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Kalispel Resident Fish Project

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KALISPEL RESIDENT FISH PROJECT

ANNUAL REPORT

2004

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EXECUTIVE SUMMARY

In 2004 the Kalispel Natural Resource Department (KNRD) implemented a new enhancement monitoring project for bull trout (*Salvelinus confluentus)* and westslope cutthroat trout (*Oncorhynchus clarki lewisi*). Largemouth bass (*Micropterus salmoides*) enhancement projects were also monitored. Additional baseline fish population and habitat assessments were conducted, in tributaries to the Pend Oreille River.

ACKNOWLEDGEMENTS

We would like to thank Glen Nenema (Chairman, Kalispel Tribal Council), the Kalispel Tribal Council and members of the Tribe for providing the support and the opportunity to conduct this project. Special thanks goes to Joe Maroney (KNRD Fisheries Program Manager) for technical and administrative support and assistance. The U.S. Department of Energy, Bonneville Power Administration, provided financial support for this project, contract number 97-BI-30242. Special thanks also to Ron Morinaka (Contracting Officer Technical Representative). The Kalispel Natural Resource Department provided field support and equipment.

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INTRODUCTION

Fire history, past timber harvest activities, and dams have influenced the landscape in the Lower Pend Oreille Subbasin. The subbasin was first logged from 1915 to 1930 and much of the old-growth timber was removed. Railroad cars and log flumes were used on the mainstem Pend Oreille River and several of its tributaries to transport harvested timber. Log flumes were common, simplified the instream habitat, and decreased the recruitment source of large woody debris. In more recent years, road construction and maintenance, timber harvest, and cattle grazing have degraded stream habitat conditions. Numerous forest fires occurred between 1910 and 1929 and impacted many watersheds. From 1917 to 1929, an estimated 60 to 70% of the LeClerc Creek watershed burned. The largest fire in the LeClerc Creek watershed occurred in 1929.

The fish assemblage existing today in the subbasin is drastically different from pre-dam development. Due to the construction of Grand Coulee Dam, anadromous fish have been extirpated and over 1,140 linear miles of spawning and rearing habitat in the Upper Columbia River System were eliminated (Scholz et al. 1985). The five dams on the lower Pend Oreille River are also believed to be a significant reason for the decline of native salmonid populations. These dams include Waneta (Canada), Seven Mile (Canada), Boundary (U.S.), Box Canyon (U.S.), and Albeni Falls (U.S.). None of these dams were built with fish passage facilities. Other dams and diversions such as Cedar Creek Dam, Sullivan Lake Dam, Mill Pond Dam, North Fork Sullivan Creek Dam, and Calispell Pumps were constructed in Pend Oreille River tributaries and further fragmented the connectivity of native salmonid populations.

In an attempt to partially mitigate for the resident and anadromous fish losses caused by hydropower development and operation, the Northwest Power Planning Council (Council) called for recommendations to develop a program that would provide measures to protect, mitigate and enhance fish and wildlife affected by the construction and operation of hydroelectric facilities located on the Columbia River and its tributaries. The Kalispel Tribe (Tribe), in conjunction with the Upper Columbia United Tribes (UCUT) Fisheries Center, undertook a three-year assessment of the fishery opportunities in the Pend Oreille River (Ashe et al. 1991) to provide the Council with recommendations. Assessment findings indicated that trout species were rare in the reservoir and compose less than 1% of the total abundance. Brown trout (*Salmo trutta*) were the most abundant trout species. Factors limiting trout production in the reservoir were identified as warm water temperatures, lack of habitat diversity and food availability. Trout were more abundant in the tributaries to the reservoir, which mostly supports brook trout (*Salvelinus fontinalis*) and brown trout; however, westslope cutthroat (*Oncorhynchus clarki lewisi*), rainbow (*O. mykiss*), and bull trout (*S. confluentus*) were also captured.

Ashe et al. (1991) also found that largemouth bass (*Micropterus salmoides*) comprised approximately 3-4 percent of the total fish population in the reservoir. Results indicate that growth rates of largemouth bass during the first four years in the Box Canyon Reservoir were lower than bass from other locations of the northern United States. The slower growth rates combined with a high rate of juvenile mortality associated with lack of overwintering habitat have reduced the potential for the bass population in the reservoir.

Bennett and Liter (1991) described the fish communities in Box Canyon Reservoir, the sloughs, and tributaries and examined factors that could limit game fish production. Their findings determined that factors such as warm water temperatures and thermal barriers at the mouths of sloughs limited native trout. They estimated that overwinter survival of age 0^+ largemouth bass in Box Canyon Reservoir ranged from 0.4-3.9%. It was suspected that poor overwinter survival is partially due to the lack of cover during the winter months.

Ashe et al. (1991) provided recommendations based upon these findings for enhancing fishery opportunities. Recommendations include: 1) construct an off-site rearing facility to supplement the number of juvenile largemouth bass within the Box Canyon Reservoir; 2) enhance tributary populations of native trout, and; 3) increase the amount of overwinter habitat in the reservoir. Bennett and Liter (1991) suggested similar management possibilities in the Box Canyon Reservoir such as supplementation of largemouth bass to enhance recruitment and introduction of a predator species to take advantage of the extensive forage base.

The recommendations from Ashe et al. (1991) were adopted and incorporated into the 1994 resident fish and wildlife section of the Council's Program and were further revised in the Council's 1995 Program. These recommendations called for:

1) Restoring tributary populations of native cutthroat and bull trout, and

2) Enhancing the largemouth bass population to provide a quality sport and subsistence fishery in the reservoir.

These goals may appear to conflict, but there is a dramatic difference in habitat between the tributaries and Box Canyon Reservoir. The Box Canyon reach of the Pend Oreille River was formed in 1955 by the construction of Box Canyon Dam. The dam changed the riverine habitat in this reach to habitat typical of a broad, shallow reservoir. The resulting high summer water temperatures exceeded Washington Department of Ecology temperature standards on a regular basis. This change in habitat made favorable conditions for warmwater species. Ashe et al. (1991) and Bennett and Liter (1991) concluded that yellow perch is the most abundant species in Box Canyon Reservoir. The other species in descending order based on relative abundance are pumpkinseed, tench, and largemouth bass. Trout species are rare and of the trout species present, brown trout are the most abundant. Tributary trapping data suggests that brown trout is the only trout species in Box Canyon Reservoir having an adfluvial population (KNRD et al. 2001). Temperature conditions limit the distribution of native trout in the reservoir. Bull trout have optimal rearing temperatures of 7-8^0C (Goetz, 1989) and temperatures exceeding 15^0C are thought to limit distribution (Fraley and Shepard, 1989, Goetz, 1991, Pratt, 1985). In Box Canyon reservoir, bull trout are limited to microhabitats in cold water springs, or metalimnion areas. Bull trout require spawning areas with clean gravel and temperatures ranging from 5-9^0C; these conditions do not exist in the reservoir. Conversely, largemouth bass have optimum temperatures of 13-26^0C and will select habitats in the littoral zone where temperatures exceed the optimum for bull trout. Thus, habitat overlap between native trout and largemouth bass is unlikely and interaction very unlikely (NEPA Doc, 1996).

Cutthroat and bull trout populations residing in the tributaries need to be protected since these appear to be the remaining populations in the Lower Pend Oreille Subbasin. The greatest impacts to these populations include: 1) habitat degradation from past land use activities; 2) habitat fragmentation and loss of connectivity due to man made structures; and 3) hybridization and competition from introduced species. Genetic analysis conducted by the Washington Department of Fish and Wildlife (WDFW) showed that Pend Oreille River tributary populations of westslope cutthroat trout were genetically distinct from one another (Shaklee and Young 2000). Of the eight tributaries surveyed in the initial year of the project, none have been stocked with hatchery fish since 1978. Four of the eight have not been stocked since the 1940's. Although relative abundance is low, genetic analysis and stocking records suggest these cutthroat trout populations are sustained without hatchery supplementation.

Isolation due to the fragmentation of native populations is likely to increase the risk of extinction through both environmental stochasticity and lack of genetic variation (Rieman and McIntyre 1993; Lacy 1987). Degraded habitat resulting in poor complexity further increases the risk of extinction for small, isolated populations because refugia from extreme environmental events are lacking (Pearsons et al. 1992, Saunders et al. 1990; Sedell et al. 1990). Hilderbrand and Kershner (2000) estimated that 8 km of stream length are required to sustain an isolated population of cutthroat trout with high abundance (0.3fish/m).

Interactions with non-native species have also had an impact on resident populations of westslope cutthroat and bull trout. Brook trout X bull trout hybridization appears to be the most prevalent problem in isolated populations (Markle 1992). Competitive interactions with introduced species (mainly brook trout) have likely contributed to depressed cutthroat trout populations in the Lower Pend Oreille Subbasin. Of the streams surveyed by the Kalispel Natural Resource Department (KNRD) in the Lower Pend Oreille Subbasin, the highest cutthroat trout densities have been observed in streams and headwater reaches where brook trout were absent. Several studies indicate that abiotic factors (e.g. water temperature and velocity) may determine which trout species will be dominate in a given length of stream (De Staso and Rahel 1994; Griffith 1988).

The habitat restoration portion of this project primarily addresses factors that limit native tributary populations. Our in-channel restoration increases habitat complexity, which provides refugia during extreme environmental events and, therefore, lowers the extinction risk for the targeted populations. The Tribe recognizes that instream habitat restoration is a temporary solution to habitat degradation and that recovery will only occur when future human impacts are minimized and watershed processes are restored. The Tribe has and will pursue opportunities for watershed restoration projects. However, watershed restoration will not yield significant improvements for years or decades. The Tribe also recognizes that some of the native fish populations in the Lower Pend Oreille sub-basin will not persist for years or decades. In some watersheds, individual native fish sightings are rare or populations are isolated in small tributaries. Restoration attempts to increase the habitat attributes that are limiting while the brook trout removal portion of this project will eliminate the threats associated with competition and hybridization with the native populations.

In summary, KNRD's plan for recovering native salmonid populations is:

1. Perform baseline stream habitat and fish population assessments to determine current distribution and abundance and identify core watersheds where recovery efforts will be focused.
2. Work to protect existing native populations and good habitat through participation in regional policy setting groups and consultation with area land, fish, and wildlife management agencies.
3. Pursue funding from various sources and participate jointly with other agencies in watershed restoration projects.
4. Implement instream and riparian restoration in identified recovery areas.
5. In recovery areas with non-native populations: 1) capture and relocate native fish, 2) treat streams to remove non-native species, and 3) translocate genetically identical or similar native fish from sister watersheds.
6. Monitor restoration and adapt management plans if needed.

The Kalispel Resident Fish Project began in 1995 with the selection of the study tributaries, habitat assessments, and assessment of fish populations in those tributaries. These baseline surveys showed that fish habitat is generally poor due to a lack of large woody debris, lack of pool type habitat, and high volumes of fine sediment. As a result of these conditions, rearing, spawning, and winter habitat were identified as limiting factors to fish populations in most reaches.

The Upper Columbia United Tribes Fisheries Center conducted a three-year baseline study to assess the fishery improvement opportunities on the Pend Oreille River (Ashe and Scholz 1992). Based on earlier estimates of aquatic macrophyte community composition (Falter et al. 1991) and limited overwinter survival of age 0^+ largemouth bass (Bennett and Liter 1991), they suggested that the winter reduction in macrophyte communities created higher predation rates on age 0^+ bass. This led to their recommendation for the construction and placement of artificial cover structures to increase the amount of winter cover available in the reservoir. Baseline species abundance was determined by electrofishing the selected treatment and control sloughs prior to structure placement. In 1997, 100 Berkley artificial structures and 100 Pradco artificial structures were constructed and placed in the study sloughs. Treatment and control sloughs have been sampled twice annually since implementation of the habitat structures. In 2004, data continued to be examined to determine: 1) if artificial structures may provide the missing winter cover component, and 2) if a difference exists between the efficiency of the Pradco and Berkley structures.

2004 TRIBUTARY HABITAT AND FISH POPULATION ASSESSMENTS

DESCRIPTION OF STUDY AREA

Habitat and snorkel surveys were conducted in Lost Creek, Diamond Fork Creek, East Branch LeClerc Creek, and Four tributaries to East Branch LeClerc Creek. East Branch LeClerc Creek is located on the eastside of the Pend Oreille River at river kilometer 90 (Figure 1). The watershed of East Branch LeClerc Creek drains approximately 9,961 hectares. The dominant geology of the watershed is comprised of glacial and alluvial deposits in the lower portion and grandiorite in the upper portion. The mean annual discharge in the month of August is 0.2 cms. In 1929 forest fires burned almost the entire LeClerc Creek watershed. The watershed is composed of a checkerboard ownership pattern between USFS and private timber companies. Current and historic logging and grazing activities have also influenced the watershed.

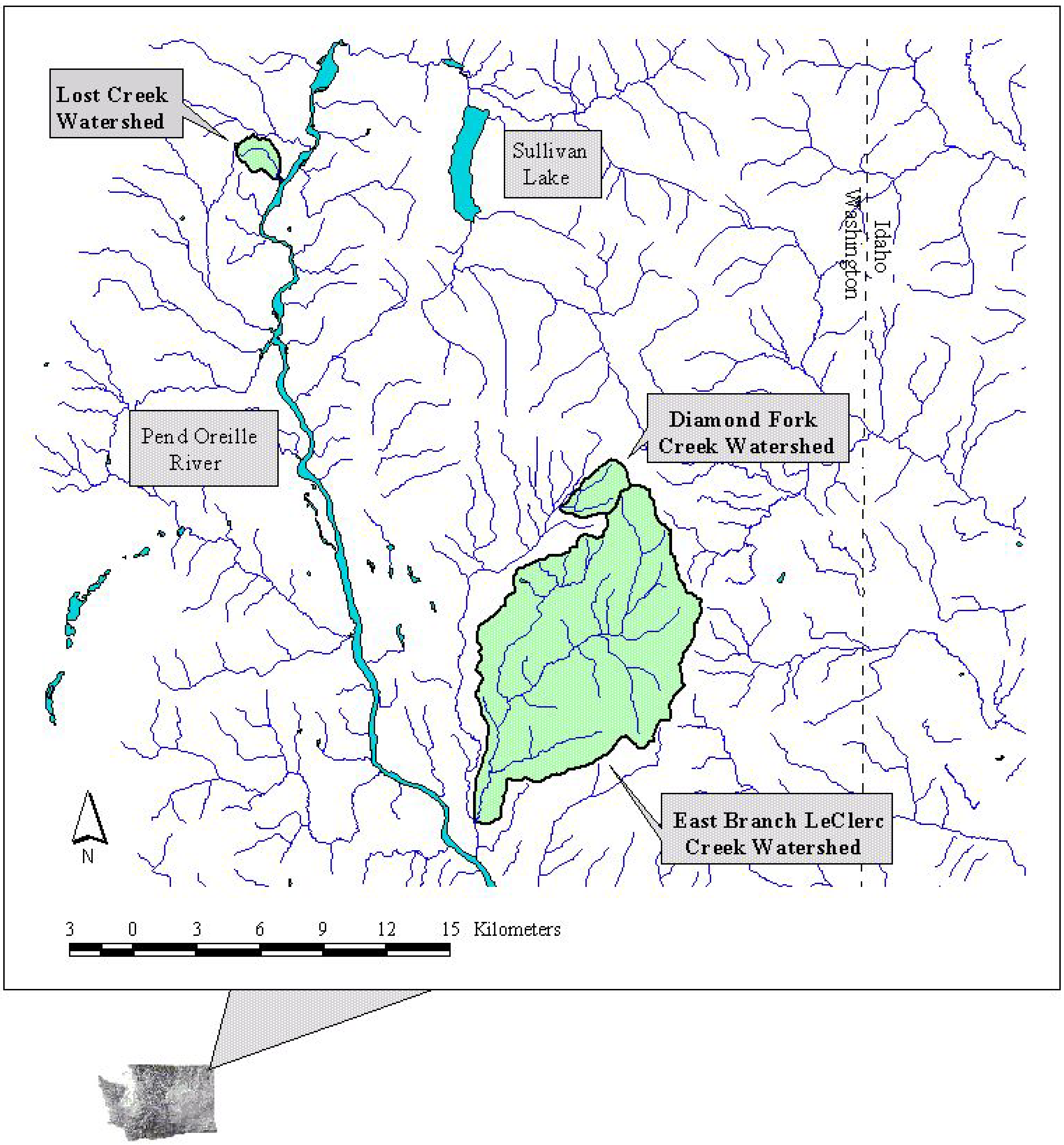

Figure 1. Map of East Branch LeClerc Creek, Diamond Fork, and Lost Creek watersheds.

Diamond Fork Creek is a tributary to West Branch LeClerc Creek (Figure 1). The geology of the watershed is composed of glacial and alluvial deposits. The 1929 forest fire that burned the LeClerc Creek watershed most likely affected this watershed. Like East Branch LeClerc Creek, logging and grazing activities have heavily influenced the Diamond Fork watershed.

Lost Creek is a small tributary on the west side of the Pend Oreille River in between the towns of Ione and Metaline. Lost Creek enters the Pend Oreille River just downstream of river kilometer 51.5 (Figure 1). The dominant geology is comprised of conglomerate in the upper portion of the watershed and glacial and alluvial deposits in the lower portion. Logging and dumping of refuse into the stream channel have affected this watershed.

METHODS

Stream and fish population survey methodologies used within the Lower Pend Oreille Subbasin were similar to those developed by Espinosa (1988) and further revised by Murphy and Huntington (1995). Habitat survey data were collected in two ways: 1) at a transect directly perpendicular to the stream thalweg, and 2) in the 30 m interval that separated adjacent transects. Primary pools, spawning habitat, unstable banks, and acting woody debris were identified and enumerated in the entire length of each 30 m stream segment between two transects. Data for the remainder of the habitat attributes (Table 1) were collected at the end of each 30 m segment: the actual transect site. Reaches were defined by lengths of stream channel with common confinement, gradient, and substrate (Rosgen, 1994). Breaks between two homogeneous areas defined a new reach. Reach overviews were completed at the end of each reach; these contained written descriptions of prominent features and/or potential impacts to habitat quality. Each reach was permanently marked, flagged and geo-referenced using a Trimble Geo-explorer III receiver.

In June, temperature loggers were placed in the lower portion of each stream and recorded temperature on hourly intervals. Loggers were also placed in the middle and/or upper sections of some of the larger streams. Temperature loggers were collected in October.

Fish density estimates for baseline surveys were collected using standard snorkel survey techniques (Espinosa 1988). In streams too small to snorkel, a 3-pass electrofishing sampling technique was used. The surveys were conducted during the period from July 15 through September 30. Snorkeling and electrofishing data included the number of each species observed in age classes 0 to 5^+. Total density of each species was reported as the number of fish per 100 m^2. The standard size/age classes for salmonid species were determined according to Espinosa (1988). Lengths of baseline snorkel and electrofishing stations were 100 m and selected so that the area snorkeled or electrofished was representative of the reach. Fish stations were permanently marked and flagged using aluminum tags and flagging.

Table 1. Transect variables and method of collection.

Variable	Method of collection
Habitat Type	Visually determine habitat types (i.e., pool, riffle, glide, pocketwater, run, alcove).
Dominant Substrate Size	Visually determine largest percentage of substrate for that habitat type (i.e., silt, sand, gravel, cobble, boulder, bedrock).
Habitat Function	Visually determine habitat functions (i.e., winter, summer, spawning or unusable).
Spawning Gravel Amount and Quality	Estimate potential square meters of spawning gravels between transects and rate quality (i.e. gravel size, location and current velocity Kalispel internal doc.1-95) Good = All criteria met. Fair = 2 criteria met. Poor = 1 criteria met.
Stream Depths	Measure depth at 1/4, 1/2, 3/4 across channel to the nearest cm.
Habitat Widths	Measure each specific habitat type in a transect to the nearest 0.1m.
Primary Pools	Number of pools with length or width greater than the avg. width of stream channel between transects.
Pool Quality	Rating based upon collection of length, width, depth, and cover.
Pool Creator	Identify item creating the pool (e.g., large woody debris, boulders, beaver, enhancement, other).
USFS Large Woody Debris	Number of woody debris with a diameter >30cm and a length >10m with some portion within the wetted channel.
Cobble Embeddedness	Visual estimate of the percentage fine or coarse sediment surrounding substrate at transect. Actual measurement was recorded with an embed meter approximately every 20 transects. Regression of the estimated numbers with the actual measurements calculated a correction factor for all estimated values.
Bank Stability	Visual estimate of the length of unstable bank between transects for possible sediment source.

Table 1 Continued

Instream Cover Rating	Percent of the stream surface covered by large woody debris, aquatic vegetation, bank vegetation in or near the surface of the water/ Amount of cover provided by undercuts, root wads, boulders or turbulence.
Dominant/Subdominant Riparian Vegetation	Visual estimate of dominant vegetation and of subdominant vegetation species.
Stream Channel Gradient	Using a clinometer measure percent slope.
Acting Woody Debris	Number of woody debris with a diameter >10cm and a length >1m within the wetted channel.
Potential Debris Recruitment	Number of trees within the transect that could potentially fall into the stream > 10 cm and a length > 1m.
Measurements for Residual Pool Depth	Measure average pool depth at the deepest portion of the pool and at the pool tailout. Measure to the nearest cm.

RESULTS

East Branch LeClerc Creek

Seventeen reaches totaling 19.7 Km (12.2 miles) were surveyed in the mainstem East Branch LeClerc Creek (Figure 2). In addition, four unnamed tributaries were also surveyed within the watershed. The survey began at the confluence of East Branch LeClerc Creek and West Branch LeClerc Creek (elevation 610 m) and was terminated in the headwaters near an elevation of 1158 m. Landownership in the watershed is primarily a checkerboard pattern with alternating sections of private (mostly large timber companies) and public (managed by USFS) ownership. Historically, the watershed has been grazed, logged, and burned. The watershed has also been affected by historic and current beaver activity. Fish data were only collected in the first 14 reaches of the survey. Westslope cutthroat trout were observed in all reaches except reaches 1 and 5 (Figure 3). Brook trout, brown trout, and rainbow trout were also observed throughout the stream up to reach 14 where a 3.5 meter cascade fish passage barrier was noted. The only species observed in reach 14 above the barrier was westslope cutthroat trout. Four temperature loggers were placed throughout East Branch LeClerc Creek to monitor water temperature (Figure 4, 5, 6, 7). The highest temperature recorded was 19^{o}C on the lowest thermograph on July 16 (Figure 4).

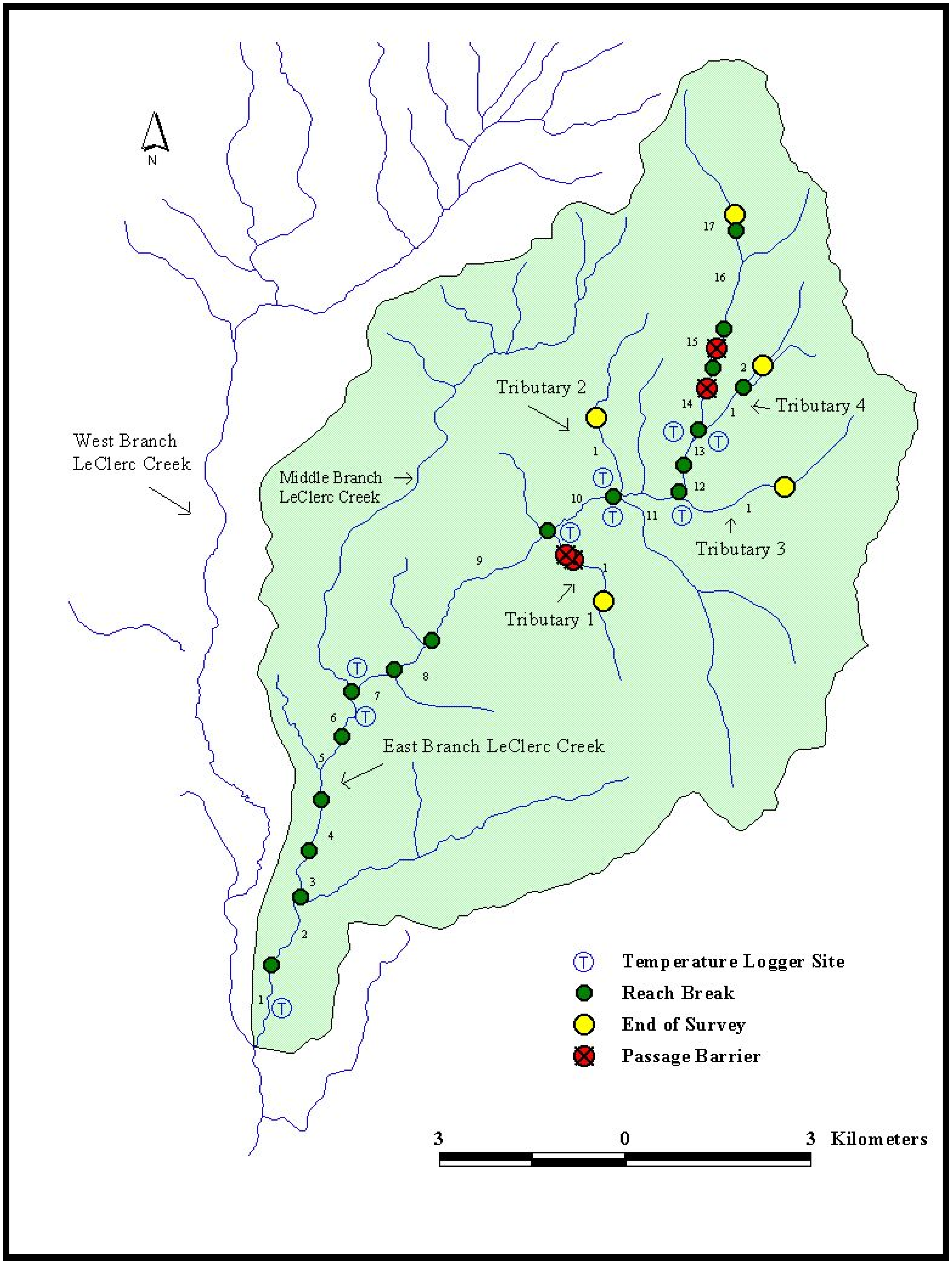

Figure 2. Map of the East Branch LeClerc Creek watershed with reach breaks, passage barriers, and temperature logger sites.

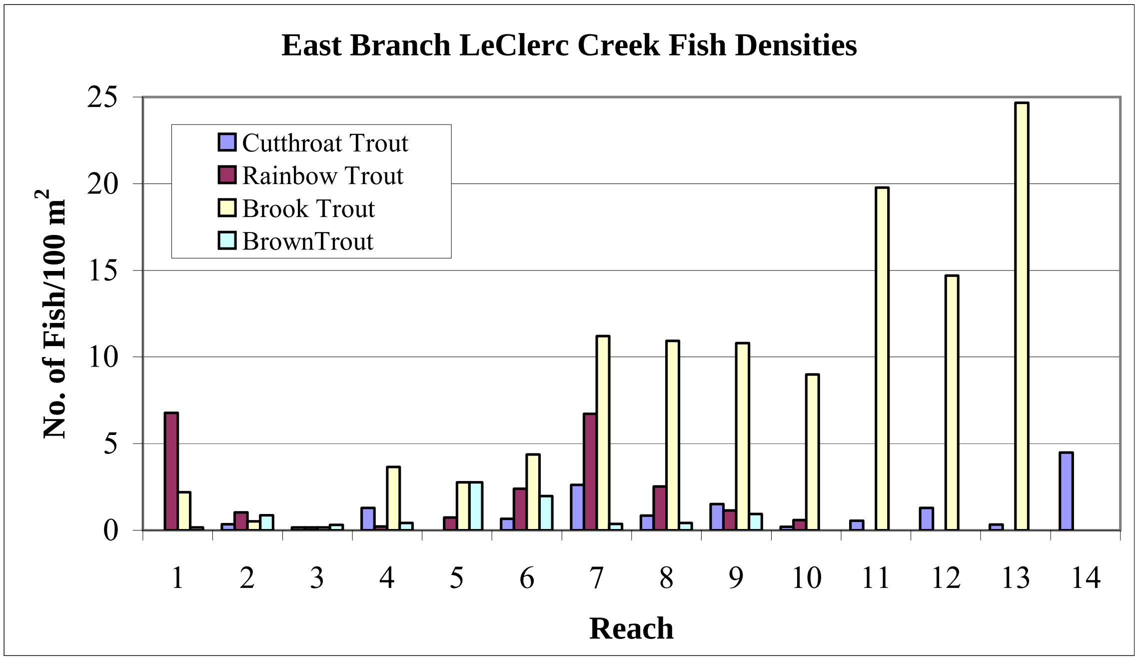

Figure 3. Fish densities for stations snorkeled in East Branch LeClerc Creek.

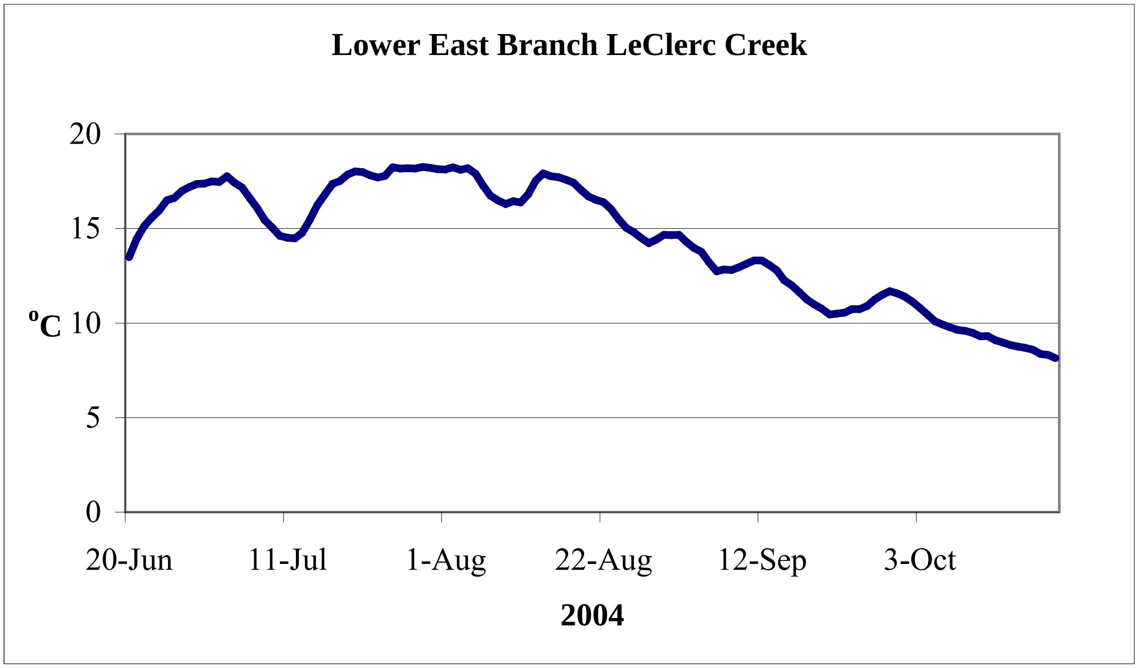

Figure 4. Seven day average daily maximum temperature for lower East Branch LeClerc Creek.

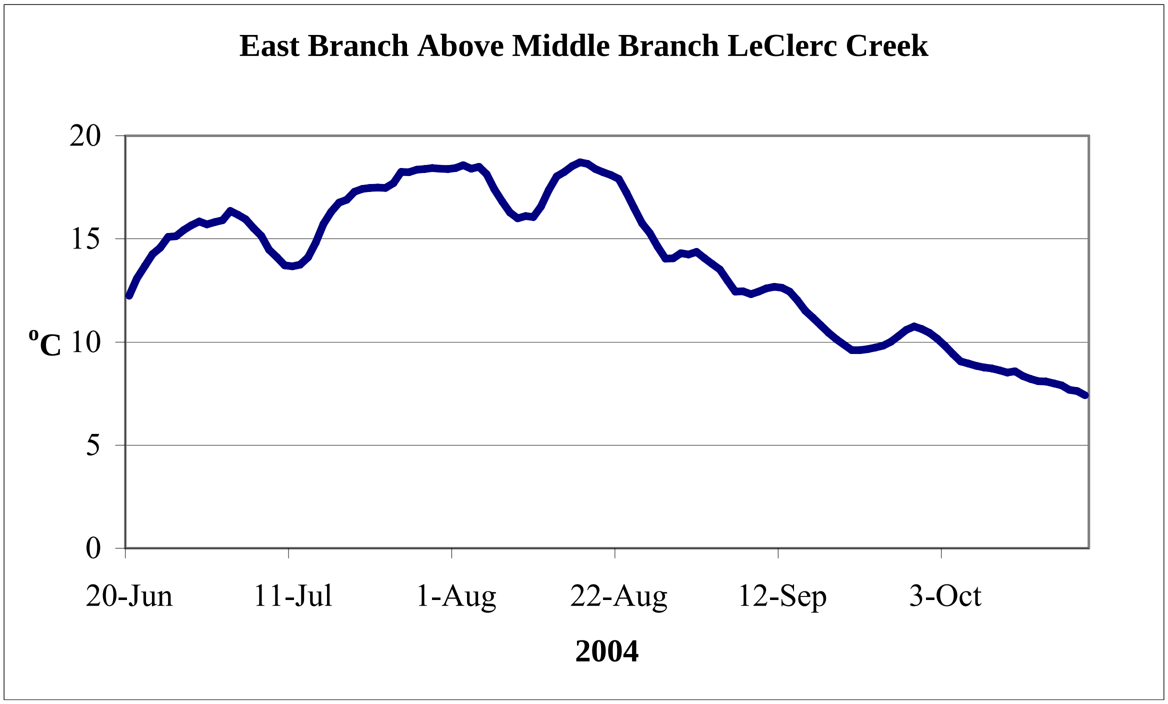

Figure 5. Seven day average daily maximum temperature for East Branch LeClerc Creek above Middle Branch LeClerc Creek.

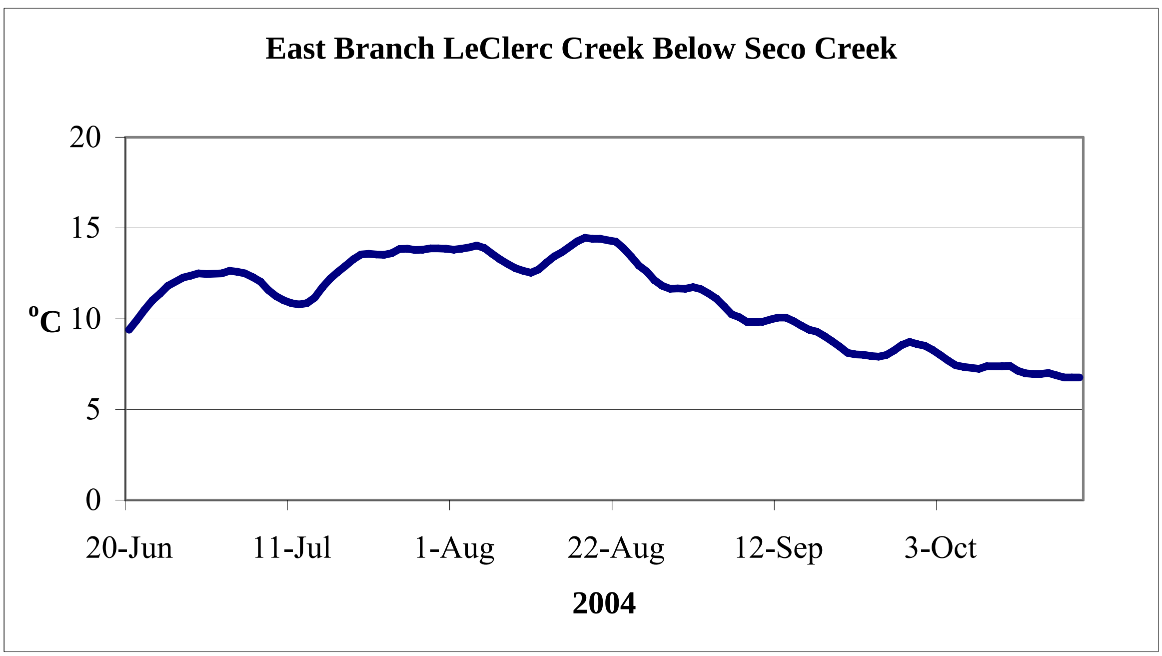

Figure 6. Seven day average daily maximum temperatures for East Branch LeClerc Creek below Seco Creek.

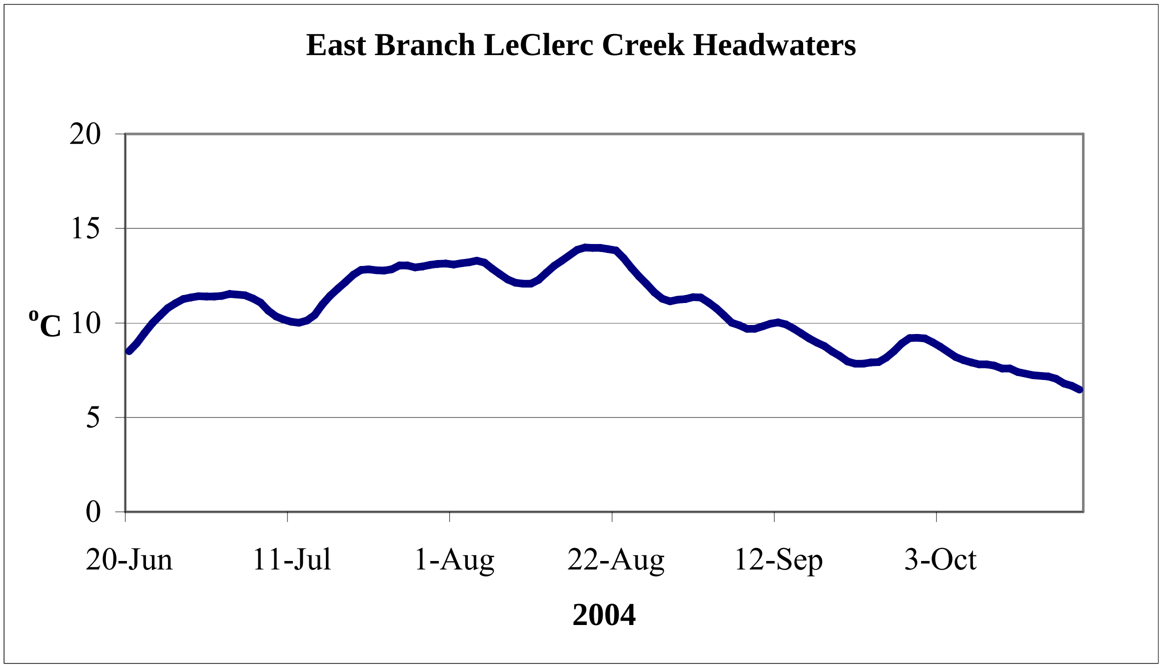

Figure 7. Seven day average daily maximum temperature for East Branch LeClerc Creek in the Headwaters.

Table 2. Rosgen (1994) channel classifications and reach scale attributes for reaches surveyed in East Branch LeClerc Creek.

East Branch LeClerc Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B2	2.5	Rubble	13.1
2	A2	3.9	Boulder	18.2
3	A2	4.6	Boulder	17.5
4	B2	3.5	Rubble	13.9
5	A2	4.7	Boulder	10.0
6	B3	3.3	Rubble	13.0
7	C2	1.9	Boulder	24.2
8	C4	1.3	Small Gravel	16.2
9	C3	1.4	Gravel	13.9
10	C5	1.8	Sand	16.0
11	C5	1.3	Sand	10.8
12	A3	4.6	Rubble	9.9
13	C5	1.3	Sand	12.7
14	A5	5.5	Sand	12.1
15	B5	2.6	Sand	7.3
16	B4	3.6	Small Gravel	8.9
17	A4	5.6	Gravel	4.3

Reach 1

Reach 1 of East Branch LeClerc Creek began at the confluence with West Branch LeClerc Creek. The reach was 1560 m in length and classified as a Rosgen B2 channel type (Table 2). The dominant substrate of the reach was rubble. The reach was composed of 69% riffle habitat (Table 3). Bank cover was relatively low (2.9) throughout the reach (Table 4). Rainbow (6.8 fish/100 m^2), brook (2.2 fish/100 m^2), and brown trout (0.2 fish/100 m^2) were all observed in the snorkel station. The lower end of the reach flows through private land where water was being withdrawn from the stream.

Table 3. East Branch LeClerc Creek limiting factor attributes.

East Branch LeClerc Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	60	98	2.9	3.0	0.2	10.5	7.7
2	56	99	3.5	3.9	0.1	12.5	6.1
3	64	97	2.7	3.9	0.0	7.0	8.6
4	37	96	3.2	2.7	0.1	10.5	12.8
5	65	95	3.1	3.6	0.1	3.5	9.3
6	54	99	2.8	2.2	0.3	9.0	2.4
7	75	95	3.4	2.4	0.2	64.5	7.3
8	88	85	4.5	2.6	0.6	260.0	11.1
9	89	90	4.0	3.3	0.2	194.0	5.1
10	93	92	3.5	3.7	0.1	41.0	3.8
11	97	88	4.5	4.3	0.4	29.0	7.0
12	90	82	4.3	4.3	0.0	0.0	1.8
13	100	83	4.9	4.9	2.3	0.0	7.8
14	76	95	3.2	3.3	0.3	2.5	9.7
15	93	97	2.5	3.3	0.2	19.5	3.5
16	70	95	2.5	3.0	0.0	6.0	0.0
17	69	94	2.9	3.8	1.0	0.0	4.2

Table 4. Habitat attributes for reaches surveyed in East Branch LeClerc Creek.

East Branch LeClerc Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	19.3	5.3	44.7	11	69	0	14.9
2	19.1	6.4	50.6	7	60	0	18.3
3	20.1	6.1	53.6	1	71	0	16.8
4	17.7	6.2	72	4	49	0	24.1
5	18.1	5.3	50	11	64	0	10.6
6	17.8	5.1	30	11	31	0	20.0
7	15.2	5.5	55.7	5	24	0	28.0
8	17.0	5.3	0.6	16	30	0	35.2
9	16.5	4.6	74.7	13	40	0	41.0
10	12.5	4.5	69.2	8	63	0	51.9
11	15.6	4.3	68.1	17	42	0	71.8
12	13.5	3.3	80.0	0	72	0	63
13	16.8	3.9	69.7	21	14	0	79.6
14	13.5	3.3	68.3	22	59	0	64.6
15	13.4	3.1	50.7	9	43	0	48.4
16	10.2	2.5	-	2	74	0	30.1
17	11.6	1.8	55.0	28	28	0	13.3

Reach 2

Reach 2 was 1440 m in length and classified as a Rosgen A2 channel type. This reach contained a large bank failure just below the mouth of Fourth of July Creek (Figure 8). Boulder was the dominant substrate in the reach, and contributed to a high instream cover rating (3.9). Westslope cutthroat (0.3 fish/100 m^2), rainbow (1.0 fish/100 m^2), brook (0.5 fish/100 m^2), and brown trout (.86 fish/100 m^2) were all observed in the snorkel station.

Figure 8. Large bank failure in East Branch LeClerc Creek reach 2.

Reach 3

Reach 3 was 780 m in length and classified as a Rosgen A2 channel type. Westslope cutthroat (0.16 fish/100 m^2), rainbow (0.16 fish/100 m^2), brown (0.32 fish/100 m^2), and brook trout (0.16 fish/100 m^2) were all observed in the snorkel station, however, this reach had the lowest total fish density of all the snorkeled reaches. Pool composition was 1%, mean gradient was high (4.6) and the bank cover rating was low (2.7); these factors likely contributed to low fish density.

Reach 4

Reach 4 was classified as a Rosgen B2 channel type that was 750 m in length. Reach 4 contained the most primary pools (12.8 primary pools/Km) and lowest embeddedness value (37%) of all the surveyed reaches. The reach contained very little riparian shading and a low instream cover value (2.7). Brook trout were the most abundant species (3.7 fish/100 m^2) followed by westslope cutthroat (1.3 fish/100 m^2); rainbow and (0.2 fish/100 m^2) and brown trout (0.4 fish/100 m^2) were also observed.

Reach 5

Reach 5 was 1,050 m in length and classified as a Rosgen A2 channel type. Reach 5 contained very little riparian shading. The reach had a relatively high gradient (4.7%) and the lowest density of LWD (10.6 pieces/100 m) of all the surveyed reaches. The reach also contained an abandoned road crossing that was contributing large amounts of sediment to the stream channel. Rainbow (0.7 fish/100 m^2), brook (2.8 fish/100 m^2), and brown trout (2.8 fish/100 m^2) were all observed in the reach 5 snorkel station.

Reach 6

Reach 6 was 810 m in length and classified as a Rosgen B3 channel type. Reach 6 had the lowest instream cover value (2.2) and a low primary pool frequency (2.4 primary pools/Km). The LWD density for reach 6 was 20 pieces per 100 m; LWD continues to increase throughout the next 11 reaches. Brook trout were the most abundant species (4.4 fish/100 m^2) followed by rainbow trout (2.4 fish/100 m^2), brown trout (2.0 fish/100 m^2), and westslope cutthroat trout (0.7 fish/100 m^2).

Reach 7

Reach 7 was 930 m in length and classified as a Rosgen C2 channel type. Reach 7 appeared to be a transitional reach. The average gradient decreased to 1.9% and the embeddedness increased (75%). Spawning gravels (64.5 m^2) and overall fish density both increased in reach 7. Instream cover continued to be low (2.4). Brook trout were the most abundant species (11.2 fish/100 m^2). Rainbow (6.7 fish/100 m^2) and cutthroat trout (2.6 fish/100 m^2) were the second and third most abundant species followed by brown trout (0.4 fish/100 m^2).

Reach 8

Reach 8 was 1,050 m in length and classified as a Rosgen C4 channel type. Reach 8 contained the most spawning gravels of any reach surveyed (260 m^2). Bank cover in reach 8 was rated high (4.5), however only 15% of the banks were classified as unstable (Figure 9). Brook trout and rainbow trout were the dominant species observed at densities of 10.9 and 2.5 fish/100 m^2, respectively. Cutthroat (0.8 fish/100 m^2) and brown trout (0.4 fish/100 m^2) were observed at lower densities.

Figure 9. Unstable bank in East Branch LeClerc Creek reach 8.

Reach 9

Reach 9 was classified as a Rosgen C3 channel type and was 3,090 m in length. Reach 9 also had a large quantity of spawning gravels (194 m^2) and relatively low bank stability (90%). The embeddedness was high (89%). Brook trout were the most abundant species observed (10.8 fish/100 m^2). Cutthroat trout (1.5 fish/100m^2), rainbow trout (1.1 fish/100 m^2), and brown trout (.94 fish/100 m^2) were less abundant. This was the last reach brown trout were sighted in mainstem East Branch LeClerc Creek. However, brown trout were observed in tributaries higher in the watershed.

Reach 10

Reach 10 was 1,560 m in length and classified as a Rosgen C5 channel type. The dominant substrate was sand. This is likely due to the heavy grazing and logging activities that were observed throughout the reach. Brook trout (9.0 fish/100 m^2) were the most common species observed. Westslope cutthroat trout (0.2 fish/100 m^2) and rainbow trout (0.6 fish/100 m^2) were observed at low densities. This was the last reach that rainbow trout were observed.

Reach 11

Reach 11 was 1,110 m in length and classified as a Rosgen C5 channel type. Reach 11 had a dominant substrate of sand and a high embeddedness value of 97%. Relatively poor bank stability (88%) was observed throughout the reach; unstable banks were partly due the effects of heavy cattle grazing. Brook trout were the most common species observed at a density of 19.8 fish/100 m^2, followed by cutthroat trout (0.5 fish/100 m^2).

Reach 12

Reach 12 was 540 m in length and classified as a Rosgen A3 channel type. The dominant substrate was rubble and gradient increased to 4.6%. The reach was well shaded; however, it contained the most unstable bank of the entire survey (18%). No transects fell on pool type habitat and only 1 primary pool was observed throughout the reach. Indicators of heavy grazing were noted throughout the entire reach. Brook trout were the dominant species (19.8 fish/100 m^2) with cutthroat trout being the only other species observed (1.3 fish/100 m^2).

Reach 13

Reach 13 was 870 m in length and classified as a Rosgen C5 channel type. The reach contained the highest LWD frequency (79.6 pieces per 100 m) and the best instream and bank cover values of the entire survey (both ratings of 4.9). The reach was 100% embedded with a dominant substrate of sand. This is likely due to impacts from heavy grazing along with historic and current beaver activity. No spawning gravels were observed throughout the reach. This reach had the highest density of brook trout (24.6 fish/100 m^2) of all the reaches surveyed. It was also the last reach where brook trout were observed. Cutthroat trout were observed at a low density (0.3 fish/100 m^2).

Reach 14

Reach 14 was 900 m in length and classified as a Rosgen A5 channel type. It contained the most pool type habitat (22%) of any reaches surveyed. The dominant substrate was sand. The overall embeddness was 76%. A fish passage barrier was observed in the reach (Figure 10). The barrier was 3.5 m high and no brook trout were observed above it. Bank stability improved from the previous 6 reaches and was up to 95%. Cutthroat trout were the only species observed at a density of 4.5 fish/100 m^2, the highest of the survey. Reach 14 was the last reach that fish data was collected.

Figure 10. Fish passage barrier in East Branch LeClerc reach 14.

Reach 15

Reach 15 was 1,950 m in length and classified as a Rosgen B5 channel type. The embeddedness was high (93%), with a dominant substrate of sand. LWD density decreased from the previous 5 reaches and was at 48.4 pieces per 100 m. Only 9% of the habitat was composed of pools.

Reach 16

Reach 16 was 660 m in length and classified as a Rosgen B4 channel type. It was composed of 74% riffle type habitat, the most of any reach in the entire survey. The gradient averaged 3.6%. No primary pools and a low bank cover value (2.5) were observed. The slopes above the reach were being heavily logged during the time of the survey.

Reach 17

Reach 17 was 210 m in length and classified as a Rosgen A4 channel type. The pool and riffle type habitat was evenly divided at 28%. No spawning gravel and little LWD (13.3 pieces/100 m) were observed. Active timber harvesting was occurring in this reach as well. The survey was terminated at the end of the reach.

East Branch LeClerc Tributary 1

Only one reach was surveyed in East Branch LeClerc Tributary 1. It was 1,680 m in length and classified as a Rosgen A3 channel type (Table 5). The reach was heavily embedded (93%) with relatively low bank stability (93%) (Table 6). The most commonly occurring habitat type was riffle habitat at 72% (Table 7). Two fish passage barriers were noted with no fish observed above either one. A temperature logger was placed near the mouth of Tributary 1 and recorded a high temperature of 15.2 ^{o}C on August 18th (Figure 11). Cutthroat trout (0.7 fish/100 m^2) and brook trout (7.3 fish/100 m^2) were both observed below the possible barriers (Figure 12).

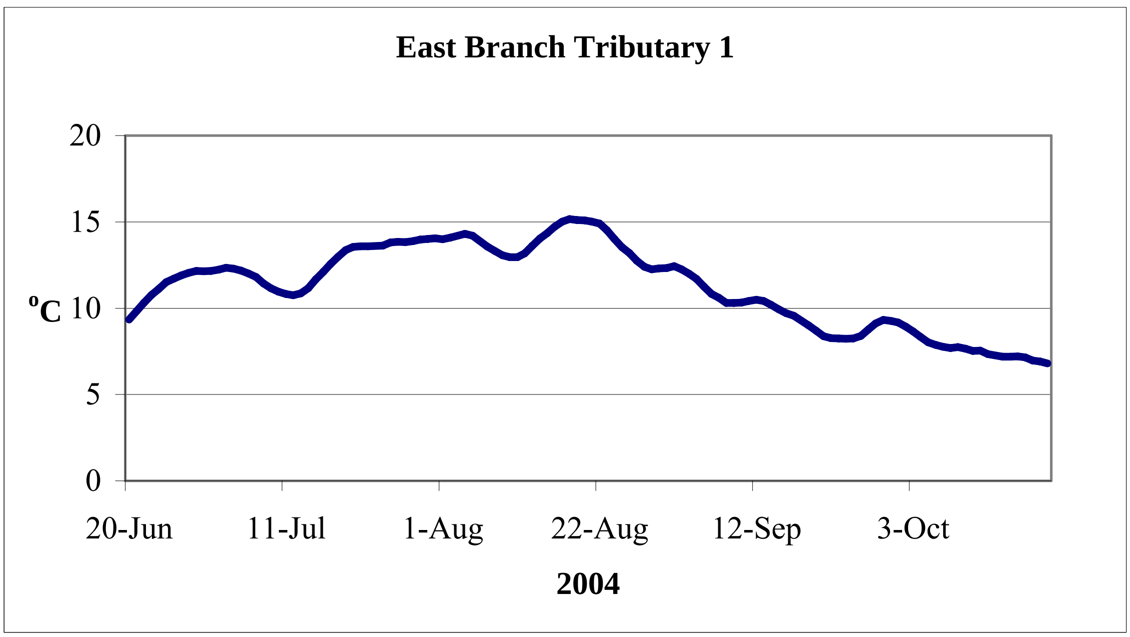

Figure 11. Seven day average daily maximum temperature for East Branch LeClerc Tributary 1.

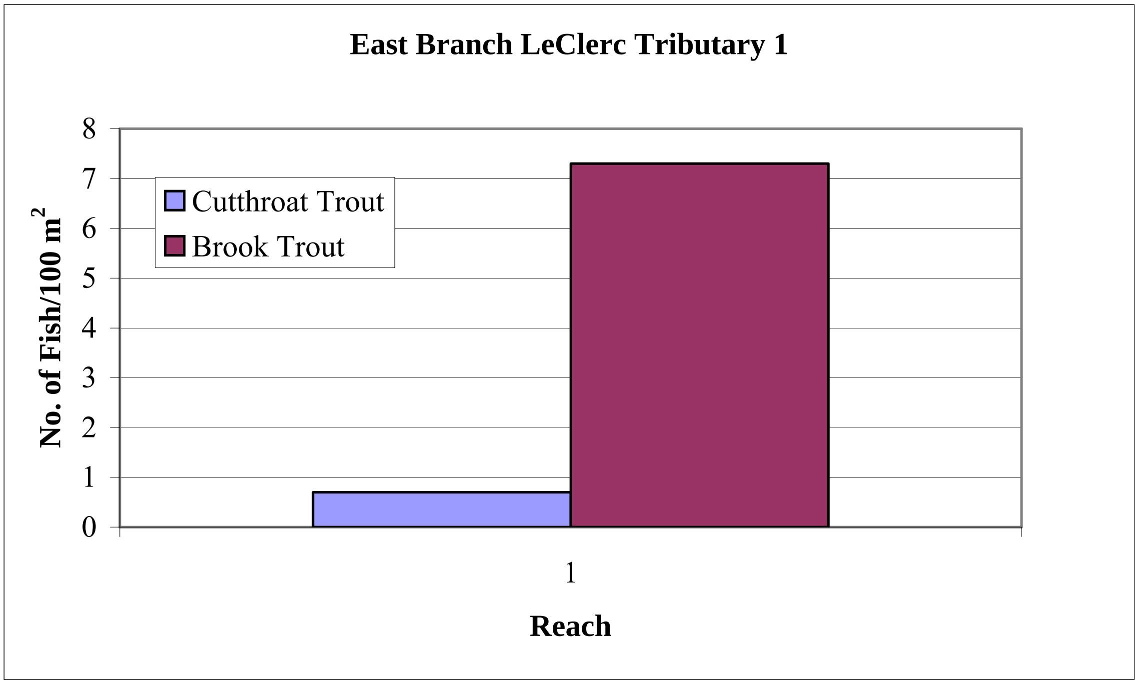

Figure 12. Fish densities for reach 1of East Branch LeClerc Tributary 1.

Table 5. Rosgen (1994) channel classifications and reach scale attributes for reaches surveyed in East Branch LeClerc Tributary 1.

East Branch LeClerc Tributary 1			
Reach	Channel Type	Average Gradient (%)	Dominant Substrate
1	A3	4.6	Cobble

Table 6. East Branch LeClerc Tributary 1 limiting factor attributes.

East Branch LeClerc Tributary 1							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	93	93	2.5	2.7	0.1	19.0	1.2

Table 7. Habitat attributes for reaches surveyed in East Branch LeClerc Tributary 1.

East Branch LeClerc Tributary 1							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	6.2	1.6	37.5	14	72	0	37.2

East Branch LeClerc Tributary 2

In East Branch LeClerc Tributary 2 only one reach was surveyed. It was 1,500 m in length and classified as a Rosgen A4 channel type (Table 8). The reach was highly embedded (88%) with relatively low bank stability (90%) (Table 9). Pool type habitat was common throughout the reach (42%). The reach also contained 33.2 pieces of LWD per 100 m (Table 10). Cutthroat trout (2.6 fish/100 m^2) and brook trout (12.2 fish/100 m^2) were the only two species observed (Figure 13).

Table 8. Rosgen (1994) channel classifications and reach scale attributes for reaches surveyed in East Branch LeClerc Tributary 2.

East Branch LeClerc Tributary 2				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	A4	3.3	Small Gravel	6.5

Table 9. East Branch LeClerc Tributary 2 limiting factor attributes.

East Branch LeClerc Tributary 2							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	88	90	3.3	3.3	0.1	3.0	1.3

Table 10. Habitat attributes for reaches surveyed in East Branch LeClerc Tributary 2.

East Branch LeClerc Tributary 2							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	6.2	1.7	27.5	42	54	0	33.2

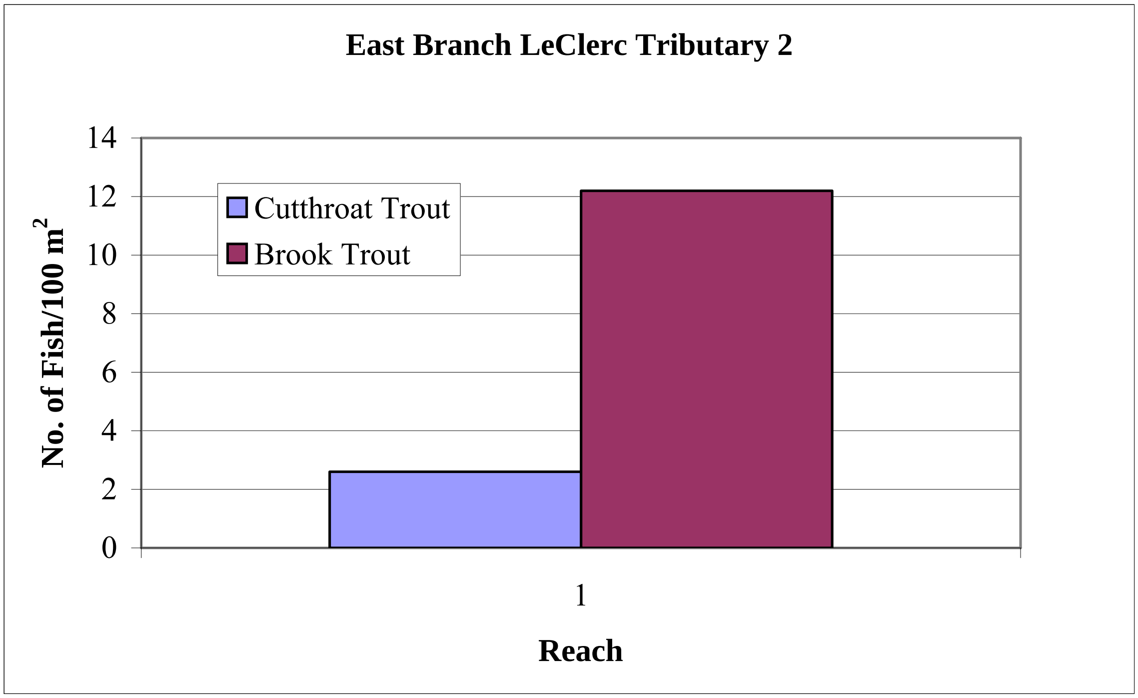

Figure 13. Fish densities for reach 1 of East Branch LeClerc Tributary 2.

East Branch LeClerc Tributary 3

Only one reach was surveyed in East Branch LeClerc Tributary 3. The reach was 1,200 m in length and classified as a Rosgen B5 channel type (Table 11). Brook trout (12.1 fish/100 m^2), brown trout (2.1 fish/100 m^2), and cutthroat trout (1.4 fish/100 m^2) were all observed (Figure 14). It was highly embedded (92%, Table 12) and contained a road crossing contributing large amounts of fine sediments to the channel. The reach was composed primarily of a riffle type habitat (65%) with relatively little pool habitat (19%, Table 13). One temperature logger was placed in the reach and recorded a high temperature of 14.2 ^{o}C on August 17th (Figure 15).

Table 11. Rosgen (1994) channel classifications and reach scale attributes for reaches surveyed in East Branch LeClerc Tributary 3.

East Branch LeClerc Tributary 3			
Reach	Channel Type	Average Gradient (%)	Dominant Substrate
1	B5	2.9	Sand

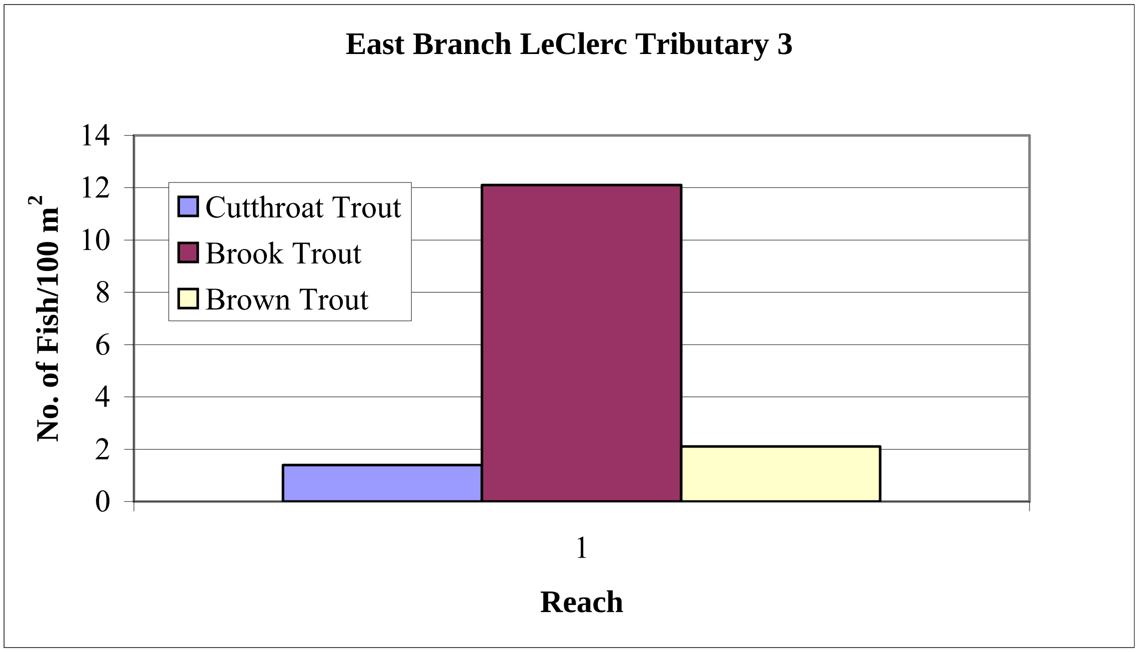

Figure 14. Fish densities for reach 1 of East Branch LeClerc Tributary 3.

Table 12. East Branch LeClerc Tributary 3 limiting factor attributes.

East Branch LeClerc Tributary 3							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	92	96	2.0	2.1	0.1	11.0	1.6

Table 13. Habitat attributes for reaches surveyed in East Branch LeClerc Tributary 3.

East Branch LeClerc Tributary 3							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	8.0	1.7	35.0	19	65	0	21.0

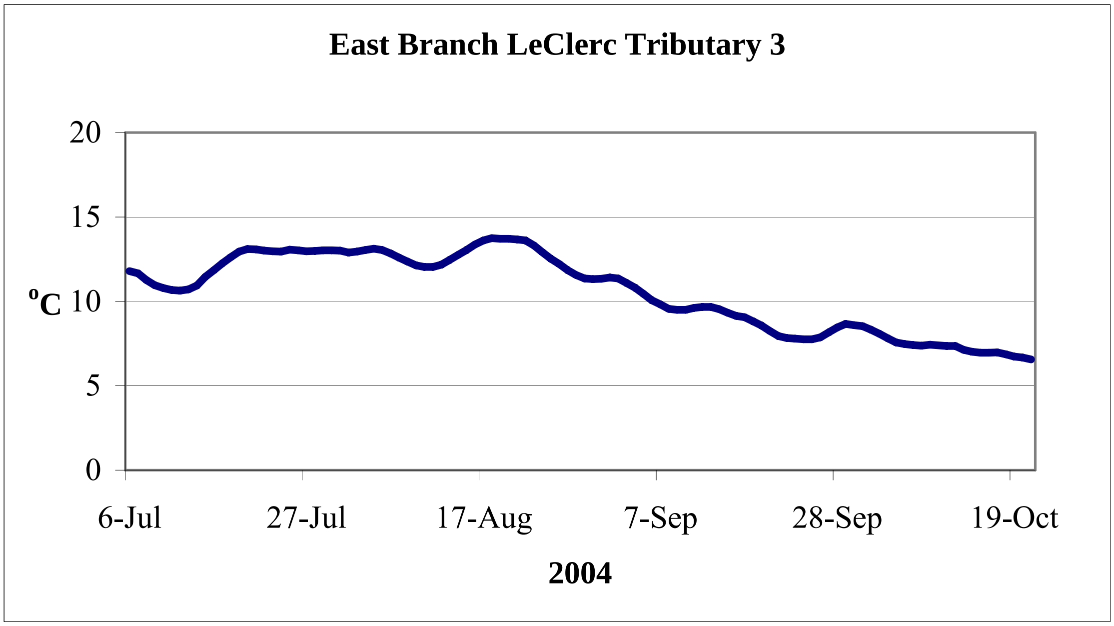

Figure 15. Seven day average daily maximum temperatures for East Branch LeClerc Tributary 3.

East Branch LeClerc Tributary 4

Two reaches were surveyed in Tributary 4 totaling 1.6 Km in length. Fish data were only collected in reach 1. Brook trout were the only species observed at a density of 45 fish/100 m^2 (Figure 16). A thermograph was placed near the mouth of Tributary 4 and recorded a high temperature of 13.5 °C on August 17th (Figure 17).

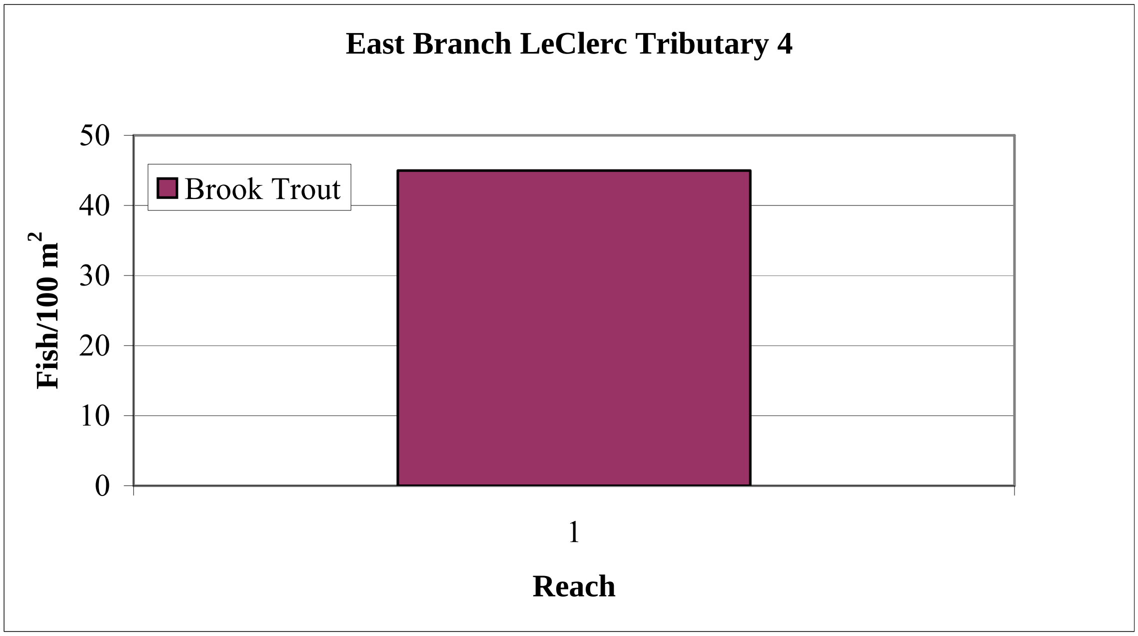

Figure 16. Fish densities for reach 1 of East Branch LeClerc Tributary 4.

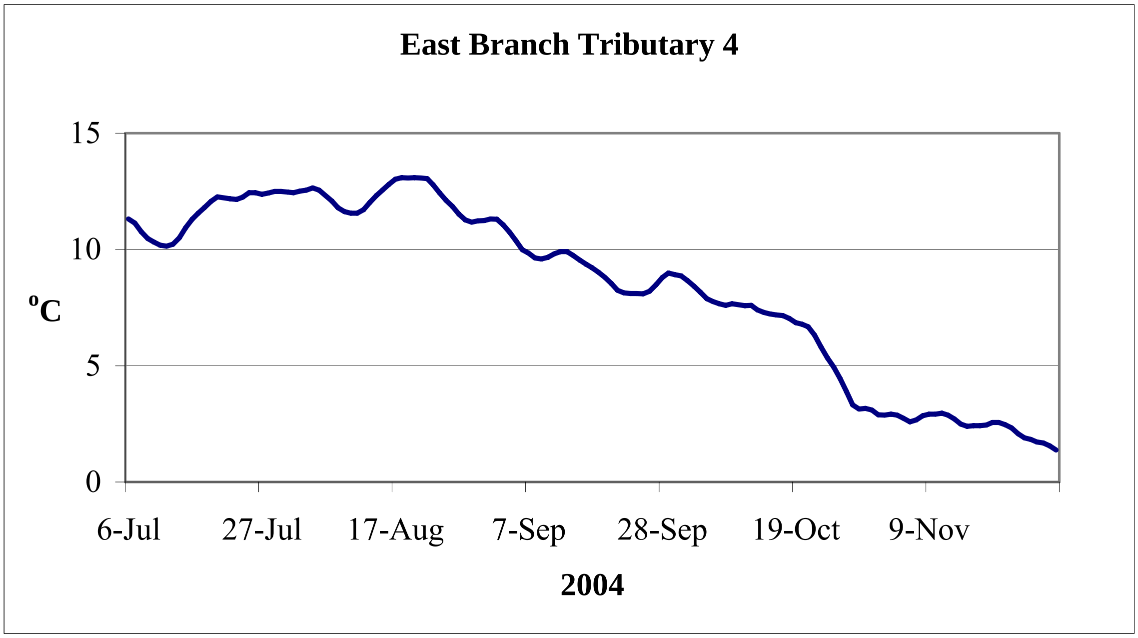

Figure 17. Seven day average daily maximum temperature for East Branch LeClerc Tributary 4.

Reach 1

Reach 1 was 1,290 m in length and classified as a Rosgen C5 channel type (Table 14). The reach was primarily composed of an old, deteriorating beaver complex. There were 6.8 primary pools/ Km. Evidence of cattle grazing was observed throughout the reach. Embeddedness was high (99%) likely due to a failing road crossing, and deteriorating beaver complex that was observed in the reach (Table15).

Table 14. Rosgen (1994) channel classifications and reach scale attributes for reaches surveyed in East Branch LeClerc Tributary 4.

East Branch LeClerc Tributary 4			
Reach	Channel Type	Average Gradient (%)	Dominant Substrate
1	C5	1.2	Sand
2	A5	5.1	Sand

Table 15. East Branch LeClerc Tributary 4 limiting factor attributes.

East Branch LeClerc Tributary 4							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	99	99	2.0	3.1	.3	9.5	6.8
2	94	94	1.3	1.6	.3	0	0

Reach 2

Reach 2 was 390 m in length and classified as a Rosgen A5 channel type. Cattle were grazing along the bank of the reach at the time of the survey. No spawning gravels or primary pools were observed (Table 16). LWD was common throughout the reach (41.4 pieces/100 m).

Table 16. Habitat attributes for reaches surveyed in East Branch LeClerc Tributary 4.

East Branch LeClerc Tributary 4							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	10.3	1.6	47.2	18	49	0	37.8
2	7.3	1.6	0	22	63	0	41.4

Diamond Fork Creek

Six reaches totaling 2.7 Km were surveyed in Diamond Fork Creek (Figure 18). The survey began at the confluence of West Branch LeClerc Creek and was terminated in the headwaters. The Diamond Fork Creek watershed is located primarily on USFS managed land. The entire riparian area of the stream appeared to be heavily grazed and logged historically. Many reaches have been or are currently occupied by beaver. Fish data were only collected in the first reach of the survey due to time constraints. Brook trout and westslope cutthroat trout were observed in reach 1 (Figure 19).

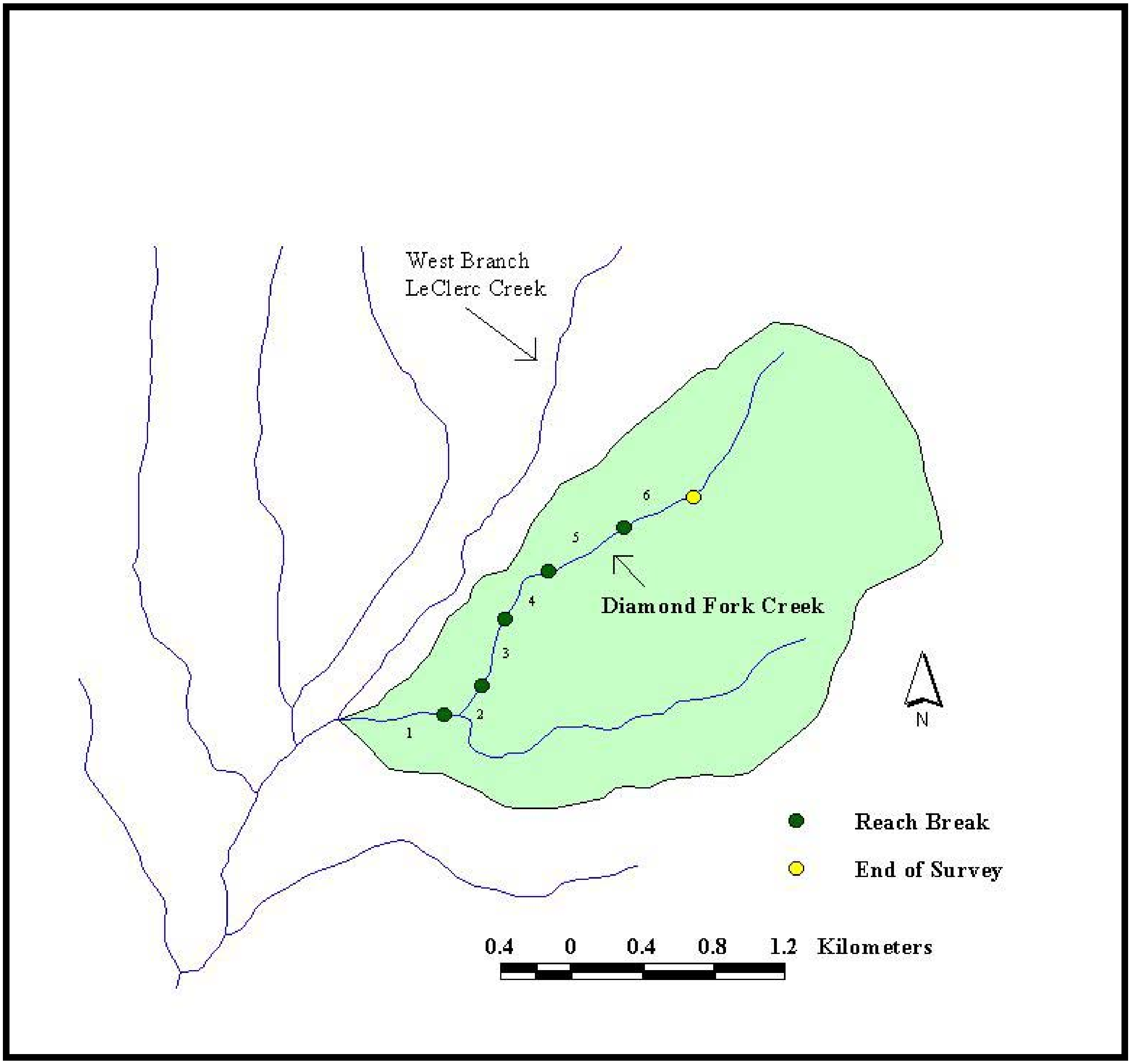

Figure 18. Map of Diamond Fork Creek watershed and reach breaks.

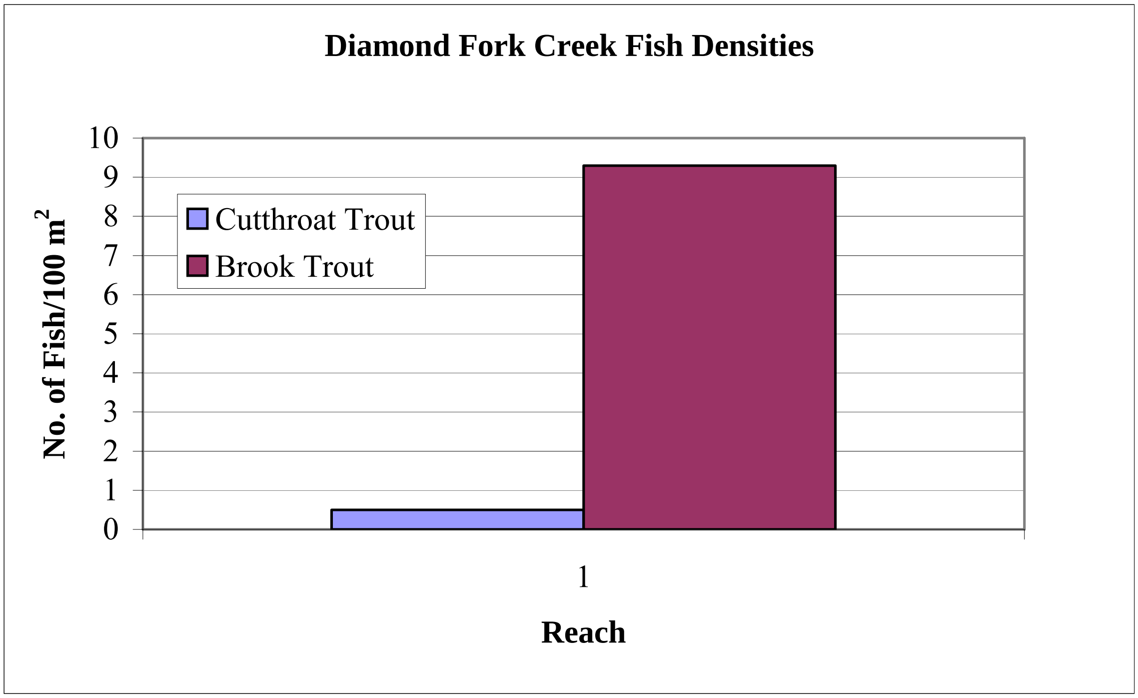

Figure 19. Fish densities for reach 1 of Diamond Fork Creek.

Reach 1

Reach 1 was 660 m in length and classified as a Rosgen B3 channel type (Table 17). Reach 1 has the largest substrate (rubble), highest gradient (2.8%), and the lowest embededness (81%) of all the reaches surveyed (Table 18). It also had the most LWD (36.5 pieces/100 m) and best shading of all the reaches surveyed (Table 19). The reach however, had no spawning gravels and was being utilized by grazing cattle. Brook trout (9.3 fish/100 m^2) and westslope cutthroat trout (0.5 fish/100m^2) were the only species observed.

Table 17. Channel characteristics for reaches surveyed in Diamond Fork Creek.

Diamond Fork Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B3	2.8	Rubble	7.4
2	C6	1.2	Silt	-
3	B3	2.7	Cobble	7.7
4	B3	2.0	Cobble	-
5	B5	2.6	Sand	16.5
6	B5	2.0	Sand	10.7

Table 18. Diamond Fork Creek limiting factors attributes.

Diamond Fork Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools/ Km
1	81	98	4.7	4.5	0.2	0.0	6.1
2	100	98	2.5	2.2	1.2	14.0	6.1
3	94	100	3.8	3.3	0.0	1.0	0.0
4	90	99	2.5	2.2	0.2	2.0	2.8
5	100	100	3.5	3.3	0.2	1.0	0.0
6	100	100	1.9	1.9	0.1	12.0	0.0

Table 19. Habitat attributes for reaches surveyed in Diamond Fork Creek.

Diamond Fork Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	11.5	2.4	30.0	23	74	0	36.5
2	30.2	2.0	40.0	54	29	0	7.3
3	11.9	2.0	-	0	75	0	24.1
4	12.3	2.3	50.0	20	65	0	26.9
5	10.9	1.8	-	21	62	0	27.6
6	9.7	1.9	-	15	85	0	24.2

Reach 2

Reach 2 was 300 m in length and classified as a Rosgen C6 channel type. The dominant substrate was silt (100% embedded). There was little instream (2.2) and bank cover (2.5). More than half of the habitat was composed of pools (54%) however; few primary pools were identified (6.1 per Km). High pool composition was a result of present and past beaver activity.

Reach 3

Reach 3 was 360 m in length and classified as a Rosgen B3 channel type. The dominant substrate was composed of cobble that was highly embedded (94%). Only 1.0 m^2 of spawning gravel was identified. No primary pools or pool type habitat was recorded in reach 3. Cattle were grazing along the stream banks at the time of the survey.

Reach 4

Reach 4 was 330 m in length and classified as a Rosgen B3 channel type. The reach lacked overstory to provide shading to the channel. The instream (2.2) and bank cover values (2.5) were both relatively low. Impacts from grazing and an old beaver pond complex were observed.

Reach 5

Reach 5 was 480 m in length and classified as a Rosgen B5 channel type. The reach contained good shading and had the second highest density of LWD (27.6 pieces per 100 m). Despite high number of LWD, no primary pools were observed. The dominant substrate was composed of sand (100% embedded). Cattle were seen in the channel throughout the reach.

Reach 6

Reach 6 was 570 m in length and classified as a Rosgen B5 channel type. Like reach 5, the dominant substrate in reach 6 was sand. No primary pools were observed. The mean instream (1.9) and bank cover (1.9) were the lowest values observed in Diamond Fork Creek. Cattle were observed in the channel throughout the reach. The survey was terminated at the end of this reach.

Lost Creek

Two reaches totaling 1.5 Km were surveyed in Lost Creek (Figure 20). Two fish passage barriers were observed in the surveyed portion of the stream. The first barrier was a culvert where Highway 2 crossed over the creek. This barrier is approximately 30 m upstream from where the stream enters the Pend Oreille River. This barrier has precluded non-native species from upstream reaches. Cutthroat trout were the only species observed up stream of the first barrier. The stream has been affected by logging, cattle grazing, and dumping of refuse (e.g. tires, boards).

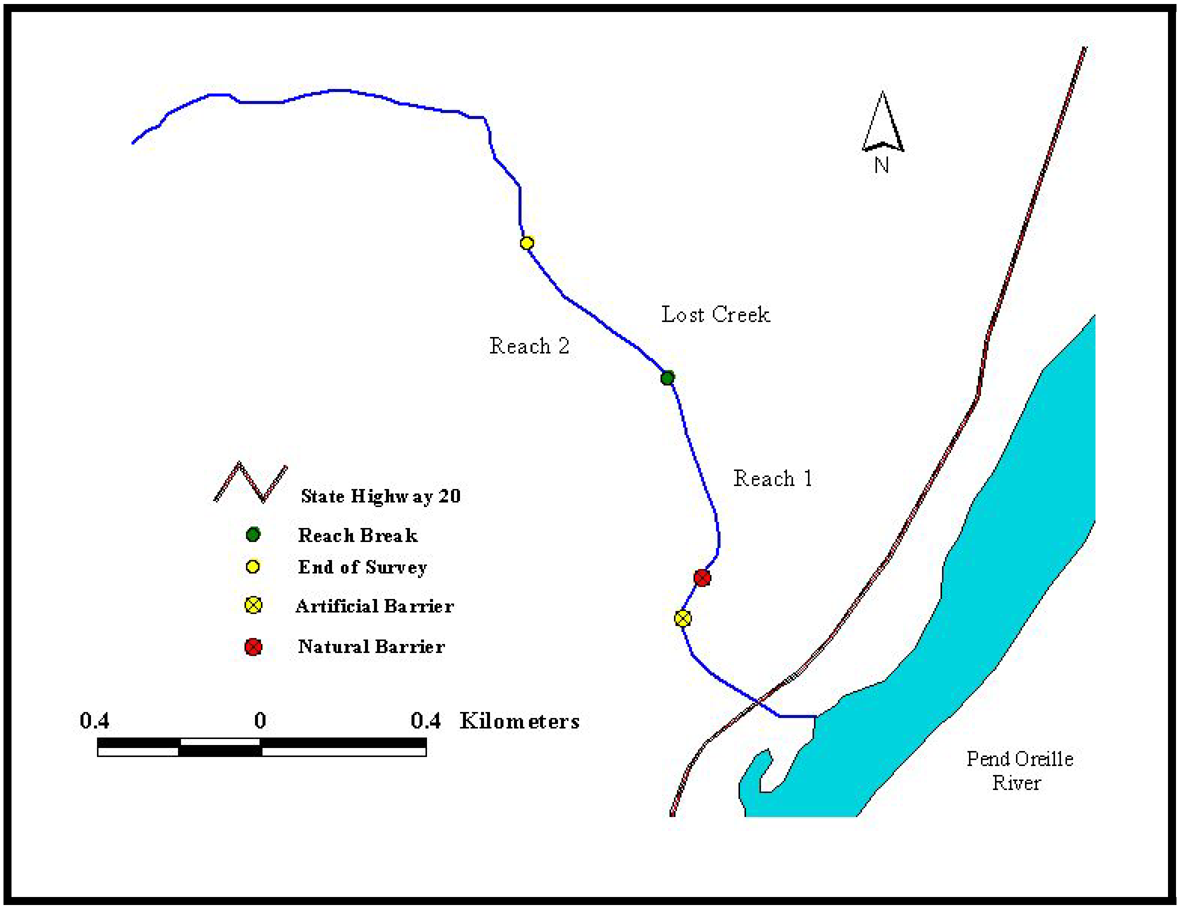

Figure 20. Map of Lost Creek reach breaks, natural, and artificial barriers.

Reach 1

Reach 1 was 1,140 m in length and classified as a Rosgen A4 channel type (Table 20). Reach 1 contained good canopy shading of the channel. The reach was highly embedded (82%) and contained no spawning gravels (Table 21). The reach was primarily made up of riffle type habitat (81%) with only 17% of the habitat composed of pools (Table 22). A 1.5 m man-made barrier was observed in the lower end of the reach. The barrier was approximately 1.5 m in height (Figure 21).

Figure 21. Man-made barrier in reach 1 of Lost Creek.

Table 20. Channel classifications and reach scale attributes for reaches surveyed in Lost Creek.

Lost Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	A4	4.7	Gravel	7.3
2	B4	2.0	Gravel	7.6

Table 21. Lost Creek limiting factor attributes.

Lost Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	82	99	2.3	2.6	0.1	0.0	0.9
2	93	98	4.3	4.3	0.1	0.0	2.2

Table 22. Habitat attributes for reaches surveyed in Lost Creek.

Lost Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	6.2	1.3	20	17	81	0	19.1
2	7.3	1.0	30	10	62	0	11.3

Reach 2

Reach 2 was 420 m in length and classified as a Rosgen B4 channel type. The reach contained an old beaver complex. Evidence of cattle grazing was observed throughout much of the reach. Mean bank (4.3) and instream cover (4.3) were both rated high. No spawning gravels were observed. The survey was terminated at the end of this reach.

DISCUSSION

Various land-use and management activities can affect native salmonid habitats. This has lead to altered and degraded riparian areas, which have adversely impacted streams throughout the west. These riparian alterations have contributed to widespread declines of inland native fishes, which often favor exotic species (Griffith 1988). Generally, the land-use activities that have the greatest impact on stream habitat are timber harvest, mining, roads, and grazing. Anderson (1988), citing a 1986 report of the Montana State Water Quality Bureau, suggested that the single greatest threat to watersheds and aquatic life is timber harvest and associated road building within forests. Increased delivery of sediments, especially fine sediments, is usually associated with timber harvesting and road construction (Eaglin and Hubert 1993; Frissell and Liss 1986; Havis and others 1993). Roads often contribute more sediment to streams than any other land management activity (Meehan 1991), but most land management activities, such as mining, timber harvest, grazing, and recreation are dependent on roads. Within the East Branch LeClerc, Diamond Fork and Lost creek watersheds, logging, grazing, and roads have all contributed to the degradation of aquatic and riparian habitat. Roads, both abandoned and in-service, run adjacent to East Branch LeClerc Creek and Lost Creek throughout much of the watersheds. In many locations, these roads are point sediment sources during precipitation events (Figure 22). Ideally, roads would be excluded from riparian zones because they are often a major source of soil erosion. In some cases as much as 90% of instream sediments have come from roads (Anderson et al. 1976).

Figure 22. Forest Service Road 1934 contributing fine sediment to the stream channel.

East Branch LeClerc, Diamond Fork and Lost Creek all contained large amounts of fine sediment. Fine sediment hinders the aquatic ecosystem in a number of ways. Fine sediment deposits may seal rubble and gravel substrates, decreasing spawning area, egg survival, escapement of fry, and hiding cover for fingerlings (Scatterland and Adams 1992). Invertebrate food supplies are reduced and pool volumes may be drastically decreased, resulting in direct loss of living space (Reiser and Bjornn, 1979; Toews and Brownlee, 1981). This was evident in East Branch LeClerc Creek; despite a high frequency of LWD, few primary pools were classified due to sediment filling.

Grazing and logging both appear to have contributed to high levels of sediment observed throughout the streams surveyed in 2004. Continuous grazing of riparian areas reduces the establishment of climax species through the processes of browsing and soil compacting (Scatterland and Adams 1992). Trampling also tends to further destroy the protective cover, and breaks down the stream banks (Scatterland and Adams 1992). Recent and historic grazing grazing of the East Branch LeClerc and Diamond Fork watersheds has left much of the riparian vegetation simplified and in early seral stages. These activities may greatly reduce the availability for LWD recruitment in the future.

Although stream degradation is detrimental to native salmonids, it generally favors introduced salmonid species, which are more tolerant to lower quality habitat conditions (Griffith 1988). Behnke (1979) described how clearcutting along two streams in the Smith River drainage of Montana increased erosion, sediment loads, and water temperatures. The westslope cutthroat population was eliminated in the disturbed area and brook trout became the principle species. However, a small area in the headwaters of one stream was not logged and a remnant cutthroat population still dominated in that reach. Platts (1974) also reported that cutthroat were common only in undisturbed reaches of stream in the Salmon River drainage of Idaho. In both East Branch LeClerc

Creek and Lost Creek fish passage barriers were observed. In both cases the only species found above the barriers were native westslope cutthroat trout. Below the barriers, non-native species appeared to be displacing and out-competing native cutthroats. The protection of high quality habitat and the use and maintenance of barriers as a management tool is essential for the continued persistence of native salmonid populations in the Pend Oreille River watershed.

2004 NON-NATIVE FISH REMOVAL

DESCRIPTION OF STUDY AREA

In 2004, brook trout removals continued in Mineral Creek, Saucon Creek, and two unnamed tributaries to West Branch LeClerc Creek. Mineral Creek is a headwater tributary to West Branch LeClerc Creek. The non-native fish removal project started approximately 350 m upstream from the confluence at an elevation of 1036 m (Figure 23). The removal project was terminated 3.7 Km upstream near an elevation of 1240 m. This is the third year of treatment on Mineral Creek.

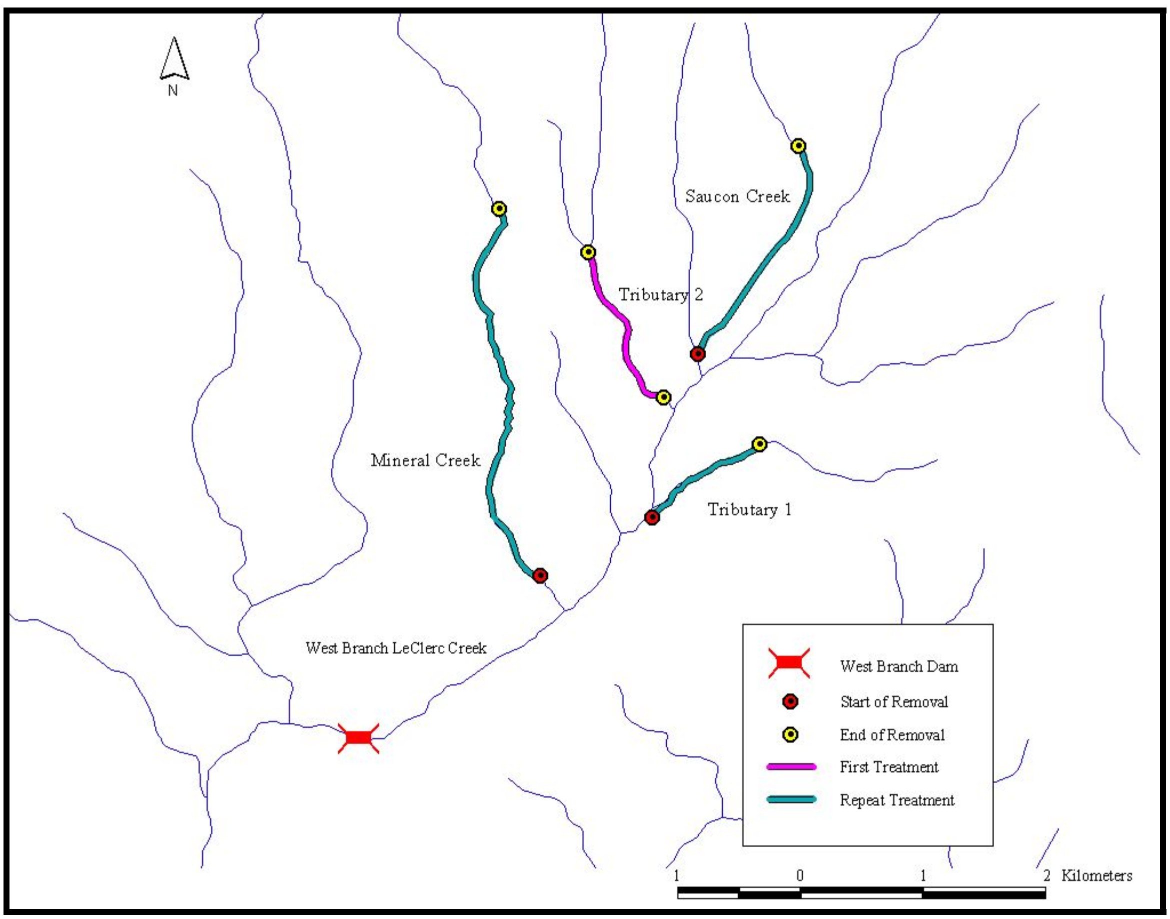

Figure 23. Map of brook trout removal sites.

Saucon Creek is located in the headwaters portion of West Branch LeClerc Creek. The removal was started just upstream of the confluence of Saucon (elevation 1103 m) and West Branch of LeClerc Creek. The removal project was terminated 2 Km upstream at an elevation of 1,280 m.

West Branch LeClerc Tributary 1 (an un-named tributary) is located just south of Saucon Creek. The removal was started at an elevation of 1,128 m and was terminated 1.2 Km (0.7 mile) upstream at an elevation of 1,219 m.

West Branch LeClerc Tributary 2 (an un-named tributary) is located just west of Saucon Creek. The removal was started at an elevation of 1,097 m and was terminated 1.4 Km (0.9 mile) upstream at an elevation of 1,219 m.

METHODS

Non-native Fish Removal

Streams were electrofished using a battery operated Smith-Root LR-24 electrofishing backpack unit. To avoid imminent re-invasion by brook trout, electrofishing commenced at a point in the channel where fish passage was difficult if not impossible. When multiple passes were made, the stream was partitioned into 100 m reaches using 1-cm mesh block nets at both ends of the reach to prevent immigration or emigration of fish before and during electrofishing. All passes were electrofished with relatively constant effort and care was taken to remove all possible stunned fish. In West Branch LeClerc Tributary 1, three electrofishing passes were made in each 100 m section. All fish captured in each pass were removed from the electrofished section. Captured cutthroat trout were released in the adjacent, downstream section (which had previously been electrofished). Captured brook trout were transported in a holding tank to another location and released. Electrofishing occurred upstream until brook trout were absent in the catch in three consecutive 100 m sections.

Due to time constraints a two-pass method was employed in West Branch LeClerc Tributary 2. All other methods were consistent with the description above.

In 2004, Mineral Creek was treated for the third consecutive year and Saucon Creek electrofished for the second consecutive year. The same methods were used; however, only one pass was made, so block nets were not utilized.

RESULTS

Non-native Fish Removal

Twelve 100 m sections of West Branch LeClerc Tributary 1 were electrofished to remove non-native fish. Brook trout were not captured in the last three sections. A total of 454 brook trout were captured and relocated to various sites (Table 23). Westslope cutthroat trout were less abundant; 312 were captured and returned to West Branch LeClerc Tributary 1.

Table 23. Number of fish captured during electrofishing removals in 2004.

Stream Name	No. Passes	Cutthroat Trout	Brook Trout	Totals
West Branch LeClerc Tributary 1	3	312	454	766
West Branch LeClerc Tributary 2	2	79	779	858
Saucon Creek	1	192	269	461
Mineral Creek	1	938	651	1589

Fourteen 100 m sections in West Branch LeClerc Tributary 2 were electrofished using a two-pass treatment. A total of 779 brook trout were captured and relocated to various sites, while 79 cutthroat trout were captured and returned back into the stream (Table 23).

Twenty 100 m sections in Saucon Creek were electrofished using a single pass treatment. Saucon Creek was treated the previous year using a three-pass treatment. A total of 269 brook trout were captured and relocated (Table 23). One hundred ninety two cutthroat trout were captured and returned to the stream.

Thirty-one 100 m sections in Mineral Creek were electrofished using a single pass treatment. Mineral Creek was treated the previous two years. In the first year a three-pass treatment was employed. A single pass treatment was used in the second year. A total of 651 brook trout were removed and relocated (Table 23).

DISCUSSION

The third phase of brook trout removal in Saucon Creek and West Branch LeClerc Tributary 1 will occur in 2005. Because they are more difficult to sight and capture, age 0^+ brook trout can have relatively low removal efficiencies (Thompson and Rahel, 1996). All of the channels that have been selected for removals contain an abundant volume of woody debris, making removal difficult with only one or two treatments. Therefore, previous sites will be electrofished again, with one pass, in 2005 with the exception of Mineral Creek.

In 2004, Mineral Creek received a third treatment to further remove non-native brook trout. The non-native fish removal in Mineral Creek has shifted the population from one dominated by brook trout to one with westslope cutthroat trout holding a slight advantage (Figure 24). In 2004, a total of 938 westslope cutthroat trout were captured along with 651 brook trout. Due to the large number of brook trout captured in 2003 it was suspected that the barrier located at the downstream end of the treatment section may be being breached. In 2003, we captured, marked, and released approximately 300 brook trout below the barrier. In 2004, we did find one marked brook trout above the barrier, however, we feel that with only one fish being able to breach the barrier that the jeopardy of the project isn't at high risk of re-invasion. The removal has greatly decreased the number of brook trout in the Mineral Creek treatment site. Mineral Creek will receive another treatment in 2006 to monitor fish numbers.

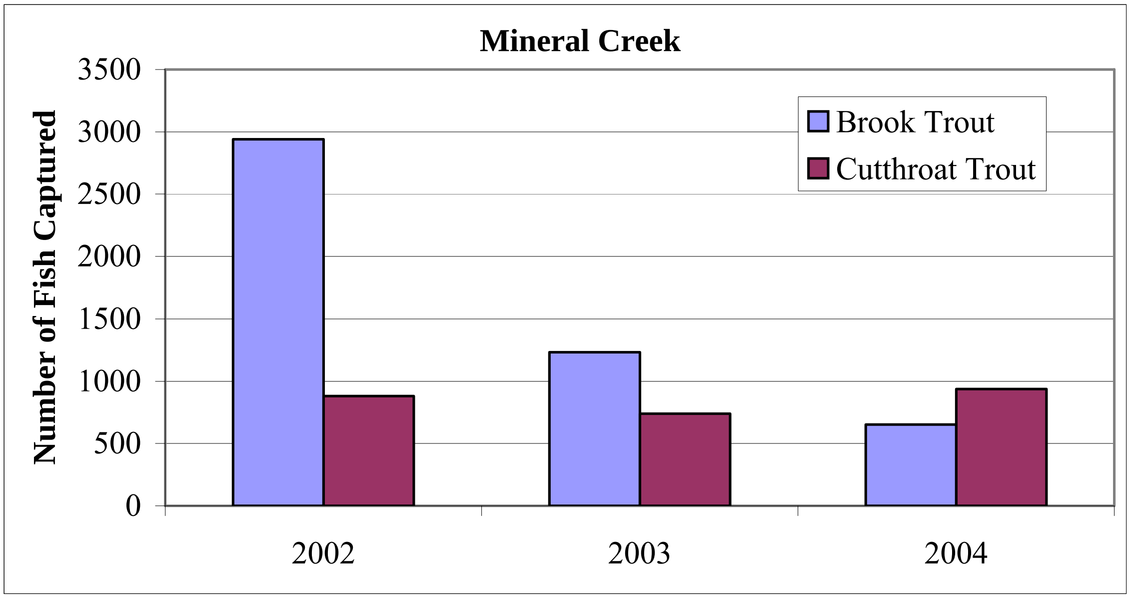

Figure 24. Number of brook trout and westslope cutthroat trout captured in all treatments of Mineral Creek.

A similar project in Montana was conducted in Sheppard Creek. The stream length treated and numbers of fish captured in the first two treatments were similar to Mineral Creek. However, the third treatment in our project produced a much lower number of brook trout. The Sheppard Creek project is considered a success by the USFS.

LARGEMOUTH BASS HABITAT ENHANCEMENT MONITORING

DESCRIPTION OF STUDY AREA

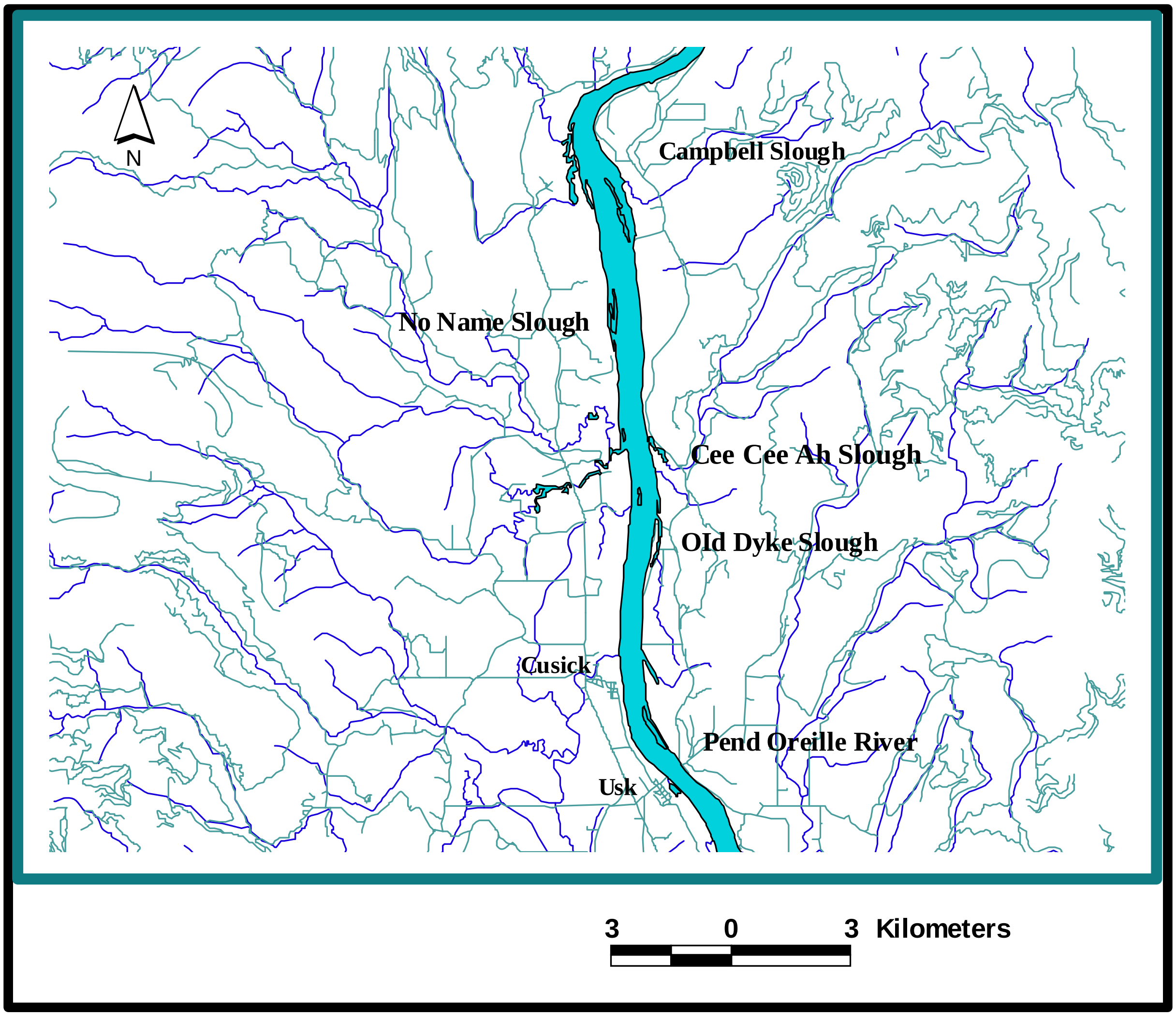

Figure 25. Location of the bass habitat enhancement sites.

The bass habitat enhancement study was located in zero flow areas of the reservoir (i.e. adjacent to and within sloughs). Four sloughs were used for the study:

1) Campbell slough adjacent to the Pend Oreille Wetlands Wildlife Mitigation Project, located on the east side of the Box Canyon Reservoir, at river km 99 (Figure 25).

2) No Name slough located directly across the reservoir from Campbell slough, on the west side of the reservoir, at river km 99.

3) Cee Cee Ah slough, located within the Kalispel Reservation on the east side of the reservoir, at river km 109.

4) Old Dike slough, contained within the Kalispel Reservation and located on the east side of the reservoir, at river km 107.

METHODS

Selection of the sloughs used in the bass habitat study was based on the two types of sloughs available within the reservoir. The sloughs are either backwater stream mouths or dead end river backwater. Four sloughs were selected: one stream fed treatment slough, one stream fed control slough, one backwater treatment slough and one backwater control slough.

Two types of artificial structures were used in the treatment sloughs. The Berkley structures are 4-ft. cubes of plastic slats that provide cover in the interstitial spaces. The Pradco structures resemble palm trees and provide cover under the palms. The placement of each type was alternated between the two treatment sloughs (Berkley in the mouth transect in one slough and in the inland transect of the second slough).

Each slough was sampled prior to artificial habitat installation. Two 75 m sampling transects were established for each slough. Between the transects, a 75 m buffer was established to avoid data collection overlap. Each transect was then electrofished for a period of 300 seconds and all fish were collected. Bass total lengths and abundance were recorded; all other fish were recorded as total numbers by species.
In the spring and fall, each transect is electrofished annually. Relative abundance (CPUE) and species composition are calculated for each transect. Analysis will include whether the structures increase the abundance of juvenile largemouth bass.

RESULTS

From 1997 (pre-assessment) to fall 2004, largemouth bass relative abundance increased at every sampling site with the exception of Cee Cee Ah Slough #1 which was unchanged. Sampling of the largemouth bass enhancement sites did not occur in the fall of 1998, 2000, and 2003. Early sub-freezing temperatures iced the sloughs over in early November and the ice remained throughout the month.

In Cee Cee Ah Slough #1, largemouth bass relative abundance was 2 in the fall of 1997 and again in the fall of 2002, however no largemouth bass were captured in 2004 (Figure 26). In Cee Cee Ah Slough #2, largemouth bass were only present in the catch in the fall of 1999 (n=2, Figure 27), 2002 (n=1), and the spring and fall of 2004 (n=1, n=3).

In No Name Slough #1, largemouth bass relative abundance appeared to increase significantly in the fall of 1999 when 14 were collected (Figure 28). No largemouth bass were collected in the 1997 pre-assessment or the 1999 to 2003 spring post assessments. Two largemouth bass were collected at this site in the fall of 2004. No bass were present in the 1997 pre-assessment sample in No Name Slough #2 (Figure 29). Two bass were collected in the spring of 1998 and four bass were collected in the fall 1999 sample. No fish were collected in the 1999, 2000, 2001, or 2003 spring sampling periods and 6 largemouth bass were present in the 2001, 2002, and 2004 fall samples.

In Old Dyke #1, two bass were captured in the 1997 pre-assessment (Figure 30). Prior to fall of 2004, largemouth bass were collected in only four other sampling periods: one in the fall of 1999, 3 in the fall of 2001and 39 in the fall of 2002. No largemouth bass were present in the catch in any of the spring sampling periods. However, in the fall of 2002 and 2004 high densities of largemouth bass were captured (39 and 18 respectively). In Old Dyke #2, largemouth bass were present in the catch in all sample periods except in the spring of 2001 (Figure 31). One bass was captured in the 1997 pre-assessment and three were captured in the fall of 2001. Twenty largemouth bass were captured in 2002; an increase of 333% over any other sampling period. In Old Dyke #1 2004, yielded the second highest overall bass catch (n=18).

In Campbell Slough #1, largemouth bass have been present in the catches of all sampling periods. Largemouth bass relative abundance increased dramatically from pre-assessment (n=1) to fall 2004 (n=15)(Figure 32). Largemouth bass abundance in the spring of 1998 and 2001 was also relatively high with 19 and 17 bass captured, respectively. Largemouth bass relative abundance initially increased in Campbell Slough #2 (Figure 33). The 1997 pre-assessed abundance was 1. Large increases were observed in spring 1998 (n=19) and spring 1999 (n=18). Five largemouth bass were captured in fall 1999. Bass numbers declined in the fall of 1999 (n=5) and spring of 2000 (n=1). However in 2001 and 2004, fall largemouth bass relative abundance was relatively high at 30 and 31, respectively.

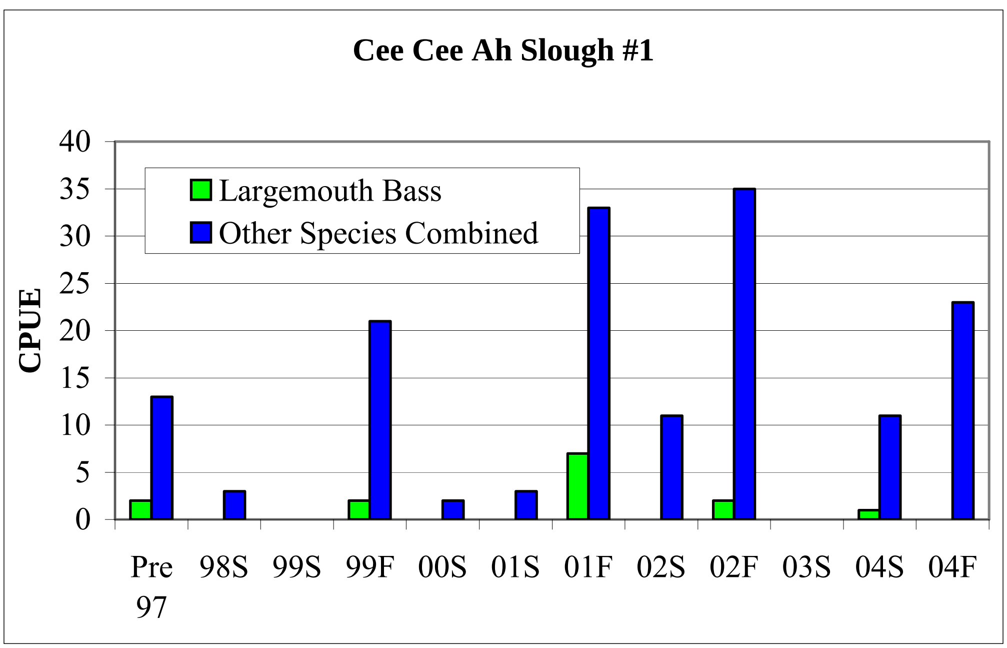

Figure 26. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #1.

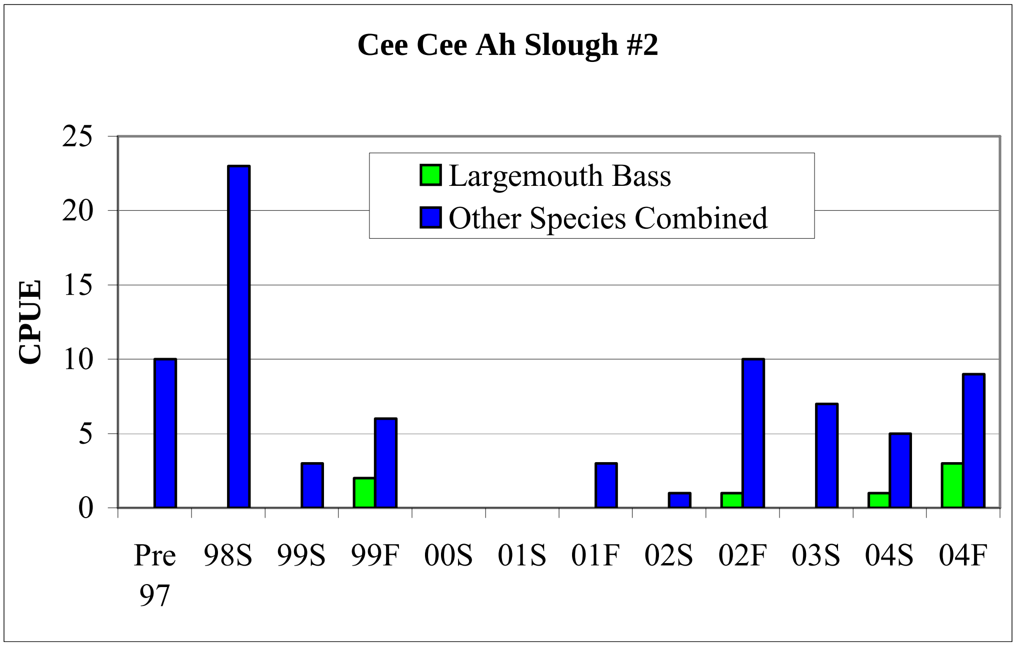

Figure 27. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #2.

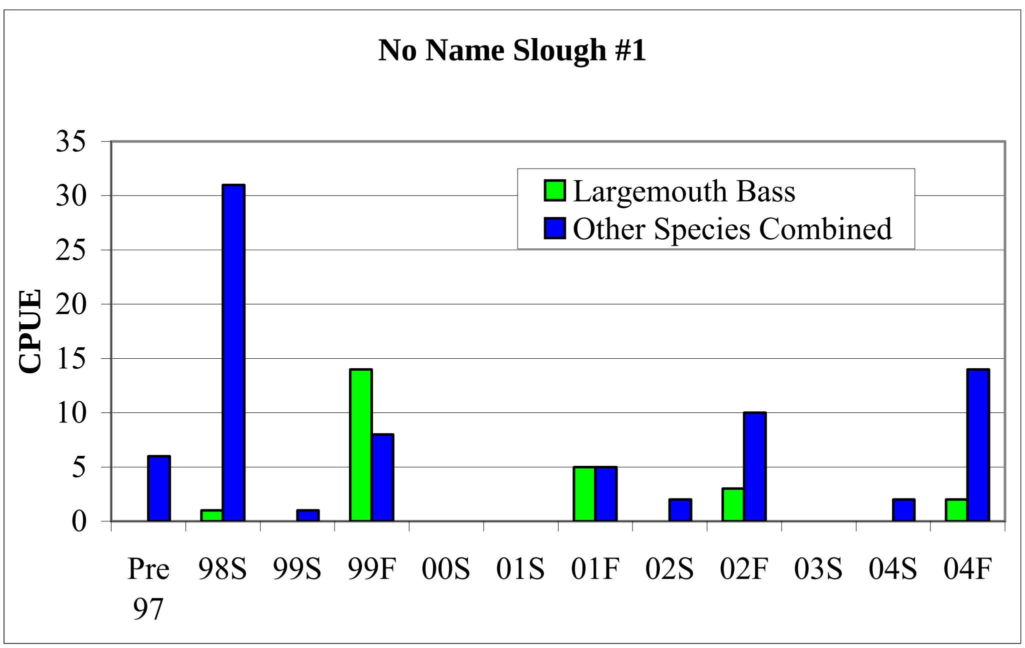

Figure 28. Largemouth bass and combined fish relative abundance for transects in No Name Slough #1.

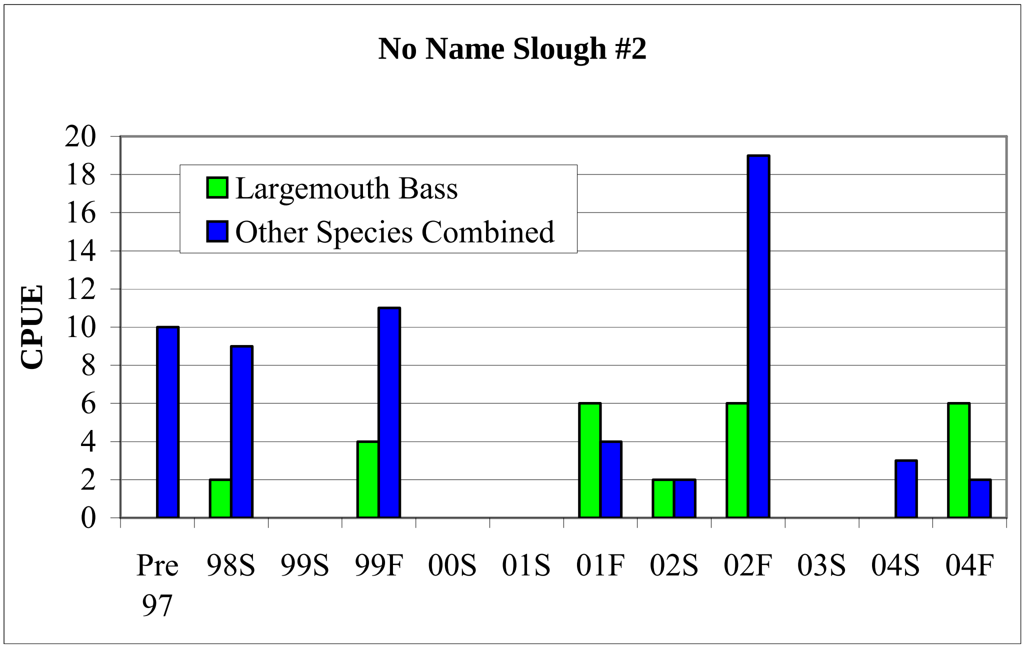

Figure 29. Largemouth bass and combined fish relative abundance for transects in No Name Slough #2.

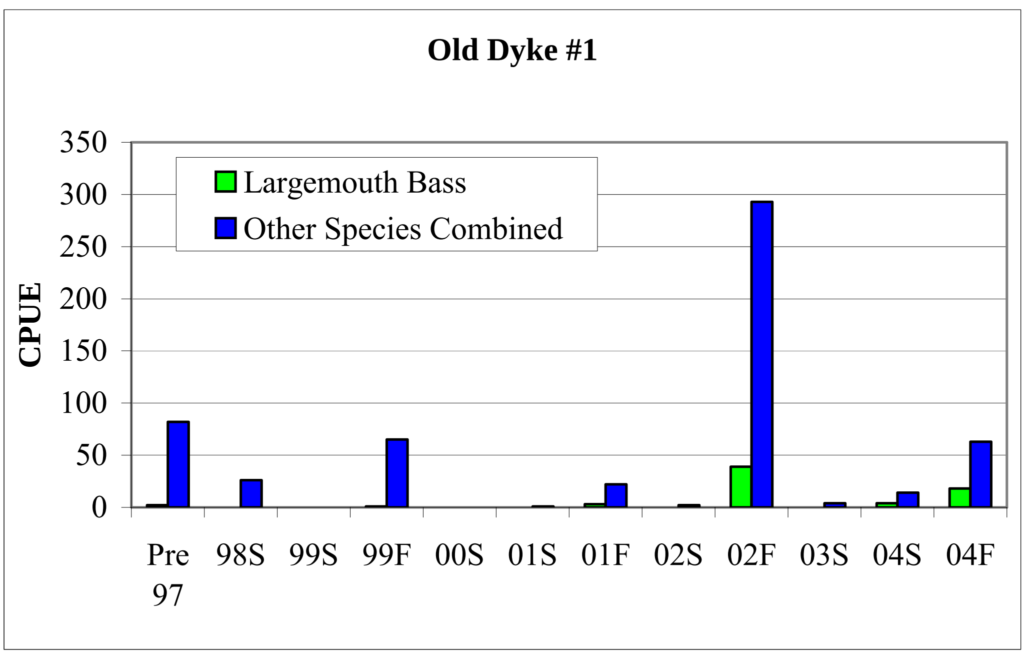

Figure 30. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #1.

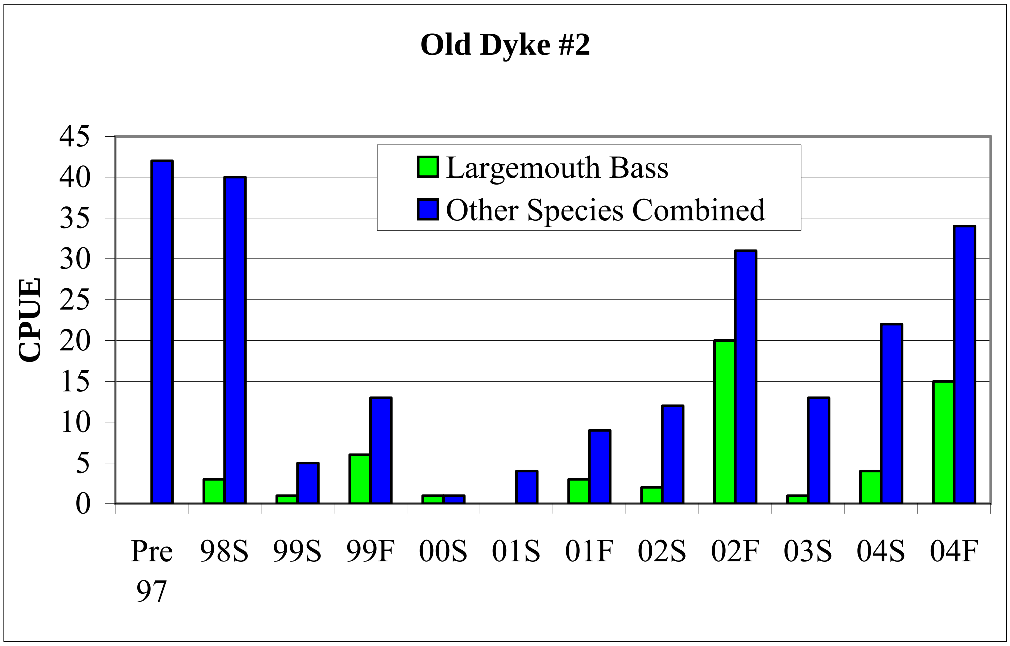

Figure 31. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #2.

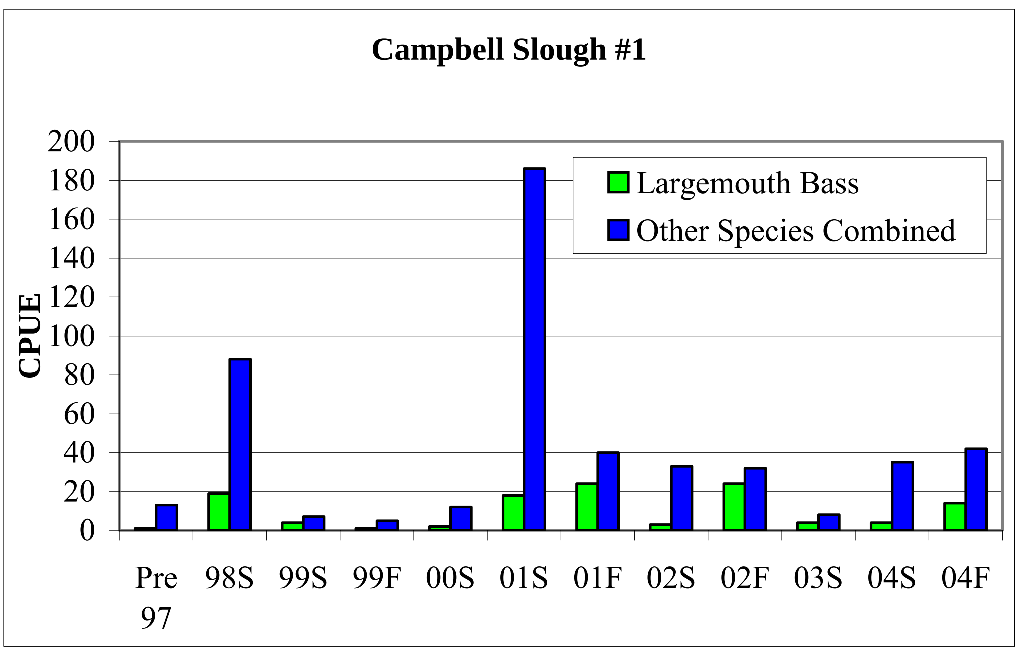

Figure 32. Largemouth bass and combined fish relative abundance for transects in Campbell Slough #1.

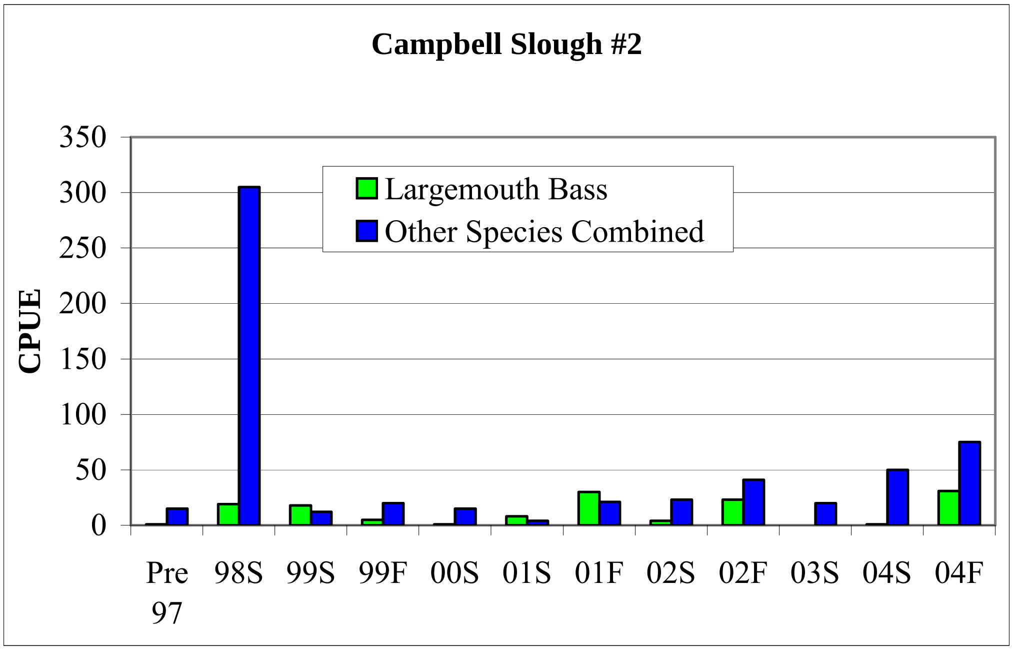

Figure 33. Largemouth bass and combined fish relative abundance for transects in Campbell Slough #2.

DISCUSSION

The mean size of largemouth bass was significantly different for fish captured in the fall and spring ($P<0.0001$). Juvenile largemouth bass are more likely to be present in the catch in the fall while larger adults are captured more frequently in the spring (Figure 34). The length frequency graph appears to have distinct modes for age 0+ and age 1+ largemouth bass. The means were 66 mm and 146 mm for age 0+ and age 1+ fish, respectively. Dampening of the length frequency modes occurred for fish older than 1+.

In the fall of 1997, before any bass structures had been placed (pre-assessment), no adult largemouth bass were captured in any of the sample sloughs. In 2004, nineteen adults were captured in the fall sampling period (Figure 35). A total of seven juvenile largemouth bass were captured in the pre-assessments of fall 1997. Juvenile numbers have increased from pre-assessment value in all fall sampling periods and a total of 80 age 0+ and 1+ largemouth bass were captured in 2004.

The percent of the catch has increased for all bass combined (Figure 36). Largemouth bass comprised 3.5% of the catch in the 1997 pre-assessment. Percent of catch was higher in all post assessment samples and ranged from 7.7% in the spring of 1998 to 44% in the spring of 1999.

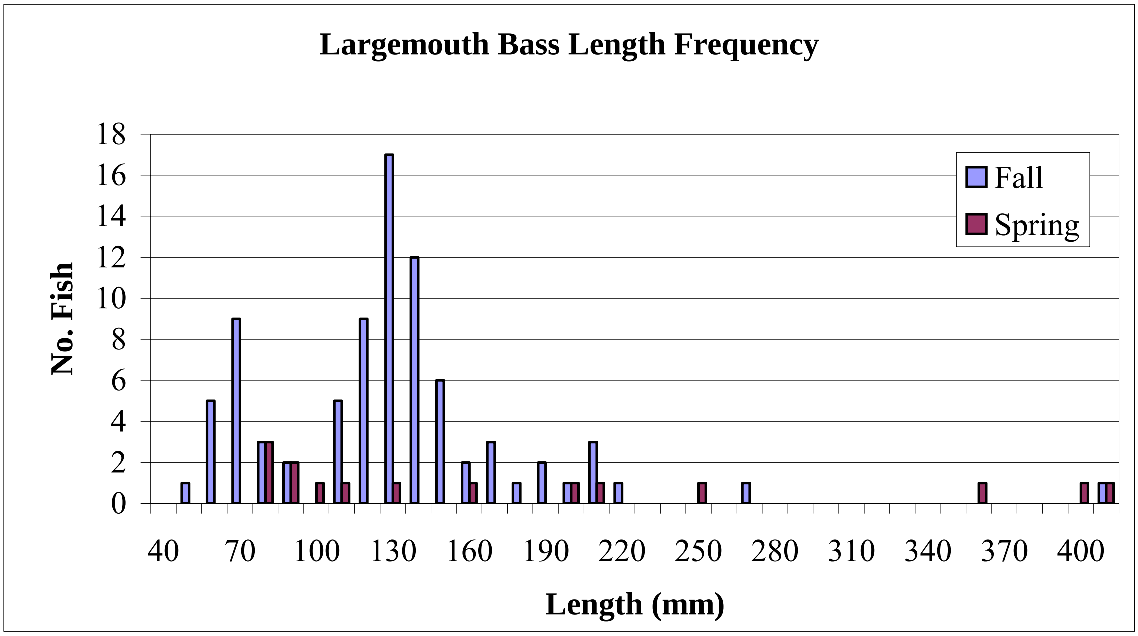

Figure 34. Largemouth bass length frequency for all stations sampled from 1997 to 2004.

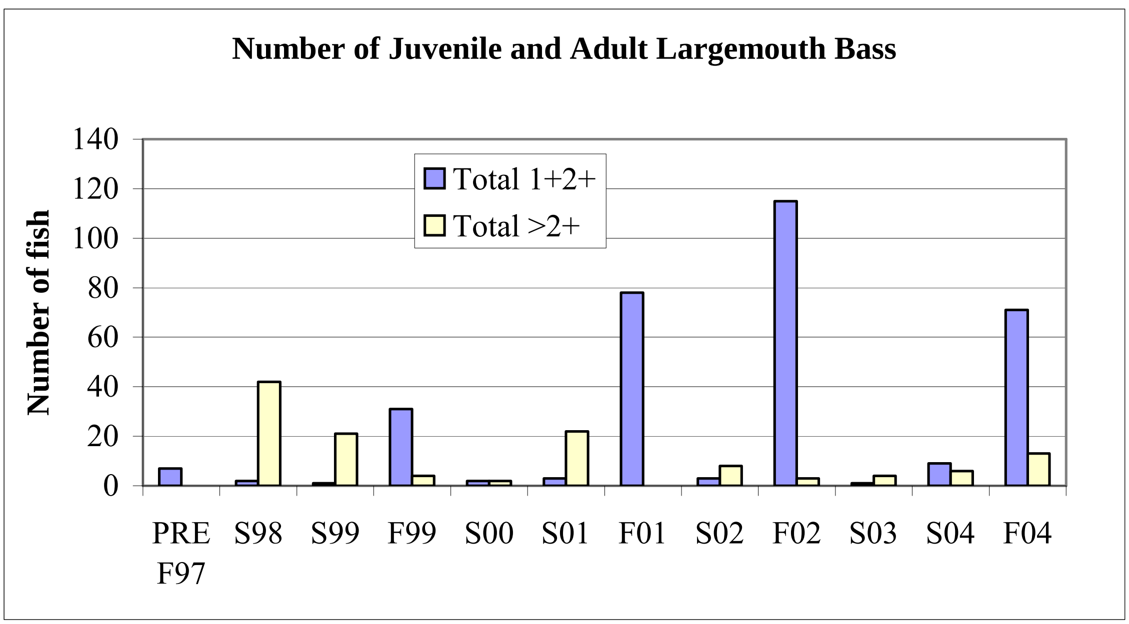

Figure 35. Numbers of juvenile and adult largemouth bass captured during spring and fall sampling periods from 1997 to 2004.

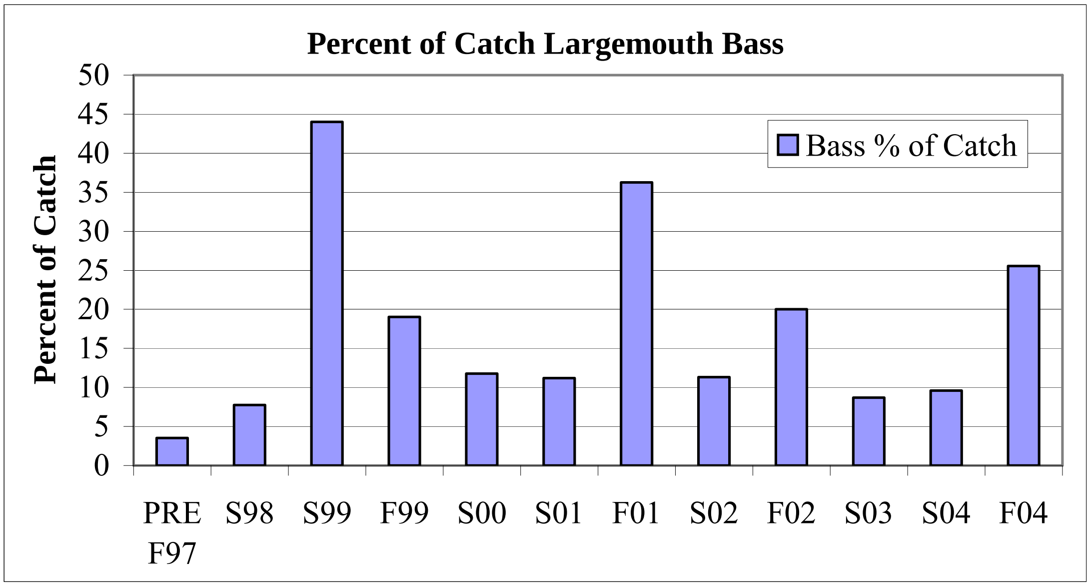

Figure 36. Annual percent of the catch of largemouth bass for all sampling transects.

Overall, largemouth bass CPUE and percent of catch have increased since bass habitat enhancement structures were implemented in 1997. However, distinct differences in seasonal utilization of the structures by juvenile and adult largemouth bass were apparent. 81% of the bass captured in the spring were adults while 97% of the bass captured in the fall were juveniles. In the fall of 2004 however, adult largemouth bass were more abundant than in any other fall sample. This overlap may be due to bass utilizing the structures all year long. The goal for this project is to provide overwinter cover to juvenile largemouth bass. Juvenile bass appear to have relatively low utilization of the structures in the spring. However, total juvenile relative abundance has increased from 7 in the fall of 1997 to 80 in the fall of 2004. In November, macrophytes in the sloughs and mainstem of the Pend Oreille River are likely providing significant cover for largemouth bass. In the spring however, macrophytes have decomposed and the artificial structures may then be the primary cover component. Adult largemouth bass may seek out the cover of the structures and displace the juvenile bass, which are vulnerable to predation. It is not known when the shift between juvenile and adult largemouth bass utilization of the structures takes place. However, given the increase in fall juvenile relative abundance, it appears that the enhancement structures may be resulting in increased overwinter survival for juvenile largemouth bass.

HABITAT RESTORATION

STUDY AREA

East Branch LeClerc (EBL) and South Fork Granite (SFG) creeks are located in the northeast corner of Washington (Figure 37). SFG is a major tributary to Granite Creek, which flows into Priest Lake in Idaho. At the location of the reference reach, SFG is a 3rd order stream. EBL is also a 3rd order tributary and joins the West Branch LeClerc Creek before flowing into the Pend Oreille River in Washington. The elevation of the reference reach on SFG was 3520 ft and watershed area was 22,194 acres. Elevation at EBL was 2120 ft and the watershed drained 24,614 acres. Both watersheds had glacial and alluvial deposits in the drainage bottoms and upper slopes were predominantly composed of grandiorite. Both streams flowed mainly in a southern direction. Discharge in SFC was estimated at 13.1 cfs (Table 24). Measured discharge in EBL was 10.5 cfs.

Timber harvest and associated road building have occurred throughout the EBL watershed. Approximately half of the watershed is privately owned and managed for timber production. Most of the remainder of the watershed is publicly owned and managed by the U.S. Forest Service for multiple use, primarily commercial timber production and cattle grazing. Historic timber harvest in SFC has been negligible and the watershed is largely roadless.

METHODS

The restoration plan for EBL was guided by parameters surveyed in a relatively un-impacted stream reach in SFG. SFG was selected because watershed size, geology, aspect, and bankfull widths were similar to EBL. Surveys were conducted in one reach of SFG (reference reach) and throughout the entire restoration reach on EBL. A longitudinal survey was completed for each reach using a laser level and measuring rod and using methods described in Harrelson et al. (1994). Elevations were measured at the thalweg, wetted edges and bankfull edges at points where changes in bed slope were apparent. Bankfull water surface slope and mean bankfull depth were calculated from elevation and length data collected during the longitudinal channel survey.

Cross sectional elevations were also surveyed using a laser level and measuring rod. Four pools in each reach were surveyed; streambed and bank elevations were measured at five cross sections for each pool. Bed and bank elevations were also measured at one cross section in four riffles of each reach.

A Wolman Pebble Count (1954) was completed in one riffle of each reach to determine stream bed composition. A core sample was extracted in a depositional bar at each site using methods described by Rosgen (1996). Data from the pebble counts were tallied using the Wentworth size classification. The data was then plotted by size class and cumulative frequency. Core samples from the depositional bar were sieved to sort

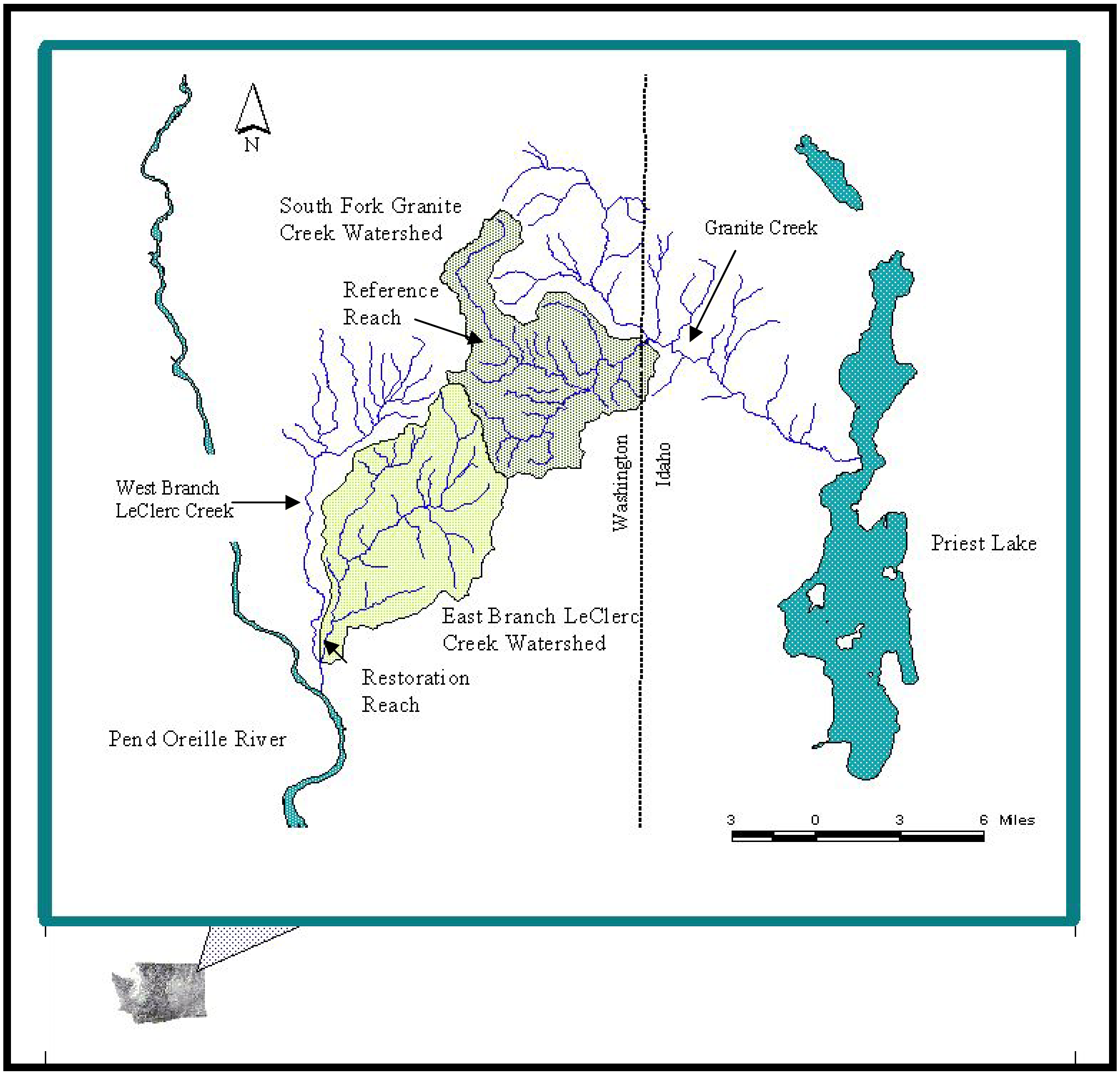

Figure 37. Location of the reference reach in South Fork Granite Creek and the restoration reach in East Branch LeClerc Creek.

particles into Wentworth size classes. Each size class was weighed and cumulative frequency was based on the weight of each size class.

Large woody debris (LWD) was counted throughout each reach. Only wood that was stable in the channel was tallied. Estimates of LWD size and orientation in the channel were made for each piece encountered. In SFG, discharge was estimated using the float method. An orange was floated through a 5.6 m riffle with a measured cross section 13 times and mean velocity was calculated. Discharge for EBL was calculated using velocities measured with a Price AA flow meter at a measured cross section just downstream of the restoration reach. Both the SFG discharge estimate and the EBL measurement were made on the same day.

Critical dimensionless shear stress was estimated using a calculation modified by Rosgen (2001):

$$\tau_{ci} = 0.0834\,(d_{50}/ds_{50})^{-0.872}$$

Where: τ_{ci} = critical dimensionless shear stress,
d_{50} = median diameter of bed material
ds_{50} = median diameter of bar sample

The critical dimensionless shear stress value was then used to calculate the bankfull mean depth and water surface slope required to entrain the largest particle in the bar samples:

$$d_r = \tau_{ci}\,\gamma_S D_i / S$$

Where: d_r = Required bankfull mean depth
γ_S = Submerged specific weight of sediment
D_i = Largest particle from bar sample
S = Existing bankfull water surface slope and,

$$S_r = \tau_{ci}\,\gamma_S D_i / d$$

Where: S_r = Required bankfull water surface slope
d = Existing bankfull mean depth

These values were used to validate the ability of the channel to move the largest bedload particle entrained at bankfull flows.

RESULTS

Surveys were conducted in 1020 ft and 1361 ft of channel in SFG and EBL, respectively. Figure 38 illustrates plan views of the reference and restoration reach; in EBL the thalweg was GPS'ed so the view accurately portrays distances and orientation. However, we were unable to collect GPS data in SFG so the planiform view is a general representation based on measured lengths between known points along the channel.

Figure 39 is the longitudinal profile that graphs thalweg, wetted edge, and bankfull elevations (elevations are relative) that were surveyed along the reaches in EBL and SFG.

Table 24 summarizes attributes for each surveyed reach. Channel slope, bankfull width, and mean bankfull depth were similar for both reaches. However, pool numbers and percent habitat composition in SFG (pool n=8, 30%) were double those in EBL (pool n=4, 15%). Although mean pool volume was greater in EBL (1082 ft^2 vs 814 ft^2 in SFG), mean pool depth and residual depth were greater in SFG (1.3 ft and 1.4 ft, respectively) than in EBL (1.1 ft and 0.9 ft, respectively). LWD was common in the SFG reach; frequency was 3.9 pieces/100 ft and 62% of the pools (n=5) were formed by LWD.

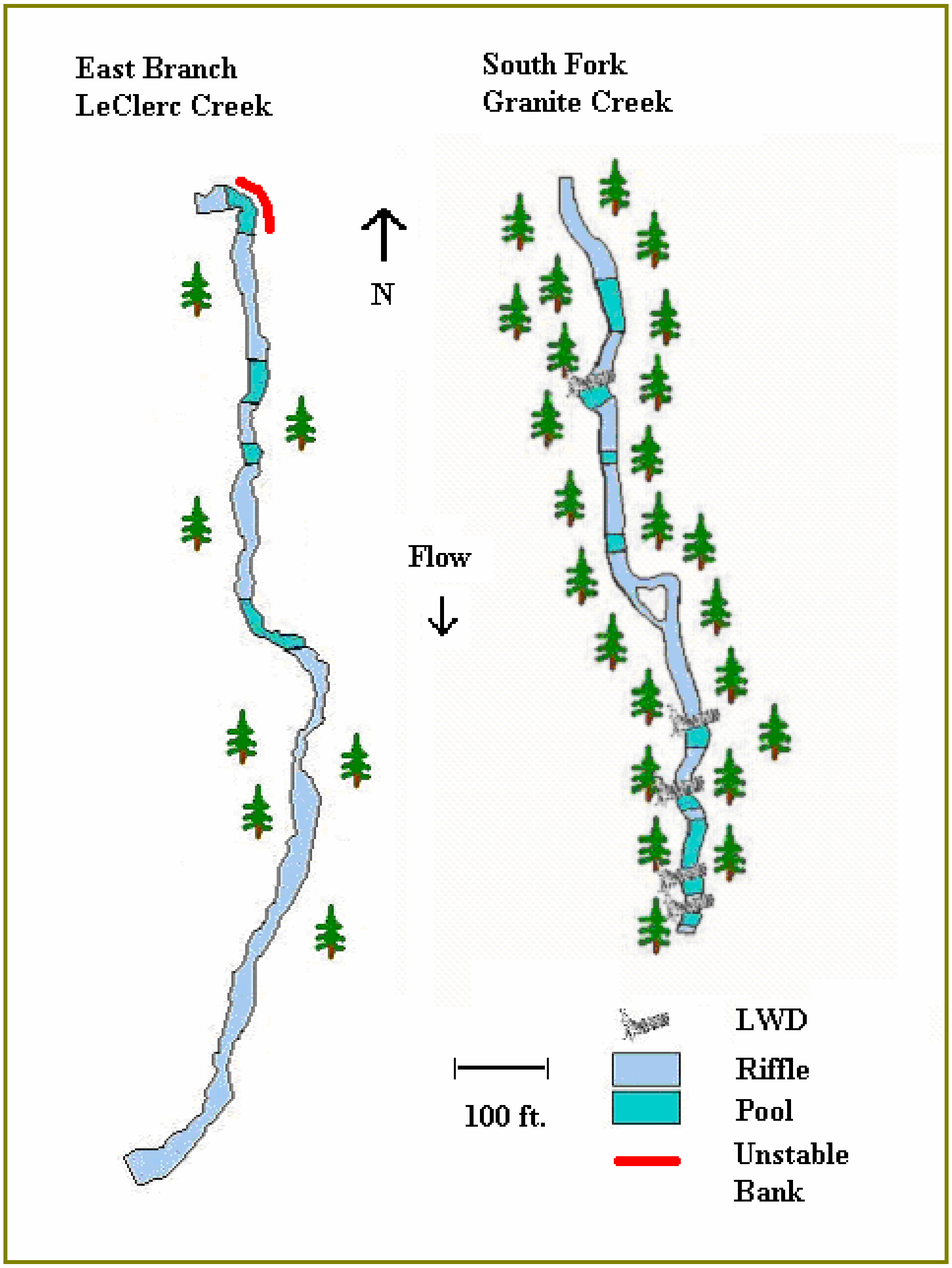

Figure 38. Site map of the EBL restoration reach and the SFG reference reach.

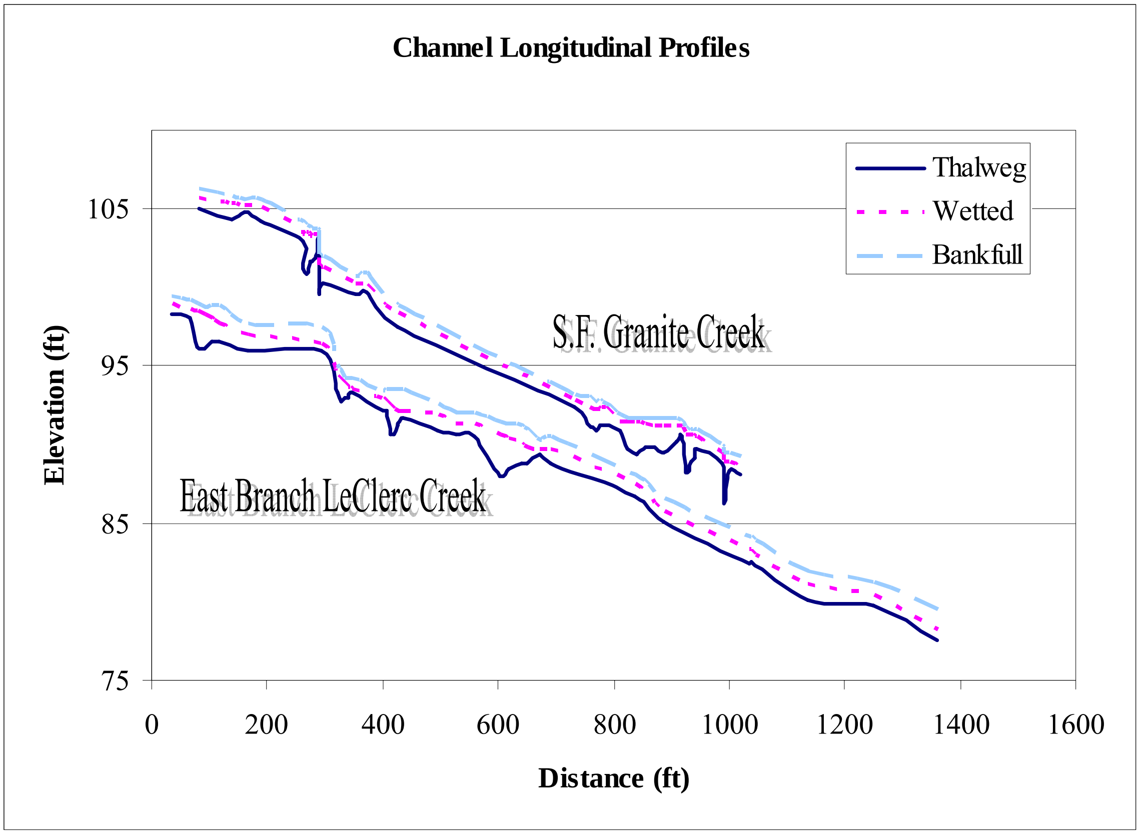

Figure 39. Longitudinal profile of restoration and reference reaches in EBL and SFG, respectively.

The LWD frequency in EBL was low (0.6 pieces/100 ft) and wood was the formative feature in only 1 pool.

Percent fines (<4 mm) were significantly greater in the sampled riffle in EBL when compared to SFG (p-value = 0.003). However, particles were generally larger in the EBL riffle (Figure 40); the D_{50} for EBL and SFG were 73 mm and 46 mm, respectively (Figure 41). In the bar sample, percent fines were also significantly greater in EBL (p-value <0.001). Fine sediment composition in the EBL bar sample was 30% and 14% in the SFG bar sample. Particle sizes were greater in the SFG bar sample relative to EBL (Figure 42). The median diameter size was also larger in the SFG bar sample; D_{50} in the SFG bar sample was 53 mm and in the EBL bar sample D_{50} was 16 mm (Figure 43).

In EBL, the critical dimensionless shear stress value was 0.022. Based on that value, the mean bankfull depth required to move the largest bar particle was calculated at 0.57 ft and the bankfull water surface slope required to move the largest particle was 0.012.

Table 24. Summarized surveyed attributes in the SFG reference reach and the EBL restoration reach.

Parameter	South Fork Granite Creek	East Branch LeClerc Creek
Length of Surveyed Channel (ft)	1020	1361
Channel Slope	1.8%	1.6%
Bankfull Width (ft)	20.0	22.0
Bankfull Mean Depth (ft)	0.76	0.77
Bankfull W:D	27.2	29.3
Rosgen Type	B4c	B3c
Discharge (cfs)	13.1	10.5
Percent Pool Habitat	30	15
No. of Pools	8	4
Pool Frequency (no. pools per BFW)	0.16	0.06
Expected No. Pools (Leopold et al. 1964)	10 - 12	13 - 16
Pool Mean Maximum Depth @ Bankfull (ft)	2.64	2.53
Pool Mean Depth (ft)	1.3	1.1
Mean Pool Volume @ Bankfull (ft^3)	814	1082
Mean Pool Residual Depth (ft)	1.4	0.9
LWD Frequency (no. per 100 ft)	3.9	0.6
No. of Full Channel-spanning LWD	9	0
Percent Wood Formed Pools	62% (n=5)	25% (n=1)
Mean Estimated Diameter of LWD (in)	23.6	26.0
Pebble Count Size Distribution		
% Fines	6%	23%
D_{15}	10 mm	2 mm
D_{35}	32 mm	50 mm
D_{50}	46 mm	73 mm
D_{84}	90 mm	210 mm
D_{95}	170 mm	300 mm
Dimensionless Shear Stress		
Critical Dimensionless Shear - $\tau_{ci}*$	0.019	0.022
Bankfull Depth Required to Move Largest Particle - D_r (ft)	0.59	0.61
BF Water Surface Slope Required to Move Largest Particle - S_r	0.014	0.012

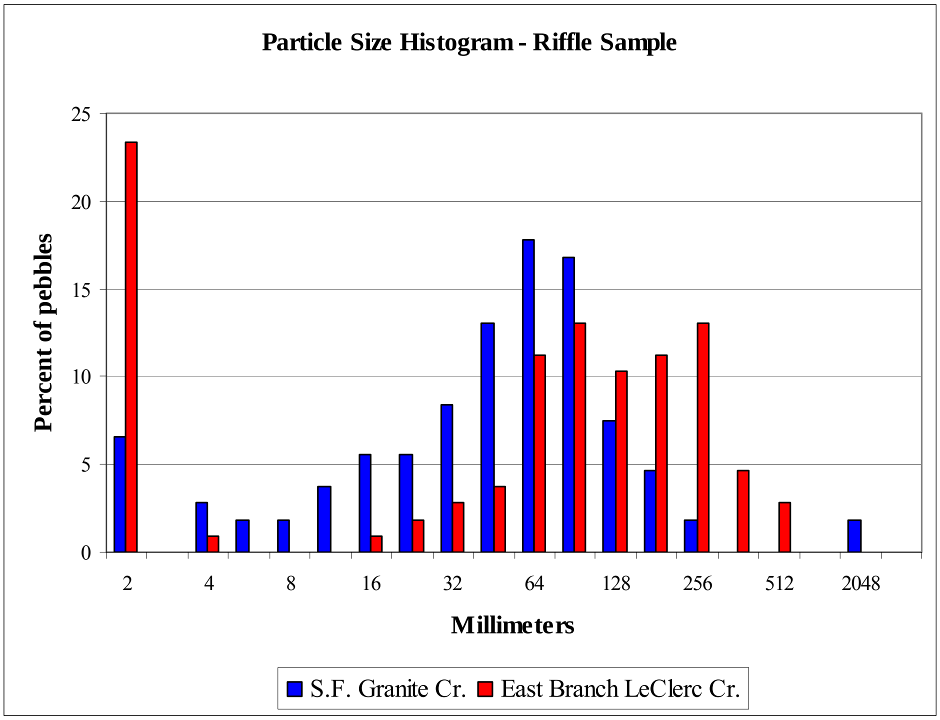

Figure 40. Particle size composition for riffles sampled in SFG and EBL.

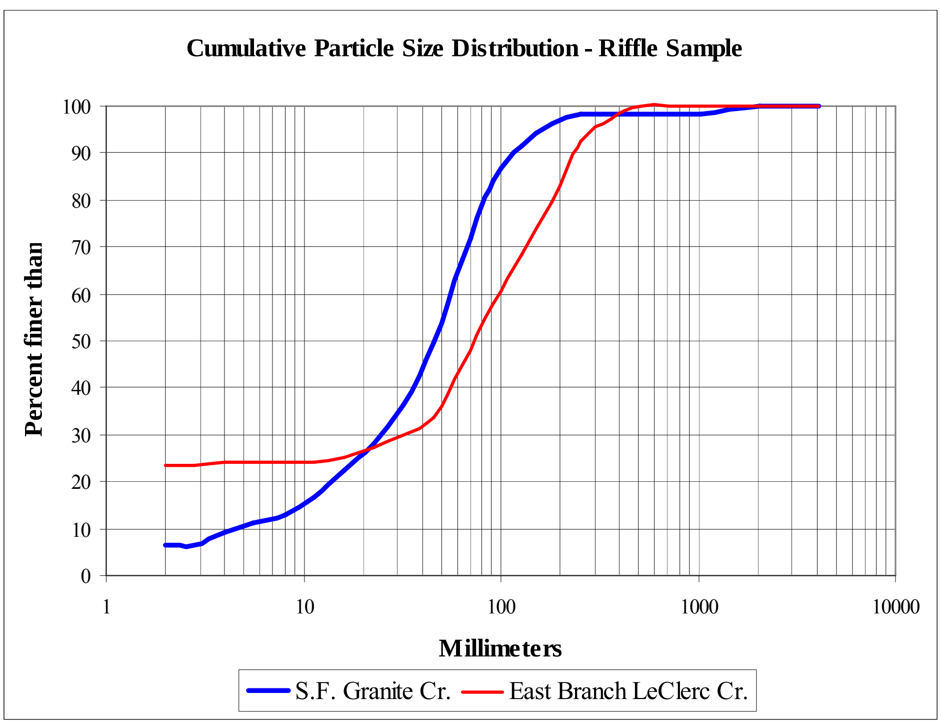

Figure 41. Cumulative frequency of particle sizes sampled in riffles of SFG and EBL.

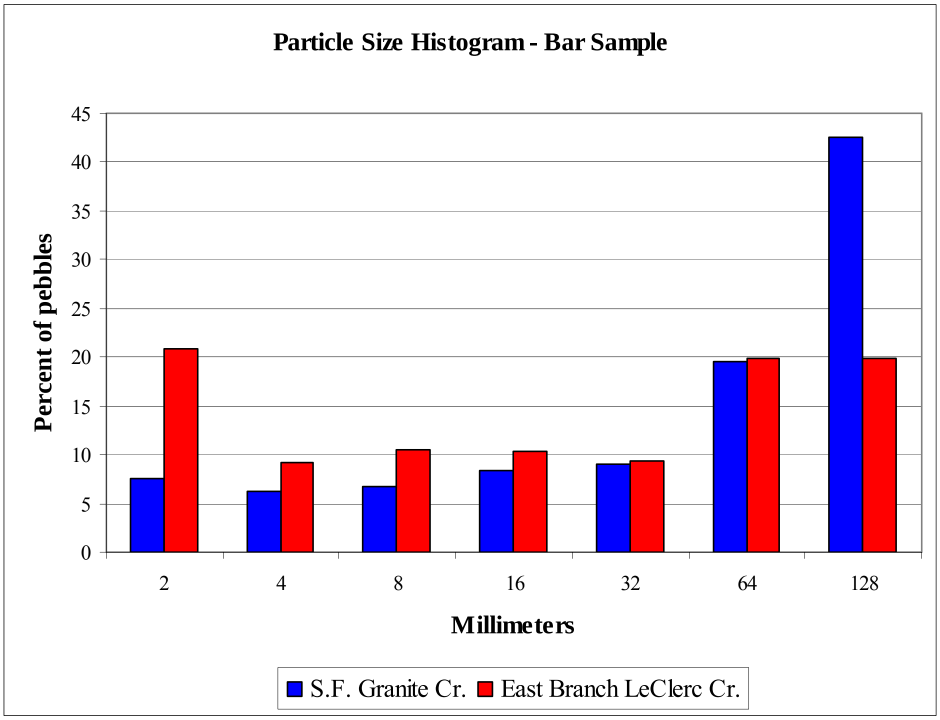

Figure 42. Particle size composition for depositional bars sampled in SFG and EBL.

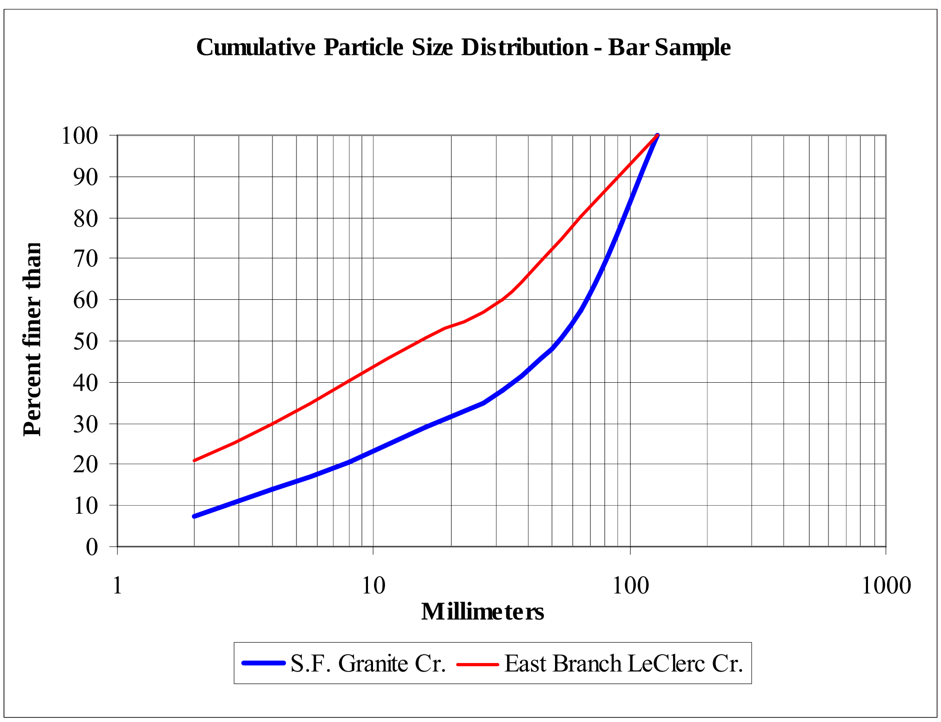

Figure 43. Cumulative frequency of particle sizes sampled in depositional bars of SFG and EBL.

Figure 44. A pool formed by LWD that spans the channel of SFG.

DISCUSSION

Impacts from past land management activities appear to have simplified the stream channel in EBL. LWD played a major role in pool formation in SFG; 62% of the pools were formed by LWD pieces that spanned the entire channel width (Figure 44). LWD was sparse in EBL and likely resulted in a relatively low pool frequency. None of the LWD pieces observed in EBL spanned the entire channel. LWD in both channels appeared to be relatively stable; the bases of the LWD were buried in well vegetated banks and the wood appeared to have been in the channel for a relatively long time. LWD sizes were similar in both channels; mean LWD diameter in EBL was 26 in (SD = 4.9) and mean diameter was 23.6 in (SD = 6.2) in SFG. Based on the size of LWD pieces, apparent stability, and a lack of large accumulations (jams), large wood likely recruits to the channel from nearby riparian areas and mobility is minimal. Numerous large (>30” diameter), old stumps were observed along the channel in the EBL

Figure 45. Old stumps observed along the banks of the EBL reach.

reach (Figure 45). These trees would likely have fallen in the channel and stabilized at a nearby location creating pool habitat and storing sediment. Given the loss of these trees, LWD in the EBL reach has not likely recruited at a rate to compensate for the decomposition of pre-existing LWD, resulting in a simplified channel.

Fine sediment levels were significantly higher in EBL than in SFG. Higher levels of fine sediment are plausibly due to erosion from road surfaces and slope failures. The Draft LeClerc Creek Watershed Analysis (1997) identified a 1.5 mile long road segment as contributing 237 tons sediment/year to the stream channel (located approximately 2 miles upstream from the restoration reach). Nearly 75% of sediment input in that section was associated with a 0.3 mile road segment that crossed a steep, unstable hill slope. In 2000, the 1.5 mile section of road was obliterated and a new section was constructed in the uplands. Efforts to stabilize the steep, eroding hill slope are ongoing. Higher levels of sediment appear to have impacted pools in the EBL restoration reach. Mean pool volume was greater in EBL than in SFG (1082 ft^3 and 814 ft^3, respectively). However, mean pool, maximum, and residual depths were all lower in EBL suggesting that pool filling has occurred.

The critical dimensionless shear stress for the EBL reach was 0.022. Based on that value, estimated bankfull mean depth required for entrainment of the largest bar sample (77 mm) was 0.57 ft. The estimated bankfull water surface slope required for

Figure 46. Unstable bank in the EBL reach (2004 photograph).

entrainment was 0.012. Both estimates were less than the measured values (0.77 ft mean depth and 0.016 bankfull slope). No indicators of vertical channel instability were observed in EBL. Therefore, we estimate that the restoration channel in EBL is competent in sediment transportation.

One section of unstable streambank was observed near the upstream end of the restoration reach (Figure 46). The unstable bank was located on the outside of a sharp bend and was higher than any other bank in the reach. No signs of up or downstream migration of the instability (i.e. calving, fracturing) were observed. Examination of aerial photographs taken in 1979 and 1994 show that no channel migration has occurred throughout the site. This unstable section could be detected in low elevation 2001 aerial photographs and appeared to be similar in size to the photograph in Figure 46. The bank appears to be self armoring as large substrate slowly accumulates at the toe of the bank as the bank erodes.

Restoration Plan and Monitoring

Ten to twelve LWD structures will be placed in the EBL restoration reach to create pools. The increase in pools will improve fish habitat and provide for storage of fine sediment. The exact number of structures will be determined prior to

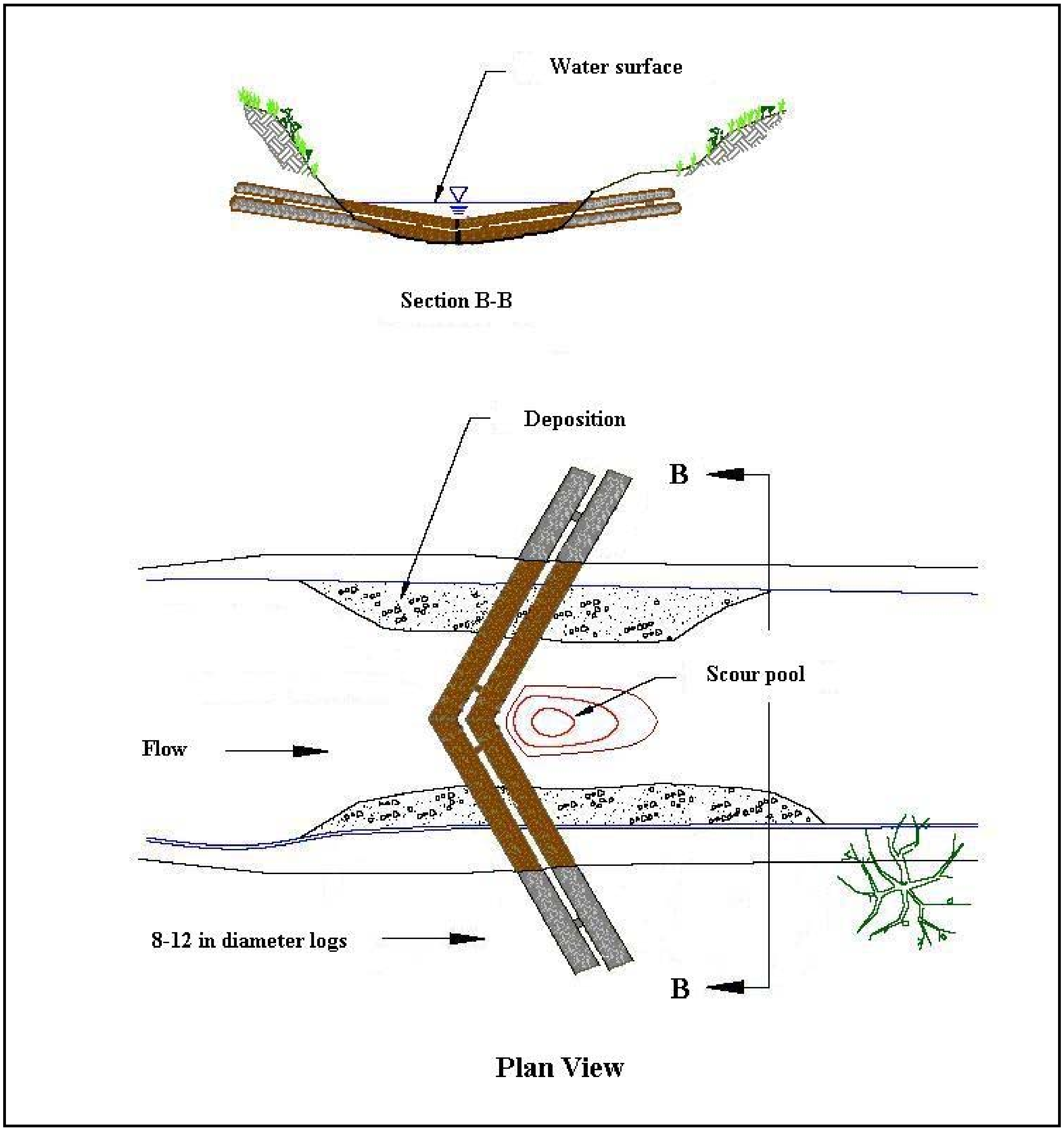

Figure 47. Conceptual design for LWD structures.

implementation based on site conditions. We will be using a guideline of one structure per 5-7 bankfull widths (110-154 ft). Structures will consist of small LWD that will be fitted together to simulate larger, single wood pieces (Figure 47). For each structure, small diameter logs (8-12 in) are interlocked with spars and create a hollow cylinder. Each structure will be 8 to 15 ft in length and 24 to 32 in. in diameter. The void in the center of the cylinder will be filled with cobble to provide ballast. If possible, structures will be placed on the upstream side of large boulders, tree trunks, or root wads to further provide stability. Given the size of the structure and the increase in weight provided by the cobbles, we anticipate no further anchoring will be required. Structures will be installed in pairs to create an upstream-oriented V-shaped log sill. The tops of the structures will be sloped down towards the center of the channel. The ends of each structure will be keyed into the streambank or butted up to the streambank and buried with large cobble. Structures may also be paired with existing natural features (e.g. natural LWD, root wads, boulders) to increase channel constriction and promote scour.

Prior to structure implementation, placement sites will be surveyed, using a laser level and measuring rod, to determine cross sectional channel profiles. Bankfull mean width, depth, and maximum depth will be monitored to determine the effectiveness of the structures to create pool habitat. The cross sections will be benchmarked and represent pre-implementation (baseline) conditions. Three cross sections will be surveyed at each site: one upstream to monitor deposition and two downstream to monitor scour. Two pebble counts, one upstream and one downstream, will also be completed at each structure site to monitor substrate composition. Monitoring will also be conducted on the fish population. Prior to structure installment, fish population estimates will be made using multiple pass electrofishing techniques. The entire restoration reach will be electrofished to determine baseline population numbers. One 100-m reach will also be electrofished upstream of the restoration reach to monitor overall population response. Another 100-m reach will be electrofished in West Branch LeClerc Creek so that natural variability can be monitored. The first post-implementation monitoring period will take place two years after the structures have been in place. However, the structures will be inspected and maintained on an annual basis and after any significant flow events.

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