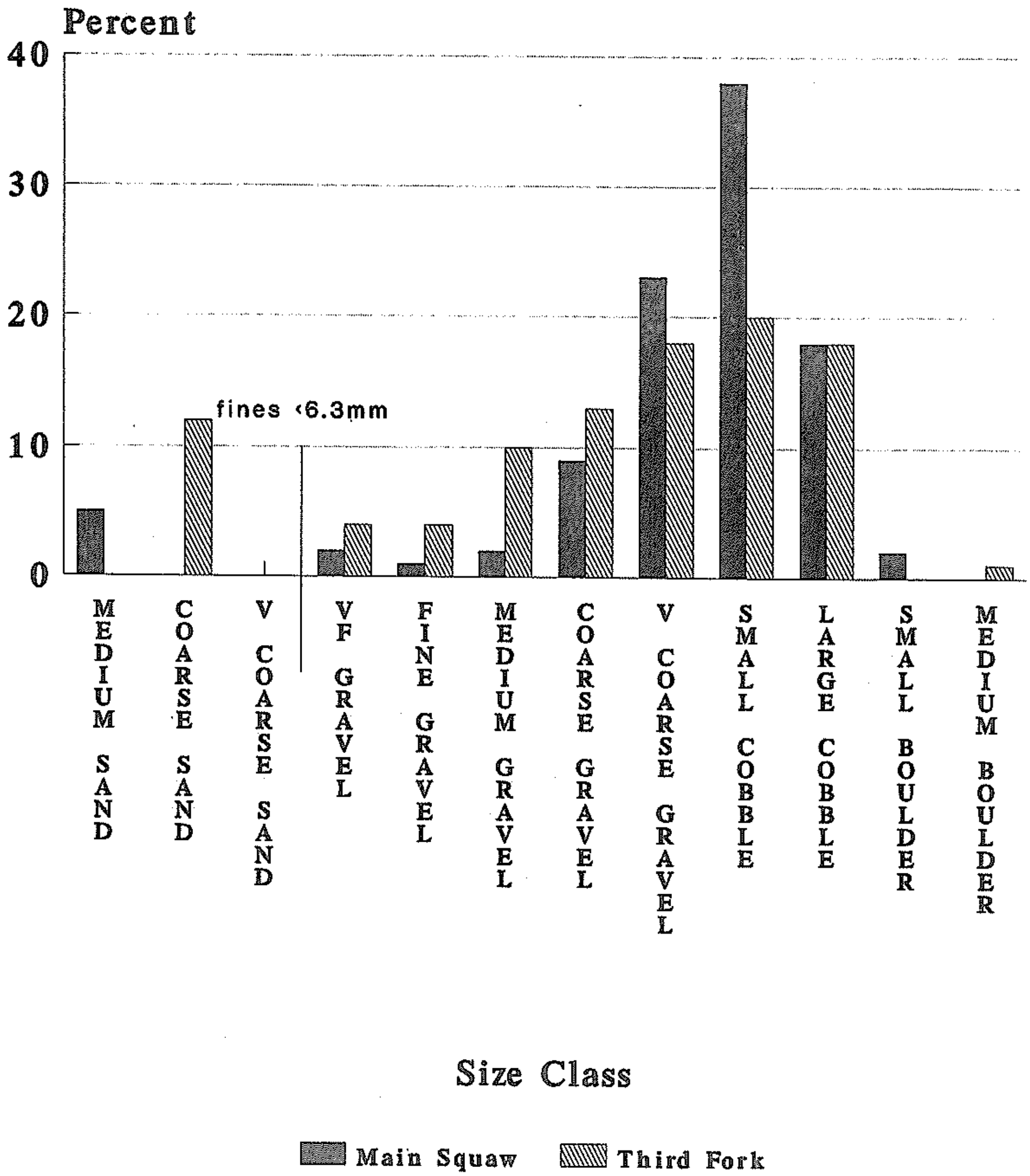


Figure 3. Stream substrate composition by size class

Table 3. Measures of substrate composition as indices of spawning quality and substrate change.

Index	Main Squaw	Third Fork
Geometric mean $dg=(d84*d16)^{0.5}$	33.2	24.6
Sorting Coefficient So=(d75/d25)	8.5	9.9
Fredel Index Fi=(dg/So)	3.91	2.49
% less than 0.85mm	6	12
d16mm	7.9	4.35
d25	15	10
d50	50.5	42
d75	128	99
d84	140.2	139

Three other indices of substrate quality and change were examined: geometric mean, sorting coefficient, and fredle index. Platts el al. (1979) found the geometric mean a useful tool in evaluating sediment effects on salmonid incubation success. Chapman and McLeod (1987) state, "Geometric mean particle size offers a workable measurement as a companion to percent fines, for a more complete index of habitat quality". Young et al. (1992) found geometric mean particle size to be the best predictor of survival to emergence of Colorado Cutthroat trout in a laboratory experiment. Geometric mean particle size for Main Squaw Creek and Third Fork was 33.2 and 24.6 respectively (Table 3). The large value for Main Squaw Creek indicates its substrate is more permeable and has higher porosity. A sorting coefficient indicates how well sorted a stream substrate is. The higher the value the less well sorted the substrate mix. Main Squaw Creek and Third Fork had sorting coefficients of 8.5 and 9.9 respectively. The fredle index combines both geometric mean and sorting coefficient as a measure of substrate quality (Lotspeich and Everest 1981). It measures both pore size and relative permeability, both of which increase as the index becomes larger. Fredle index values for Main Squaw Creek and Third Fork were 3.91 and 2.49 respectively. Young et al. (1992) found percent of substrate less than 0.85mm to be the best indicator of substrate change in their study of substrate change due to sediment deposition. Beschta (1982) also found the amount of substrate less than 0.85mm to be the best indicator of intensity of land use in a watershed. Third Fork had twice as much fines, less than 0.85 mm, than did Main Squaw Creek (Table 3).

LARGE WOODY DEBRIS

Rescue of large woody debris (LWD) is recognized as an important component in controlling channel morphology, storage and routing of sediment and organic matter, and the creation of fish habitat (Bisson et al. 1987). Main Squaw Creek had 11.3 m^3/304 m of stream, whereas Third Fork had 12.7 m^3/304 m of stream (Figure 4). The distribution of LWD was more clumped in Main Squaw Creek and more even in Third Fork (Figure 4). The presence of a large winter blowdown between stations 6 and 7 on Main Squaw Creek, significantly affected LWD distribution. More interesting was the number of LWD pieces occurring in each study reach (Figure 5). Third Fork had 48 total pieces (in 304 m of stream) compared to 29 in Main Squaw Creek, Third Fork having 58 percent more than Main Squaw Creek. A Kolmogorov-Smirnov test of LWD distribution indicated there was a significant difference between the two systems at the 0.05 level. Hicks et al. (1991) and Bisson and Sedell (1984) noted that the removal of LWD reduced the quantity and quality of pools and lead to channel widening and enlarged riffles. The following are indicators of habitat lacking sufficient LWD; (1) insufficient numbers and quality of pools, (2) lack of storage sites for sediment, (3) loss of hydraulic complexity, (4) lack of hiding places from predators and (5) loss of winter cover (Bisson et al. 1987)

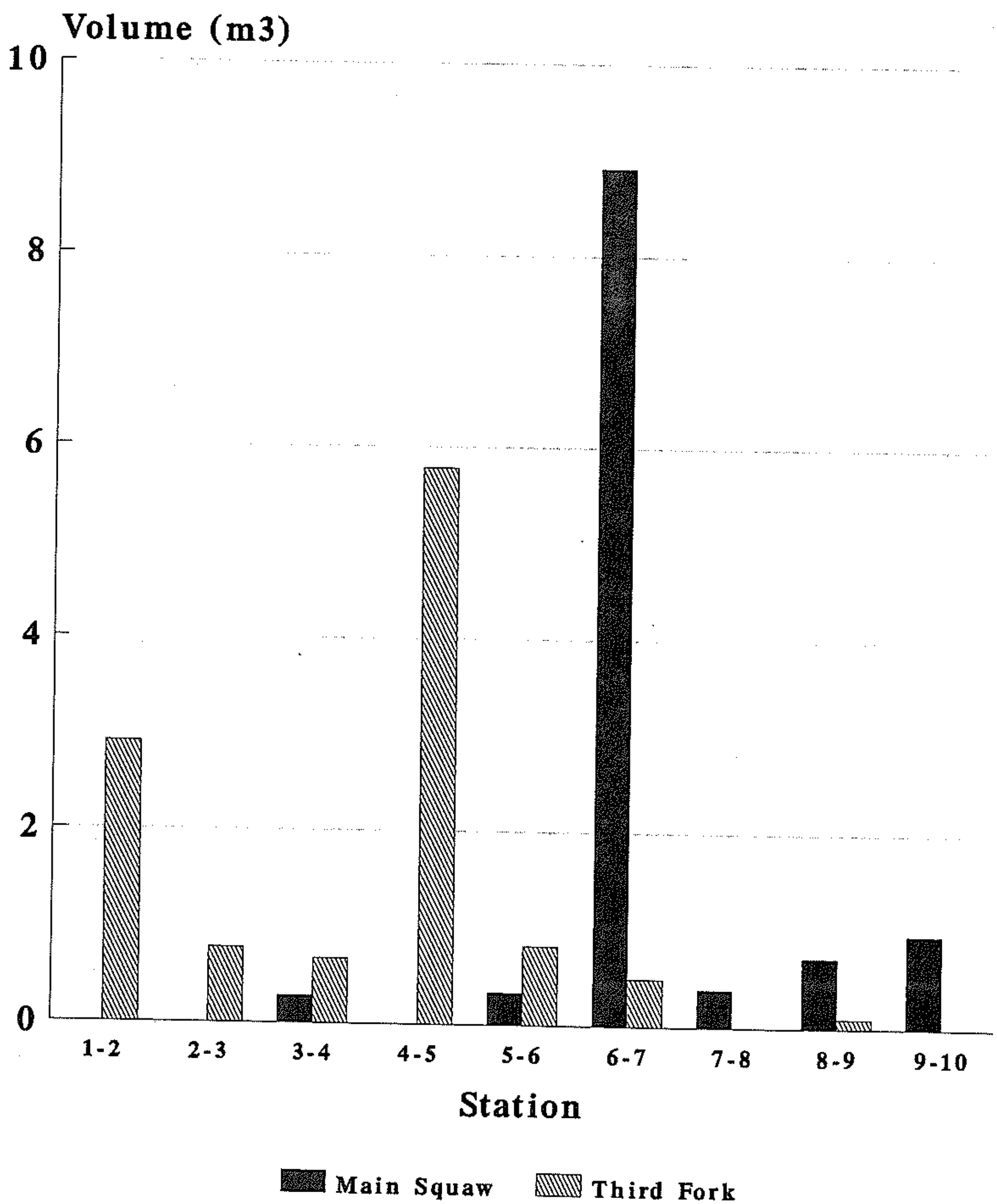


Figure 4. Distribution and volume of large woody debris

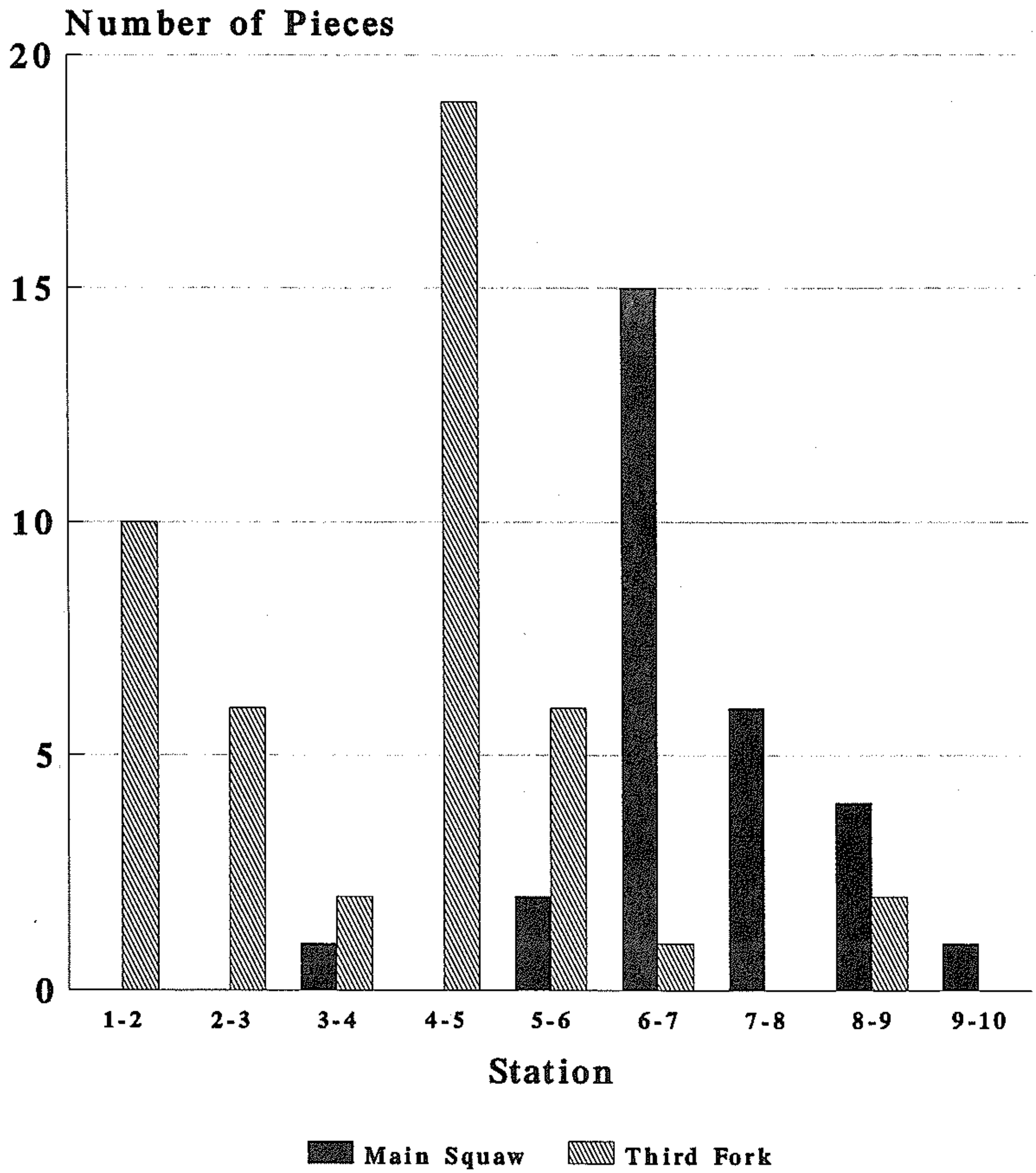


Figure 5. Distribution and number of large woody debris

SOLAR INPUT AND SHADE

A Solarpathfinder and a densiometer were used to gather information on the amount of energy, as solar input, reaching each stream and the quantity and quality of the shade ameliorating that input. Results are displayed in Table 4 and Figure 6. Main Squaw Creek received approximately 25 percent more energy in August and 16.4 percent more in July (maximum solar input months) than Third Fork. However, the means between the two sites were not significantly different at the 0.05 using a Mann Whitney U Test. Canopy cover or shade density averaged over all 10 stations for Main Squaw Creek was 19.1 percent and 15.8 percent for Third Fork; however, the variability of that shade was much higher in Main Squaw Creek than Third Fork (Figure 6). A Mann Whitney U Test showed no significant differences in canopy cover between the two systems ($p<0.05$).

TEMPERATURE

Continuous temperature recorders were used to measure water temperature at each site. Temperature was averaged over each hour and the mean recorded for every hour from July 21 through November 18, 1992. Results are displayed in Figures 7 and 8. From July 21 through September 16, Main Squaw Creek averaged 1-2°C warmer than Third Fork, but the pattern (daily regime) was very similar (Figure 7). In the second period from September 18 through November 18 the pattern was more variable and the absolute difference between them was greater, 2° C-4° C (Figure 8). Main Squaw Creek had 161 total hours greater than 20° C, while Third Fork had only 62 hours; thus, Main Squaw Creek exceeded 20° C 12 percent of the time, and Third Fork exceeded 20° C 4.6 percent of the time. Between July 27 and August 19 (warmest water temperature period) Main Squaw Creek had 15 instances of greater than 5 continuous hours at or above 20°C, and Third Fork had only 1 instance.

Elevated summer water temperatures and depressed winter water temperatures reduce habitat suitability for salmonids (Beschta et al. 1987; Bjornn and Reiser 1991). During the warm summer months pool habitat offers thermal refuge for adult and juvenile fish. Conversely in winter, pools are generally warmer than other stream habitats (Bjornn and Reiser 1991). Temperature decreases in the autumn signal behavioral changes in salmonids, causing them to move to more suitable overwintering habitats (Hillman et al. 1987, Holtby et al. 1989, Blatz et al. 1991). Third Fork first reached 4°C on September 26, 1992, eleven days sooner than Main Squaw Creek. When the temperature recorders were removed on November 18, 1992, a majority of Third Fork was covered in anchor ice, while Main Squaw Creek had none. Swanston (1991) noted "...wide shallow streams are more susceptible to anchor ice formation than deep narrow ones...and that anchor ice forms more quickly on uncanopied streams where more rapid cooling can occur".

Table 4. Solar energy input measurements for Squaw Creek. Measurements made July and August, 1992 with a Solar pathfinder.

	Main Squaw				Third Fork			
STN	**JUL%**	**BTU**	**AUG%**	**BTU**	**JUL%**	**BTU**	**AUG%**	**BTU**
1	74	1932	86	86	56	1462	58	1273
2	61	1606	59	1295	64	1684	46	1010
3	76	1984	73	1602	66	1723	48	1065
4	81	2115	82	1800	39	1018	33	724
5	86	2245	70	1536	38	992	26	570
6	76	1984	76	1668	84	2139	67	1471
7	76	1984	76	1668	89	2324	86	1888
8	76	1984	76	1668	93	2428	89	1953
9	76	1984	70	1536	40	1057	39	856
10	51	1331	39	856	43	1123	37	823
Mean	73	1915	71	1552	61	1600	53	1163

Difference	**JUL**	**AUG**
Main	1552	1915
Third	1163	1600
	388	314
% Diff	25	16
Max. BTU*		
Available	2611	2195

*** BTU/ft^2 /d as measured at Boise ID**

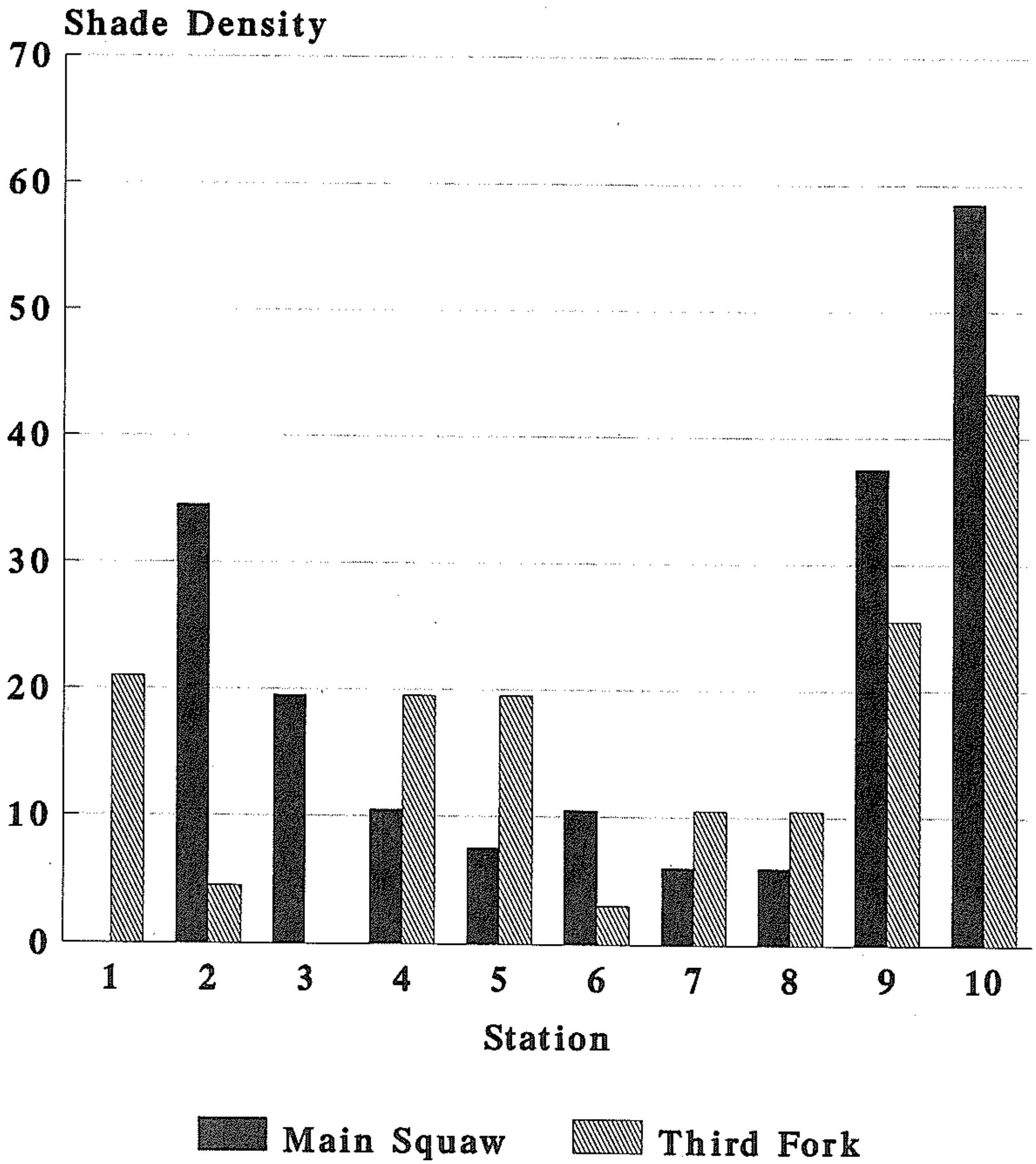


Figure 6. Percent canopy closure as an index of shade quality

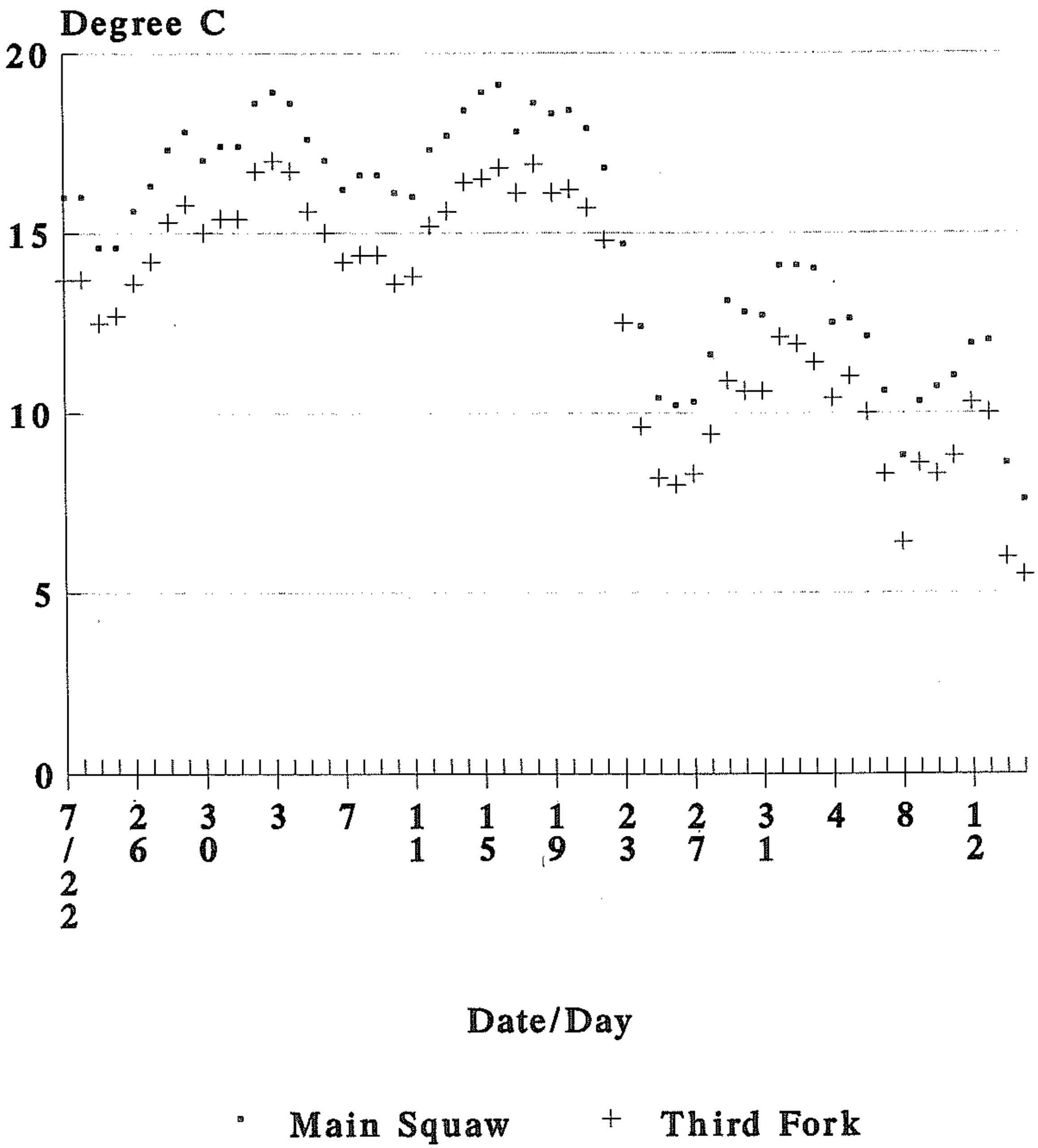


Figure 7. Mean stream temperature for Squaw Creek 7/22 to 9/16

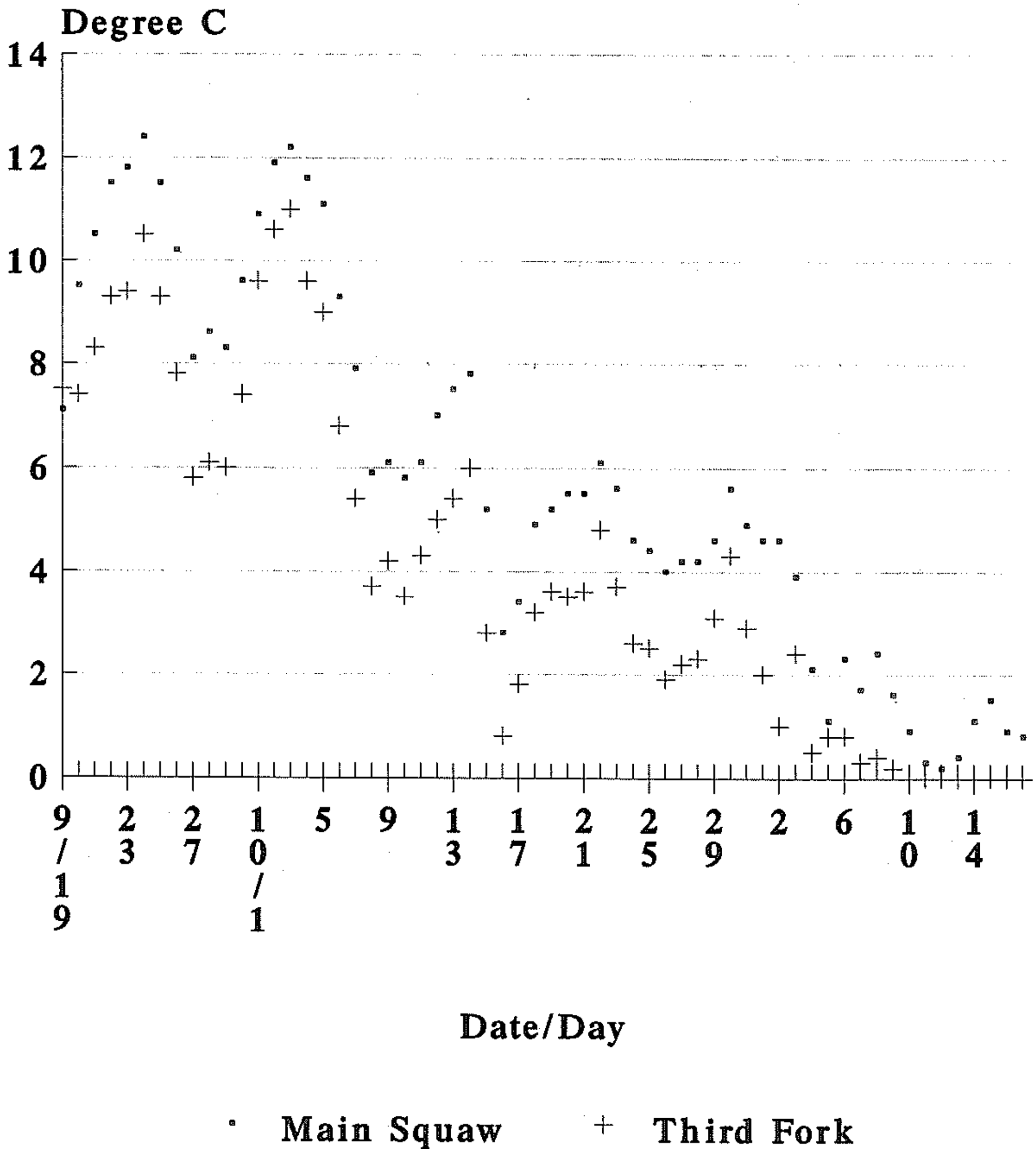


Figure 8. Mean stream temperature for Squaw Creek 9/19 to 11/18

MACROINVERTEBRATES

Tables 5 and 6 list the results of the macroinvertebrate sampling as well as the biological metrics used in their evaluation. These metrics intergrated aspects of community, population and functional components of macroinvertebret community structure. They were used to gain more information on impacts to aquatic insects from nonpoint source pollution:

1) species richness
2) percent Empheroptera, Plecoptera, and Trichoptera (EPT), commonly known as mayflies, stoneflies and caddisflies
3) modified Hilsenhoff Biotic Index (HBI)
4) trophic structure
5) abundance
6) Jaccard's coefficient of similarity
7) invertebrate community integrity
8) ratio of Hydrophyche to Brachycentrus
9) percent embeddedness to percent shredders
10) percent boulders to percent EPT
11) percent boulders to percent scrapers

Main Squaw Creek had fewer taxa than Third Fork, lower percent EPT, lower HBI, three times fewer scrapers, three times more filterers, and seven times more shredders. Third Fork had the highest insect abundances of the two, 3,518 per m^2. Jaccard's coefficient of similarity was 0.26 and the invertebrate community integrity index was 0.74. The ratio of Hydrophyche to Brachycentrus was 0.33 in Main Squaw Creek and could not be computed in Third Fork because Brachycentrus were not present (n=5). Percent EMB to shredders was 1.8 and 12.6 for Main Squaw Creek and Third Fork, respectively. Percent boulders to percent EPT was 0.04 for both systems, and percent boulders to scrappers was 0.25 in Main Squaw Creek and 0.07 in Third Fork.

Plafkin et al. (1989) found streams with higher taxa richness were generally the healthier system, on a comparision basis. Third Fork had only two more taxa present than Main Squaw Creek. Percent EPT isolates the groups considered to be pollution sensitive, so a high percentage would indicate a preponderance of pollution sensitive species (Barbour et al. 1992). Third Fork had three percent more EPT than Main Squaw Creek. Western occurring insects were used in modifying the Hilsenhoff Biotic Index. The lower the value the lower the pollution tolerance of the system (Barbour et al. 1989). Main Squaw Creek HBI was almost a third lower than Third Fork, indicating a higher percentage of intolerant (sensitive) species.

Trophic Structure (Table 5) refers to the different macroinvertebrate feeding groups present in streams (Merrit and Cummins 1984, Pennak 1989, Wisseman 1990). Percent Scrapers reflects the riffle community food base. The metric indicates the availability of periphyton. Scrapers tend to decrease in relative abundance following sedimentation and organic pollution. Scrapers were highest in Third Fork (40%) suggesting a significant periphyton community. Percent Filterers are macroinvertebrates that filter their food from the water column, indicating the relative abundance of fine particulate organic matter. Percentages for this group was low in both

Table 5. Biological monitoring results for Squaw Creek and Third Fork Squaw Creek.

Biotic Indices	Main Squaw	Third Fork
Interstitial Space Index (m/m^2)	7.4	6.0
Macroinvertebrate Species Richness	20	22
% EPT	71.1	74
Modified HBI	2.03	2.72
Trophic Structure		
%Scrapers	12.0	40.6
%Filterers	7.6	2.4
%Shredders	19.1	2.7
Abundance (m^2)	2,994	3,518

Table 6. Biological monitoring results for Squaw Creek and Third Fork Squaw Creek continued.

Biotic Indices	Main Squaw	Third Fork
Jaccard's Coefficient of Similarity	0.26	0.26
Invertebrate Community Integrity	0.74	0.74
Ratio of Hydrophyche/Brachycentrus	0.33	0
% EMB to %Shredders	1.8	12.6
% Boulders to %EPT	0.04	0.04
% Boulders to Scrapers	0.25	0.07

systems, but particularly low in Third Fork (2.7%). Percent shredders reflects the importance and reliance on coarse particulate organic matter. Forested headwater streams such as these receive much of their allochthonous inputs from the riparian zone in the coarse particulate category (Vannote et al. 1980). Thus shredders are particularly sensitive to riparian changes. Main Squaw Creek had six times as many shredders as did Third Fork. This may be a reflection of the riparian exclosure on Main Squaw Creek, which has precluded cattle grazing the last two seasons, while the riparian area in Third Fork has been open to grazing during this time.

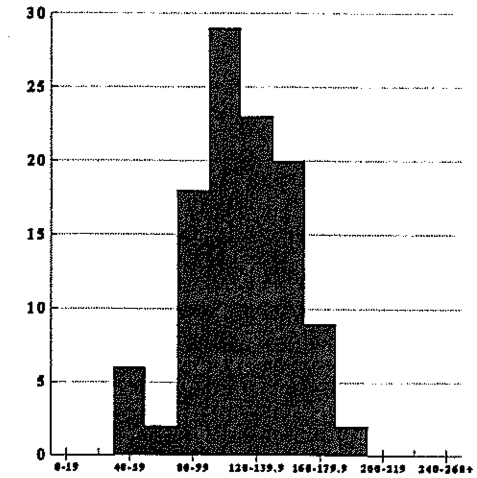
Jaccard's coefficient of community similarity measures the degree of similarity between two streams, 1 being completely similar and 0 meaning they are 100 percent dissimilar. The Jaccard's coefficient of similarity was 0.26, indicating the two streams were only 25 percent similar, or conversely, 75 percent dissimilar (Table 6). The ratio of Hydrophyche to Brachycentrus may reveal impacts from sediment (Dr. G. Wayne Minshall, personal comm., Idaho State University). A ratio greater than one would indicate potential sediment impacts. The ratio in Main Squaw Creek was 0.33, and could not be computed for Third Fork because Brachycentrus, which are the sediment sensitive species, were not present. Percent Burton (1992) found a strong relationship between certain habitat and biotic variables, specifically, EMB to shredders and percent boulders to EPT and scrapers. However, in this study these metrics merely reflected the trophic structure of the two systems. That is, Main Squaw Creek had a high component of shredders (Table 5) relative to Third Fork, thus its percent EMB to shredders is low. Since Third Fork has a high percentage of scrapers it has a corresponding low value for percent boulders to scrapers relative to Main Squaw Creek.

FISH

Three sites were sampled for fish: a second order tributary to Third Fork, Third Fork and Main Squaw Creek. Electroshocking results are displayed in Figure 9 as trout length frequencies, trout densities and total number of trout removed for each system. All the fish removed from the two Third Fork systems were rainbow trout/redband trout (n=208). No other species were encountered. In Main Squaw Creek two salmonids and 3 non-salmonids were removed: rainbow trout (n=99), mountain white fish (n=4), mottled sculpin (n=63), longnose dace (n=22), and redside shiner (n=1). In second order Third Fork, 38 percent of the trout removed were young of the year, and 19 percent were greater than 120 mm. In Third Fork proper, 7.3 percent of the trout removed were young of the year, with 49 percent greater than 120 mm. In Main Squaw Creek, two percent were young of the year and 70 were greater than 120 mm. Boise National Forest personnel noted their electroshocker was experiencing a selectivity bias for young of the year (Don Corley personnel communication). Since only length were recorded, biomass could not be calculated. Densities of fish per m^2 were 0.692, 0.374 and 0.085 for second order Third Fork, Third Fork and Main Squaw Creek, respectively.

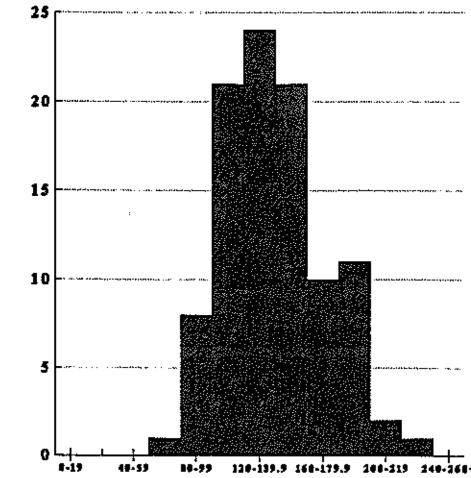
Robinson and Minshall (1992) found the number and percent of salmonids to be a good predictor of water quality impairment in their Snake River Ecoregion study. They found that a larger percent or number of non salmonids in a stream corresponding to a the higher the water quality impairment. Accordingly, the higher number and percentage of non salmonids in Main Squaw Creek would suggest a higher level of impairment. The smaller tributaries have higher percentages of young of the year present, while the larger systems (Third Fork and Main Squaw Creek) have higher percentages of larger fish (> 120 mm). It would appear that a majority of trout spawning or recruitment is taking place in the smaller tributaries. Two possible explanations exist for this. First, even though Third Fork has a higher percentage of fines, the substrate being smaller is more suitable for rainbow trout spawning. Smith (1973) noted that 6 mm to 52 mm was the optimal size spawning material for rainbow trout. The substrate and hence spawning material found in Third Fork relative to Main Squaw Creek is smaller and probably more suitable (Figure 3 and Table 3). Secondly, as trout grow, their habitat preference shifts from shallow riffle habitat to larger deeper pools (Bjornn and Reiser 1992). Though Third Fork had more pools, 10 versus 8, many of these were of poor quality due to shallow depth, while the quality of the pools in Main Squaw was higher given the greater depths.

Trout Length Frequency For Third Fork Squaw Creek (8/92)



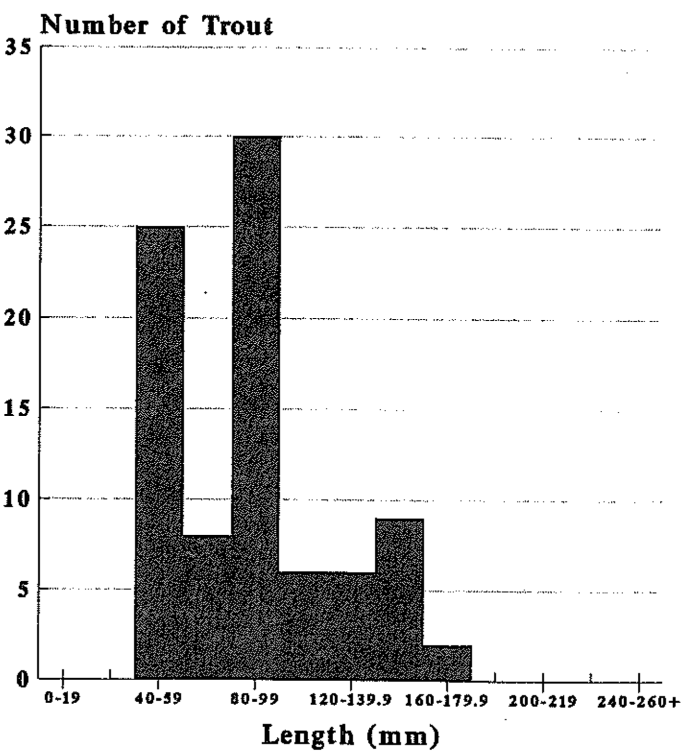
Total number of Trout 109
Density (fish/m2) .374

Trout Length Frequency For Main Squaw Creek (8/91)



Total number of Trout 99
Density (fish/m2) .085

Trout Length Frequency 2nd Order Tributary to Third Fork (8/92)



Total Number of Trout 86
Density (fish/m2) .692

Figure 9. Trout lengths, numbers and densities.

CONCLUSIONS

1. Both streams had very few pools, and existing pools were of poor quality, based on general lack of cover and shallow depth.

2. Both streams exhibited poor instream cover, be it large woody debris or undercut banks.

3. Main Squaw Creek warmed more quickly and to a higher degree in summer than did Third Fork, while Third Fork cooled more quickly and to a lower degree than did Squaw Creek in the fall. More anchor ice was observed on Third Fork than on Squaw Creek in early winter.

4. Main Squaw Creek exceeded 20° C 12% of the time and had 15 instances of >20° C for more than five continuous hours, while Third Fork exceeded 20° C only 4.6% of the time and had only 1 instance of 20° C for five hours. This reflects the greater amount of solar energy reaching Main Squaw Creek.

5. Third Fork had higher percentage of fines, both <6.3 mm and <0.85 mm, lower geometric mean and fredel index and higher sorting coefficient than Main Squaw Creek. Third Fork also had a lower interstitial space index and Hydrophyche, the sediment tolerant macroinvertebrate was present, while the intolerant Brachycentrus was not. All these suggest sediment impacts associated with aggregation.

6. Despite having the poorer substrate conditions noted in 5 above, the overall smaller sized bottom material in Third Fork is probably more appropriate for Rainbow Trout spawning. Third Forks d50 was 42 mm, while Main Squaw Creek was 50.5 mm.

7. The second order tributary to Third Fork had the highest densities of fish and the highest percentage of young of the year (.374 fish/m^2 and 38% YOY). Third Fork while having lower density and percentage of YOY, still was higher in both of these categories than Main Squaw Creek.

8. While trout recruitment appears to be taking place in the smaller systems, Main Squaw Creek has the highest percentage of large fish (70% >120 mm). This probably reflects the better quality of the pools present due to depth in Main Squaw Creek, as opposed to Third Fork proper.

9. Both systems appear to be out of equilibrium with the amount of sediment being produced and transported, and this is reflected in the high width to depth ratios and a low number of pools with shallow depths, than would be expected. Third Fork has a higher density of roads and percent harvest than Main Squaw Creek. This probably explains the degraded substrate and physical habitat circumstances noted above.

RECOMMENDATIONS

The U.S. Forest Service has been implementing Best Management Practices since their inception in Idaho, in 1974. The Boise National Forests Guidelines and Standards, generally set higher requirements for BMP's than those in the Idaho Forest Practices Act for timber harvest. Despite the implementation of these BMP's, along with reduced grazing pressure for 19 years, Squaw Creek continues to show evidence of degraded physical habitat. Degraded physical habitat impacts beneficial uses through the lack of adequate rearing habitat for salmonids.

In light of the above, it is the opinion of the author that sediment production and entrainment needs to be reduced in Squaw Creek. Reducing new sediment production and transport, should free-up additional energy for transport of existing in-channel sediments, thus improving pool quality over time.

Reducing sediment production and entrainment involves reducing timber harvest and/or grazing from current levels. Since 19 years of BMP's have not improved physical habitat conditions in Squaw Creek, it seems reasonable to step back from current management directions and reassess total watershed health. This seems prudent in light of the Endangered Species Listing petitioning for Bull Trout.

In particular the following could be done to reduce the amount of sediment being produced in the watershed:

1. Identify watershed problem areas and rehabilitate them.

2. Close and reclaim as many roads as possible.

3. Reduce new road construction.

4. Where possible use helicopter logging and other "light on the ground" harvest techniques.

5. Look at different grazing allotment strategies that eliminate or reduce pressure on riparian areas. Work closely with permittee to insure implementation of grazing seasons and closures.

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