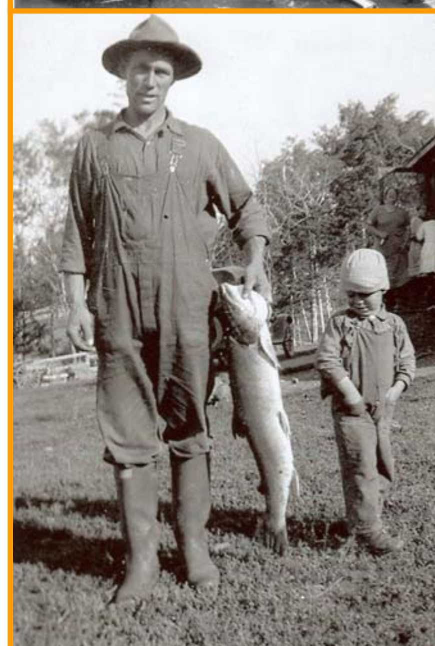
The Big Blackfoot River Fisheries Restoration Report for 2004 and 2005



Montana Fish,
Wildlife and Parks

The Big Blackfoot River Fisheries Restoration Report for 2004 and 2005

by

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INTRODUCTION

The Blackfoot River is one of the most popular, scenic, physically diverse and biologically complex rivers in western Montana. Segments of the river system however support low densities of *wild trout* due to an array of natural conditions and human impairments. Densities of *imperiled native trout* (westslope cutthroat trout - *Oncorhynchus clarki lewisi* and bull trout - *Salvelinus confluentus*) are particularly low. Natural *limiting factors* involve cycles of drought, areas of high instream sediment loads, low instream productivity, naturally intermittent tributaries, summer warming and periods of severe icing of the lower mainstem river channel. Human impairments apply to mining contamination in the upper Blackfoot Watershed, the loss of upstream fish passage at the mouth of the Blackfoot River, expansion of exotic organisms including whirling disease at the low elevations of the watershed, and pervasive perturbations on >90% of tributaries. The sum of natural conditions and human impairments produce an array of trout assemblages that vary regionally within the watershed and longitudinally among river and tributary reaches.

With an emphasis on correcting human impairments to the river ecosystem, the Blackfoot River watershed is the site of a comprehensive wild trout restoration initiative, with emphasis on the recovery/conservation of imperiled native fish. The initiative began in 1988-89 when Montana Fish, Wildlife and Parks (FWP) identified declining Blackfoot River fisheries and the degradation of primary tributaries. These early findings led to the adoption of *catch-and-release* regulations for native fish in 1990, followed by the initiation of early riparian improvement projects. Fisheries restoration has since evolved to a *ridge-top to ridge-top* philosophy of coordinated conservation through the assistance of many stakeholders.

Conservation of wild trout relies on the voluntary involvement of resource agencies, conservation groups and private landowners. While the philosophy of managing *wild trout* provides the biological foundation of this endeavor, the *Blackfoot Cooperators* (*see* below) form the social and technical base necessary to fund and implement the initiative. By correcting human-induced *limiting factors*, this initiative further provides a framework for the recovery of dwindling stocks of imperiled native fish when integrated with appropriate harvest regulations, and site-specific restoration measures often undertaken in remote but critical areas of the watershed.

Correcting environmental damage over large connected tracts of public and private land and industrial forest involve long-term protection (conservation easements) and restoration of biologically important but fisheries-impaired streams. Improving habitat involves mostly passive (e.g. compatible grazing), but also active (e.g. channel reconstruction) measures depending on the degree of degradation and a stream's recovery potential. When properly implemented, fisheries restoration is also *iterative* – a process that relies on continued habitat and population monitoring, expanding the scope of projects and modifying methods of restoration based on monitoring results. *Iterative restoration* leads to site-specific restoration measures of individual tributary populations involving methods such as enhancing flows in rearing areas, preventing juvenile fish loss to irrigation in migration corridors, reconstructing altered streams, fencing livestock from spawning areas, and expanding these types of actions to adjacent tributaries as limiting factors are identified and as opportunities allow.

Since 1988, FWP has inventoried or otherwise assessed 102 tributaries and six reaches of the Blackfoot River, and identified fisheries impairments on a great majority (96) of these water bodies (Pierce et al 2005, Appendix F). With information derived from these and other investigations, and with the cooperation of stakeholders, forty-four tributaries have been targeted for fisheries restoration actions (Appendix E). The geographic focus of restoration has been lower-river tributaries and bull trout *core area* streams. With restoration progressing in these areas, projects have expanded to other waters of the basin.

In addition to the scale of restoration, the scope of stakeholder involvement in the fisheries initiative continues to expand. The Blackfoot Challenge (BC) has expanded their role to include: 1) coordinating studies and fund-raising for water quality impaired (TMDL) streams; 2) facilitating conservation easements; and 3) lending field staff support. Likewise, the Big Blackfoot Chapter of Trout Unlimited (BBCTU), North Powell Conservation District (NPCD), Nature Conservancy (TNC) and Five Valleys Land Trust (FVLT) are increasingly engaged in the development and oversight of many fisheries-related restoration projects. The combined services of federal agencies - U.S. Fish and Wildlife Service – Partners for Fish and Wildlife (USFWS), Natural Resource Conservation Service (NRCS) and Bureau of Reclamation (BOR) are providing a wider range of resource expertise, project funding and technical services. The Bonneville Power Administration (BPA), the Trout Unlimited Western Water Project and Department of Natural Resource Conservation (DNRC) are helping coordinate drought, instream flow and water leasing projects. Northwestern Energy (NWE) - Milltown Mitigation Funds help cost-share restoration and research, as well as FWP fisheries monitoring personnel. Private landowners, private foundations and others also contribute significant resources to fisheries-related projects. This affiliation - the *Blackfoot Cooperators* herein, form the general support base of the *Blackfoot River Fisheries Restoration Initiative*. A summary of their support by individual stream is located in Appendix G.

This expansion has produced new fisheries initiatives and restoration opportunities. One new initiative – the *Expedited EQIP Bull Trout and Westslope Cutthroat Trout Conservation* program directs federal (NRCS) resources to FWP-identified priority native trout streams. A *Native Fisheries Habitat Conservation Plan* (HCP) - a cooperative venture between FWP, USFWS, TNC and Plum Creek Timber Company now in the development phases will perpetually protect large tracts of industrial forest containing critical native fish waters, if approved. The future land use of large tracts of federally designated *roadless* lands of the Blackfoot Watershed, including many native fish-bearing streams, is now being reviewed by the Governor's office. Decisions regarding the disposition of these areas will have broad implications to the future conservation of native fish. Other important fisheries projects involve the impending removal of Milltown dam and recent removal of the Stimson weir, both located near the mouth of the Blackfoot River. The Mike Horse Mine, a contaminated mining area posing extreme ecological risk to the mainstem Blackfoot River, is a focus of clean-up discussions. The USFS (Lolo and Lewis and Clark National Forests) has also expanded their role with watershed groups with respect to correcting problem road crossings in streams supporting priority fisheries. Although promising, growth has also generated its own set of challenges, such as pressure to identify projects and expend funds. In some cases, growth has led to communication, planning and oversight problems. In some cases, projects have been pursued with only limited resource justification or potential for measurable outcomes.

Attempts to promote fisheries conservation, while managing the challenges of growth, are occurring on many fronts. These attempts involve: 1) a BBCTU decision to hire a full time manager dedicated to project oversight; 2) the addition of NRCS planning staff; 3) an increased level of coordination and monitoring requirements on BC funded projects: and 4) a heightened level of permitting scrutiny. Strategic planning, undertaken both within and between the principal watershed groups, is also proceeding. Planning documents prioritizing fisheries and water quality projects have been written and adopted by the Blackfoot Cooperators (Pierce et al. 2005; Blackfoot Challenge 2005). These plans outline project development methods and monitoring actions associated with restoration processes, such as: 1) the collection of baseline data; 2) the development of concise, attainable and measurable objectives; 3) proper project oversight; and 4) post-project monitoring methods. Although *effectiveness* monitoring (e.g. did the project meet fisheries and water quality objectives) is critical and continuous need to this program, project maintenance (fences, irrigation fish screens, shrub plantings, etc.) and periodic review of riparian grazing plans are likewise critical due to the large number (>200) of fisheries-related restoration projects now complete in the Blackfoot River basin.

With attention to these strategies, the *Blackfoot Cooperators* should avoid regional (and national) trends of exponential growth in restoration funding, but which generally fail to provide adequate quality control (over-sight and maintenance) and assess project outcomes (Fisheries 2005-Vol. 31 No. 1; Roni 2005). These concerns are outlined in the *National River Restoration Science Synthesis* (a database of 38,000 restoration projects - most in the Pacific Northwest), which found only 14% of projects document any form of project monitoring (Fisheries 2005-Vol. 30 No. 6).

EXECUTIVE SUMMARY

The 2004-2005 reporting period ended with the sixth straight year of drought. During this six-year period: 1) mean monthly flows during the critical summer (July and August) period averaged 66 - 76% of normal; 2) the river set an 18-year record for warm water temperatures; 3) normal "flushing flows" occurred only once (Results Part I); and 4) emergency angling restrictions were enacted

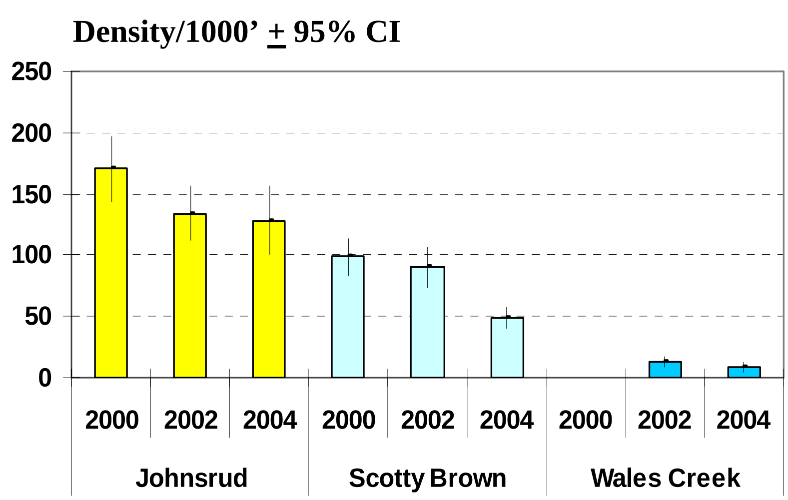


Figure 1. Total trout densities (fish>6.0") for three sections of the Blackfoot River, 2000-2004.

in four of the last six years. As a result of drought-related stressors, certain fisheries have expressed large declines. Notable declines include a 57% decline in bull trout redds counts for two spawning streams (Monture Creek and North Fork) between 2000 and 2005, and a 51% decline in total trout densities (fish>6.0") in Scotty Brown Bridge section of the middle Blackfoot River (Figure 1; Results Part II). Many tributary fisheries have also declined; however as this report details, restoration of habitat has improved many local populations at the project scale despite drought and the presence of whirling disease. Over the long term, continued habitat work is expected to make wild trout populations more resilient to environmental limiting factors such as drought.

Whirling disease has expanded in recent years. It is now firmly established at the low elevations of the watershed, where infections vary within and between streams. The disease overlaps with spawning and rearing areas for rainbow and brown trout and mountain whitefish. The escalation of whirling disease corresponds with a recent decline in rainbow trout in the middle Blackfoot River and certain nearby tributaries. Conversely, populations of less susceptible species have expanded in the presence of high whirling disease infections in some waters where restoration has corrected physical limiting factors (Results Part III). The disease is intensively monitored and evaluations of fish populations (and their habitats) in infected waters are ongoing, including several infected streams at various stages of restoration (Results Part III and IV). Although rainbow trout declines in the Blackfoot River correspond with whirling disease increases, the relative degree to which declines relate to disease, drought or other factors remains unclear. Two Blackfoot watershed research projects hope to provide insights into the ecological relationships of the disease with the salmonid host. One ongoing study relates telemetered rainbow trout from the Blackfoot River to geomorphic features of rainbow trout spawning streams and to variable infections therein (Results Part IV). The second, now in the planning phases, hopes to examine the influence of whirling disease on mountain whitefish, a species whose susceptibility remains in question.

In addition to whirling disease and rainbow trout telemetry studies, this report outlines many other fisheries investigations undertaken during 2004 and 2005. These include fisheries and habitat restoration assessments on 26 streams (Results Part III); spawning site assessments on 22 streams (Results Part IV); a survey of angler behavior in critical native fish recovery areas (Results Part IV); mountain lake surveys (Results Part IV); and a summary integration of all tributary assessments into a restoration prioritization strategy (Results Part IV).

In this report, we consolidate recent results of the FWP Blackfoot River fisheries restoration monitoring and related investigations. Our objectives are to: 1) summarize the status of Blackfoot River wild trout and their environments; 2) summarize fisheries-related monitoring in tributaries undergoing restoration; 3) present the preliminary results of a fluvial rainbow trout telemetry study; 4) communicate the current status of whirling disease; 5) present results of other major studies; and 5) help guide future fisheries restoration actions.

Bull Trout Recovery

The Blackfoot River watershed supports *fluvial*, *stream resident* as well as *adfluvial* (in the Clearwater drainage) bull trout. Of primary concern is the recovery of the fluvial (or migratory) Blackfoot River life history form. Migratory bull trout exhibit local adaptations that involve spawning in discrete areas, tributary use by early life-stages, large home ranges, extensive migrations at higher flows, and seasonal use of larger, more productive river habitats. Fluvial bull trout also require complex habitats, colder water, lower sediment and more tributary access than currently exists in many areas of the Blackfoot Watershed. Stream resident bull trout require similar environments and complete their life cycle in tributary streams. Adfluvial bull trout occupy the Clearwater chain of lakes and migrate to tributaries for spawning and rearing.

Fluvial bull trout, a native charr capable of attaining large size, inhabit ~125 miles of the Blackfoot River mainstem. Densities remain very low in the upper river, but increase downstream of the North Fork at mile 54. Outside of the Clearwater River drainage, bull trout occupy approximately 25% of the drainage or approximately 355 miles of stream. Most bull trout spawning streams (Gold Creek, Dunham Creek, Monture Creek, Copper Creek, and the North Fork of the Blackfoot River) support migratory fluvial fish, although some streams (Poorman, Cottonwood and Belmont Creeks) seem to support predominately stream resident bull trout. Migratory bull trout use the larger, colder streams north of the Blackfoot River and larger, more productive river reaches. Fluvial bull trout reproduce in only a few discrete groundwater-fed spawning sites and seek cold-water refuge during periods of river warming. Juvenile rearing of fluvial fish can occur in the small and cold, non-spawning tributaries, in addition to the larger spawning streams and Blackfoot River.

Bull trout recovery began in the Blackfoot Watershed in 1990 when the FWP Commission adopted basin-wide *catch-and-release* regulations. Recovery then expanded in the 1990s with an emphasis on improving fish passage, restoring degraded habitat, and screening irrigation diversions in "*core area*" (Gold Creek, Cottonwood Creek, Monture Creek and North Fork) watersheds (Pierce et al. 2001). In 1998, bull trout in the Columbia River drainage were listed as *threatened* under the *Endangered Species Act* (ESA). In 2003, the USFWS designated *proposed critical habitat* for bull trout for the mainstem Blackfoot River and primary tributaries of all *core area* watersheds, including all major spawning and rearing areas therein. In 2005, the USFWS designated *critical habitat* for bull trout. This recent designation excluded all federal and private industrial forestlands and all major fluvial bull trout spawning and rearing areas within the

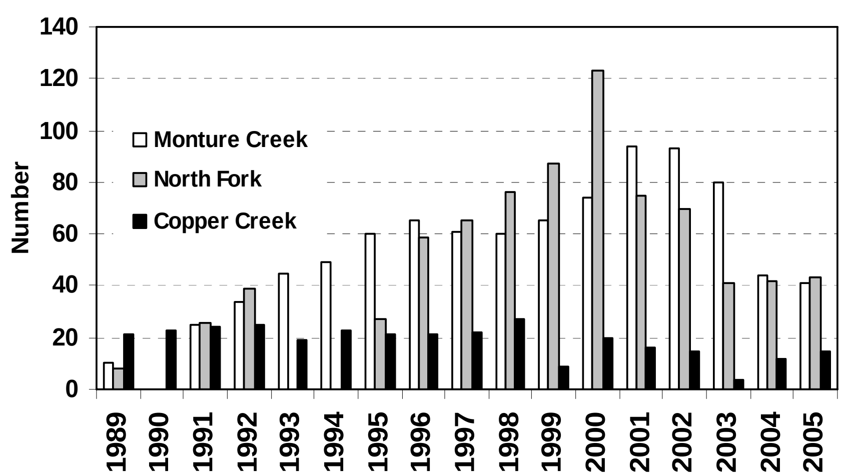


Figure 2. Bull trout redd counts in index sections of three primary spawning streams, 1989-2005.

Blackfoot watershed. This designation is not representative of the species needs and is now undergoing a legal challenge.

To assist in bull trout recovery, the Montana Bull Trout Recovery Plan established recovery goals for the Blackfoot watershed (MBTRT 2000). Goals are to: 1) maintain self-reproducing migratory fish in the Blackfoot River with access to tributary streams and spawning in all *core area* watersheds; 2) maintain the population genetic structure throughout the watershed; 3) maintain and increase the connectivity between the Blackfoot River and its tributaries; 4) establish a baseline of redd counts in all drainages that presently support spawning migratory bull trout; and 5) maintain a count of a least 100 redds or 2,000 individuals in the Blackfoot drainage with an increasing trend thereafter (MBTRT 2000). Both the USFWS and State of Montana have developed similar recovery plans that outline measures needed to help remove bull trout from the ESA list, similar to the Montana Bull Trout Recovery Team (USFWS 2002; MBTRT 2000).

Since 1990, many actions targeting the recovery of bull trout in the Blackfoot Watershed are ongoing or completed (Pierce et al 2004). During 2004 and 2005, bull trout recovery efforts continued on several fronts, including: 1) continued restoration work in core areas (Cottonwood, Monture, and Copper Creeks, the North Fork Blackfoot River) as well as four non-core area bull trout-bearing streams (Arrastra Creek, Poorman Creek, Nevada Spring Creel; Results Part III); 2) completion of a bull trout spawning site assessment (Results Part IV); 3) the removal of the Stimson weir and completion of designs for the removal of Milltown Dam; and 5) assessments of angler behavior in critical recovery areas (Results Part IV). We also monitored bull trout population trends in the Blackfoot River and five spawning streams, monitored screened irrigation canals on spawning tributaries and completed other assessments in bull trout habitat (Results Part II, III and IV). All of these bull trout recovery actions have provided insight into the complex nature of native species recovery and conservation.

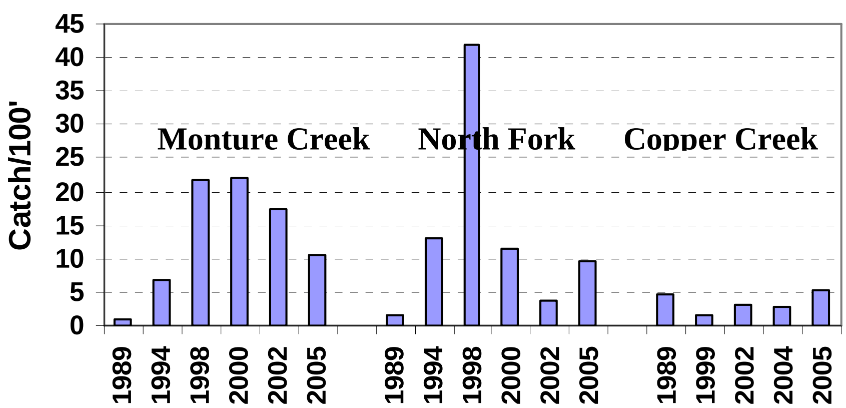


Figure 3. CPUE for juvenile bull trout near spawning sites of three primary spawning streams.

During the 1990s, bull trout densities in the lower Blackfoot River increased, with an inclination towards large fish (Pierce et al 2004). However since 2000, bull trout spawning surveys (redd counts) revealed a sustained watershed decline involving all primary spawning streams (Figure 2). Redd surveys in index reaches of the two primary lower Blackfoot River spawning streams (Monture Creek and the North Fork) have declined 56% and 65% from recent highs. Redd counts in the index reach of Copper Creek have declined from a pre-drought (1989-1999) mean of 20 redds to a mean of 12 from 2000-2005. Juvenile bull trout densities have declined in both Monture Creek and the North Fork, while Copper Creek surveys suggest more static juvenile densities (Figure 3).

Bull trout declines were also detected in the lower Blackfoot River main stem at both (Johnsrud and Scotty Brown) long-term monitoring locations in 2004. At the Scotty Brown section of the lower Blackfoot River, bull trout (>6.0") densities declined from 7.7 to 2.4 bull trout/1000' between 2000 and 2004. Our inability to generate a bull trout population estimate at the Johnsrud section, a result of low catch rates, suggests a similar decline (Results Part II). Bull trout population surveys in upper Cottonwood Creek indicate low, but stable juvenile densities. Bull trout redd counts and juvenile population densities increased in Dunham Creek following the correction of a severe erosion problem at a small spawning site (Results Part III). However, in 2005 both redds and juvenile production have declined. Conversely, in 2004-05 we detected bull trout in both Nevada Spring Creek and lower Nevada Creek for the first time; both are areas where restoration has improved habitat conditions and lowered water temperatures to levels more suitable to bull trout (Results Part III).

In 2004 and 2005, the Blackfoot Cooperators completed habitat restoration projects in *core area* bull trout streams including: 1) planning road crossing and grazing improvements on the mainstem of Cottonwood Creek; 2) channel reconstruction in Hoyt Creek – (a tributary to Monture Creek); 3) flow enhancement on Murphy Spring Creek; 4) the reconstruction of Jacobsen Spring Creek, and 5) continued habitat work on both Rock Creek and Kleinschmidt Creek (all in the North Fork Blackfoot River basin); and 6) the identification of bull trout use in Snowbank Creek, a tributary of Copper Creek (Results Part III). Other bull trout related projects included the removal of a culvert that acted as a partial upstream fish passage barrier in Arrastra Creek, and two improved road crossings in upper Poorman Creek.

Although bull trout are particularly sensitive to many threats, at this time whirling disease appears to be less of a concern for bull trout than for other salmonids. Compared with WSCT, rainbow trout and brook trout, bull trout exhibit a greater physiological resistance to whirling disease (Vincent 2002). In 2004, as whirling disease infection rates continued to escalate, we expanded whirling disease monitoring to the bull trout spawning and rearing areas of Cottonwood Creek, Monture Creek and the North Fork. Sentinel fish exposures indicate that whirling disease is not yet present at these locations, although the disease is present at various levels in lower reaches of these streams (Results Part IV).

Based on "recreational risks" for bull trout recovery, we recently identified *bull trout recovery - recreational conflict areas* (Pierce et al. 2001). These *conflict areas* refer to biologically critical sites (key spawning, rearing and staging areas, important migration corridors and areas of thermal refuge) that overlap with recreational developments, increased angler pressure and illegal bull trout harvest problems. In 2004, we completed an angler-survey at these areas to assess regulation compliance, fish identification skills, angling methods and angler demographics. The survey found high regulation compliance but poor fish ID skills particularly among those intending to keep fish. The study identified a need for education of specific angler groups and concerted river recreation planning efforts in order for native fish recovery to be successful. Survey results also provided a catalyst for funding of a partial warden position directed to these conflict areas in 2006.

Finally, we completed a study quantifying the physical characteristics of bull trout spawning sites. Study results can be used to 1) assist in future restorations actions, 2) assess spawning suitability of restored sites, and 3) help identify historical spawning areas (Results Part IV).

Westslope Cutthroat Trout Conservation

WSCT, a *Species of Special Concern* in Montana, have declined over much of their historic range within the last century. These declines are most pronounced east of the Continental Divide in the upper Missouri River drainage (Shepard et al. 2003). Reasons for the decline include habitat loss and degradation, genetic introgression with introduced rainbow trout and Yellowstone cutthroat trout, over harvest and competition with introduced brook trout and brown trout (Liknes 1984; Allendorf and Leary 1988; Liknes and Graham 1988; McIntyre and Rieman 1995; Shepard et al. 2003). In the Blackfoot Watershed, WSCT occupy ~90% of historical range. The Blackfoot River also supports one of the larger fluvial meta-populations of genetically unaltered WSCT (upper drainage) in Montana (Pierce et al. 2004), but at population abundance well below habitat capacity (Shepard et al. 2003).

Within the Blackfoot Watershed correcting habitat degradation, understanding (and managing) the specific threats by non-native brook trout while maintaining the full expression of WSCT life histories represents a formidable long-term conservation challenge. In order to better understand the ecological relationships of WSCT and brook trout with their environments, FWP undertook a doctorate-level research project in waters of western Montana beginning in 2005. This research involves examining the interactions of both species in habitats ranging from a reach to a landscape level. The project will also examine WSCT-related restoration techniques. Results of this study, particularly those generated within the Blackfoot, should help focus local future WSCT conservation measures.

Degradation and alteration of WSCT habitat are extensive in the Blackfoot Watershed, particularly at the low elevations of the basin where heavy riparian grazing, irrigation and road crossings are common WSCT impairments (Pierce et al. 2004; 2005). A recent telemetry study of fluvial WSCT in the Blackfoot River upstream of the North Fork found no use by fluvial Blackfoot River WSCT for a large contiguous region covering 43% of the upper basin (Pierce et al. 2004). This area extends from Garnet Mountains upstream of the North Fork confluence and includes the Nevada Creek watershed. This large-scale level of impairment may explain extremely low densities of WSCT and other trout species in the Wales Creek section of the Blackfoot River (Results Part II; Appendix C).

WSCT conservation began in 1990 with the adoption of *catch-and-release* angling regulations for all Blackfoot drainage streams and then expanded with habitat restoration. In conjunction with fluvial bull trout recovery, the focus of WSCT recovery is re-establishing the fluvial life-history form by: 1) reducing or eliminating *controllable* sources of anthropogenic mortality; 2) maintaining and restoring existing spawning and rearing habitats; 3) restoring damaged habitats; 4) improving connectivity from the Blackfoot River to fluvial spawning areas; and 5) maintaining certain genetically "pure" population isolates. Most of the current WSCT work occurs in *core area* watersheds or streams containing known fluvial WSCT (Pierce et al. 1997; 2001; 2002; 2004; Results Part III)

To date, restoration projects in WSCT habitat have involved 38 streams. Projects focus on improving habitat conditions in both fluvial and resident isolet WSCT populations. In 2004 and 2005, the Blackfoot Cooperators continued to develop or implement projects on 13 WSCT-bearing streams (Arrastra Creek, Ashby Creek, Clearwater River, Cottonwood Creek, Murphy Spring Creek, Nevada Creek, Nevada Spring Creek, North Fork Blackfoot, Rock Creek, Pearson Creek, Poorman Creek, Snowbank Creek and Wasson Creek), during which time FWP monitored WSCT populations on 17 project streams (Results Part III).

During 2004 and 2005, we expanded fisheries inventories to the backcountry of the watershed, including both lakes and streams in *wilderness* and *roadless* areas. We inventoried three streams in the headwaters of the North Fork and 13 mountain lakes of the upper Landers Fork and North Fork drainages (Results Part IV). Initial *Oncorhynchus* genetic testing indicates mild introgression in waters of the Dry Fork arm of the North Fork. However, initial genetic testing of mountain lakes in upper Landers Fork and East Fork of the North Fork basin reveal hybrid swarms of rainbow trout, Yellowstone cutthroat trout and WSCT in certain headwater lakes (Results Part IV; Appendix I). Additional backcountry inventories and genetic tests will continue through 2007. We also re-tested WSCT populations in two streams – Union and Game Creeks and tested the North Fork of Frazier Creek (Appendix I).

In response to harvest restrictions and tributary restoration, densities of fluvial WSCT have been increasing in the lower Blackfoot River (Johnsrud and Scotty Brown Bridge sections) since 1990 (Results Part II). In 2004, WSCT estimates (>6.0") ranged from a low of ~0.5 fish/1000' below Nevada Creek (Wales Creek Section) to 14-18 fish/1000' at monitoring stations of the lower river (Johnsrud and Scotty Brown Bridge sections). Low densities in the Wales Creek section reflect impaired water quality and degradation of nearby tributaries. In the Scotty Brown section, WSCT densities are generally stable compared with other trout species - all of which have declined in this section during the drought (Results Part II).

The distribution of whirling disease is generally at elevations below most known WSCT spawning and rearing sites with some exceptions, including Chamberlain Creek - an important fluvial WSCT spawning stream in lower Blackfoot Watershed. Continued monitoring of WSCT in Chamberlain Creek during 2004-05 suggests stable densities in the presence of high infection levels (Results Part III).

STUDY AREA

The Blackfoot River is one of twelve renowned "*Blue Ribbon*" trout rivers in Montana with a 1972 appropriated "*Murphy*" in-stream flow water right of 700 cfs at the USGS Bonner (#12340000) gauging station. The Blackfoot River, located in west central Montana, begins at the junction of Beartrap and Anaconda Creeks, and flows west 132 miles from its headwaters near the Continental Divide to its confluence with the Clark Fork River in Bonner, Montana (Figure 4). Mean annual discharge is 1,563 cubic-feet-per-second (cfs) near the mouth (USGS 2005 provisional data).

This river system drains a 2,320 square mile watershed through a 3,700-mile stream network, of which 1,900 miles are perennial streams capable of supporting fishes. The physical geography of the watershed ranges from high-elevation glaciated alpine meadows, timbered forests at the mid-elevations, to prairie pothole topography on the valley floor. Glacial landforms, moraine and outwash, glacial lake sediments and erratic boulders cover the floor of the entire Blackfoot River valley and exert a controlling influence on the habitat features of the Blackfoot River and the lower reaches of most tributaries. The Blackfoot River is a free flowing river to its confluence with the Clark Fork River where Milltown dam, a run-of-the-river hydroelectric facility, has blocked upstream fish passage since 1907.

Between March 2003 and February 2004, the mainstem Blackfoot River supported an estimated 39,023 angler days. Of this total, Montana residents comprised 69% (26,854) and non-residents 31% (12,171) of the total. Most of this angling pressure was concentrated in the lower 54.1 miles of the Blackfoot River (downstream of the North Fork) where estimates range from 532-585 anglers/mile compared to 132-146 anglers/mile upstream of the North Fork.

Current land ownership in the Blackfoot watershed is approximately 42% National Forest, 25% private ownership, 19% Plum Creek Timber Company, 7% State of Montana, and 6% Bureau of Land Management. In general, public lands and large tracts of Plum Creek Timber Company properties comprise large forested tracts in mountainous areas of the watershed, while private lands occupy the foothills and lower valley areas (Figure 4). Traditional land-use in the basin includes mining, timber harvest, agriculture

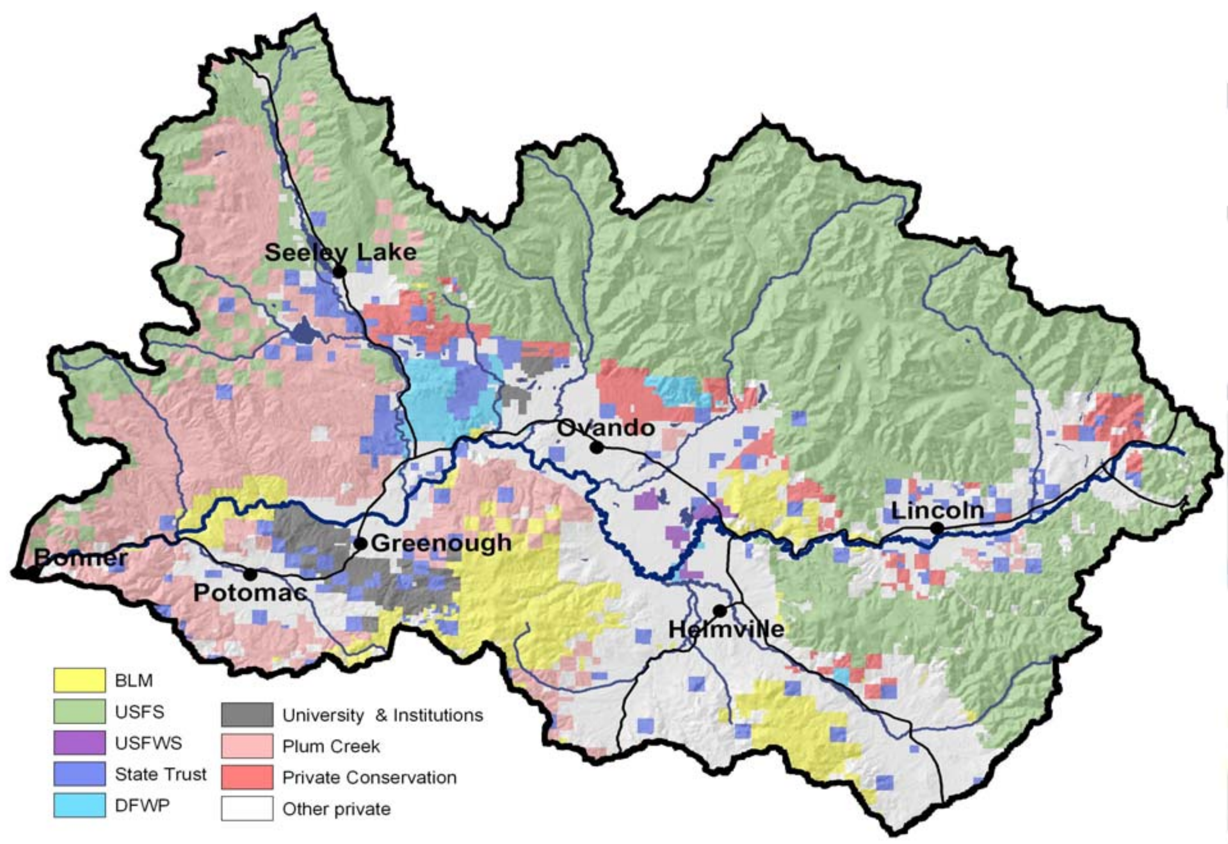


Figure 4. Land ownership map of the Blackfoot River Watershed.

and recreation activities, all of which have contributed to habitat degradation or fish population declines. Of 108 inventoried streams or river reaches, ninety-six have been altered, degraded or otherwise identified as fisheries-impaired at some level (Pierce et al 2005). The majority of habitat degradation occurs on the valley floor and foothills of the Blackfoot watershed and largely on private agricultural ranchlands. However, problems also extend to commercial timber areas, mining districts, and state and federal public lands.

Distribution patterns of most salmonids generally conform to the physical geography of the landscape, with species richness increasing longitudinally in the downstream direction (Figure 5). Species assemblages and densities of fish can also vary greatly at the lower elevations of the watershed. Native species of the Blackfoot Watershed are bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki lewisi*), mountain whitefish (*Prosopium williamsoni*), pigmy whitefish (*Prosopium coulteri*), longnose sucker (*Catostomus catostomus*), largescale sucker (*Catostomus macrocheilus*), northern pikeminnow (*Ptychocheilus oregonensis*), peamouth (*Mylocheilus caurinus*), redside shiner (*Richardsonius balteatus*), longnose dace (*Rhinichthys cataractae*) slimy sculpin (*Cottus cognatus*) and mottled sculpin (*Cottus bairdi*). Non-native species of the Blackfoot Watershed include rainbow trout (*Oncorhynchus mykiss*), kokanee (*O. nerka*), Yellowstone cutthroat trout (*O. clarki bouvieri*), brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), artic grayling (*Thymallus arcticus*), white sucker (*Catostomus commersoni*), fathead minnow (*Pimephales pomelas*), northern pike (*Esox lucius*), brook stickleback (*Culaea inconstans*), Pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens).*

Most salmonids (WSCT, bull trout, rainbow trout and brown trout) in the main stem river system exhibit fluvial migratory life-history characteristics, whereas tributaries support both migratory and resident populations. WSCT have a basin-wide distribution and is the most abundant species in the upper reaches of the tributary system. Bull trout distribution extends from the main stem Blackfoot River to headwaters of larger tributaries north of the Blackfoot River main stem. However, juvenile bull trout will rear in smaller "non-spawning" tributaries, some of which are located in the Garnet Mountains. Rainbow trout distribution is limited to the Blackfoot River downstream of Nevada Creek and lower reaches of the lower river tributaries, with the exception of Nevada Creek upstream and downstream of Nevada Reservoir. Rainbow trout occupy ~10% of the perennial streams in the Blackfoot watershed, with river populations reproducing primarily in the lower portions of larger south-flowing tributaries. However, populations of rainbow trout are also established in back country mountain lakes, primarily in the upper North Fork drainage. Brown trout inhabit ~15% of the perennial stream system with a distribution that extends from the Landers Fork down the length of the Blackfoot River and into the lower foothills of the tributary system. Brook trout are widely distributed in tributaries, but rare in the main stem Blackfoot River below the Landers Fork.

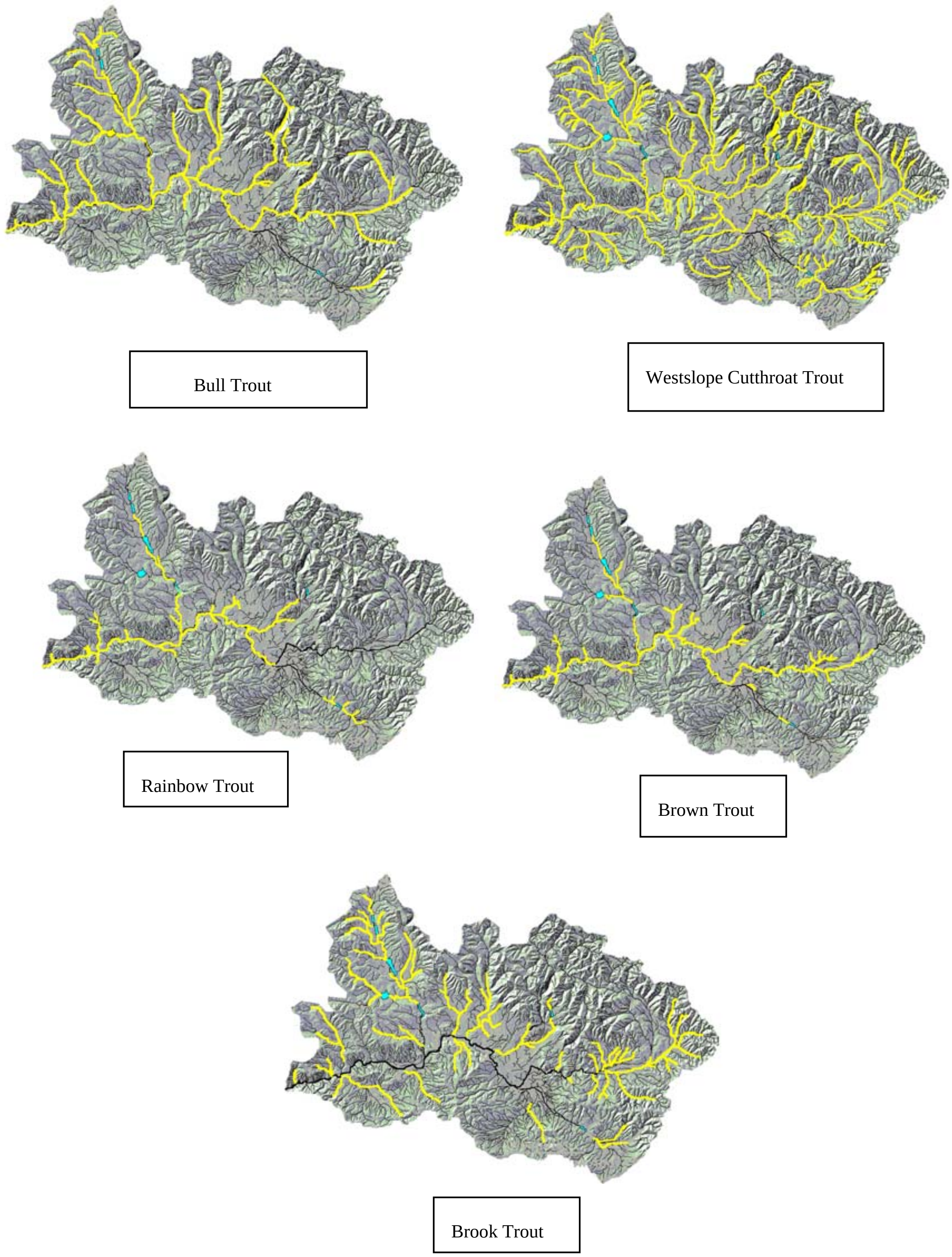


Figure 5. Generalized trout distribution in the Blackfoot River watershed.

PROCEDURES

Methods associated with Results Part II and III are identified below; those related to special projects are located in Results Part IV.

Working with Private Landowners: the Key to Successful Restoration

Typically, each tributary restoration project involves multiple landowners, professional disciplines, funding sources, plus involvement of the watershed groups. Restoration has focused on addressing obvious impacts to fish populations such as migration barriers, stream de-watering, fish losses to irrigation canals, and degraded riparian areas. All projects are cooperative endeavors between private landowners and the restoration team, and occur throughout the drainage. Projects are administered at the local level by agency resource specialists in cooperation with two watershed groups - the BBCTU and the BC, or local government groups such as the North Powell Conservation District (NPCD). Tax incentives of the non-profit 501(c)3 status of watershed groups provide a mechanism for generating private funds.

FWP biologists identify priorities by performing fisheries studies, communicating biological findings, review proposed fisheries projects, provide funding support and monitor fisheries on completed projects. Federal (USFWS, USFS and NRCS) biologists and other agency specialists (BOR, DNRC) help develop and fund projects usually in conjunction with watershed groups (BBCTU and BC) and landowners. Agency staff and project leaders generally enlist help from interagency personnel or consultants including range conservationists, hydrologists, engineers, and water right specialists as necessary. Watershed groups help with fundraising, administration of budgets, bid solicitation, apply for permits, help oversee consultants and contractors, assist with landowner contacts, coordinate volunteers, help resolve local conflicts and address other social issues.

Project funding comes from many sources including landowner contributions, private donations, foundation grants, state and federal agencies. Agencies and watershed groups project managers jointly undertake fund-raising. BBCTU generally obtains project permits on behalf of cooperating landowners. Project bids (consulting and construction) conform to State and Federal procurement policies. These policies included the development of Blackfoot watershed *qualified vendors lists* (QVL) derived through a competitive process managed primarily through the BBCTU. A minimal project cost triggers use of the QVL. The watershed groups solicit bids from the QVL for both consulting and contractor services. Bid-contracts are signed between the watershed group and the selected vendor upon bid acceptance.

Depending on the specific project, landowners are responsible for certain costs, construction and project maintenance. Addressing the source of stream degradation usually requires developing riparian/upland management options sensitive to the requirements of fish and other riparian-dependent species. Written agreements (10-30 year period) with landowners to maintain projects are arranged with cooperators on each project. These agreements vary by funding source and may include agencies, the NPCD and/or the Fish and Habitat Committee of BBCTU. Landowner awareness of the habitat requirements of fish and wildlife, and their full participation and commitment to project goals and objectives are crucial to the long-term success of the restoration initiative. We encourage landowners to participate fully in all phases of restoration from fish population data collection and problem identification, to development and monitoring of completed projects. Although many restoration projects have been completed in the Blackfoot River watershed, this effort is considered educational at a broad level and is far from complete.

Fish Population Estimators

Fish population densities were calculated using single-pass, mark-recapture, or multiple pass-depletion methods. We used mark-recapture in the Blackfoot River and Monture Creek (Appendix C) and depletion estimates (Appendix B) and single pass catch-per-unit-effort (CPUE) in smaller streams (Appendix A).

Population densities using the mark-recapture method were estimated using Chapman's modification of the Petersen formula (Ricker 1975), and standard equation for calculating variance. For this estimator:

$$N = \frac{(m+1)(c+1)}{r+1} - 1$$

$$V(N) = \frac{\{(m+1)(c+1)\}\{(m-r)(c-r)\}}{(r+1)^2(r+2)}$$

Where:

N= population point estimate
m= the number of marked fish
c= the number of fish captured in the recapture sample
r= the number of marked fish captured in the recapture sample
V(N) = variance for point estimate

Confidence intervals (CI) were calculated using the equation $N \pm 1.96\,(V(N))^{-2}$ and calculated at the 95% confidence level (Appendix C).

For fish population estimates in small stream, we used a standard two-pass depletion estimator and standard equations for calculating variance (Leathe 1983). For this estimator:

$$N = \frac{(n_1)^2}{n_1 - n_2}$$

$$P = \frac{n_1 - n_2}{n_1}$$

Where:

N = point estimate,
n_1 = the number of fish collected on the first pass
n_2 = number of fish captured on the second pass
P = probability of capture ($\geq$0.5 for N$\geq$50 or $\geq$0.6 for N $\leq$50 for valid estimates)

$$\text{Standard deviation} = \frac{n_1 n_2 (n_1+n_2)^{-2}}{(n_1-n_2)^2}$$

95% confidence interval = N $\pm$ 1.96 (Standard deviation). The 95% confidence intervals for these estimates are found in Appendix B.

For small stream population assessments, we commonly use a single pass catch-per-unit effort (CPUE) method as a simple index of relative abundance (Appendix A). From monitoring sections with both CPUE and depletion estimates, we also recently developed linear regressions to help predict densities from CPUE (Pierce et al 2004). These regressions confirm correlations between CPUE and density estimates for fish

<4.0” (y=1.7236x–0.1513; R^2=0.86; P=<0.001) and for fish >4.0” (y=1.3162x + 0.5.5495; R^2=0.86; P=<0.001).

Although these regressions demonstrate CPUE to be a predictor of population density, estimates derived from these equations do not have a confidence interval like the actual (depletion) population density estimate, and should be used with caution. For this report, we use only CPUE and actual depletion estimates for tributary assessments. CPUE refers to the number of fish collected in a single electrofishing pass and is adjusted per 100’ of stream (i.e. CPUE of 8 means 8 fish captured per 100’ of sampled stream). Actual population estimates are referred to as density/100’. CPUE catch statistics are located in Appendix A and population estimates are in Appendix B.

Fish were captured using a boat or backpack mounted electrofishing unit. In small streams, we used a battery powered (Smith/Root) backpack mounted DC electrofishing unit. The anode (positive electrode) was a hand-held wand equipped with a 1-foot-diameter hoop; the cathode (negative electrode), a braided steel wire. On the Blackfoot River, we used an aluminum drift boat mounted with a Coffelt Model VVP-15 rectifier and 5,000 watt generator. The hull of the boat serves as the cathode and two fiberglass booms, each with four steel cable droppers, serve as anodes. We used direct current (DC) waveform with output less than 1000 watts, which is an established method to significantly reduce spinal injuries in fish associated with electrofishing (Fredenberg 1992). Juvenile trout including young-of-the year (YOY) were sampled in the tributaries from August to November. Extra effort was used to sample stream edges and around cover to enable comparisons of densities between years and sampling sections. Captured fish were anesthetized with either tricaine methanesulfonate (MS-222) or clove oil, weighed (g) and measured (mm) for total length (TL). For this report, we converted all weights and lengths to standard units.

Whirling Disease Sentinel Cage Studies

Whirling disease surveys involving sentinel fish exposures were undertaken throughout the Blackfoot Watershed in 2004 and 2005. Sentinel cage studies are controlled experiments used to detect levels of whirling disease. Cages consist of an 18 x 24” cylindrical screened container placed into a stream site, which allows stream water to flow through the cage. Each cage contained 50 uninfected rainbow trout or WSCT (35-60 mm) supplied by a state fish hatchery. In specific studies, brook and brown trout were also used to detect levels of whirling disease infection. Timing of field exposure was based on anticipated mean daily temperatures in the 50's (F), which correlates with peak triactinomyxon (TAM) production, and corresponds to peak infection rates in fish (Vincent 2000), except in spring creeks (Kleinschmidt and Nevada Spring Creek) where recent research indicated peak infection occurred in late winter and early Spring (Anderson 2004). The exposure period for each live cage was standardized at 10 days. At the end of the 10-day exposure period, the trout were transferred to Pony, MT, where they were held for an additional 80 days at a constant 50 ^{o}F temperature to insure the WD infection if present would reach its maximum intensity (Vincent 2000). At the end of the holding period, all surviving fish were sacrificed and sent to the Washington State University Animal Disease Diagnostic Laboratory at Pullman, WA. At the lab, the heads were histologically examined using the MacConnell-Baldwin histological grading scale, which ranks infection intensity from 0 (absent) to 5 (severe) (Baldwin et al. 2000). The results of this histological rating were presented as mean grade infection. Mean grade infections above 2.7 are likely to result in population level declines (Vincent 2000). Each sentinel cage also had an accompanying thermograph to establish mean daily water temperatures during the exposure period.

WSCT Genetic Investigations

In 2004 and 2005, we tested *Oncorhynchus* genetic composition in WSCT habitat in seven waterbodies (Appendix I). Samples consisted of non-lethal tissue samples (fin-clip) taken from a minimum 25 individual fish when possible. Samples collected were immediately preserved in 95% ethyl alcohol and taken to the University of Montana, Conservation Genetics Laboratory for analysis. The Paired Interspersed Nuclear DNA Element-PCR (PINE-PCR) method is used to determine each fish's genetic characteristics at 21 regions of nuclear DNA. This method produces DNA fragments (PINE markers hereafter) that distinguish WSCT, from rainbow trout and Yellowstone cutthroat trout. These species specific PINE markers, therefore, can be used to determine whether a sample came from a suspected genetically pure population of one of these fishes or one in which hybridization between two or all three of them has occurred. With a sample size of 25 fish, this testing method has a 95% chance of identifying as little as 1% introgression.

Stream Temperatures

Water temperatures (^{o} F) were recorded at 48 to 72 minute intervals using Hobo temperature or tidbit data loggers. Data for each station are summarized with monthly mean, maximum, minimum and standard deviation in Appendix H. All water temperature data collected between 1994 and 2005 (92 sites with 180 individual data bases) was also complied into a GIS (ArcView) layer. For some streams we compared temperature differences using paired *t-tests* and results were considered significant at the alpha $\leq$ 0.05.

Objectives of the temperature data collections were to: 1) continue long-term data collections at established monitoring sites; 2) profile temperatures over the length of the river; 3) identify and monitor thermal properties of tributaries entering the river; 4) identify thermal regimes favorable and unfavorable for trout; 5) monitor temperature triggers used in the Blackfoot Emergency Drought Plan; 6) monitor stream restoration projects; and 7) establish winter baseline and influence of upwelling in bull trout spawning area; 8) assess relationships of water temperature to movements of rainbow trout; and 9) compile data for future studies.

RESULTS PART I: BLACKFOOT RIVER ENVIRONMENT

Blackfoot River Discharge: USGS Bonner gauging station #12340000

During 2004 and 2005, the Blackfoot River watershed was subject to a 5th and 6th year of consecutive drought. Mean discharge was 1,241 cfs in 2004 and 1,232 cfs in 2005, compared to a 69-year mean of 1,563 cfs (Figure 6).

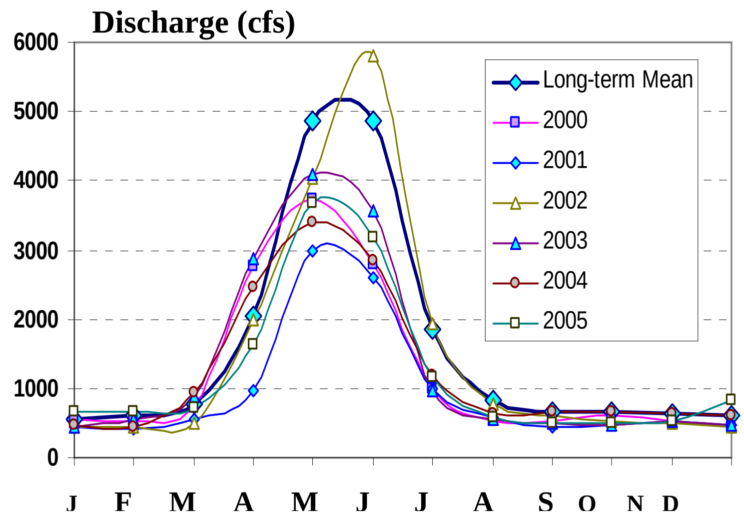


Figure 6. Blackfoot River hydrographs at the USGS Bonner gauging station, 2000-2005 provisional data.

Since the beginning of drought in 2000, annual flows in the Blackfoot River USGS Bonner gauging station have ranged from 61-96% of normal, and averaged 80% of normal over this six-year period. During this time, minimum monthly flows ranged from 47–80% of normal. Critical late summer low flows (July and August) were 66-76% of normal with monthly flows as low as 53% in 2003 (Table 1). The 2000 to 2005 annual hydrographs also show consistent lack of normal high (i.e. flushing) flows, with the exception of 2002 (Figure 6). The Blackfoot River near Bonner fell below "minimum instream flows" of ~700 cfs on 207 days in 2004 and 174 days in 2005 based on provisional USGS flow data. Minimal river flows were estimated at 300 cfs during mid-winter periods in both years (USGS 2006).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Long-term Mean	554	599	781	2052	4867	4877	1844	831	670	653	649	606
2000	542	532	744	2770	3741	2779	1004	528	521	608	517	450
2001	445	421	560	959	2980	2595	996	584	441	472	520	477
2002	455	429	503	1980	4036	5814	1939	788	600	517	487	439
2003	441	553	881	2885	4081	3579	970	554	491	467	520	471
2004	458	438	932	2471	3402	2838	1181	635	670	650	625	598
2005	670	668	726	1626	3690	3178	1167	579	504	504	518	841
Mean 2000-05	502	507	724	2115	3655	3463	1209	611	537	536	531	546
% of normal	92	85	93	103	75	75	66	76	80	82	82	90
Low range of normal	80	70	64	47	61	53	53	67	64	70	75	72

Table 1. Provisional mean monthly flow statistics for the Blackfoot River at the USGS Bonner gauge, 2000-2005.

Blackfoot River and tributary temperatures

Temperatures studies during 2004 and 2005 involved: 1) baseline and long-term data collections at established sites throughout the Blackfoot watershed; 2) assessing tributary restoration projects; 3) identifying thermal regimes (natural and anthropogenic) favorable and unfavorable for trout; 4) monitoring temperature triggers of the Blackfoot Emergency Drought Plan; and 5) relating other biological assessments (migrations and spawning) to thermal properties of the river system. Summaries of temperature data are found throughout this report. All raw and summary data for all monitoring sites are located in Appendix H.

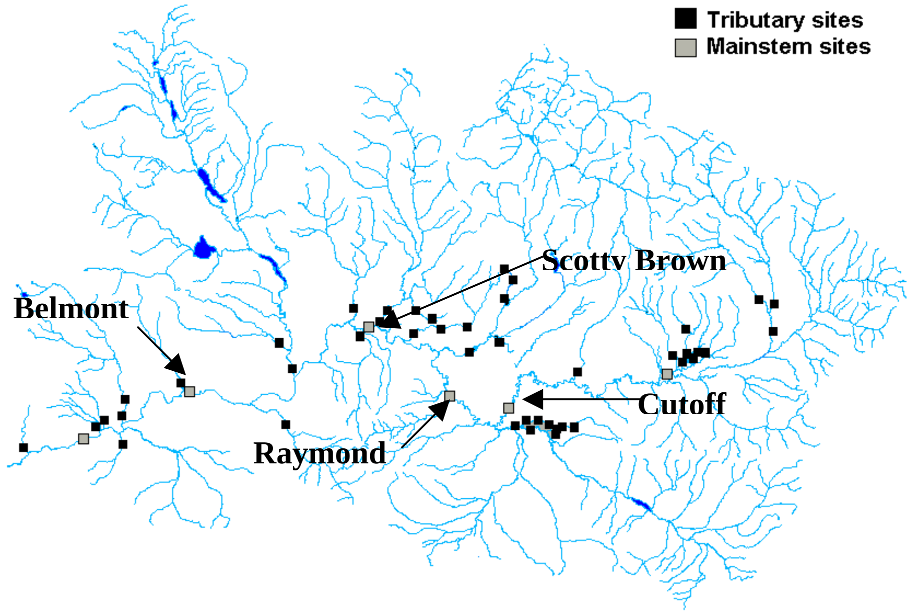


Figure 7. Temperature monitoring locations in the Blackfoot Watershed, 2004 and 2005.

During 2004 and 2005, we collected 56 water temperature samples at 44 locations in 26 tributaries, along with 12 samples at six sites in the Blackfoot River, including four long-term monitoring sites (Figure 8, Appendix H). Figure 8 shows a portion of the river data at these four sites for the mid-summer (1999 – 2005) period, compared to the mean. These data show the wide range of inter-annual summer temperatures for the lower ~70 miles of the Blackfoot River. This includes temperatures >70 °F, which are generally considered above the optimal range of most salmonids; temperatures > 65 °F are considered harmful to bull trout.

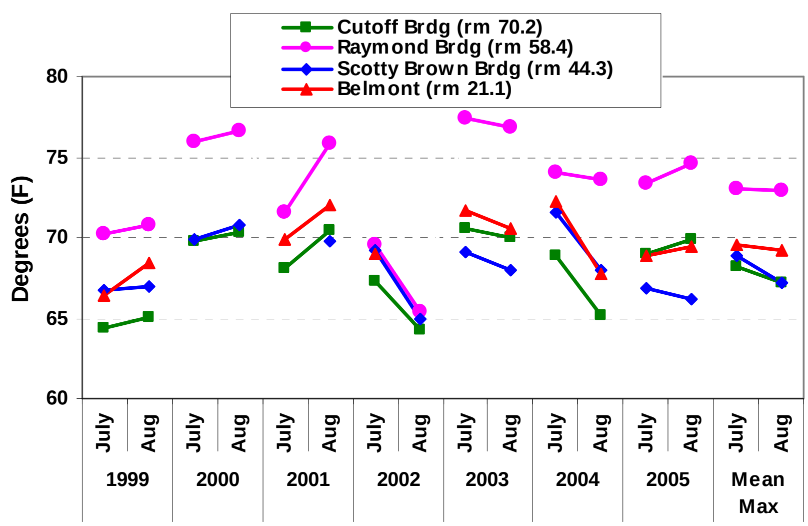


Figure 8. Maximum monthly summer (July-August) water temperatures at 4 monitoring sites on the Blackfoot River, 1999-2005.

Figure 8 outlines the warming influence of Nevada Creek (rm 67.8) located between the Cutoff and Raymond Bridge sections, as well as cooling influence of the North Fork (rm 54.1) between the Raymond Bridge and Scotty Brown sections of the Blackfoot River.

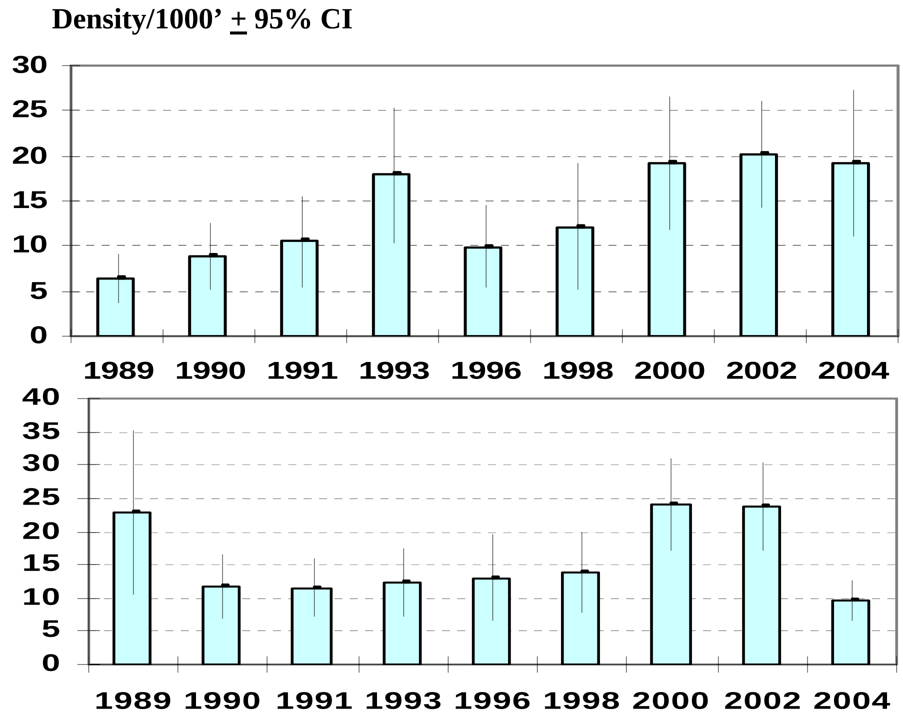


Figure 9. Densities of brown trout (>6.0') in the Johnsrud (top) and Scotty Brown (bottom) sections of the Blackfoot River, 1988-2004.

RESULTS PART II: BLACKFOOT RIVER TROUT POPULATIONS

In June 2004, FWP completed bi-annual fish population surveys at three monitoring sections, including two long-term monitoring sections (Johnsrud at river mile mid-point 13.5 and Scotty Brown Bridge at river mile mid-point 43.9) of the lower Blackfoot River, and the Wales Creek section - a site established in 2002 downstream of Nevada Creek. For these surveys, population estimates and related statistics are located in Appendix C.

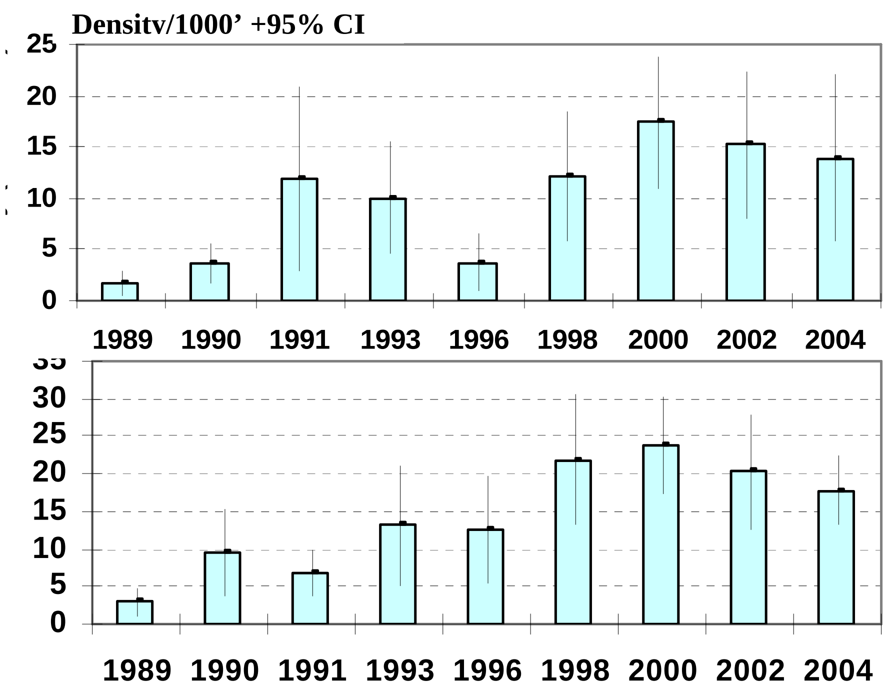


Figure 10. Densities of WSCT (>6.0") in the Johnsrud (top) and Scotty Brown (bottom) sections of the Blackfoot River, 1989-2004.

Johnsrud Section

The 2004 trout species

composition (% of total catch for fish >6.0”) in the Johnsrud section was 67.6 % rainbow trout (n= 499), 18.7 % brown trout (n=138), 11.4% WSCT (n= 84) and 2.3% bull trout (n=17). Based on the total trout point estimate (fish >6.0”), the total trout density estimate for the Johnsrud section decreased slightly from 134 to 129 fish/1000’ a decline of 4% between 2002 and 2004. Total trout biomass (fish >6.0”) however declined 26% from 105 to 78 pounds/1000.’

Densities of native WSCT (> 6.0”) decreased slightly from 15.2 to 13.9 fish/1000’ (Figure 10). Because of small sample size and a low recapture rate, we were unable to generate a valid bull trout estimate, although catch statistics suggest a substantial decline. The 2004 point estimate for brown trout (> 6.0”) was static at 19.2 compared with 20.1 fish/1000’ in 2002 (Figure 9). The density estimate for rainbow trout (>6.0”) indicates a slight decline of 88/1000’ in 2004 compared to 94/1000’ in 2002 (Figure 12).

In 2004, we observed one northern pike in the Johnsrud section, compared with two in 2002, six in 2000, two in 1998, one in 1996, and none prior to 1996. Our observations of the clinical signs of whirling disease (cranial deformities) have increased slightly from 2002 to 2004 (Results Part IV).

Scotty Brown Bridge section

The 2004 percent trout composition for the total catch in the Scotty Brown Bridge Section was 33.3% rainbow trout (n=173), 24.2% brown trout (n=126), 37.1% WSCT (n=193), 5.4 % bull trout (n=28). Total trout (fish >6.0”) densities decreased ~ 46% from 89.9 to 48.7 fish/1000’ between 2002 and 2004. Total trout biomass (fish >6.0”) has declined 49% from 94 to 48 pounds/1000’ of River between 2002 and 2004.

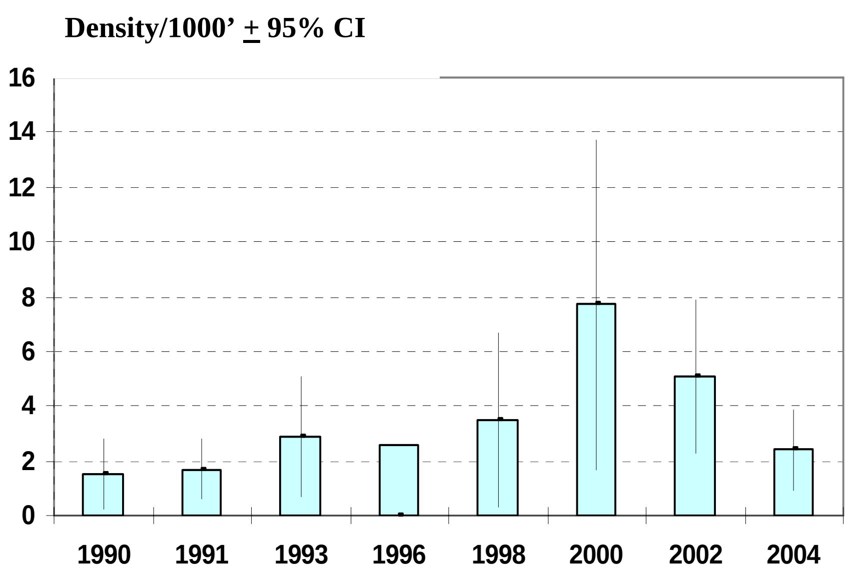


Figure 11. Densities of bull trout (>6.0”) in the Scotty Brown section of the Blackfoot River, 1990-2004.

Density estimates for rainbow trout (fish >6.0”) are shown in Figure 12. Data show a significant recent decline for the species. This decline occurred within the intermediate (11.0-13.9) and larger (>14.0”) size classes (Appendix C). Likewise, brown trout (>6.0”) showed a large decline from 23.8 fish/1000’ in 2002 to 9.6 fish/1000’ in 2004 (Figure 9). Estimated bull trout densities (fish >6.0”) also declined from 5.1 to 2.4 fish/1000’ between 2002 and 2004 (Figure 11). WSCT densities (fish >6.0”) also decreased from 20.3 to 17.8 fish/1000’ between 2002 and 2004 (Figure 10).

During our surveys, we observed a high incidence of fungal infections (saprolignia) in brown trout. Unlike the Johnsrud section, we have not observed northern pike in the Scotty Brown Bridge section in samples to date. Our observations of the clinical signs of whirling disease (cranial deformities) increased from 2002 to 2004 (Results Part IV).

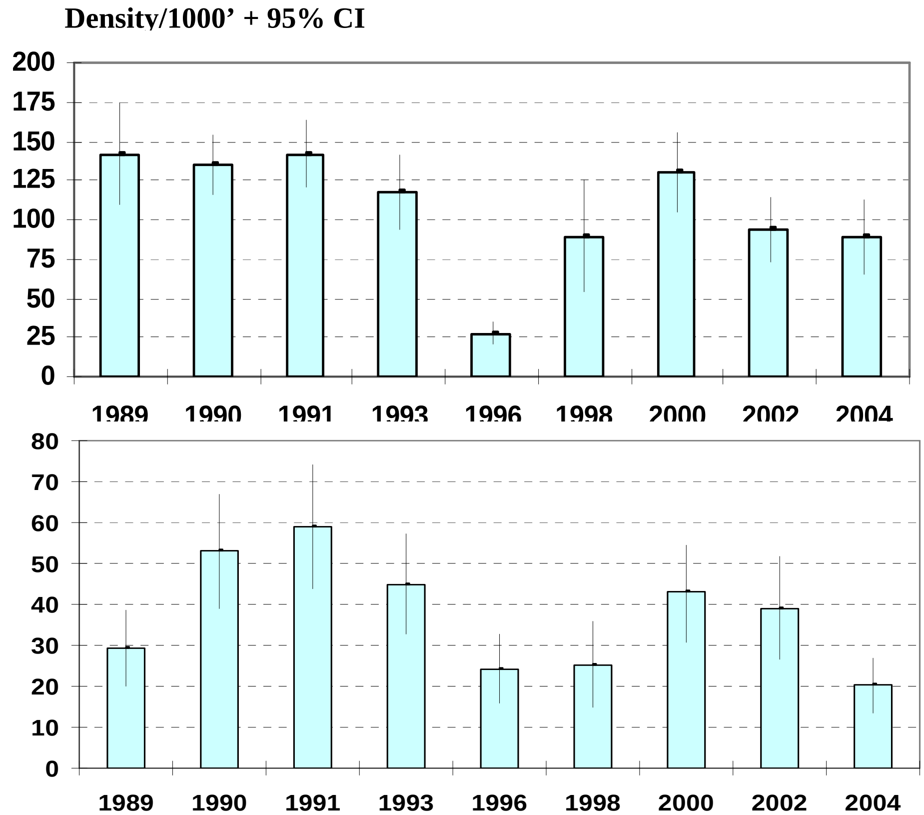


Figure 12. Densities of rainbow trout (> 6.0") in the Johnsrud (top) and Scotty Brown (bottom) sections of the Blackfoot River, 1989-2004.

Wales Creek Section

In 2002, we established a new fish population survey site (the Wales Creek Section) in a middle reach of Blackfoot River between the North Fork Blackfoot River and Nevada Creek (rm 60.0-66.2). This section of the Blackfoot River suffers from impaired water quality (high levels of fine sediment, summer water temperatures, and nutrient levels) and degraded tributaries, all of which limit juvenile trout production and recruitment to this reach of the Blackfoot River (Pierce et al. 2001; 2004).

In May 2004, trout species composition (% of total catch for fish >6.0") in the Wales Creek section was 84.8% brown trout (n=151), 5.6 % WSCT (n=10) and 1.7 % bull trout (n=3). We sampled no rainbow trout >6.0" in the Wales Creek section in 2004 compared with 14 in 2002. We estimated total trout density (> 6.0") for the Wales Creek section at 9.1 fish /1000' in 2004 compared to 12.7 in 2002, a decline of 28%. Of the total trout estimate, the brown trout (> 6.0") point estimate was 8.6 fish/1000'. We did not attain density estimates for the other species due to small sample sizes. The total trout density estimate (>6.0") in the Wales Creek Section was only 19 % of the total estimate in the Scotty Brown Bridge section, which is the nearest downstream main stem survey section.

RESULTS PART III: RIVER RESTORATION TRIBUTARY ASSESSMENTS

As a continuation of eight previous reports detailing fisheries investigations of Blackfoot River tributaries (Peters 1990; Pierce and Peters 1990; Pierce, Peters and Swanberg 1997; Pierce and Schmetterling 1999; Pierce and Podner 2000; Pierce, Podner and McFee, 2001; 2002: Pierce, Anderson and Podner 2004), this section summarizes the 2004 and 2005 restoration actions and fisheries-related monitoring for 26 streams. Fish population statistics, catch and sizes and density estimates, for these streams are located in Appendices A and B, respectively.

Ashby Creek

Restoration objectives: Protect the genetic purity of a WSCT population in the upper Ashby Creek watershed by using an existing wetland as a migration barrier, and improve WSCT habitat by creating a natural channel that provides complexity, increases riffle-pool habitat features and available spawning substrate and increases shade and small diameter wood recruitment to the channel. Improve and re-establish wetland functionality.

<u>Project Summary</u>

Ashby Creek, a 2nd order tributary in the Union Creek basin enters Camas Creek at stream mile 0.5. Upper reaches originate in forested areas including Plum Creek and BLM properties before entering private ranch lands near mile 3.0. Below stream mile 3.0, Ashby Creek has been severely altered by agricultural practices. Alterations involve the loss of the historical channel to farming and irrigation, livestock degradation of streambanks, loss of woody plant communities, an inter-basin transfer of water to Arkansas Creek and associated dewatering of the channel and downstream wetlands.

Over the last several years a comprehensive restoration project has been in the development phases, with implementation planned for 2006. The project will involve landscape protection measures (conservation easements), creation of ~17,000' of new stream channel and revegetation, upgrades to a diversion structure, riparian grazing changes, instream flow enhancement and wetland restoration – all within the context of a working agricultural operation.

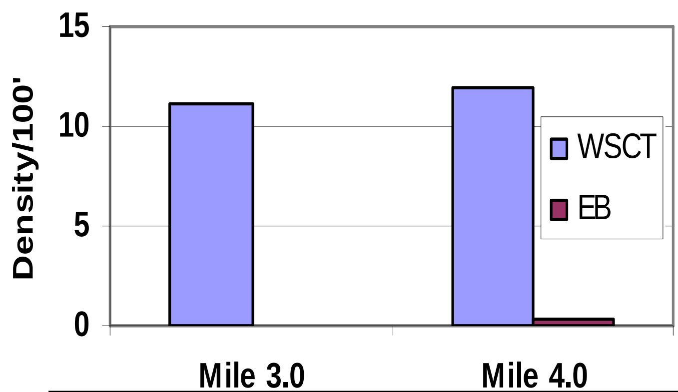


Figure 13. Densities of fish >4.0" at two sites in Ashby Creek, 2005.

<u>Fish populations and other monitoring</u>

In 2005, FWP established pre-project control (mile 4.0) and treatment (mile 3.0) fish population monitoring sections in order to measure the influence of the upcoming project (Figure 13). On August 8th, during the peak irrigation season we measured flows at 2.6 cfs above the diversion and 0.9 below the diversion. This 0.9 cfs downstream value in expected to approximate the minimum instream summer flows in the new channel.

Arrastra Creek

Restoration objectives: Restore upstream fish passage for fluvial native fish of the Blackfoot River.

Project Summary

Arrastra Creek, the largest and among the coldest Blackfoot River tributary between Beaver Creek (rm 105.2) and Nevada Creek (rm 67.8), enters the Blackfoot River at river mile 88.8. Arrastra Creek is also the only stream between Poorman Creek (rm 108) and the North Fork (rm 54.1) to support a bull trout population. Arrastra Creek was also identified as the primary spawning tributary for fluvial WSCT in the middle Blackfoot River based on telemetry studies (Pierce et al 2004). All telemetered WSCT spawned downstream from a set of undersized culverts located at mile 3.2. During the WSCT migration period of 2003, we measured flow velocities through the culverts in excess of 8 ft/second – well above velocities WSCT can navigate. In 2005, these culverts were replaced with a bridge. The bridge allows access to ~6 miles of perennial stream upstream of the crossing.

Fisheries populations and other monitoring

Arrastra Creek supports bull trout and genetically pure WSCT throughout the mainstem as well as brown trout and brook trout in lower reaches. Fish populations in lower Arrastra Creek have been periodically monitored since 1989 and most recently in 2004. The monitoring shows an increased number of WSCT in the lower 2.4 miles of stream compared to the original 1989 surveys (Figure 14). This increase is thought to result from the increased number of fluvial adult WSCT in the middle Blackfoot River using Arrastra Creek for spawning and concentrated spawning downstream of the culverts.

Other data collections in Arrastra Creek included a geomorphic and substrate survey of the WSCT spawning areas. Detailed results of the spawning site survey are located in Results Part IV.

Arrastra Creek recently tested positive for whirling disease in 2003 with an initial infection 0.34, which then increased to 1.23 in 2004.

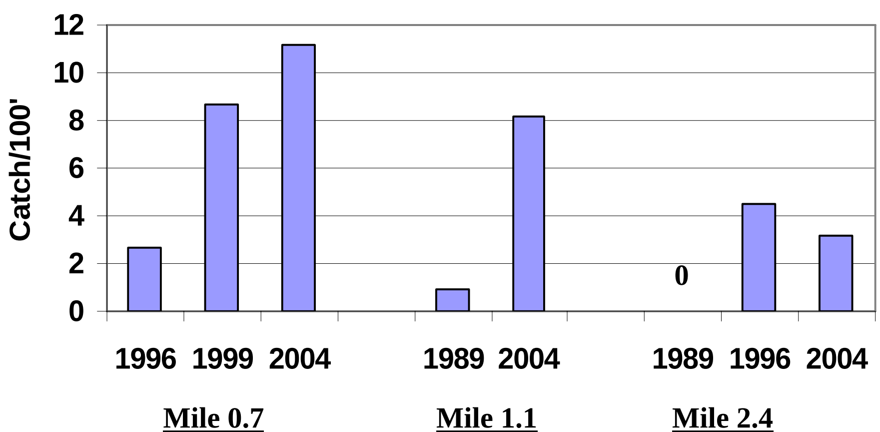


Figure 14. CPUE for WSCT at three locations in lower Arrastra Creek

Bear Creek

Restoration Objectives: Restore habitat degraded by historical activities in the channel, restore fish passage and thermal refugia, and improve recruitment of trout to the Blackfoot River.

Project Summary

Bear Creek, a small 2nd order tributary to the lower Blackfoot River, flows six miles north to its mouth where it enters the Blackfoot River at river mile 12.2 with a base flow of 3-5 cfs. Bear Creek is one of the colder tributaries to the lower Blackfoot River. For August 2002 and 2003, mean daily temperatures (mile 1.0) were in the low 50's with maximum summer temperature ~6^{o} F cooler than the Blackfoot River at the USGS gauging station at river mile 7.9 (Appendix H).

Bear Creek has a long history of adverse habitat changes. These include placement of undersized culverts, road drainage and siltation, irrigation, channelization of the stream, excessive riparian grazing and streamside timber harvest (Pierce et al. 1997; Pierce and Schmetterling 1999). At least one road crossing is still considered a barrier to movement. These fisheries impairments contributed to the loss of migration corridors and the simplification and degradation of salmonid habitat. Projects completed included: 1) upgrading culverts and addressing road drainage problems; 2) improving water control structures at irrigation diversions; 3) reconstructing 2,000' of channel; 4) enhancing habitat complexity on an additional 2,000' of stream; 5) shrub plantings; and 6) the development of compatible riparian grazing systems for one mile of stream.

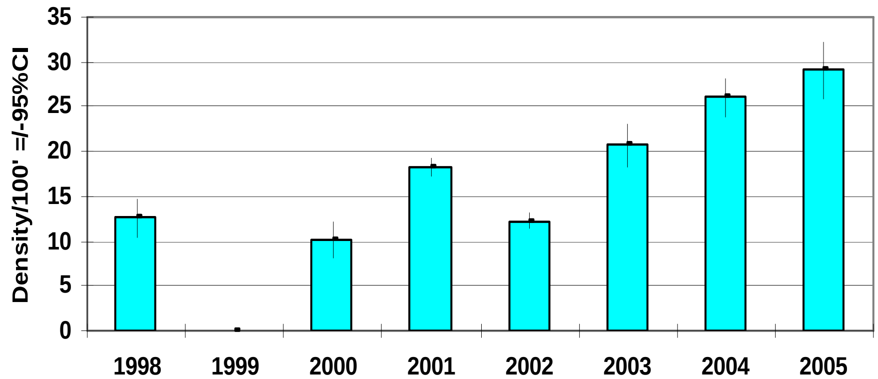


Figure 15. Total trout densities (all trout >4.0") for Bear Creek at mile 1.1, 1998-2005

Fish Populations

Bear Creek supports populations of rainbow trout, brown trout and brook trout, along with WSCT in the upper basin and very low densities of juvenile bull trout. Bear Creek is an increasingly important spawning and rearing tributary to the lower Blackfoot River sport fishery.

In 2004 and 2005, we continued fish population monitoring in a reconstructed section of Bear Creek. The results of the CPUE analysis are shown in Figure 15. These monitoring results show an upward trend in the densities of larger (fish >4.0') fish, primarily rainbow trout (Appendix B).

At stream mile 1.1, we tested for whirling disease in 2004, the results of which were negative. We also monitored water temperatures (Appendix H), and completed a spawning site (McNeil core) surveys at mile 1.1, the results of which are presented in Results Part IV.

Clearwater River

Restoration objective: Enhance instream flows to the lower Clearwater and Blackfoot River during critical drought periods.

Project summary

The Clearwater River is the largest tributary to the lower Blackfoot River with an estimated base flow of ~80 cfs. Located at river mile 3.5 on the Clearwater River, is an unscreened irrigation diversion that diverts measured flows up to 35 cfs and entrains nine species of fish, based on a trapping survey undertaken in 2003 (Pierce et al. 2004).

Fisheries restoration actions at the diversion are proceeding on two fronts. First is a ditch fish-screening project, developed and funded, but not yet installed. The second is an instream flow project designed to enhance Blackfoot River flows during critical drought periods. The flow enhancement agreement, completed in 2004, involves 1) limiting irrigation to 12 cfs at the Clearwater diversion when flows at the USGS Bonner gauge fall below 700 cfs, and 2) stopping irrigation from the Clearwater diversion when flows at the Bonner gauging station reach 600 cfs. In exchange for these irrigation reductions, FWP, USFWS and BBCTU purchased a new pivot and pump for a separate Blackfoot River diversion. This agreement further allows the irrigator to continue late season irrigation (as measured at the USGS Bonner gauging station) from the new Blackfoot pivot despite a junior water right to the 700 cfs FWP Murphy rights on the Blackfoot River.

These increased flows are expected to enhance flows in the lower Clearwater River and Blackfoot River below the junction of the Clearwater during critical drought periods by up to ~25 cfs based on recent measured use.

Flow monitoring

Continued drought in the summer of 2005 called for the implementation of the Clearwater instream flow project. The project involved reducing instream flows from 20 to 12 cfs on August 2nd 2005 approximately two days after the Blackfoot River fell below 700 cfs. The Clearwater diversion was shut down in mid-August when flows fell below 600 cfs. Flow monitoring revealed the ditch continued to divert water measured at 1.9 cfs on August 29th, 20005. A

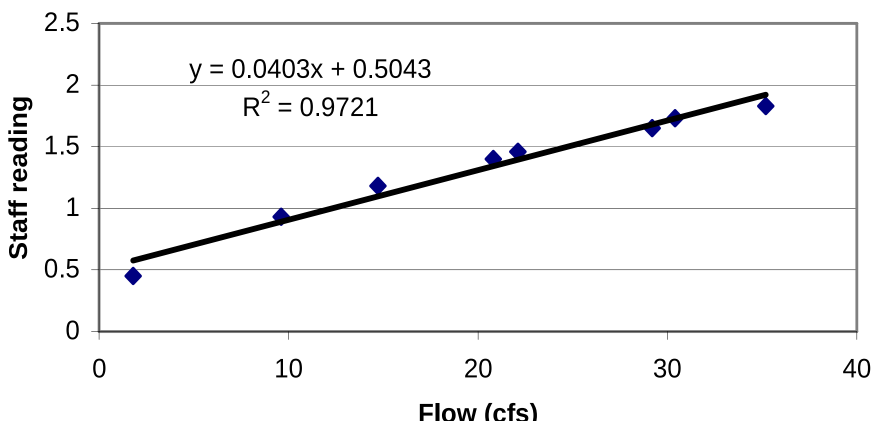


Figure 16. Stage/discharge relationship for the Clearwater ditch.

stage discharge relationship was developed near the diversion to assist in the monitoring (Figure 16).

Copper Creek

Copper Creek, the largest tributary to the lower Landers Fork entering at mile 3.6, is a critical spawning and rearing stream for genetically pure fluvial WSCT and fluvial bull trout in the upper Blackfoot River drainage. Copper Creek supports an entirely native fish community basin-wide, and provides the only major spawning migration of fluvial bull trout in the upper Blackfoot River basin. Copper Creek's consistent cold-water temperatures help moderate temperatures in the lower Landers Fork.

During August 2003, the Snow/Talon wildfire on the Helena National Forest ran through the Copper Creek drainage. This high intensity, stand replacement fire burned significant portions of the basin including a fluvial bull trout spawning site approximately three weeks prior to spawning. The spawning area was also subject to an accidental drop of fire retardant (Fire-trol LCG-R), considered toxic to aquatic life, during fire-fighting activities.

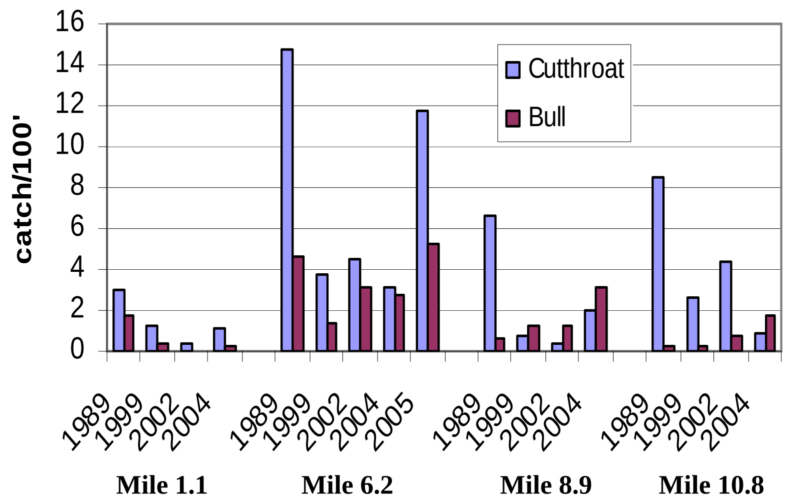


Figure 17. CPUE for native trout at four locations in Copper Creek, 1989-2005

Fish Populations

In 2004, we duplicated fish population sampling at four long-term monitoring sites established in 1989 and last sampled one year prior to the wildfire in 2002. We also continued to monitor juvenile bull trout densities near the bull trout spawning area in 2005 (Figure 17). A comparison of the pre-to post-fire survey results suggests no post-fire negative influence on juvenile bull trout production. Although bull trout redd counts in the index reach have recovered from a sharp decline during the 2003 wildfire (Figure 2), redd counts in the index section average 40% lower during the current drought (2000-2005) compared to pre-drought (1989-1999) period.

Other monitoring in Copper Creek for the 2004-2005 period involved an assessment of bull trout spawning sites (Results Part IV) and water temperature monitoring downstream of the burn area. Water temperature monitoring in 2004 indicates warming of Cooper Creek in the summer post-fire environment with temperatures >3 ^{o}F higher than previously recorded maximum monthly temperatures.

Cottonwood Creek
Restoration objectives: improve degraded habitat; eliminate fish losses to irrigation ditches; restore instream flows and migration corridors for native fish.

Project Summary

Cottonwood Creek flows from Cottonwood Lakes 16-miles to its junction with the middle Blackfoot River entering at river mile 43 with a base flow of ~15 cfs. Cottonwood Creek supports bull trout, genetically pure WSCT, rainbow trout, brown trout and brook trout. WSCT and bull trout dominate the headwaters. Rainbow trout inhabit the lower mile of stream while brook trout and brown trout dominate middle stream reaches.

In 2003, we also assessed a road-crossing problem related to an undersized culvert at stream mile 15.9. This undersized and perched culvert causes severe channel downcutting and high erosion immediately below the culvert, along with aggradation below the incised reach (Dave Rosgen, personal communication). This instability appears to contribute to the loss of surface flows during base flow periods and isolation of fish between the dewatered section and the perched culvert. We measured a decrease in flows from 0.4 cfs to the complete loss of surface flow over a distance of 765’ in September 2003. We further identified road drainage into this portion of Cottonwood Creek. In 2005, we also

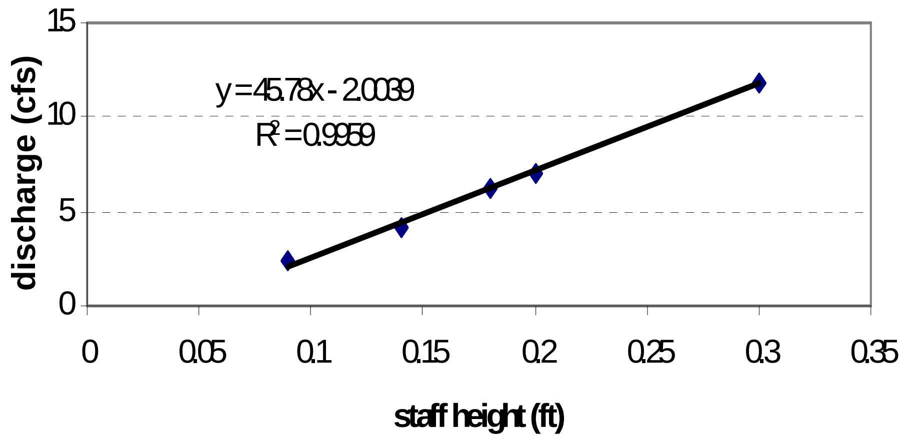


Figure 18. Stage discharge relationship for the Dreyer ditch on Cottonwood Creek, May 2005.

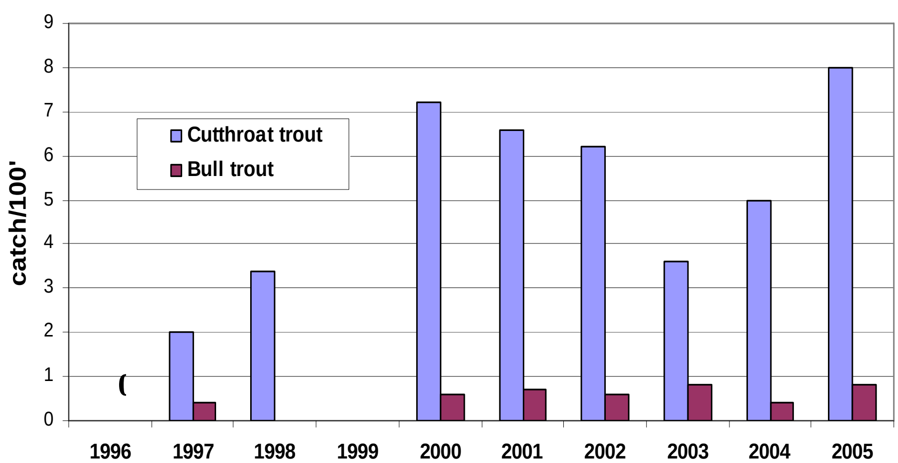


Figure 19. CPUE for native trout in Cottonwood Creek at mile 12.0, 1996-2005.

recently identified grazing-related impacts and the inappropriate use a diversion on State properties. Corrective measures are now being planned for all of these identified problems beginning in 2006.

Fisheries and other Monitoring

In 2004 and 2005, we continued to monitor fish populations in upper Cottonwood Creek in the area of a water lease, downstream of the Dreyer Diversion. The water lease was initiated in 1997, prior to which time a major diversion (Dreyer Diversion) completely dewatered a middle portion of Cottonwood Creek during the late irrigation season. We also developed a new stage discharge relationship for the Dreyer ditch, which will be used to monitor irrigation and instream flows (Figure 18)

Fish population monitoring in the water lease area (mile 12.1) show higher densities of WSCT following increased flows and the recent recovery of WSCT from a recent drought-related low in 2003 (Figure 19). Whirling disease monitoring continued near the mouth of Cottonwood Creek. The whirling disease results show a continuous severe infection. We also completed related geomorphic and spawning site surveys for Cottonwood Creek near the mouth (Results Part IV).

Chamberlain Creek

Restoration objectives: Improve access to spawning areas; improve rearing conditions for WSCT; improve recruitment of WSCT to the river; provide thermal refuge and rearing opportunities for fluvial bull trout.

Project Summary

Chamberlain Creek is a small Garnet Mountain tributary to the middle Blackfoot River, entering at river mile 43.9 with a base flow of ~2-3 cfs. Sections of lower Chamberlain Creek were severely altered, leading to historic declines in WSCT densities. Adverse changes to stream habitat included channelization, loss of instream wood, dewatering, streambank degradation from livestock, road encroachment, and elevated instream sediment from road drainage. Other problems included fish losses to irrigation ditches, impaired fish passage, and more recently the escalation of whirling disease in lower reaches.

Between 1990 and 1996, Chamberlain Creek was the focus of a comprehensive fisheries restoration effort. Projects include: road drainage repairs, riparian livestock management changes, fish habitat restoration, irrigation upgrades (consolidate ditches, water conservation, eliminate fish

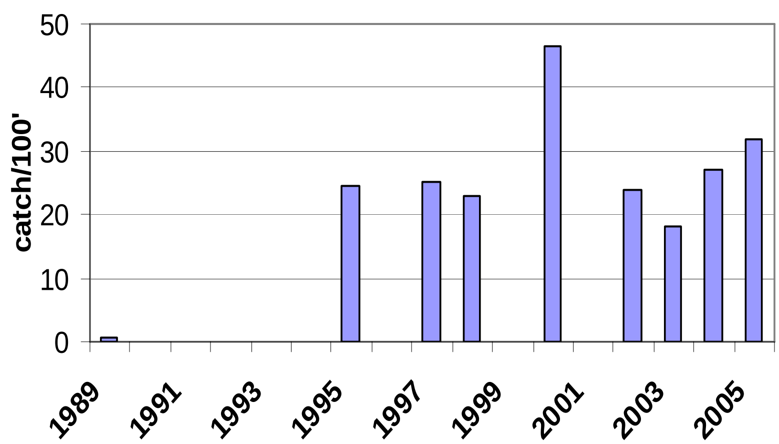


Figure 20. CPUE for WSCT in Chamberlain Creek at mile 0.1, 1989-2005

entrainment, fish ladder installation on a diversion), and improved stream flows through water leasing. Restoration occurred throughout the drainage but focused mostly in the lower mile of stream.

Fish Populations

Chamberlain Creek is a WSCT dominated stream over its entire length, with low densities of rainbow and brown trout in lower reaches. Chamberlain Creek supports a significant migration of fluvial WSCT from the Blackfoot River. In 2004 and 2005, we continued to monitor fish populations at mile 0.1 (Figure 20). Recent fish population surveys indicate generally stable WSCT densities in the lower-most portion of Chamberlain Creek. Whirling disease sampling in 2004 recorded the continued escalation of whirling disease in lower Chamberlain Creek. A time-series whirling disease assessment indicates high infections (mean grade range 3.3-4.3) levels during the critical WSCT emergence period.

Dunham Creek

Restoration objectives: Eliminate the loss of native fish to irrigation canals; restore habitat conditions and migration corridors; improve recruitment of bull trout and WSCT to the Blackfoot River.

Project Summary

Dunham Creek, a spawning stream for fluvial WSCT and bull trout, enters Monture Creeks at mile 11.5. Two types of fisheries impairment – entrainment of native fish to the Dunham canal and an altered channel, were identified in Dunham Creek. The Dunham canal entrainment problem was corrected with a fish-screening project in 1996. The channel alteration was identified in the early 1970's when ~ 1.3 miles of the Dunham riparian area was clear-cut and burned and the stream channelized. This channelized reach had since become vertically and laterally unstable, resulting in downcutting, increased bank erosion, as well as a channel braiding in downstream reaches. The reconstruction and renaturalization of this channelized section was completed in 2000.

The primary objective of the renaturalization project was to stabilize the stream to allow riparian vegetation to encompass the stream over a 10-15 year period, and thus provide long-term stability. Our review of the project indicates that surface water is now reestablished to the lower portion of the reconstruction project where the channel was braided and

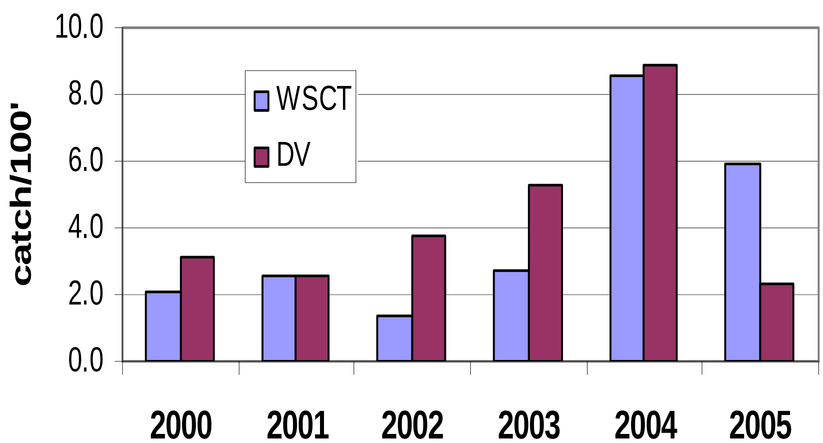


Figure 21. CPUE for WSCT and bull trout in Dunham Creek at mile 2.3, 2000-2005

intermittent prior to reconstruction.

Fish Populations

Dunham Creek supports populations of genetically pure fluvial WSCT, fluvial bull trout and brook trout. In 2004 and 2005, we completed bull trout redd counts and continued to monitor fish populations at mile 2.3. The 2.3-mile survey is located 0.6 miles downstream of the project,

Consistent with adult bull trout-spawning declines in Monture Creek, redds counts have declined in Dunham Creek since 2002. This decline is thought to contribute to declining juvenile densities observed during population monitoring (Figure 21). We also observed active poaching during 2004 and 2005 at this monitoring site. Recent bull trout spawning, in both 2004 and 2005, has been identified in the newly constructed channel. We also completed geomorphic and bull trout spawning site characterization surveys in Dunham Creek in 2004 (Results Part IV).

Hoyt Creek

Restoration Objectives: Reduce irrigation demand, increase downstream flows and improve water quality.

Description

Hoyt Creek, a small tributary to lower Dick Creek, originates from alluvial aquifers located immediately north of Ovando. This spring-influenced creek flows ~4 miles exclusively through private agricultural ranch land. Water from Hoyt Creek is used for irrigated hay production and livestock. The topography of the area consists of knob and kettle terrain. The stream loses water to four irrigation canals and receives water from two return-flow channels and a small, degraded spring at mile 0.5. This spring approximately doubles the base flow of Hoyt Creek and likely exerts a cooling influence. Fisheries impairments located throughout the stream include channel instability (incision), irrigation dewatering and suppressed riparian vegetation and hoof-shear damage to stream banks.

Hoyt Creek is also the site of a developing restoration project. The project proposes reconstruction of 10,300' of incised (G-type) channel to a stable E-type channel, while elevating the new stream to its historic floodplain. The project is expected to restore 334 acres of wetland, improve sub-irrigation, reduce irrigation demand and improve downstream water quality in Hoyt Creek. Grazing changes are also planned.

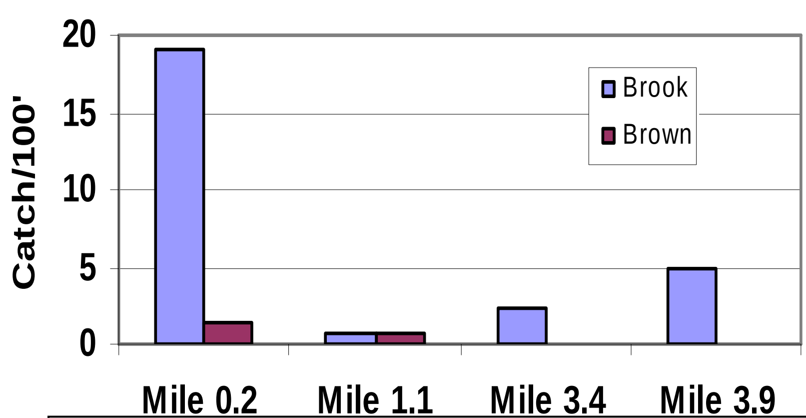


Figure 22. CPUE for fish at four sites in Hoyt Creek, 2005.

Fish Populations and other Monitoring Activities

In order to establish a pre-restoration baseline, we inventoried fish populations, measure water temperatures. discharge and aspects of channel morphology in Hoyt Creek.

Fish population surveys, completed at four locations in 2005, recorded low densities of primarily brook trout, except downstream of the spring where densities were significantly higher. Brown trout are also present in lower Hoyt Creek (Figure 22).

We measured stream discharge at three locations: 1) 0.30 cfs in the small spring creek to lower Hoyt Creek; 2) 0.38 cfs in lower Hoyt Creek immediately upstream of the spring creek confluence; and 4) 0.30 cfs upstream the project area and all diversions at mile 4.0. All irrigation was shut off during these surveys.

Water temperature sensors recorded a high of 64.9 ^{o}F upstream of the project (mile 4.3) compared to 74.6 ^{o}F downstream of the proposed project (mile 1.2) (Appendix H). We used a "cumulative bankfull width" survey to calculate channel width characteristics of lower Hoyt Creek upstream of the spring. The survey is based on a stable (i.e. reference E-type) bankfull width and involves a systematic upstream survey of 30 bankfull widths at 10' intervals beginning at the "reference" cross-section width. This survey indicates the existing lower Hoyt Creek channel has a cumulative bankfull width approximately 50% wider than the cumulative reference condition (Figure 23). Based on observations, this widening is a function of hoof-shear damage.

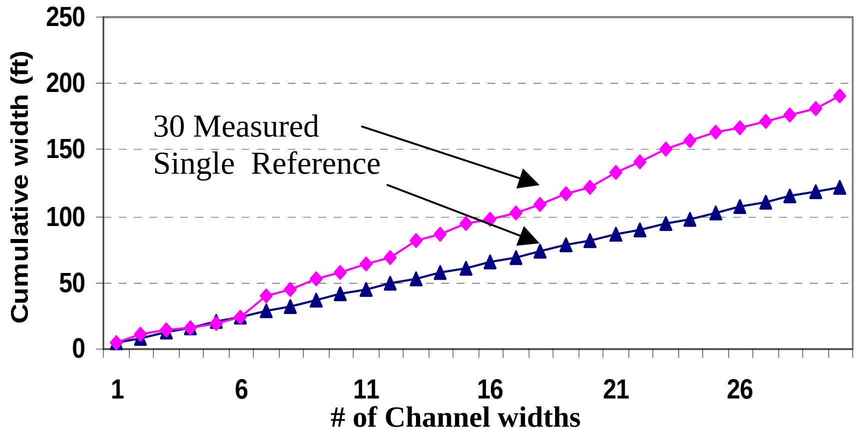


Figure 23. Cumulative bankfull width relationship for a reference and 30 measured channel widths.

Jacobsen Spring Creek

Restoration objectives: Maximize secondary instream productivity; maximize quality of shoreline rearing areas; restore spawning site potential by reducing levels of fine sediment in riffles to a level suitable for maximum spawning; reduce summer water temperatures suitable for bull trout use (<60 ^{o}F); provide high quality pools with a high level of complex cover; maximize use of existing channel belt width and existing shoreline areas.

Description

Jacobsen Spring Creek(s), a series of two small, inter-connected spring creeks totaling 13,700’ in length, merge at stream mile 0.7 and enter the North Fork of the Blackfoot River at mile ~4.0 with a base flow of ~4-7 cfs (Appendix D). Based on landowner accounts, the spring creek system was a historical bull trout and WSCT stream. Jacobsen Spring Creek is now highly degraded and currently supports low densities of brown trout, brook trout and rainbow trout, based on FWP fish population surveys completed in 2004 and 2005 (Appendix A). Currently, the stream maintains low sinuosity and is over-widened approaching maximum widths of ~50’ (Table 2).

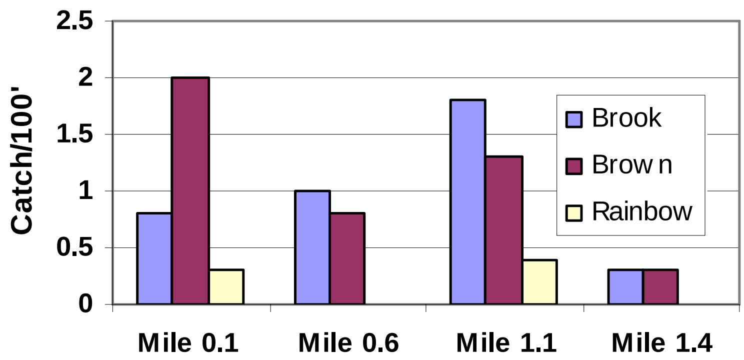


Figure 24. CPUE for trout at four sites in Jacobsen Spring Creek, 2004.

Despite a degraded condition, the spring creek appears to posses the basic habitat components necessary for improved fisheries, including bull trout use. These include cold groundwater input, sufficient base flows, a gravel base and a surrounding spruce forest that will provide shade, complexity and the input of wood to the channel. Current habitat impairments on the spring creek include areas of livestock-induced channel degradation and suppressed riparian vegetation, which has resulted in channel over-widening, elevated temperatures and excessive sediment input and accumulation. Historical timber harvest contributes to reductions of instream wood, further contributing to the simplification of habitat.

Channel measurements	
Stream channel length	3150
Sinuosity	1.37
Total # Pools	19
# Sampled Pools	10
Pool Frequency	6.0/1000'
# Pools Measured with LWD	9(90%)
Pool Length	37±21(14 -79)
Wetted Pool Surface Area	858±626(224-1859)
Maxim Pool Depth	1.7±0.7(0.9-3.3)
Wetted Pool Width @ Max Depth	20±10(9-44)
Wetted Width @ Riffle Crest	24±12(8-47)
Bankfull Width @ Max Pool Depth	21±10(9-44)
Bankfull Width @ Riffle Crest	24±12 (8-47)
Riffle Crest Depth	0.6±0.2(0.4-0.9)
Residual Pool Depth	1.1±0.7(0.3-2.7)

* all in standard (ft) units

Table 2. Summary of pre-project channel measurements for the lower reach of Jacobsen Spring Creek.

The initial phases of channel restoration, including 5,800’ of reconstruction, began in 2005 and will continue through 2006. The goal of the project is to restore a high quality spring creek capable of self-maintaining complex habitat suitable to all salmonids in the North Fork Blackfoot River. Phase two of this project, slated for 2006, includes another 7,900’ of channel work. When completed, this project will narrow and deepen the channel, increase stream sinuosity, place instream wood and sod mats and perform other revegetation measures for 2.6 stream miles. The project is to include land management (grazing and timber harvest) plans consistent with project goals and objectives.

Fish Populations and other monitoring

During the 2004 and 2005 project development period, we completed fish population surveys, water temperature and discharge measurements, a pre-project habitat inventory and whirling disease sampling. Fish population surveys at four locations revealed very low densities of rainbow trout, brown trout and brook trout (Figure 24). Flow monitoring near the mouth recorded a high of 11.3 cfs in June 2004 and a low of 4.4 cfs in August 2004 during the peak irrigation season (Appendix D). Water temperature studies completed in 2004 recorded maximum summer temperatures near the mouth ranging from 61.5 - 66.3 ^{o}F (Appendix H). The results of pre-construction habitat survey for the lower 3,100' of channel are located in Table 2. Whirling disease testing of the spring creek in summer 2004 showed a mild 0.13 mean grade infection.

Keep Cool Creek

Summery

Keep Cool Creek is a largest spring creek in the Lincoln Valley. It forms north of Lincoln from both an alluvial groundwater aquifer and small basin-fed streams in its headwaters. It is joined at the mouth by Beaver Creek (mile 0.7) and Lincoln Spring Creek (mile 0.5) before entering the Blackfoot River at mile 105.2. The combined flow of this stream system provides a significant percentage of the upper Blackfoot River flow during low flow periods. Excessive livestock access to riparian areas has degraded portions of Keep Cool Creek and tributaries therein. Other mainstem fisheries-related impairments include channel alterations and irrigation practices. A middle reach of Keep Cool Creek is now under more sensitive grazing.

Fish Populations and other sampling

Headwater tributaries in the Keep Cool drainage (Beaver, Theodore, Klondike, Yukon, Stonewall Liverpool and Sucker Creeks) all support genetically pure WSCT. Recently, radio telemetry confirmed bull trout from the Blackfoot River use the lower portion of Keep Cool Creek (Pierce et al 2004). In 2004, FWP sampled fisheries in the mainstem of Keep Cool Creek at one location (mile 1.8). The survey found a community of sculpins and very low densities of brown trout (CPUE of 1.7) and no young-of-the-year brown trout. We measured discharge at 39.9 cfs on June 14th, 2004 at mile 1.9. Water temperature monitoring at two locations found maximum summer temperatures of 75.2 ^{o}F in upper Keep Cool (at the Sucker Creek road) compared to a high of 62 ^{o}F at the Beaver Creek Road. This cooling result from large inflows of groundwater between these two sites (Appendix H).

Kleinschmidt Creek

Restoration objectives: reduce whirling disease infection levels; restore stream channel morphology for all life stages of trout; increase recruitment of trout to the Blackfoot River; and restore thermal refugia and rearing areas for North Fork Blackfoot River bull trout.

Project Summary

Kleinschmidt, a spring creek tributary with a base flow of ~9 cfs joins with Rock Creek at mile 0.1 before entering the North Fork of the Blackfoot River at mile 6.2. Kleinschmidt Creek has a long history of stream degradation involving livestock over-use and channel alterations related to instream rock dams, undersized culverts and highway channelization (Pierce 1991). Restoration of Kleinschmidt Creek began in 1991, and expanded substantially in 2001 when 6,250' of the stream was reconstructed to a longer (8,494'), narrower, deeper and more sinuous channel. Restoration continues to expand upstream where grazing changes and limited channel reconstruction are planned for 2006. Summaries of pre-and post-project fisheries and channel measurements are described in Pierce et al. 1997; 2002; and 2004

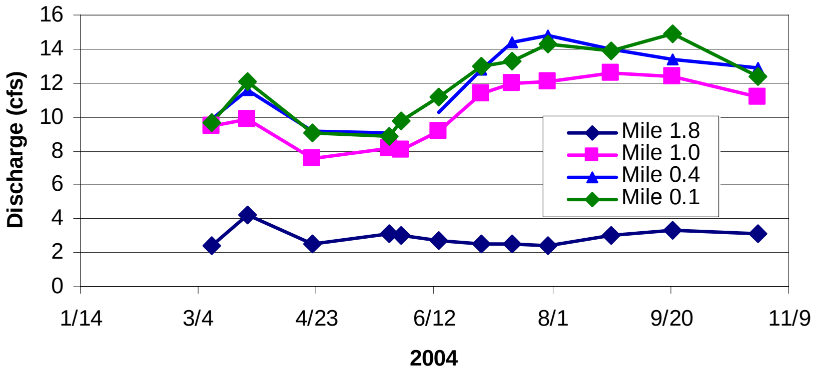


Figure 25. Summary of flow measurements at four locations in Kleinschmidt Creek (data from USFWS, 2004).

Fish Populations and other monitoring

During the 2004 and 2005, we monitored fish populations, water temperatures, whirling disease and spawning substrates in Kleinschmidt Creek. Fish populations were resurveyed at two locations (mile 0.5 and 0.8) of lower Kleinschmidt Creek established in 1998 prior to channel reconstruction. These sites were established not only to assess the fisheries responses to restoration, but also to assess restoration techniques involving the placement of large instream wood into E4-type channels. We placed no instream wood in the reconstructed channel at mile 0.5, whereas the rest of the channel, including the mile 0.8 survey site, included instream wood placements.

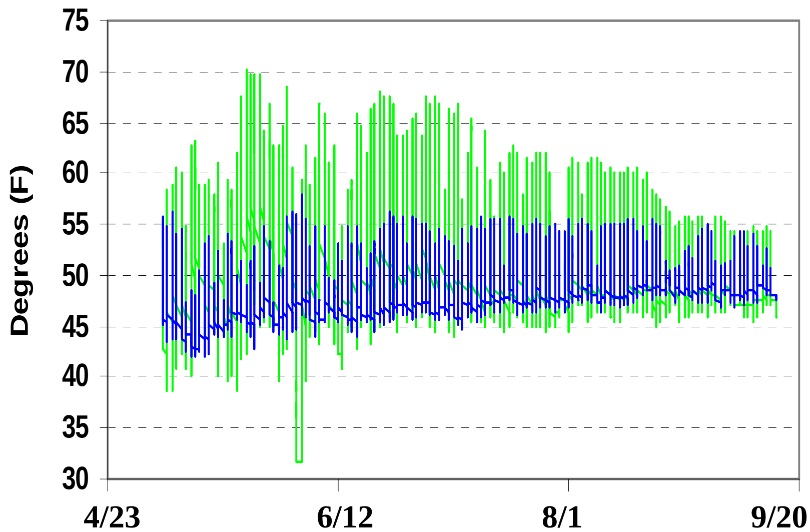


Figure 26. Pre-project (2001-green) and post-project (2004-blue) restoration water temperature comparison for Kleinschmidt Creek.

Both sites show higher densities of age 1+ brown trout compared to the pre-project periods (Figure 27). During the post-project monitoring period (2002-05), densities of age I+ brown trout were 168% higher in the wooded section compared to the woodless section. Unfortunately, livestock access to the mile 0.5 site has confounded early phases of the study, making full interpretation of these results difficult. The survey site at mile 0.8 was not subject to streamside livestock damage.

In 2005, we also established a new pre-project fish population survey upstream of the groundwater influence area (mile 2.0) in order to assess the influence of planned restoration. This survey revealed very low densities of fish with a total trout CPUE of 1.7 fish/100' (Appendix A). This portion of channel is degraded from livestock over-use and appears to suffer from seasonal dewatering.

The USFWS measured stream discharge at four locations between mile 0.1 and 1.8 in 2004 (Figure 25). The data shows significant groundwater inflows between mile 1.0 and 1.8 and a mid-summer peak in the hydrograph that extends into the fall.

Water temperature monitoring has shown substantial reduction in water temperatures in the newly constructed channel, with maximum water temperatures 12 ^{o}F lower in 2004 than the 2001 pre-project temperatures (Figure 26).

Whirling disease sampling in 2004 recorded a continued severe 4.9 mean grade infection.

We also completed and assessment of spawning areas in Kleinschmidt Creek (Results Part IV), which generally show that Kleinschmidt Creek substrates are comprised largely of "fine" textured material (<6.35mm - silt, sand and fine gravel) in high quantities sufficient to inhibit trout reproduction.

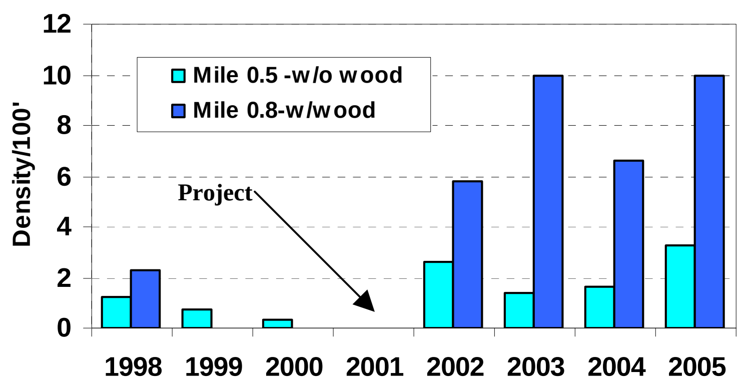


Figure 27. Estimated densities of age 1+ brown trout in two sections of Kleinschmidt Creek, 1998-2005.

Lincoln Spring Creek

Restoration objectives: To be identified.

Summery

Lincoln Spring Creek is a large spring creek tributary to Keep Cool Creek that forms east of Lincoln from an alluvial aquifer. It surfaces on private ranch land, flows through a residential area of Lincoln before joining with Keep Cool Creek at mile 0.5. Excessive livestock access to riparian areas and residential development have degraded and simplified salmonid habitat. Other fisheries-related impairments include irrigation practices upstream of Lincoln, a reduction of instream wood and at least one stream crossing (undersized culvert) downstream of Lincoln. A review of the stream indicates high sediment levels and limited spawning areas downstream of Lincoln. A review of the stream upstream of Lincoln suggests potential for spawning and other habitat improvement measures but also low winter flow conditions. The upper portion of Lincoln Spring Creek is heavily degraded and currently being considered for restoration.

Fish Populations and other sampling

According to local accounts, Lincoln Spring Creek historically contained bull trout and WSCT, although none have been recorded in sampling undertaken in either 1994 or 2004. In 2004, FWP sampled fisheries at one location downstream of Lincoln (mile 1.5). The survey found a community of sculpins and low densities of brown trout (CPUE of 5.1). Juvenile brown trout were present in low numbers and concentrated in areas of dense cover formed of beaver caches. On June 15th, 2004, we measured flow at 18.2 cfs immediately downstream of Lincoln (mile 3) and at 25.6 cfs at mile 2 (Highway 200) (Appendix D). Water temperature monitoring at these same two locations found maximum summer temperatures of 57.4 ^{o}F compared to a high of 61.5 ^{o}F at the downstream site (Appendix H). Whirling disease testing in 2004 revealed a severe (grade 5) infection.

McCabe Creek

Restoration objective: Restore instream flows and habitat conditions for bull trout and WSCT. Eliminate entrainment of WSCT to irrigation ditches

Project Summary

McCabe Creek, a cold basin-fed tributary to lower Dick Creek, enters at stream mile 3.8 with a base flow of ~4 cfs. McCabe Creek begins as a steep mountain stream in its headwaters, before entering knob-and-kettle topography in the lower basin. In lower reaches, McCabe Creek passes through a beaver-influenced wetland bog before entering Dick Creek, a lower tributary to Monture Creek.

McCabe Creek has a long history of adverse fisheries impacts related to channel alterations and agricultural activities. These include intensive riparian grazing, physical alterations to the channel, poorly designed road crossings, chronic dewatering, and fish losses to irrigation ditches.

A comprehensive restoration project for McCabe Creek began in 1999 and was completed in 2002. This project: 1) consolidated four irrigation ditches into one pipeline and screened the intake; 2) converted flood to sprinkler irrigation; 3) restored habitat conditions including the placement of instream wood and shrub plantings along 1/2 mile of stream; 4) incorporated necessary riparian livestock management changes; and 5) replaced a county road culvert with an open-bottom box culvert. In 2001-02, the project completed the irrigation conversion, developed off-stream livestock watering, and reconstructed ~1/2 mile of stream channel. Additional grazing management measures are planned for the immediate project area in 2006.

Fish Populations

Benefits to fish population relate to increasing stream flows, reducing water temperatures in Dick Creek, eliminating WSCT losses to ditches, and restoring habitat complexity to a damaged stream channel.

McCabe Creek is a WSCT dominated stream, with brook trout present in lower stream reaches. Due to cool summer temperatures, McCabe Creek likely supported bull trout historically. In 1999, prior to habitat restoration, we established a fish population survey section in a degraded section of stream (mile 2.2), an area of low habitat complexity and chronic low flows. Following the initial surveys, we screened the upper diversion, enhanced stream flows by 3-5 cfs and improved habitat in the survey reach by adding LWD to the channel. We also implemented some grazing changes and developed off-stream livestock water.

In 2004, we continued to monitor fisheries at mile 2.2. (Figure 28). Both WSCT and brook trout (> 4.0") have responded to the project compare to the pre-project (1999) condition. Less encouraging is an increase in brook trout at the monitoring site.

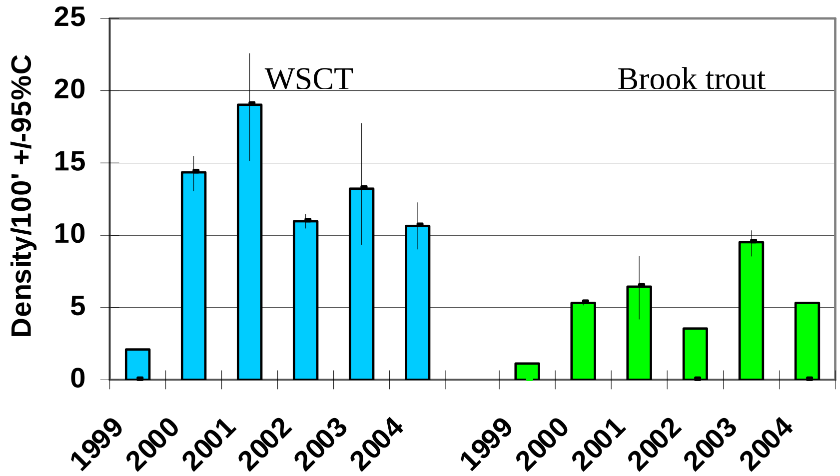


Figure 28. Densities of fish > 4.0" in McCabe Creek at mile 2.2. 1999-2004.

Monture Creek

Restoration objectives: Restore habitat for spawning and rearing bull trout and WSCT; improve recruitment of bull trout and WSCT to the Blackfoot River; improve staging areas and thermal refugia for fluvial bull trout.

Project Summary

Monture Creek, a large tributary to the middle Blackfoot River, is a primary spawning and rearing tributary for fluvial bull trout and fluvial WSCT. Monture Creek also serves as thermal refugia for fluvial bull trout during periods of Blackfoot River warming. Reproduction of WSCT and bull trout occurs primarily in the mid-to-upper basin. Fluvial rainbow trout and brown trout inhabit the lower portions of the drainage. Brook trout are found throughout the drainage.

Riparian areas in the mid-to-lower reaches of Monture Creek have a long history of riparian timber harvest and improper grazing practices, with resulting adverse impacts to native fish habitats. All lower tributaries of Monture Creek from Dunham Creek downstream likewise were identified as fisheries-impaired. Many identified problems were corrected through a decade of cooperative restoration activities (Pierce et al. 1997; Pierce et al. 2001), which contributed to improving the health of Monture Creek. Excessive livestock access to Monture Creek however, continues to adversely influence Monture Creek at multiple locations.

Fish Populations and other monitoring

Monitoring for 2004 and 2005 period included: 1) bull trout redd counts; 2) assessments of juvenile trout abundance at long-term monitoring stations; 3) water temperature monitoring; 4) continued whirling disease studies; 5) geomorphic and spawning site assessments; and 6) radio telemetry study involving rainbow trout.

Bull trout redd counts have been upward trending since restrictive angling regulations in 1990, but also show a sharp recent decline in 2004 and 2005 (Figure 2). This downturn is consistent with other drought-related bull trout declines in the Blackfoot watershed. Likewise, assessments of juvenile bull trout abundance at a long-term monitoring station revealed increases through the 1990s, but also a recent decline proportional to declining redds (Figure 3).

Preliminary results from a rainbow trout telemetry study show Monture Creek to be the primary spawning tributary for the Blackfoot River rainbow trout upstream of Clearwater River. Spawning occurred primarily in lower Monture Creek, but extended upstream as far as lower Dunham Creek (Results Part IV).

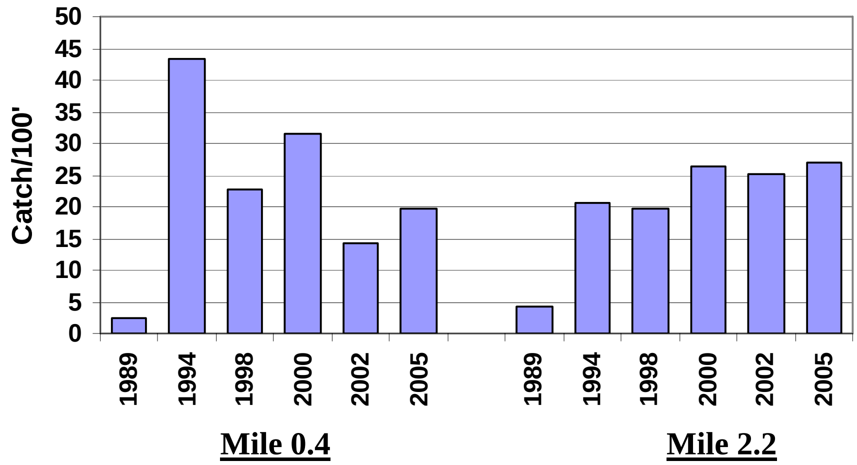


Figure 29. CPUE for juvenile rainbow trout at two lower Monture Creek sampling locations, 1998-2005.

Lower Monture Creek tested positive for whirling disease in 2000. The disease has since increased in intensity to a mean grade infection of 4.8 in 2005. Surveys of juvenile rainbow trout in infected waters of lower Monture Creek indicate rainbow declines near the mouth but stable densities at an upstream site (Figure 29). Whirling disease testing at upstream bull trout spawning sites of Monture Creek remained negative when last tested in 2003.

Spawning area assessments at two sites were completed in 2004 and 2005 with results located in Results Part IV. Water temperature data is located in Appendix H.

Murphy Spring Creek

Restoration objectives: Restore habitat conditions suitable to WSCT and juvenile bull trout; prevent irrigation ditch losses; maintain minimum instream flows and provide rearing and recruitment for fluvial bull trout and cutthroat trout to the North Fork

<u>Project Summary</u>

Murphy Spring Creek, a small WSCT dominated tributary, originates on the north side of Ovando Mountain and flow six miles south to its confluence with the lower North Fork at mile 9.9. Murphy Spring Creek has a history of irrigation impacts and fish passage problems. Irrigation problems involve chronic dewatering and entrainment of WSCT to the Murphy ditch at mile 1.8. Fish passage problems involved an undersized culvert at mile 0.5 and the defunct condition of the Murphy diversion. The culvert reduced the upstream movement of juvenile bull trout from the North Fork, while the diversion reduced downstream movement of WSCT from the headwaters to the North Fork through dewatering and entrainment.

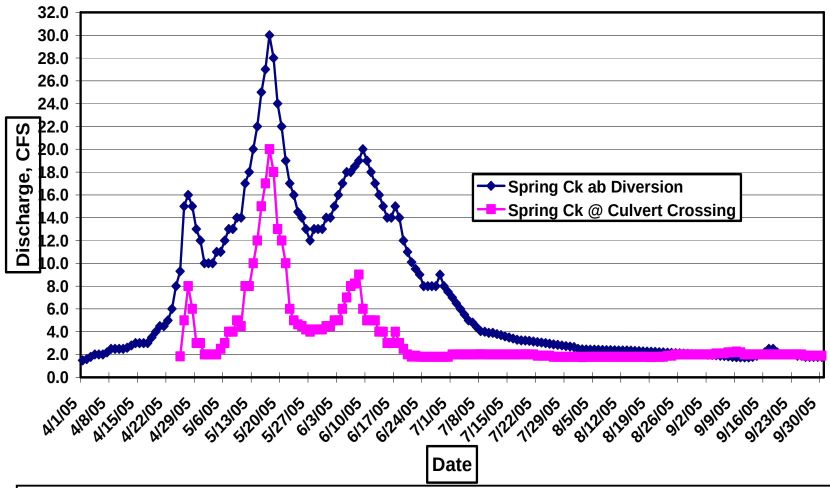


Figure 30. Flow regimes for Murphy Spring Creek at two sites, April-September of 2005 (*data* from Ron Sheilds, 2005).

The Murphy Spring Creek restoration project began in 1998 with the installation of a new diversion fitted with a Denil fish ladder. In 2000, we replaced the culvert with a larger baffled culvert designed to allow the upstream movement of YOY bull trout. In 2004-05, the Blackfoot Cooperators continued to expand on restoration actions by developing an instream flow agreement that granted habitat maintenance flows as well as a 2.2 cfs minimal instream flow in Murphy Spring Creek. The project at the Murphy diversion also seeks to eliminate entrainment of WSCT with the installation of a fish screen planned for 2006.

<u>Fish population and other monitoring</u>

Figure 30 shows the instream flow monitoring results above and below the Murphy diversion for 2005. The measurements at the culvert crossing (~2 cfs) compare to a measurement of <0.5 cfs in September 2004. Fish population surveys indicate a modest increase in densities in lower Murphy Creek in 2005 compared to 2001 (Figure 31).

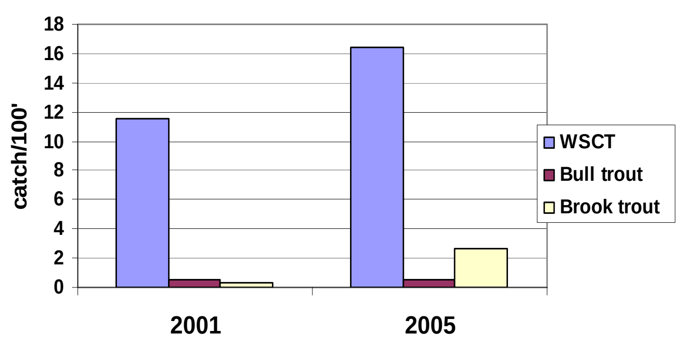


Figure 31. CPUE for salmonids in Murphy Spring Creek at mile 0.6, 2001 and 2005.

Nevada Spring Creek

Restoration objectives: Restore habitat suitable for cold-water trout; improve downstream water quality, and reduce thermal stress in Nevada Creek and the Blackfoot River.

<u>Project Summary</u>

Nevada Spring Creek, a tributary of lower Nevada Creek, originates from an artesian spring and flows through agricultural lands to its junction with Nevada Creek at mile 6.2. The spring source produces between six and nine cfs. Nevada Spring Creek is joined at the source by Wasson Creek, a small, basin-fed tributary that brings and additional base flow of approximately two cfs during the non-irrigation season. Water temperatures at the artesian source are a constant year-around 44.1^{o}F (Appendix I).

A comprehensive habitat restoration project for the upper 4.2 miles of Nevada Spring Creek was completed between 2001 and 2004. The project entailed the complete reconstruction of Nevada Spring Creek, riparian grazing changes, instream flow enhancement, wetland restoration and shrub plantings. Prior to restoration, summer water temperatures in the lower portion of Nevada Spring Creek exceeded >75^{o}F due to the over-widened condition of the channel (Pierce et al. 2002). This warming and agricultural runoff from adjacent lands contributed to water quality degradation, and created unsuitable habitat conditions for coldwater salmonids in the lower portion of Nevada Spring Creek and contributed to impaired water quality in lower Nevada Creek (Pierce et al. 2002).

	Before	After	Percent Change
Stream legnth (ft)	18,811	22,563	20
Sinuosity	1.65	1.98	20
Surface Area (acres)	22.8	6.6	-71
Mean wetted width (range) (ft)	47(14-98)	10.1(6.7-16.6)	-79
Pool Frequency	0.8/1000	13.5/1000	1587
Mean pool depth (ft)	2.5	3.45	38
W/D Ratio	23.5	2.9	-88

Table 3. Comparison of channel morphometrics in Nevada Spring Creek before and after reconstruction.

<u>Fish populations and other project monitoring</u>

Prior to channel restoration, Nevada Spring Creek supported low densities of brown trout in upper reaches and non-game species (redside shiners, northern pikeminnow, and largescale sucker) in lower reaches (Pierce et al 2002). WSCT thought

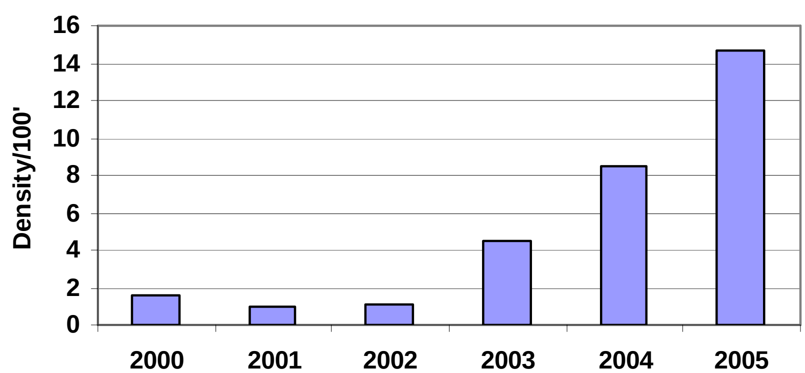


Figure 32. Brown trout densities (fish >4.0") in upper Nevada Spring Creek, 2000-05.

to originate in Wasson Creek, also inhabited Nevada Spring Creek in very low densities, where historically abundant (Frank Potts, personal communication).

In 2004 and 2005, restoration monitoring occurred on several fronts. We completed measurements of the new channel, monitored water temperatures at several locations, surveyed fish populations in upper and lower reaches of the spring creek, and documented the introduction and rapid escalation of whirling disease into the spring creek system.

The post-project habitat survey completed between 2002 and 2004 measured channel bedforms (pools, riffles) and channel pattern. Objectives for the Nevada Spring Creek habitat survey were to characterize the new channel consistent with a pre-project habitat survey (Pierce 1990). The post-project survey began from a randomly selected pool (1-4) near the spring source and proceeded downstream, measuring every fourth pool and preceding downstream riffle. Pool measurements included total pool length, maximum pool depth and wetted width at max pool depth. Riffle measurements included riffle crest depth and wetted widths at the riffle crest. Residual pool depth was calculated by subtracting maximum pool depth form riffle crest depth. Aerial photographs were used to calculate sinuosity. Summary results of the pre-and post project comparison are outlined in Table 3.

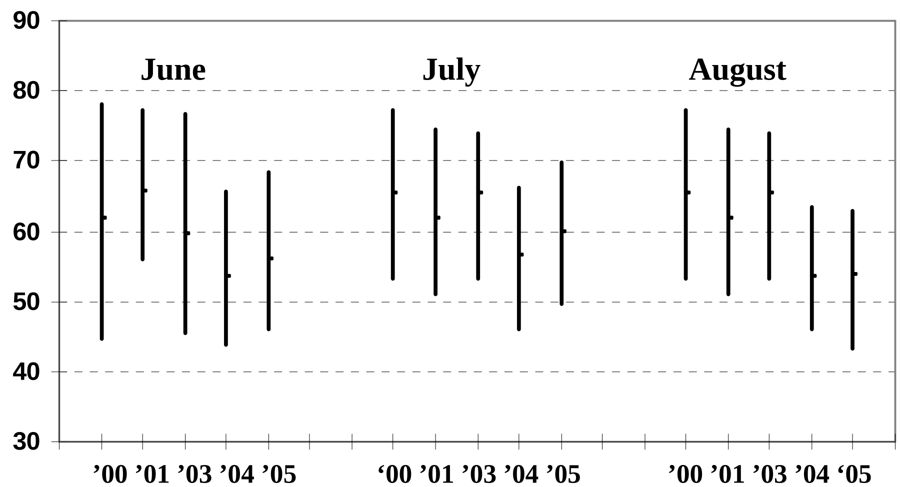


Figure 33. Comparison of summer water temperatures three years pre-project (2001-03) and two years post-project (2004-05) for Nevada Spring Creek near the mouth.

Water temperature monitoring was completed at four locations in the spring Creek (Appendix H), including near the mouth. Survey results from this site show a 5-10 ^{o}F cooling influence during the summer period compared to the pre-project condition (Figure 33).

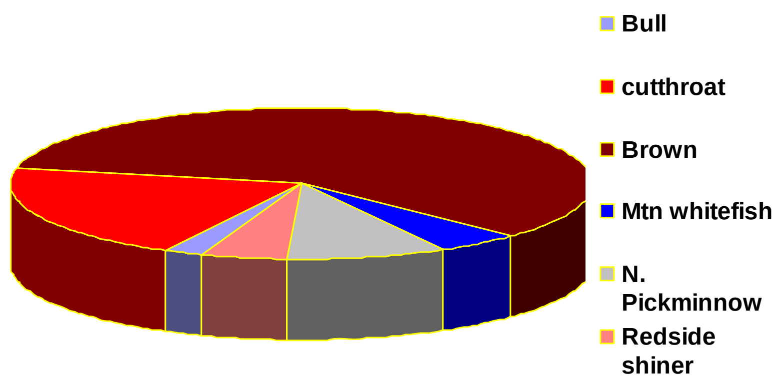


Figure 34. Combined species composition for lower Nevada Spring Creek, 2004 and 2005.

In 2004 and 2005, FWP continued monitoring fish populations near the source and near the mouth. Near the source, densities of brown trout >4.0" increased 1,030 % from mean pre-project (2000 and 2001) densities of 1.3 to 14.5 fish/100' in 2005 (Figure 32). Total biomass of brown trout (fish >4.0") have increased from 1.4 lbs/1000' to 46.7 lbs/1000' between 2001 and 2005, a 3,242 % increase.

Sampling near the mouth in 2004-05 revealed a community-level shift from non-salmonids (northern pikeminnow, largescale sucker and redside shiner) to a salmonid community (Figure 34). The salmonid community currently includes low densities of brown trout, cutthroat trout, and mountain whitefish. In 2004 a single bull trout was also found in the sample. WSCT are now present throughout the spring creek in low densities ranging from a CPUE of 0.2 near the source to 1.2 near the mouth (Appendix A).

Nevada Creek

Restoration objectives: Restore water quality and fish habitat to levels suitable for trout.

Nevada Creek is a major tributary to the Blackfoot River entering at rm 67.8. It flows through a wide valley converted from a historical beaver wetland to hay and grazing meadows. Nevada Creek contributes a significant amount of water to the overall flow of the Blackfoot River. Unfortunately, impaired water quality in Nevada Creek originating from non-point runoff, including high temperatures, high nutrient loading and high levels of sediment degrades water quality in the Blackfoot River.

It has long been held that Nevada Spring Creek in a restored state could moderate water temperatures, improve water quality and provide a source of trout recruitment to Nevada Creek (Pierce and Peters 1990; Pierce et al. 1997).

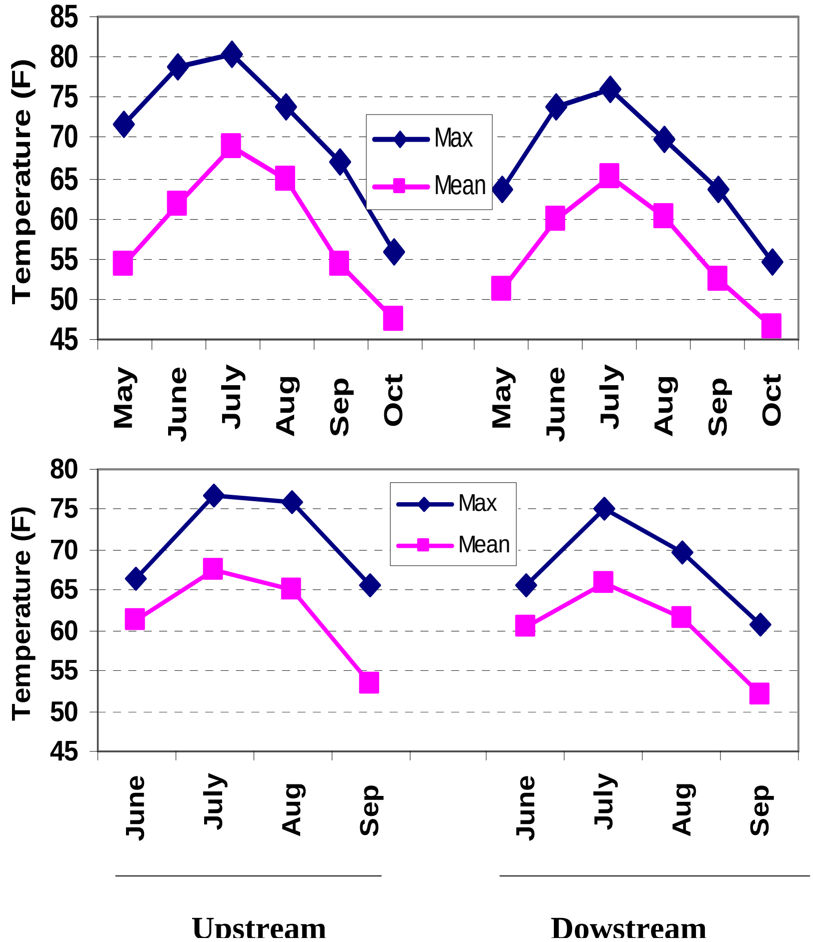


Figure 35. Comparison of water temperatures in Nevada Creek up- and downstream of Nevada Spring Creek, 2004 (top) and 2005 (bottom)..

<u>Fish Populations and other monitoring</u>

Fish population surveys in lower Nevada Creek in the 1990s downstream of mile 4.0 recorded a community of long nose sucker, large scale suckers, reside shiners and northern pikeminnow along with low numbers of sculpins. Extremely low numbers of trout were identified when in April 1990 a drift boat electrofishing survey found a single brown trout in the lower 3.8 miles of Nevada Creek (Pierce et al. 1997).

Following the reconstruction of Nevada Spring Creek, we monitored summer water temperatures up- and downstream of the Nevada Spring Creek confluence during both 2004 and 2005 (Appendix H). To ensure mixing of the Nevada and Nevada Spring Creek waters, we placed the downstream sensor 6300’ below of the new Nevada Spring Creek confluence. The upstream sensor recorded peak summer temperatures in Nevada Creek >80 °F but >4 °F lower downstream of the spring creek confluence (Appendix H). The 2005 monitoring found comparable maximum July temperatures but notably lower August temperatures (Figure 35). These temperatures although still elevated are now within the tolerance limits for most trout species. This is a result of two main factors: the cooler water now exiting Nevada Spring Creek and the low stream flows in Nevada Creek.

Using a drift boat electrofishing unit, in September 2005 we established a new fish population survey section (mile 4.5-5.7) in Nevada Creek immediately downstream of the Nevada Spring Creek confluence (Appendix A). Consistent with community-shift to salmonids in lower Nevada Spring Creek after restoration, we found four trout species and mountain whitefish present in Nevada Creek downstream of Nevada Spring Creek. Densities are however still very low, but notably higher compared to the 1990 survey (Figure 36).

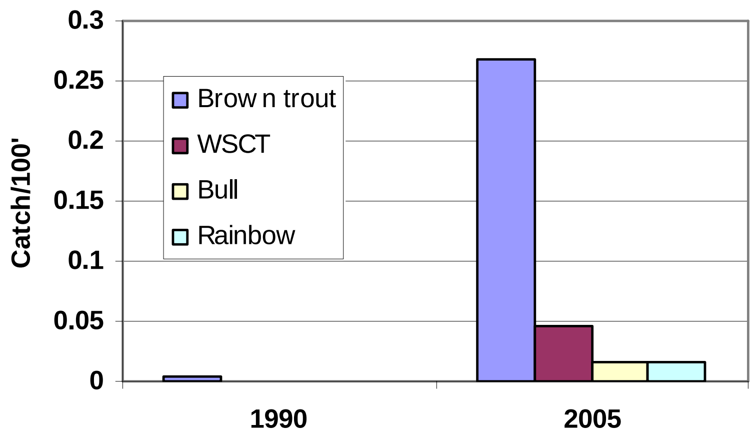


Figure 36. CPUE for trout in lower Nevada Creek, 1990 and 2005

North Fork Blackfoot River

Restoration objectives: Eliminate the loss of bull trout and WSCT to irrigation canals; manage riparian areas to protect habitat for native fish; improve recruitment of native fish to the Blackfoot River.

<u>Project Summary</u>

The North Fork of the Blackfoot is the largest tributary to the Blackfoot River, with headwaters draining the Scapegoat Wilderness. Upon exiting the mountains near mile 12, the North Fork enters Kleinschmidt Flat, a large glacial outwash plain before entering the middle Blackfoot River at river mile 54. Five irrigation canals, located on the Flat between mile 8.8 and 15.3, divert an estimated 40-60 cfs from the North Fork. In addition, this reach of the North Fork naturally loses water to glacial alluvium. The combined influences of this dewatering periodically traps native fish including large numbers of the adult bull trout spawners in intermittent pools downstream of the irrigation diversions during the late summer and early fall.

The North Fork is one of three primary fluvial bull trout-spawning streams for the Blackfoot River. Bull trout recovery and related "core area" fisheries conservation projects involve developing compatible riparian grazing systems and eliminating fish entrainment on five canals. More recently, the North Fork restoration project evolved to a more holistic watershed approach, enrolling landowners in conservation easement programs, incorporating water conservation measures in leaky ditches, and restoring habitat conditions to six impaired tributaries (Murphy Spring Creek, Jacobsen Spring Creek, Rock Creek, Kleinschmidt Creek, Dry Creek and Salmon Creeks). In 2004 and 2005, the Blackfoot Cooperators continued to work closely with landowners on a wide range of conservation measures involving instream flow enhancement, riparian grazing changes, and channel re-naturalization on North Fork and its tributaries.

Fish Populations and other monitoring

The North Fork of the Blackfoot River supports fluvial bull trout and fluvial WSCT, as well as rainbow trout, brown trout and brook trout in the lower basin. Fisheries-related monitoring for 2004 and 2005 included: 1) bull trout redd surveys; 2) assessments of juvenile fish abundance; 3) assessments of ditch screening projects; 4) whirling disease studies in tributaries; and 5) water temperature recordings.

Bull trout redds declined from a high of 123 in 2000 to lows ranging from 41 to 43 during the 2003 - 2005 monitoring period. Recent juvenile bull trout abundances in four long-term monitoring sections of the North Fork are showing similar declines (Figure 3). In 2005, we surveyed four irrigation canals (mile 8.7, 10.4, 11.6 and 15.5) downstream of fish screens and found bull trout at the mile 11.6 and 15.5 canals (Appendix A). Screens at these two sites should be evaluated.

Temperature monitoring in the lower North Fork Blackfoot River (mile 2.3) recorded a maximum summer temperature of 63.1 ^{o} F in August, 12.7 ^{o} F cooler than the 75.8 ^{o} F detected in the Blackfoot River at Raymond Bridge (mile 60.2).

Whirling disease infection levels remain low in the lower North Fork upstream of its spring creek tributaries (Kleinschmidt Creek and Rock Creek and Jacobsen Spring Creek). The disease remains absent from upstream bull trout spawning sites in the North Fork (Results Part IV).

Pearson Creek

Restoration objectives: Restore the stream to its original channel; improve stream flows, access to, and

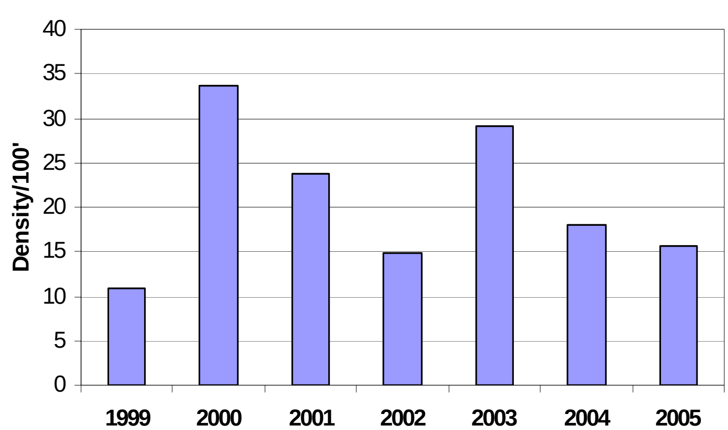


Figure 37. Density of age 1+ WSCT in Pearson Creek at mile 1.1, 1999-2005

the condition of a historical fluvial WSCT spawning site.

<u>Project Summary</u>

Pearson Creek is a small tributary to Chamberlain Creek with a base-flow of approximately one cfs. Pearson Creek has a history of channel alterations, and adverse irrigation and riparian land management (grazing and timber harvest) practices in its lower two-miles of channel. Beginning in 1994, Pearson Creek has been the focus of a holistic restoration project involving channel reconstruction and instream habitat work, instream flow enhancement (water leasing), conservation easements and riparian grazing changes. Additional riparian grazing improvements are planned for lower Pearson Creek for 2006.

<u>Fish Populations</u>

Pearson Creek is a fluvial WSCT spawning stream. In 2004 and 2005, we continued fish population surveys at the site (mile 1.1) established in 1999 prior to a 2000 habitat restoration project (Figure 37). We also established in 2005 a new pre-project fish population survey section at mile 0.5. The new site recorded a WSCT catch of 6.0/100' compared to 29.4/100' at mile 1.1 (Appendix A). This site was totally dewatered prior to 1996 water lease; it will be used to measure the future influence of grazing changes to WSCT.

Poorman Creek

Restoration objectives: Improve riparian habitat conditions and enhance instream flows; eliminate fish losses to irrigation ditches; restore migration corridors; improve recruitment of native fish to the Blackfoot River.

<u>Project Summary</u>

Poorman Creek is one of the larger tributaries entering the Blackfoot River from the Garnet Mountains, entering at river mile 108.0. Poorman Creek is an impaired stream adversely influenced by hard rock and placer mining, channel alterations, poorly designed road crossings, excessive livestock grazing and irrigation dewatering. Poorman Creek also supports a naturally intermittent section of stream near the mouth. In 1999, we assessed fish populations and habitat conditions on lower Poorman Creek. These surveys identified irrigation dewatering, fish losses to ditches, channel instability and excessive riparian grazing pressure in the lower two miles of stream. The problems these surveys identified helped set the stage for a comprehensive restoration project for lower Poorman Creek beginning in 2002. Restoration projects involve the conversion of flood to pivot irrigation (consolidation of two ditches to a single pipe), screening of the intake, instream flow enhancement, the replacement of two culverts with bridges and riparian grazing changes. Grazing changes involve corridor fencing (FSA *continuous conservation reserve* program), off-stream water developments and shrub plantings – all of which continued in 2005. Upstream culvert replacements were also completed on the Stemple Pass road through the combined assistance of the Blackfoot Cooperators.

<u>Fish Populations and other monitoring</u>

Poorman Creek supports genetically pure WSCT, brown trout and brook trout, and is one of only two known Garnet Mountains stream to support bull trout reproduction. Native fish densities increase in the upstream direction while non-native fish occupy lower Poorman Creek. In 2001, we established fish population monitoring sites in lower Poorman Creek immediately up-and downstream of the irrigation project. In 2004-05, we repeated these surveys. Survey results through 2005 have not recorded a noticeable population response below the diversions (Figure 38), despite increasing flows in lower Poorman Creek. Continued drought, channel instability and past grazing impacts appear to be factors limiting population response at this early recovery phase.

Monitoring of instream flows below the diversions found less diverted resulting in better connectivity to downstream waters (Mike Roberts, personal communication; Table 4)

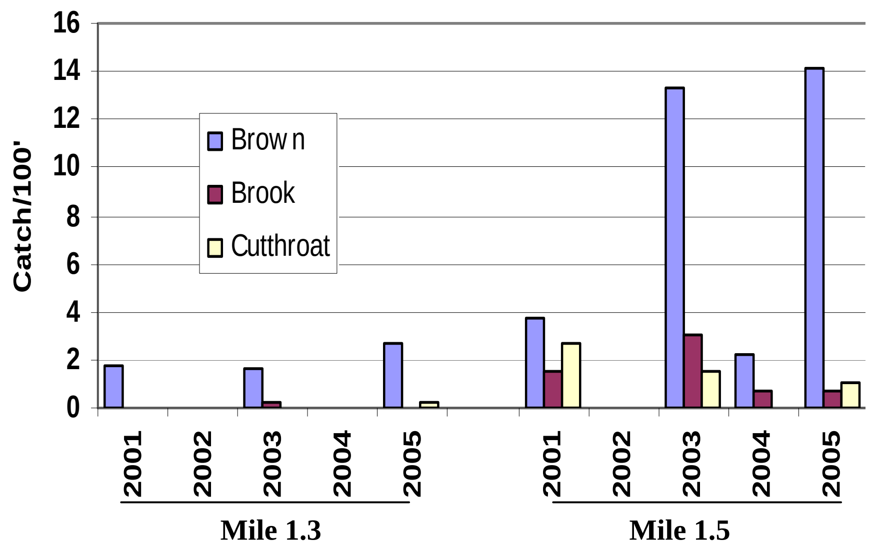


Figure 38. CPUE for fish in Poorman Creek at two locations, 2001-2005

Rock Creek

Restoration Objectives: Restore migration corridors for native fish; restore natural stream morphology to improve spawning and rearing conditions for all fish using the system.

	2001	2005
Channel seepage	40-50%	40-50%
Diversion (flow)	4-8 cfs	<3 cfs
Diversion (frequency)	nearly continuous	periodic
Connectivity	thru mid-July	thru early September
Average August flows at mouth	<0.5 cfs	2.1 cfs

Table 4. Comparison of flows in lower Poorman Creek, 2001 and 2005 (data from Mike Roberts, DNRC hydrologist).

Project Summary

Rock Creek, a basin-fed stream over most of its length, receives significant groundwater inflows between mile 1.2 and 1.6. Rock Creek is the largest tributary to the lower North Fork of the Blackfoot River, but has been degraded over most of its 8.2-mile length due to a wide range of past channel alterations and riparian management activities (Pierce 1990; Pierce et al. 1997). Rock Creek has also been the focus of continued restoration since 1990.

In 2004-05, the Blackfoot Cooperators reconstructed ~3,000' the South Fork of Rock Creek, a spring creek tributary entering Rock Creek at mile 1.7. This spring generates the majority of flow to lower Rock Creek during base flow periods. Additional projects included constructed floodplain for an adjacent ~3,000'an over-widened stream between mile three and four. These projects also employed shrub plantings and grazing changes with fencing and off-stream water developments. Active restoration is now completed over the entire 8.2-mile length of Rock Creek and its primary tributary, the South Fork of Rock Creek. Recovery of riparian areas, including plant communities, is expected to take several years.

Fish Populations

Rock Creek supports spawning migrations of brown trout and rainbow trout in lower reaches, and brook trout throughout the length of the stream. Middle reaches provide bull trout rearing and fluvial migration corridors to small headwater populations of WSCT. In 2002, we continued to survey fish populations in a section (mile 1.6) of stream reconstructed in 1999. Survey results show a continued increase in trout densities and a community dominated by brown trout (Figure 39). Prior to restoration this section of Rock Creek was brook trout dominated. Bull trout and rainbow trout also periodically utilize this portion of Rock Creek in low abundance.

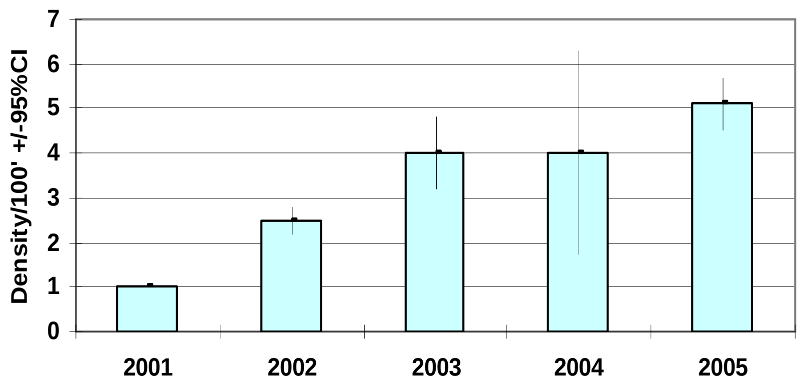


Figure 39. Densities of age 1+ brown trout in Rock Creek at mile 1.6, 2001-2005.

Snowbank Creek

Restoration objectives for Snowbank Creek are not yet defined

Description

Snowbank Creek is a 1st order tributary flowing 4.4 miles through the Helena National Forest and enters Copper Creek at mile 5.9. Snowbank Creek was identified as fisheries impaired in 2003 during an assessment of a defunct diversion at mile 0.4. The Snowbank diversion was constructed in 1962 to divert water to create a *put-and-take* fishery at Snowbank Lake (FWP files; Pierce et al 2004). Identified fisheries impairments in lower Snowbank Creek include: 1) native fish entrainment from a diversion to Snowbank Lake; 2) fish passage problems at the diversion and a culvert near the mouth; and 3) dewatering below the diversion. There is also no legitimate water right allowing the legal use of Snowbank Creek water for Snowbank Lake.

Fish Populations and other monitoring

In August 2004 and 2005, we continued fish population surveys immediately above and below the diversion located at mile 0.4 at two sections established in 2003

(Appendix A). This work was conducted in cooperation with the Helena National Forest during a period when the diversion was shut down due to water right and downstream drought concerns.

The 2004-05 surveys identified juvenile bull trout use in Snowbank Creek. This use was not detected during initial (2003) surveys. We suspect enhanced instream flows attracted bull trout in to Snowbank Creek from downstream Copper Creek spawning sites, a pattern of use observed in other small non-bull trout spawning tributaries connected to similar spawning streams. This sampling also recorded substantially fewer bull trout upstream of the diversion than below the diversion (Figure 40). These differences in catch rates demonstrate the barrier influence of the diversion to juvenile bull trout. Sampling found comparable WSCT densities above and below the diversion, and we observed high densities of YOY WSCT in the area of the diversion. We also salvaged wild fish from Snowbank Lake during a drawdown period. We identified multiple year classes of wild WSCT during the fish rescue as well as low numbers juvenile bull tout, confirming bull trout entrainment from the diversion. The Helena National Forest is currently assessing ground-and surface water hydrology and water right options in order to identify corrective actions.

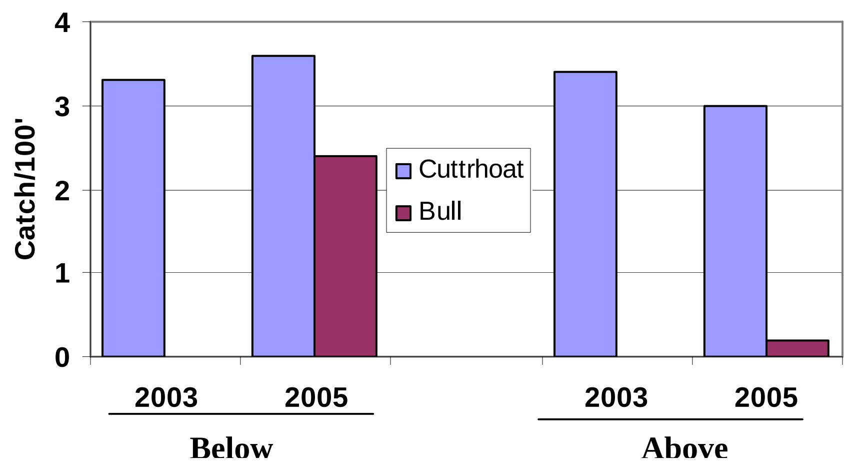


Figure 40. CPUE for native fish above and below the Snowbank Creek diversion, 2003 and 2005.

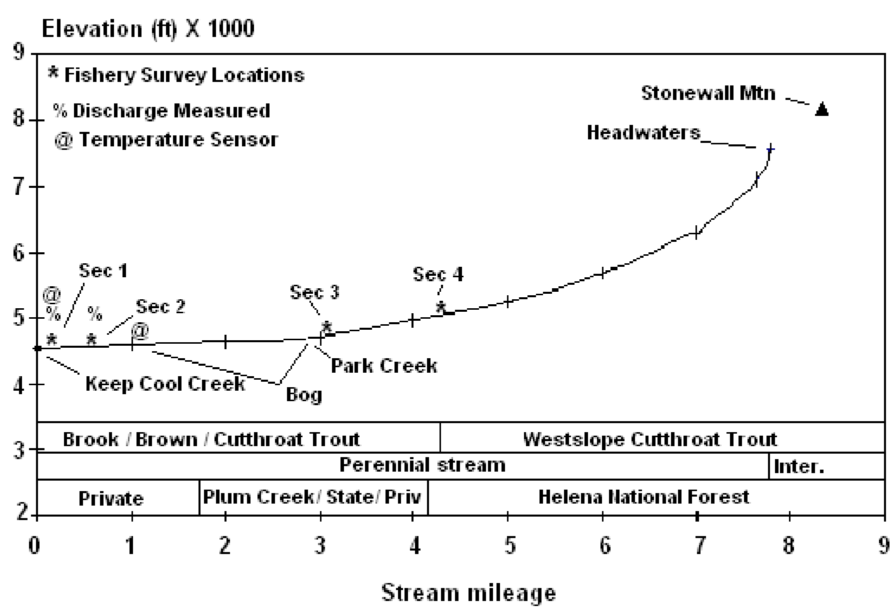


Figure 41. Longitudinal profile for Stonewall Creek.

Stonewall Creek

Stonewall Creek, a 2nd

order tributary, drains the western slopes of Stonewall Mountain. A perennial stream, Stonewall Creek flows south approximately 7.6 miles through Helena National Forest, private land, including Plum Creek Timber Company and public state land, before entering Keep Cool Creek at stream mile 2.3. Stream gradients range from 600'/mile in the upper reaches to 60'/mile near the mouth (Figure 41). Near the confluence with Park Creek (mile 2.7) downstream to approximately mile 1.1, Stonewall Creek flows into a beaver influenced bog with only short stretches of observable stream channel.

Riparian plant communities vary between the upper and lower watershed. Riparian vegetation in the lower reach consists of willow, alders, red osier dogwood, and sedge communities beneath a canopy of black cottonwood and ponderosa pine. We observed areas of intense livestock impacts to the stream channel including degraded stream banks, over-widen and braided channel, high sediment levels and heavy grazing impacts to the riparian vegetation.

On the National Forest, the riparian vegetation was generally in good shape composed predominately of rocky mountain maple, alder, willow, red osier dogwood, snowberry mixed with grasses under a conifer over-story of ponderosa pines and Douglas fir. The majority of the stream banks in the upper reaches are stable.

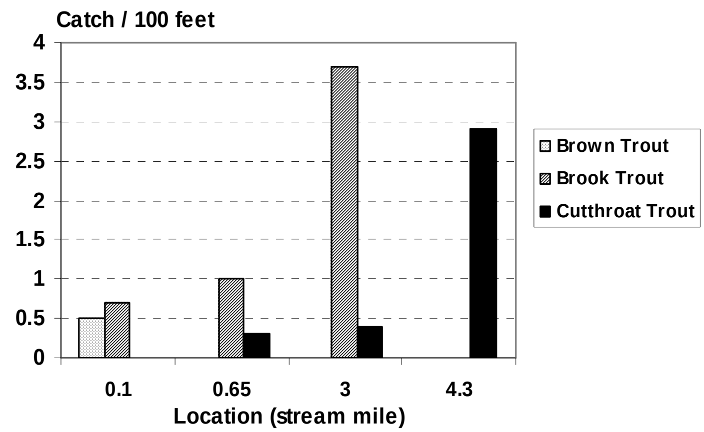


Figure 42. CPUE for fish > 4.0" at 4 locations on Stonewall Creek, 2004.

In 2004, we conducted fish population surveys at four locations (miles 0.1, 0.65, 3.0 and 4.3) and measured stream flow measurements at 0.65 cfs near the mouth (mile 0.1) and 4.3 cfs at mile 2.4 (Appendix D). Water temperature sensors were placed at miles 0.1 and 1.0 (Appendix H).

Fish Populations

Fish population inventories at the four locations recorded low numbers of three salmonid species (Figure 42). Sampling at the mile 0.1 recorded very low numbers of eastern brook trout mixed with brown trout. Fish population sampling at stream mile 0.65 and 3.0 recorded very low numbers of both WSCT and brook trout. Brook trout numbers increased slightly at mile 3.0 but remained low (CPUE = 3.7). WSCT was the only species found at the upper sampling location (CPUE = 2.9) (Appendix A).

Warren Creek

Restoration Objectives: Restore riparian vegetation and stream habitat for all life stages of trout; improve spawning and rearing conditions; increase recruitment of trout to the middle Blackfoot River; moderate whirling disease.

Project Summary

Warren Creek, a small tributary to the middle Blackfoot River, originates on Ovando Mountain, flows 12 miles southwest through knob-and-kettle topography until its junction with the Blackfoot River at rm 50, with a base flow of ~3-4 cfs. Warren Creek water is used for irrigated hay production and livestock watering. Irrigation causes the middle section of Warren Creek to dewater, although the lower section gains inflow from springs and maintains perennial base-flows of 3-5 cfs. Some riparian areas in mid-to-lower Warren Creek were cleared, heavily grazed, dredged and straightened in some cases using dynamite (Don McNally, personal communication). These actions all contribute to extensive degradation of salmonid habitat over most of Warren Creek.

Since 1995, Warren Creek has been the focus of extensive restoration actions. The actions involve removal of several streamside corrals, implementation of grazing plans, shrub plantings, several miles of channel reconstruction, instream flow enhancement near the mouth, wetland restoration and the enrollment of private landowners in conservation easement programs. In 2004-2005, the Blackfoot Cooperators continued to work with private landowners on riparian grazing plans, irrigation diversions and reconstruction of channelized stream. The reconstruction project, between stream mile 5.1 and 6.8, increased stream length 96%, from 4,750' to 9,300'. The new channel contains ~5,400' of E-type and ~3,900' of C-type channel and a combined mean frequency of 17 pools/1000.

<u>Fish Populations and other monitoring</u>

In 2004 and 2005, FWP continued to monitor fish populations at five locations (miles 1.1, 2.1, 3.6, 6.8 and 8.2), all in areas of previous restoration actions. Population survey results are outlined in Figure 43. The three downstream monitoring sites (mile 1.1, 2.1 and 3.6) are in an area of channel reconstruction and grazing exclosures completed in 2000. Fisheries at these sites have not responded as anticipated, although densities of fish have

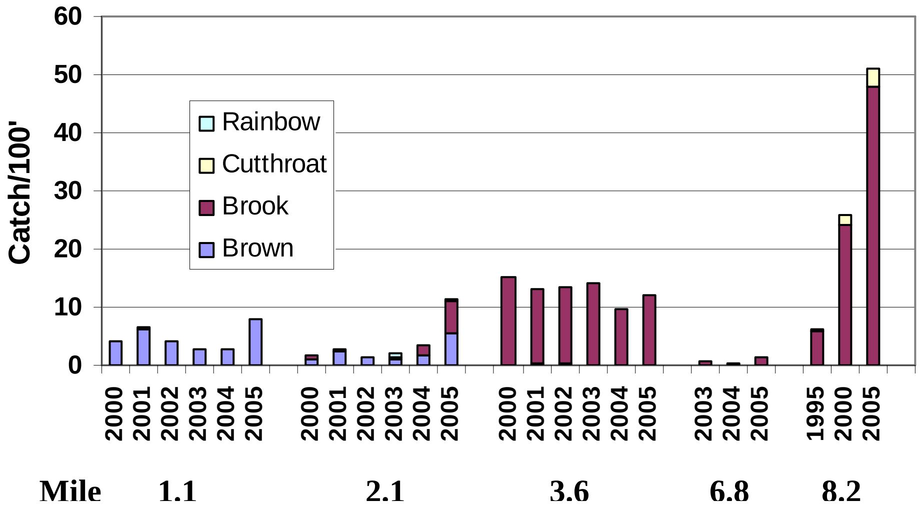


Figure 43. CPUE for trout at five sites in Warren Creek, 2000-2005.

Channel and habitat type	Total Habitat Units	# Sampled Units	Bankfull Width	Bankfull Depth	Wetted Depth	Residual Pool Depth	Riffle Crest Depth	BNKFL W/D Ratio
C-type pools	70	24	11.1+1.8(8.3-14.4)	2.6+0.6(1.6-3.9)	1.2+ 0.3(0.5-1.8)	1.0+0.3(0.3-1.6)		
C-type riffles	70	24	10.9+2.0(6.3-15.2)	1.6+0.3(1.0-2.2)	0.3+0.1(0.2-0.5)		0.3± 0.1(0.2-0.4)	6.8
E-type pools	51	16	9.3+ 0.9(6.7-10.4)	2.9+0.4(2.2-3.6)	1.1+0.3(0.6-1.5)	0.8+0.3(0.4-1.3)		
E-type riffles	51	16	9.0+ 0.7(7.6-10.0)	2.4+0.3(1.9-2.9)	0.4+0.1(0.2-0.5)		0.3± 0.1(0.2-0.4)	3.8

* all measurements in feet (tenths) with mean, SD and range

Table 5. Summary of channel measurements for the Warren Creek channel reconstruction.

increased in 2005. Drought, whirling disease, low summer flows and warm summer temperatures are suspected contributors to this static trend.

Fish population surveys at mile 6.8 show two years (2003 and 2004) of pre-restoration monitoring and one year (2005) of post-restoration monitoring. These surveys reveal very low densities of fish. This reach is subject to chronic dewatering, fish passage barriers and livestock degradation of the stream. Other monitoring of this project involves a post-project habitat survey (Table 5). During the survey, we identified an incision over a 4000' segment of the new "E" channel. Incision related to a faulty design, compounded by insufficient grade control. A reentry into the project in spring 2006 elevated the new channel to its proper elevation within the floodplain.

The mile 8.2 monitoring site dates to 1995 when it was established to monitor fish population response to upcoming riparian grazing project. Here, survey results show a significant increase in the densities of brook trout and WSCT. During this period of recovery brought on by grazing exclusion, the stream has evolved from an F-type channel to a more stable E-type channel.

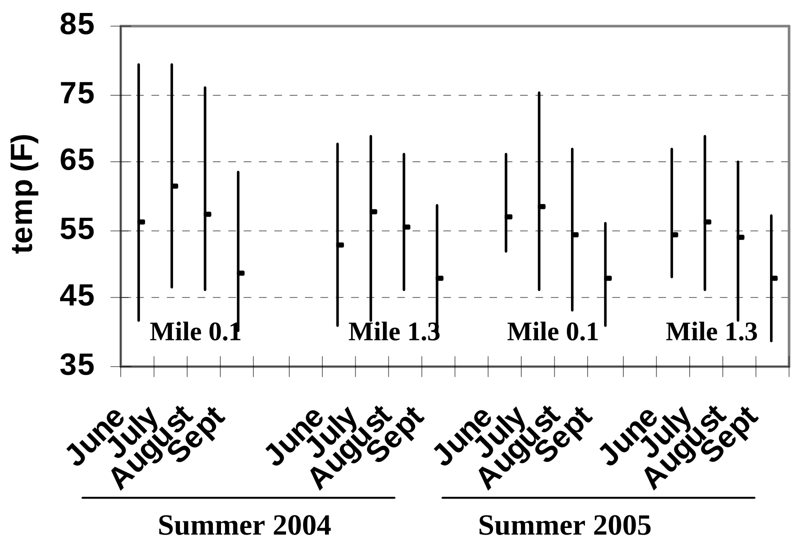
We continue to observe suspected clinical signs of whirling disease (opercular deformities) in a high percentage of sampled brook trout throughout Warren Creek.

FWP measured the post-restoration discharge (mile 6.7, Murphy ranch) on Warren Creek in September recording above diversion 2.06 cfs and below diversion 1.24 cfs.

Wasson Creek

Restoration Objectives: Restore channel maintenance flows; restore migration corridors in lower Wasson Creek in order to provide significant downstream recruitment; restore channel conditions to support spawning and rearing conditions in lower Wasson Creek; prevent fish losses to irrigation ditches; prevent the introduction of unwanted fish into the drainage; provide periodic flushing flows to Nevada Spring Creek

Figure 44. Monthly maximum, mean and minimum water temperatures for two sections of Wasson Creek, 2004 and 2005 (data from Don Peters).



Project Summary

Wasson Creek is a small 2nd order basin-fed tributary to Nevada Spring Creek. Wasson Creek begins on the Helena National Forest, before entering private ranchland at stream mile 3.8. Wasson Creek enters Nevada Spring Creek ~100' below the spring source, bringing a base flow of ~one cfs during the non-irrigation season. Wasson Creek has a long history of fisheries problems that include fish passage barriers throughout the system, irrigation dewatering and entrainment of fish to ditches, excessive livestock damage to streambanks, channel straightening and water quality impairments from agricultural runoff.

The goal of the project is to ensure that Wasson Creek will be a significant source of WSCT recruitment to Nevada Spring Creek, Nevada Creek and the Blackfoot River, and provide sufficient forage production for economic sustainability to ranchlands, while demonstrating a successful collaborative effort.

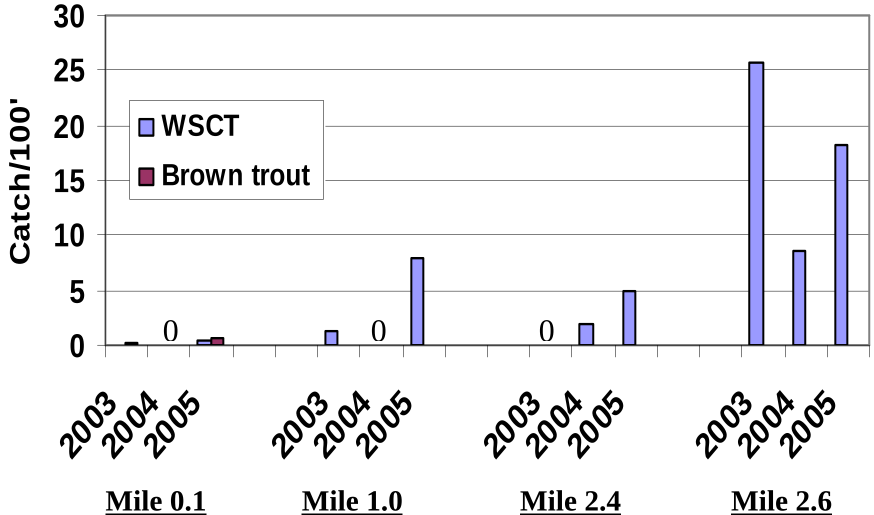


Figure 45. CPUE for WSCT and brown trout in four sections of Wasson Creek, 2003-2005.

Fisheries elements of the project include: 1) grazing management over the length of the project area; 2) irrigation changes to accommodate instream flows (low flows and channel maintenance) and fish passage, while preventing fish losses to ditches; 3) reconstruction of 3,625' of new stream in a channelized reach to increase sinuosity from 1.2 to 1.4; and 4) floodplain containment measures on ~2000' of stream to prevent losses of high flows and improve water conveyance to Nevada Spring Creek. Preventing unwanted fish species into the drainage is also to be considered in the future if needed. The Blackfoot Cooperators began implementation of the Wasson Creek restoration project in 2005 and completion is expected in 2006.

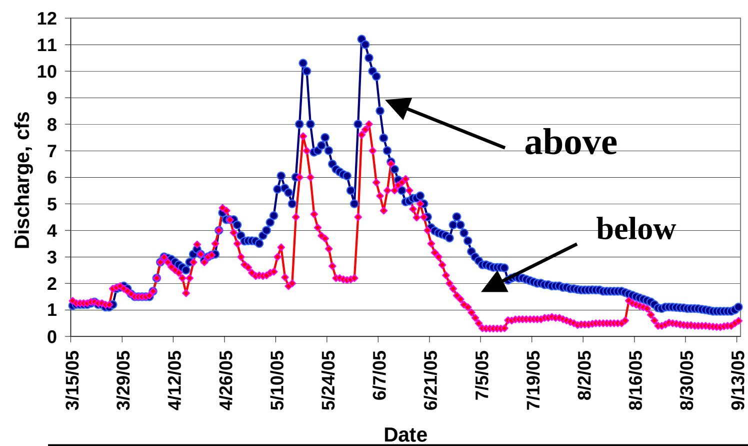


Figure 46. Flow measurements above and below the Wasson Creek diversions in 2005 (data by R. Sheilds).

Instream flow targets (habitat maintenance and minimum flows) relate to channel "bankfull" cross-sectional area below the lower irrigation diversion, which is ~3.0 sq. ft or ~ 60% lower than the ~7.5 sq. ft upstream of the diversions. Based on these cross-section differences, we measured bankfull flows at 6.75 cfs above the upper diversion and 3.05 cfs at bankfull below the lower diversion. This 3.05 cfs value represents the flow target for channel maintenance. Likewise, minimal instream flows are also reduced proportional to the channel cross-section from ~2.0 cfs (derived from the Montana Method instream flow model) to ~0.75 cfs, maintained as such during base-flow periods. These flows ranging from a high of 3.05 cfs to minimal base flows of 0.75 cfs are to emulate the natural Wasson Creek hydrograph, which has been modeled from USGS flow data in the Nevada Creek Watershed. Flows above these targets are available for irrigation.

Fish Populations and other monitoring

FWP sampled fish populations at four locations (miles 0.1, 1.0, 2.4 and 2.6), measured water temperatures at two sites (mile 0.1 and 1.3), instream flows at 3 locations in 2004 and 2005 and initiated whirling disease monitoring in lower Wasson Creek at mile 1.5. Fish population surveys show substantially lower WSCT densities below the upper diversion at mile 2.6, but increasing densities in the downstream direction (mile 1.0 and 2.4) during initial phases (2004 and 2005) of the restoration project (Figure 45). Near the mouth of Wasson Creek (mile 0.1), we also found WSCT in low densities (1.3/100') and low densities of brown trout near the mouth of Wasson Creek, in addition to longnose and largescale suckers and redside shiners.

Flow monitoring results 2005 for Wasson Creek above and below the irrigation diversion are located in Figure 46. We also calculated bankfull flows from staff gauges located at stable channel cross sections in order to develop both channel maintenance (3.05 cfs) and minimal instream flow (0.75 cfs) values.

Water temperatures for summer 2005 were consistently lower (range 4-9 ^{o}F) near the mouth (mile 0.1) compared to 2004, while temperatures at mile 1.3 showed no change (Figure 44). This cooling is likely the result of restoration measures including the early recovery of streamside plant communities.

A spawning site (McNeil core) survey was also conducted in 2005 on Wasson Creek upstream of the diversions (mile 2.W6). The results show high levels of "fine" sediments in spawning riffles (Results Part IV). This survey provides a baseline for monitoring in spawning areas under alternative grazing methods.

RESULTS PART IV: ADDITIONAL INVESTIGATIONS

Whirling disease status

Whirling disease, caused by the exotic myxosporean parasite *Myxobolus cerebralis*, was first detected in the Blackfoot River in 1995 near Ovando, MT. Since then, the disease has increased in both distribution and intensity. It now infects salmonids in the entire main stem Blackfoot River and continues to expand in the lower reaches of most tributaries (Figure 47; Table 8). The highest infections are found in tributaries of the middle Blackfoot River as well as certain spring creeks. Many of the lower river tributaries, those with higher gradients and streams with colder summer temperatures currently support lower infection levels. The low-elevation distribution of the disease currently overlaps with the distribution of many salmonids.

Myxobolus cerebralis has a complex, two-host life cycle involving a salmonid and the aquatic oligochaete worm, *Tubifex tubifex*. There are also two spore forms of the parasite; a fragile triactinomyxon (TAM) that is released by the worm and infects young trout and a hardy myxospore later released by infected fish and ingested by the worm host, where the myxospore is then converted back to the TAM stage. The development and severity of whirling disease in exposed salmonids is dependent on many factors involving: 1) the fish host (species, strain, age, size) (Thompson et al. 1999; Vincent 2002; Ryce 2003); 2) the worm host (Granath et al. 2002); 3) the environment (water quality parameters, water temperature, flow rates) (MacConnell and Vincent 2002; Smith et al. 2002); and 4) the overlap of contact with both spore types (overlap of TAM with susceptible fry species and myxospore being encountered by the worm) (Kerans and Zale 2002).

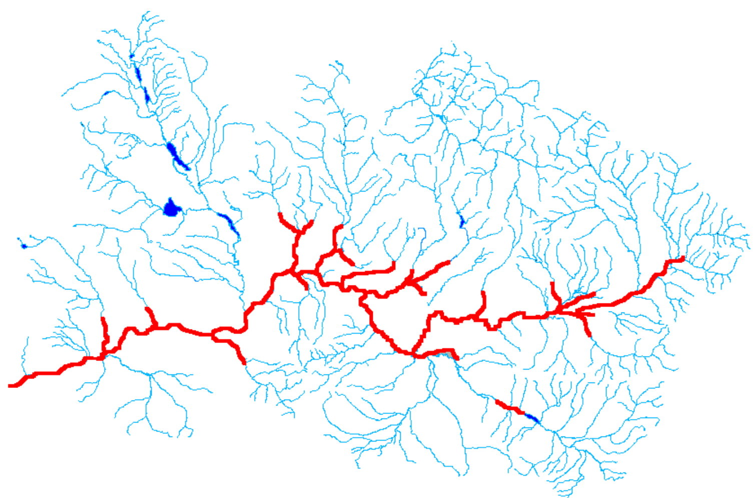


Figure 47. Generalized distribution of whirling disease in the Blackfoot Watershed.

Sentinel cages provide an indirect measure of TAM abundance and disease severity. They were first deployed in the Blackfoot Watershed in 1998 (*see* Procedures). Sentinel cage monitoring has continued through 2005 at established Blackfoot River sites and throughout tributaries in order to assess disease expansion. A mean grade infection is determined from histology results from sentinel fish exposed in each cage to determine

Mean grade category	Infection Level Description
0.0-2.0	Low
2.01-2.74	Medium
2.75-3.7	High
3.71-5.0	Very High

Table 6. Mean grade category descriptions (Baldwin et al. 2000).

infection severity at individual locations (Table 6). An important criterion for determining cage deployment dates is based on water temperatures. Previous studies have shown the highest infection levels coincide with a specific water temperature range of 50 to 61 ^{o}F (Baldwin et al. 2000; Downing et al. 2002; Vincent 2002). In the Blackfoot River, these temperatures coincide with an early summer (mid-June through early July) sampling period for many basin-fed streams.

The recent escalation of the disease appears to be expressing itself through population declines in rainbow trout in the middle Blackfoot River (Results Part II). Likewise, clinical signs of whirling disease (cranial and skeletal deformities), first noticed in 1998, continue to increase in rainbow trout at both long-term monitoring sections of the Blackfoot River (Figure 48). Observations of opercular deformities, thought to be a clinical signs specific to brook trout, are also present in highly infected waters (FWP unpublished data).

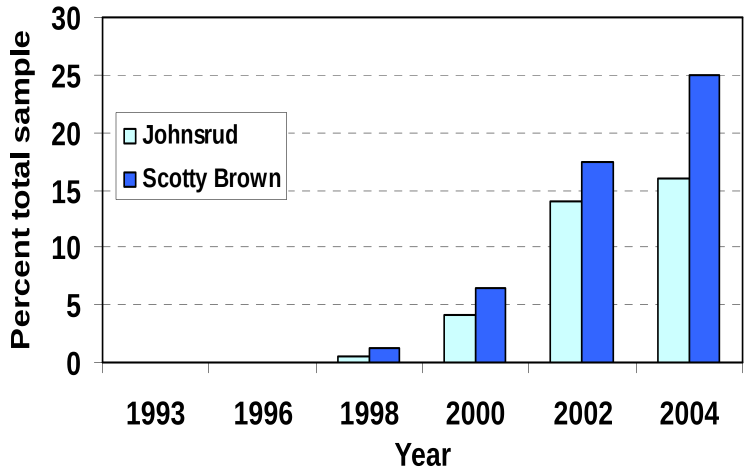


Figure 48. Percent rainbow trout with observed clinical signs of whirling disease at two survey sites of the Blackfoot River.

Previous studies have classified salmonids based on susceptibility to the disease, which varies considerably by species (MacConnell and Vincent 2002). All salmonids in the Blackfoot Watershed (WSCT, bull trout, rainbow trout, brown trout, brook trout, and mountain whitefish) can be infected by the parasite. Rainbow trout are reported to be the most susceptible and brown trout and bull trout more resistant (Table 7). The susceptibility of mountain whitefish is unclear but a concern as unpublished research suggests high susceptibility (MacConnell 2005). Caudal deformities of mountain whitefish are also increasing in some waters of western Montana (Craig Barfoot, personal communication). Unfortunately, populations of mountain whitefish are difficult to sample, making assessments of WD risk problematic. Research into the ecology, life history within a context of WD susceptibility is needed and a topic of research

Common Name	Susceptibility
Rainbow Trout	3
Westslope Cutthroat	2
Brook Trout	2
Bull Trout	1
Brown Trout	1
Mountain Whitefish	2S

Table 7. Susceptibility to whirling disease among species of salmonids in the Blackfoot River. Scale of 0 to 3 or S: 0 = resistant; 1= partial resistance; 2 = susceptible; 3 = highly susceptible; S = susceptibility is unclear (conflicting reports). (adapted from MacConnell and Vincent 2002).

currently being pursued by FWP and University of Montana.

Blackfoot River native WSCT and bull trout appear to have a diminished risk of contracting whirling disease due to habitat use and life history strategies that entail spawning and rearing in tributaries, above the general elevation of highly infected waters. Whirling disease severity typically increases in the downstream direction in Blackfoot River tributaries. This inverse relationship between elevation and infection has been detected in previous studies (Smith 1998; Hiner and Moffitt 2001; Sandell 2001; Hubert 2002; Anderson 2004), and may be a result of the parasite's recent introduction in the area, low numbers of myxospores in the environment, or a lack of suitable habitat supporting *T. tubifex*.

In Cottonwood Creek, Smith (1998) reported higher gradient, higher elevation habitats typically support lower *T. tubifex* densities and thus fewer TAMs. Periodic sentinel cage samplings confirm high infections near the mouth but negative results in the upper drainage in support of this relationship (Pierce et al 2002). "Headwater" conditions (water temperature, substrate and channel type) similar to upper Cottonwood Creek occur in tributaries of the lower drainage (Gold, Belmont and Bear Creeks), and many other tributaries to the Blackfoot River. Many of these streams show mild infection levels, despite higher infections in nearby receiving waters. Water temperatures in basin-fed streams are also typically much lower in forested and upper stream reaches (Pierce et al. 2002) and out of the reported critical temperature range of high-risk waters (Vincent 2002, FWP unpublished data). As a result, exposure risk appears to have a longitudinal component.

Downstream-infected areas often overlap with spawning and rearing areas rainbow and brown trout, mountain whitefish and other species. Conversely, telemetry studies of WSCT and bull trout show these native species generally reproduce upstream of the disease, while occupying infected water at non-vulnerable (early) life-stages. One notable exception however is lower Chamberlain Creek where concentrated WSCT spawning and high juvenile densities in the lower stream overlap with a high whirling disease infection. Infection levels in July have reached mean grades of 3.9, a grade considered to cause population declines in exposed fish (Vincent 2002). At this time, population monitoring suggests generally stable WSCT densities.

In the Blackfoot watershed, the role of habitat restoration to fisheries in highly infected streams is being investigated on many fronts. One objective is to determine if restoring an infected system (i.e. reducing favorable worm habitat by regaining flushing flows and reducing sediment input through stabilizing banks) will moderate the disease. The premise behind this idea is a result of several ecological risk factors being hypothesized to influence whirling disease severity. These factors include: high productivity, lack of flushing flows, low gradient, human altered or enriched habitats that amplify the density of *T. tubifex*, and the presence of brown trout that can act as a reservoir for the disease (Modin 1998; McWilliams 1999; Zendt and Bergersen 2000). A second objective is to relate infection levels to the longitudinal continuum of morphological (and other physical) characteristics of channel-types (Vannote et al 1980; Smith 1998; Rosgen 2002). The premise here relates to perceived regional relationships of infections and potential opportunities for specific enhancement techniques associated with predictable spatial changes in channel-types and salmonid species (and life-stages) therein. The relationships of WD to channel-types and other biophysical attributes of

Waterbody	Mean Grade Infection							
Blackfoot River	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Blackfoot River-Below Gold Cr	0.22	nd	2.44	nd	0.59	2.42	2.2	2.06
Blackfoot River-Below Elk Cr	nd	nd	2.3	nd	1.59	nd	2.3	3.28
Blackfoot River-above Clearwater	1.1	0.22	3.11	nd	2.79	3.16	3.41	2.96
Blackfoot River-Below North Fork	0.25	nd	nd	nd	nd	nd	2.64	2.86
Blackfoot River-below Nevada Cr	0	0	0.84	nd	0.9	2.12	3.93	3.89
Blackfoot River-Below Lincoln	0	0	0.6	nd	2.44	nd	nd	na
Blackfoot River-Headwaters	nd	nd	0	nd	0.02	0.32	nd	0
Basin-fed Streams								
Johnson Creek	nd	nd	nd	nd	nd	nd	nd	0
West Twin Creek	nd	nd	nd	nd	nd	nd	nd	0
East Twin Creek	nd	nd	nd	nd	nd	nd	nd	0
Bear Creek	nd	nd	nd	nd	nd	nd	nd	na
Union Creek	nd	nd	nd	nd	nd	nd	0	nd
Gold Creek	nd	0.12	0	nd	0	0	nd	0
Belmont Creek	nd	nd	0	nd	0.19	0.38	1.55	2.48
Elk Creek	nd	0	0	nd	0	2.84	4.32	4.82
Clearwater Creek	nd	nd	nd	nd	nd	nd	0	nd
CottonwoodCreek	3.66	4.52	nd	nd	4.5	nd	nd	3.78
Chamberlain Creek	0.16	2.71	3.88	nd	2.63	nd	4.33	3.78
Monture Creek	0	0	1.76	nd	3.22	nd	nd	4.81
Warren Creek	0.21	2.1	1.72	nd	nd	nd	nd	0.0
North Fork Blackfoot River	0	nd	0	nd	0.78	nd	nd	0.27
Arrastra Creek	nd	nd	nd	nd	nd	0.34	1.23	na
Beaver Creek	nd	nd	nd	nd	nd	nd	0.45	na
Poorman Creek	nd	nd	nd	nd	nd	nd	0.78	na
Landers Fork	nd	nd	nd	nd	nd	nd	0.14	na
Upper Willow Creek	nd	nd	nd	nd	nd	nd	0	na
Spring Creeks								
Jacobsen Spring Creek	nd	nd	nd	nd	nd	nd	0.13	nd
Rock Creek	nd	0	2.3	3.9	nd	3.38	nd	nd
Kleinschmidt Creek	2.83	3.56	4.52	3.77	nd	4.9	4.7	nd
Nevada Spring Creek	nd	nd	nd	nd	0	nd	3.66	2.22
Grentier Spring Creek	nd	nd	nd	nd	nd	nd	0.06	1
Lincoln Spring Creek	nd	nd	nd	nd	nd	nd	5	4.7

Table 8. Summery of whirling disease sentinel cage test results for the Blackfoot River, confluence areas of basin-fed streams and spring creeks, 1998-2005.

streams are currently being researched in the Blackfoot. A third objective is to address limiting factors related to physical habitat through restoration and assess the degree to which non-susceptible species, or susceptible species at non-susceptible life stages, will occupy restored habitats. In these cases, monitoring shows some promising early results where populations of brown trout are responding rapidly to habitat restoration. Species such as bull trout and WSCT at non-vulnerable life-stages are beginning to pioneer into restored habitats that harbor high infections in some cases. Examples of these types of responses include both the Kleinschmidt Creek and Nevada Spring Creek restoration projects (Results Part III).

Recent research on the ecology of whirling disease has shown infections in spring creeks occur at much lower temperatures than previously identified in basin-fed streams (Anderson 2004; Vincent 2002). Anderson (2004) further detected a pattern of infection timing highest in winter and early spring and fall. FWP sampling of WD in Blackfoot valley spring creeks confirm this relationship, but also finds comparable high infections during the summer (FWP unpublished data) at certain sites. This contrasts with June and July peaks observed in the Blackfoot River. These combined results suggest that assemblages of vulnerable species maybe at a higher risk in certain spring creeks than basin-fed streams.

In summary, many factors will influence future distributions of whirling disease and impacts to salmonids in the Blackfoot River. Monitoring through the disease escalation period is necessary to assess restoration objectives and determine the extent to which whirling disease will be contained by the physical features of the Blackfoot Watershed. At this time, the disease continues to expand at the low elevations of the watershed where infections vary considerably depending upon the specific stream environment. The current distribution of whirling disease overlaps directly with the distribution of rainbow trout, brown trout, brook trout and mountain whitefish spawning and rearing areas and occurs at levels harmful to certain species.

Basic strategies to help moderate impacts of the disease include managing for multiple species and life-history strategies. From the perspective of restoration, these strategies involve: 1) improving migration corridors and rearing areas between headwater spawning streams and the Blackfoot River; 2) restoring native populations of WSCT and bull trout, whose life history could help reduce risk of infection by allowing the continual recruitment of these species to downstream river reaches; and 3) lowering sediment and nutrient input to streams by developing compatible streamside grazing practices and reducing other anthropogenic sediment sources.

Preliminary summary of spawning migrations and tributary use of telemetered rainbow trout in the lower Blackfoot River basin: An initial evaluation of WD risk

Abstract

To help assess the influence of whirling disease (WD) on wild rainbow trout (i.e. RBT-hybrids – *see* results), we used radio telemetry to identify spawning areas and movement patterns by RBT in the lower Blackfoot Watershed of Montana. Telemetry confirmed a majority of Blackfoot River RBT rely on tributaries for spawning; however movement patterns also suggest mainstem spawning. Spawning migrations to tributaries began in early March as maximum daily water temperatures approached 43 ^{o}F. From presumed wintering areas in the Blackfoot River, pre-spawning movements averaged 10.1 miles (range: 0.5-47.4) to tributary spawning sites. Migratory RBT spawned in the lower reaches of most spawning streams with peak spawning occurring in late April, which translates to predicted fry emergence by late June. Fish captured downstream of the Clearwater River spawned primarily in the lower reaches of smaller, higher gradient tributaries that support low-level whirling disease infections during the post-emergence period. RBT implanted with transmitters upstream of the Clearwater confluence spawned primarily in Monture Creek, the lower portion of which supports a high level of WD during the infectious post-emergence period. Spawning in Monture Creek extended further upstream than observed in the lower river tributaries. Initial findings suggest "lower" River RBT are currently at a reduced risk of contacting WD; whereas RBT in the "middle" River are at a higher, but variable risk of contracting WD depending upon where early rearing occurs. Prior to WD, the middle Blackfoot River was identified with high juvenile (age 0 and I) RBT (winter) mortality and recruitment problems.

Introduction

Whirling disease (WD), caused by the myxosporean parasite *Myxobolus cerebralis*, has been associated with significant declines in some wild RBT populations in the western United States (Nehring and Walker 1996; Vincent 1996). First detected in Montana in 1994, this disease has been described as one of the single greatest threats to wild trout (MWDTF 1996). Clinical signs of the disease include the characteristic "whirling" behavior, black tail, skeletal and cranial deformities (MacConnell and Vincent 2002). *Myxobolus cerebralis* has a complex, two-host life cycle involving the aquatic oligochaete worm *Tubifex tubifex*, and a salmonid (member of the trout family). The development and severity of the disease is dependent on species, fish age and size and parasite dose at time of exposure (Vincent 2002). However young trout, particularly RBT have been shown to be the most vulnerable when infected at less than nine weeks of age (Ryce 2003). High mortality and recruitment collapse can occur in infected populations. This type of collapse is now rapidly occurring in the fluvial RBT of the Rock Creek drainage near Missoula, Montana (FWP unpublished data). Recent population surveys in the Blackfoot River indicate early stages of similar RBT declines in the middle Blackfoot River, an area of highly infected spawning streams (Results Part II, Results Part IV).

WD was first detected in the Blackfoot Watershed in 1995 in Cottonwood Creek, near Ovando. Since then, the disease has increased in distribution and intensity in both upstream and downstream directions. WD now infects the entire main stem Blackfoot River, as well as the lower reaches of many tributaries (Figure 47), many of which are important spawning and rearing streams for migratory Blackfoot River trout (Pierce et al. 2004, *this report*). Coinciding with WD expansion, declining densities for vulnerable species are now being detected. RBT (fish >6.0") density in the middle Blackfoot River between the North Fork and Clearwater River confluences has declined 52% in 2004 compared with the long-term mean (1989-2002). Lower Cottonwood Creek is also highly infected and RBT have declined 50% relative to estimates conducted prior to detection of WD. In this stream, there has been a community-level shift towards brown trout, a WD resistant species.

For this study, we hypothesize that WD severity will be limited to specific streams based on the physical and biological features of each tributary. Study objectives are to: 1) identify life-history characteristics and relative use of fluvial RBT spawning areas using radio telemetry; 2) determine the timing of RBT emergence and mean grade infection levels at these sites during susceptible (post-emergence) phases; and 3) relate these finding to WD infections in juvenile rainbow trout and the specific habitat parameter in RBT spawning and rearing areas. Ongoing companion studies involve the quantification of stream morphometrics and other physical characteristics. Our purpose is to develop methods that help identify and predict environmental conditions conducive to WD in tributaries and help assess the ultimate influence of WD on wild RBT populations of Blackfoot River. Implications relate to: 1) the management of species that may inhabit the open niche if significant RBT declines occur; 2) potential harvest regulations changes for affected species; 3) the development of specific habitat enhancement measures suited to different channel-types and salmonid species; and 4) conservation of WSCT from the perspective of reduced introgression.

Study Area

The Blackfoot is managed for a diversity of self-sustaining "*wild trout*" populations. RBT distribution is limited to the Blackfoot River downstream of Nevada Creek and the lower reaches of lower river tributaries. Although RBT occupy only ~10% of the perennial streams in the Blackfoot watershed, they represent the dominant game fish in the lower river, comprising as much as 70% of the total trout community in the lower Blackfoot River (Results Part II, Appendix C). RBT thereby provide a large segment of the recreational fishery in the lower Blackfoot River. Past studies suggest fluvial RBT reproduce primarily in the lower portions of larger south-flowing tributaries (FWP unpublished data). Within the range of RBT, this study stratified the lower

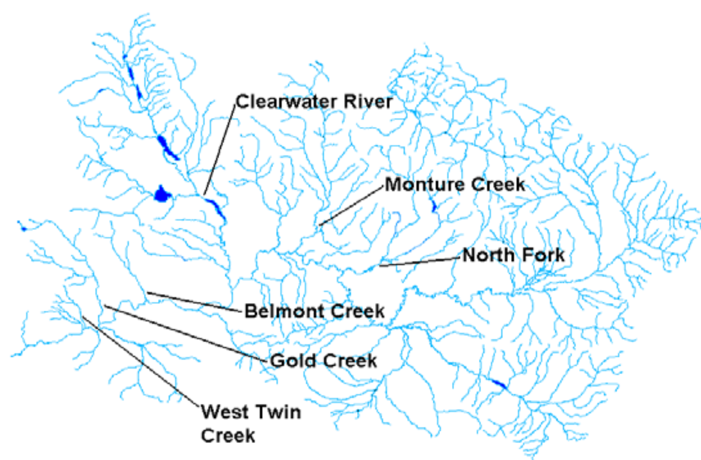


Figure 49. Blackfoot River watershed showing locations of primary RBT spawning tributaries.

Blackfoot River into a lower and upper reach based on the physical characteristics of nearby tributaries. The lower reach extends from the mouth of the Blackfoot River upstream 34.7 river miles to the mouth of the Clearwater River. For this reach, spawning tributaries have higher gradients, lower summer temperatures and currently support generally lower WD infections (*this report*). The upper reach extends from the confluence of the Clearwater River 19.4 river miles upstream to the confluence of the North Fork. For this reach, spawning streams are lower gradient, support warmer summer water temperatures, higher sediment levels and higher WD infections (*this report*).

Methods

Twenty-seven RBT (10 in the lower reach and 17 in the upper reach) were captured and implanted with radio (Lotek) transmitters on March 8, 2004 and between February 28 and March 8, 2005. As a pilot project for the larger 2005-06 study, the 2004 fish involved seven RBT in the upper reach. Transmitters for these fish had only an estimated ~100-day battery-life. For the 2005 RBT, we implanted radios in 20 adult fish with ten transmitters in each of the two reaches. We selected fish that possessed the morphological features of adult female in pre-spawning condition and avoided fish that exhibited obvious westslope cutthroat trout (*O. Clarki lewisi*) characteristics. Transmitters were evenly distributed throughout reach one, and concentrated near the center of reach two due to limited access. Fish captures were made in suspected wintering pools, prior to spawning migrations using a boom-mounted electrofishing drift boat.

We followed surgery methods described by Swanberg (1997) and Schmetterling (2001). Transmitters weighed 7.7 grams and did not exceed 2% of fish weight as previously suggested (Winter 1996). Transmitter life for the 2005 fish was estimated at 450 days. Incisions were closed with Reflex-One 35W surgical staples (Swanberg et al. 1999). Following surgery, the fish were held in a live car in the river until fully recovered and then released at or near capture locations. Each transmitter emits an individual coded signal.

Fish locations were determined from the ground, using either an omni-directional whip antenna mounted on a truck or a hand held three-element Yagi antenna when walking. We located fish weekly prior to migrations, daily during migrations and spawning, once per week following spawning and once per month during the late summer, fall and winter due to reduced movements. Fish were categorized as spawning (entered a tributary) or non-spawning (did not enter tributary). Fish were assumed to have spawned if they ascended a tributary during the spawning period. The mean date between two contacts surrounding an event, such as a migration start, was used to estimate the date of an event (Schmetterling 2001).

Thermographs (Tidbit sensors) were placed in both reaches of the Blackfoot River and (Hobo sensors) and at the mouth of all tributaries to evaluate the effect of temperature on the onset of migration and spawning. These thermographs recorded temperature every 48 minutes (Tidbit sensors) in the mainstem and 72 minutes (Hobo sensors) in tributaries. All temperature statistics were obtained from maximum daily temperatures. Blackfoot River daily discharge data were obtained from U.S. Geological

Survey gauging station (#12340000) at Bonner at river mile 7.9 to examine potential relationships between discharge and fish movement.

The incubation period for RBT was calculated from known water temperatures and a median spawning date of RBT in Monture Creek, using a 340 temperature-unit value (Ron Snyder, Arlee Hatchery, personal communication). Emergence was estimated at approximately three weeks post-hatch. The University of Montana, Trout and Wild Salmon Genetics Laboratory, Missoula, Montana using DNA (PINES) analysis of anal fin clips, assessed likely genetic status of the twenty 2005 individuals.

Relocation data was spatially located using GPS receivers (Garmin III), 1:24,000 maps, recognizable landmarks or a combination of these techniques. Relocations were converted to latitude and longitude and entered in degree decimals to ArcView GIS point coverage with all relational data attached using EXCEL databases and converted to river miles. Within tributaries, movements were expressed as the distance upstream from the mouth.

Following identification of primary spawning sites by telemetered RBT and to determine infection severity, sentinel cages - each with 50 young-of-the-year RBT were placed central to spawning locations in July 2005. We also placed sentinel cages at all other known spawning basin-fed tributaries in areas of known RBT spawning. At the end of the holding period, all surviving fish were sacrificed and sent to the Washington State University Animal Disease Diagnostic Laboratory at Pullman, WA. At the lab, the heads were histologically examined using the MacConnell-Baldwin histological grading scale, which ranks infection intensity from 0 (absent) to 5 (severe) (Baldwin et al. 2000) *(See* Procedures section of sentinel cage testing).

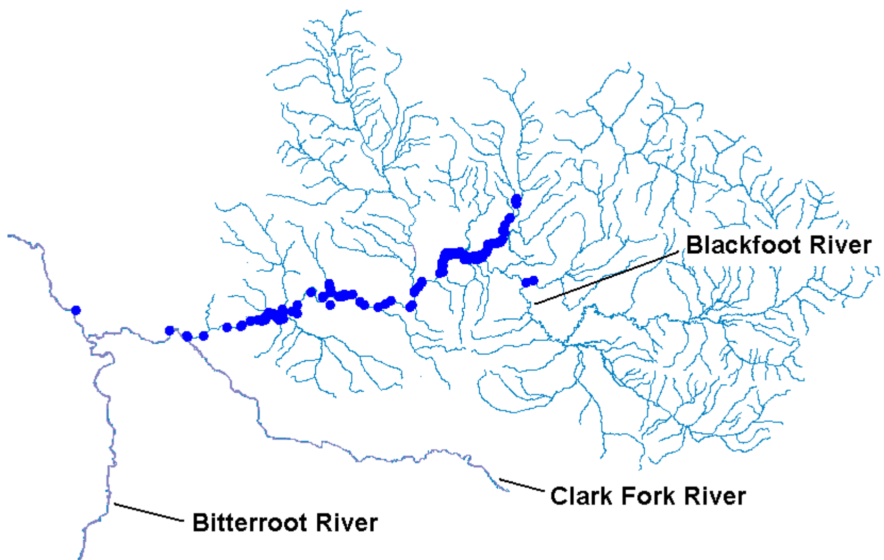


Figure 50. Summary of all RBT telemetry locations in 2004 and 2005.

Although not included in this preliminary report, we also measured the physical characteristics of all RBT spawning areas where sentinel cages were located. These included geomorphic surveys (Rosgen 2002), McNeil substrate core samples (Results Part IV), water chemistry (PH, conductivity and total dissolved solids) testing and measurements of summer water temperatures.

Preliminary telemetry results

Of the 27 telemetered RBT, we successfully tracked 15 to spawning tributaries. The remaining 12 either made no spawning-related movements (n=3), or exhibited river movements only during the spawning period (n=9). Tracking began March 2004 and continued into December 2005. We made 1,757 contacts and averaged 65 contacts (range: 9-83) for each fish. A summary of all RBT locations for 2004 and 2005 is located on Figure 50. Of twenty 2005 presumed *Oncorhynchus mykiss* (RBT) that underwent DNA analysis, eighteen (90%) possessed genetic markers consistent with either rainbow trout (n=1) or late generation RBT x WSCT hybrids (n=17) with a predominant rainbow genetic composition (Appendix I).

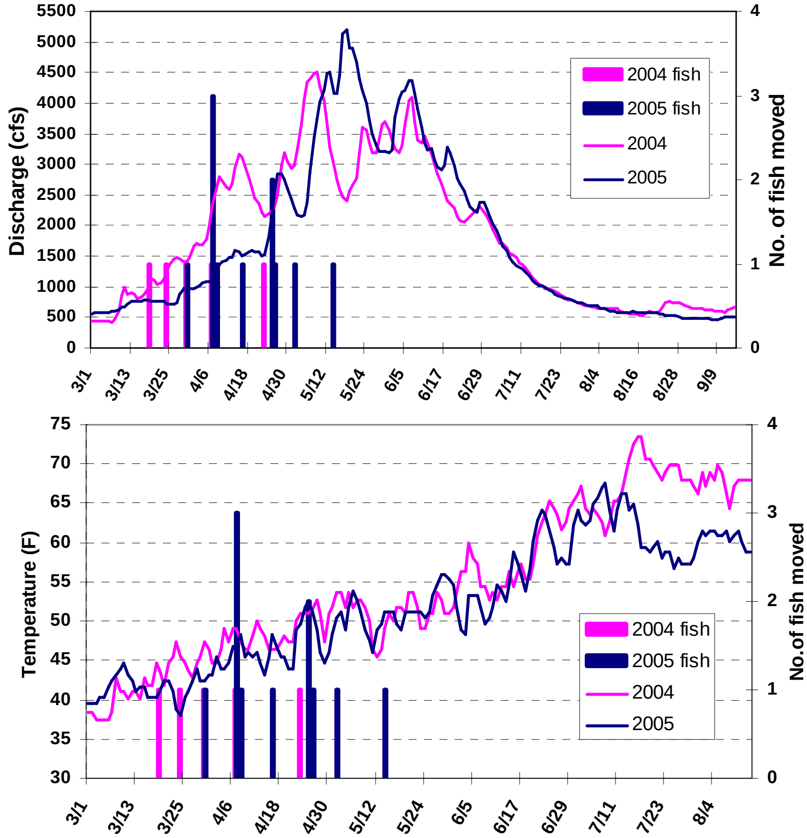


Figure 51. Relationship of discharge (top) and temperatures (bottom) to dates RBT began migrations in 2004 and 2005.

River temperatures were slightly higher and runoff began earlier in 2004 than 2005. RBT began their tributary spawning migrations on March 19th (range: 34 days) in 2004 and March 30th (range: 34 day) in 2005. Migrations began on the rising limb of the hydrograph, as temperatures approached 43 °F. (Figure 51). Fourteen RBT migrated upstream, and one moved downstream before ascending spawning streams. Blackfoot River migrations averaged 8.7 days (median 9.0; range 1-25), and covered an average distance of 5.8 miles (median 3.4; range 0.3-35.1) before ascending tributaries. Streams entered by RBT varied in size from 1st to 4th order. Rainbow trout spawning occurred in 5 tributaries (East Twin (n=1), Gold Creek

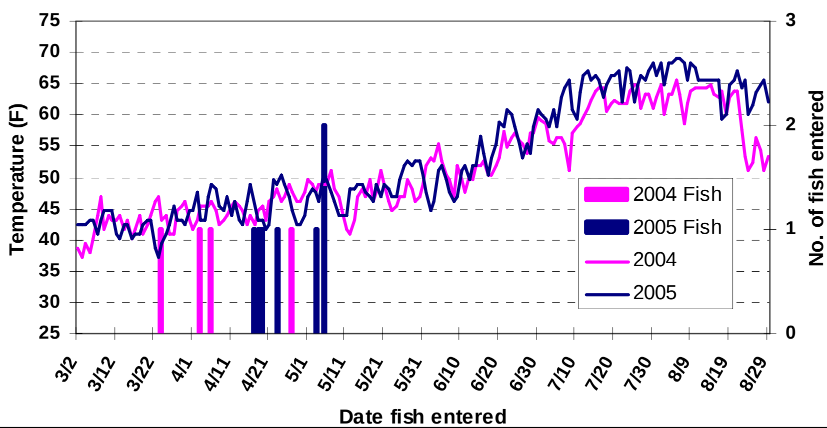


Figure 52. Relationship of water temperatures to dates RBT entered Monture Creek, 2004 and 2005.

(n=1), Belmont Creek (n=1), the North Fork (n=1), while Monture Creek (n=9) and its largest tributary Dunham Creek (n=2) supported by far the highest proportion of RBT spawners (11 total RBT or 73%).

RBT entered tributaries from late March through early May (mean date: April 17). Average upstream tributary movement was 4.3 miles for RBT (median 4.0; range 0.2-12.3). Of the nine RBT that entered Monture Creek, two migrated 11.2 miles upstream to ascend the lower 1.1 miles of Dunham Creek - the primary tributary to Monture Creek. Fish entered Monture Creek at temperatures of 43 - 48 ^{o}F (Figure 52), and moved an average of 5.6 (median 4.4; range 0.2-12.2) miles upstream to spawn.

Based on small sample sizes (n=7), spawning in 2004 began and ended earlier in 2004 compared with 2005. Spawning began on March 30th and ended on April 28th in 2004; whereas spawning extended from April 25th to May 14th in 2005. The combined median date of spawning (both years) was April 26th. Spawning occurred at a mean water temperature of 47 ^{o}F (range 43-49 ^{o}F). Upon their exit of spawning streams, 47 % (n= 7) of migratory RBT returned to their original Blackfoot River capture locations an average of 47 days after migrations began.

Except for two migratory RBT that moved downstream of Milltown dam, the remaining eight (of ten) 2005 spawning RBT returned to or near original capture sites by late May. Three returned to original capture locations and the remaining five returned to within (a mean of) 0.9 miles (range 0.2-5.7 miles) of their original capture sites.

A majority of non-spawning RBT (n=9) – those that did not ascend a spawning tributary, also exhibited movements during the spawning period. Similar to spawning RBT, non-spawning RBT in 2005 (n=8) began movements at 43 ^{o}F on April 14th (and extended to May 21st), and average distance of 9.6 rm (median 6.4; range 1.6-37.3). One RBT, captured at rm 23.6, moved upriver ~18 miles to the mouth of Cottonwood Creek before returning to its original capture location. Only one of seven RBT recorded mainstem movement in 2004, beginning 41^{o} F on March 13th. After these mainstem movements, eight of nine non-spawning RBT returned to within (a mean of) 3.1 rm (range 0-14.1rm) of their original capture locations. Following these spring (March-May) movements, non-spawning fish exhibited very little additional movement through December.

Three of 20 (15%) RBT telemetered in 2005 moved downstream of Milltown Dam - a run-of–the–river dam between May and July. One migratory RBT from the upper reach, after spawning in Monture Creek, moved downriver 46 miles to a location downstream of Milltown Dam. A second spawning RBT, a fish that ascended Gold Creek in April moved downstream to river mile 1.8. The radio of this fish was later found in a heron rookery adjacent to the Clark Fork River ~20 river miles downstream of Milltown Dam. The third fish, a non-spawning RBT moved 2.4 miles up the Blackfoot River to near the mouth of Bear Creek in early May and then moved 12.4 miles to a location downstream of Milltown dam.

Due to a short radio-life from the seven 2004 RBT, it was not possible to assess mortality or other information beyond the immediate spawning period. Suspected mortality sources for the twenty 2005 RBT included: 1 bald eagle kill, one heron kill, one suspected poaching and two unknowns. We observed no mortality directly attributed to spawning activities.

Discussion

Genetic results confirm Blackfoot River stocks of suspected RBT to be RBT - WSCT hybrids with a predominant rainbow genetic composition. For these fish, early results suggest inter-annual variations in temperature and flow influence the timing of migrations and spawning. Early study results also suggest spawning for "lower" River RBT occurs in the lower reaches of several lower river tributaries; however a portion of these lower river RBT also migrate long distances to middle River tributaries (e.g. Monture Creek). In contrast, >90% of RBT telemetered upstream of the Clearwater River spawned in the Monture Creek watershed.

River movements of non-tributary spawning RBT also occurred during the normal migration period. Because we tracked RBT on a daily basis during the spawning period is appears unlikely these RBT entered tributaries. Rather, this movement pattern suggests limited, but as yet unconfirmed, mainstem spawning. Because of WD infection levels in the mainstem Blackfoot River upstream of the Clearwater River are approaching lethal levels, emergent fry in this section of the Blackfoot River are at some heightened risk of contracting WD compared to the lower river where WD is at lower levels.

All lower tributaries used by telemetered RBT currently support a low (sub-lethal) WD infection. Conversely, a majority of RBT spawning upstream of the Clearwater River, including Monture Creek, support high (lethal) WD infections in lower stream reaches. Mean grade WD infection in Monture Creek at stream mile 2.1 was 4.8 in July 2005. However, because WD infections tend to decrease in the upstream direction, it appears the upper segment of emergent Monture Creek rainbow fry may be at a reduced risk of exposure to lethal spore levels compared to RBT fry in lower Monture Creek. Based on the Monture Creek median spawning date of April 26th (both years), peak hatching of RBT eggs is within the first week on June, with emergence expected 2-3 weeks thereafter (Ron Snyder, personal communication). This post-emergence period corresponds both peak period of RBT disease vulnerability (Ryce 2003), and severe infectious period measured from sentinel caged RBT in Monture Creek during mid-July.

The escalation of WD in the middle Blackfoot River and primary spawning tributaries therein coincide with 1) declining juvenile densities of RBT in the lower-most sampling sites of Monture Creek compared to an upstream site, 2) declining RBT densities in the middle Blackfoot River, and 3) an increasing incidence of cranial deformities in the Blackfoot River downstream of Monture Creek (*this report*). Although these indices all suggest a high risk of WD in the middle river, six years of drought currently confounds a clear interpretation of the influences of WD on river populations. Further compounding concerns of WD, past juvenile RBT surveys identified recruitment problems resulting from high juvenile (winter) mortality the middle Blackfoot River (Peters and Spoon 1989). Additional telemetry work, whirling disease monitoring and related research are expected to continue through 2006-07.

A hierarchical assessment of bull trout spawning areas in the Blackfoot River basin: A baseline for identifying potential spawning areas

Introduction

Substrate composition, cover, water quality and quantity are important elements for salmonid spawning. The amount and suitability of stream substrate for spawning also varies by valley morphology, stream size (order) and species (Bjornn and Reiser 1994, *this study*). Developing a better understanding of bull trout spawning areas is particularly relevant due to the ESA "threatened" status of bull trout and the discrete nature of the few existing known spawning areas within the Blackfoot Watershed. In order to foster a better understanding of local bull trout spawning requirements and pursue methods to identify potential spawning areas, we assessed four existing fluvial bull trout spawning areas at various spatial scales. The study was undertaken in a physiographic region dominated by glacial valleys and high basin relief. Our objectives were to characterize properties of spawning areas at the regional, reach and spawning site spatial scales. Study implications relate to the identification and assessment of historical spawning areas within comparable settings, evaluations of emergent fry survival, the monitoring and correction of anthropogenic sediment-producing activities.

Study area

The study area included four spawning streams (Copper Creek, Dunham Creek, Gold Creek and Monture Creek) that originate from two glaciated mountain blocks, separated by the Clearwater River, and located in the northern region of the Blackfoot Watershed (Figure 53). Most local streams in this area originate in high (sub)alpine basins of Belt rock geologic origin. Most of the larger streams begin in cirques and flow south in glaciated U-shaped valleys through coniferous sub-alpine and montane forests. Significant portions of the region are roadless or managed for wilderness, except west of the Clearwater River where a majority of the land is largely managed as private industrial forest. These streams generally exit the mountains as larger, colder tributaries of the Blackfoot River.

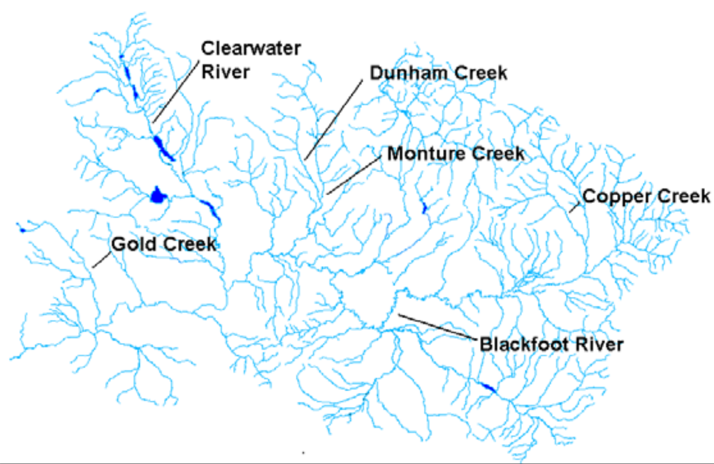


Figure 53. Bull trout spawning area survey study area.

Methods

We characterized regional physiographic features using ecoregion and valley-type classification (Omnerick 1988; Rosgen 2002), perennial stream-order calculations (Strahler 1957) and landform interpretation from 1:24:000 topographic maps. At the reach scale, we quantified channel morphology using modified level II surveys at each spawning area (Rosgen 2002). At the spawning site scale, we measured: 1) individual redds; 2) spawning substrates; 3) discharge; and 4) placed thermographs for continuous winter temperature monitoring as described below. All field surveys were completed in October 2004 following the bull trout-spawning period.

To characterize spawning substrates, we extracted 33 McNeil core samples (range 6 – 12 per stream) from spawning areas using modified methods of McNeil and Ahnell (1964). Core samples were collected immediately adjacent (within 18 inches) to the center of the redd. For streams with fewer than six redds, cores were taken adjacent to redds where possible and at comparable sites deemed suitable to spawning. Extracted core samples were sent to the Helena National Forest Hydrology Lab in Helena for sieving and lab analysis. Streambed samples were oven dried and shaken through sieve series containing 76.2 50.8, 25.4, 12.7 6.3 4.76 2.38, 0.85, 0.074 mm mesh screens. The material retained within each sieve and the pan was weighed to the nearest hundredth of a gram. The estimated dry weight of the sediment within the Imhoff cone (a measure of the suspended sediment) was added to the weight of material <0.074. Stream compositions were reported as a percentage of each size class by weight. Lab calculations also included 1) measures of central tendency ("Fredle" index and geometric means) to classify substrate quality in terms of reproductive potential of spawning gravel, and 2) quantification of "percent fines" (<0.84mm and <6.35mm) within each of the spawning areas. Survival of emergent bull trout fry was also estimated from the equation: $y = -1.29462x$ (% fines<6.35) +72.4615 (R^2= 0.91, $p=<0.05$) (Fraley and Weaver 1991).

To further characterize the properties of redds, we measured 37 individual bull trout redds (Copper Creek (n=14), Dunham Creek (n=3), Gold Creek (n=6) and Monture Creek (n=14)). Seven measurements were taken at each redd, including velocities and depths at 5 locations (V_{up}, V_{pit}, V_{tail}, d_{left} and d_{right}) and lengths (tail and pit) at two sites (Figure 54). We selected only redds that displayed a definite pit and tailspill and avoided areas of superimposition. All velocity measurements were taken with Marsh-McBirney model 2000 flow meter at 0.6 times the water column depth. We measured depths with the top-setting rod and lengths with a tape. Similar to Schmetterling (1999), redd pit lengths were measured from the upstream edge of the pit to the upstream edge of the tailspill. Similarly, tailspill lengths were measured from the upstream end of the

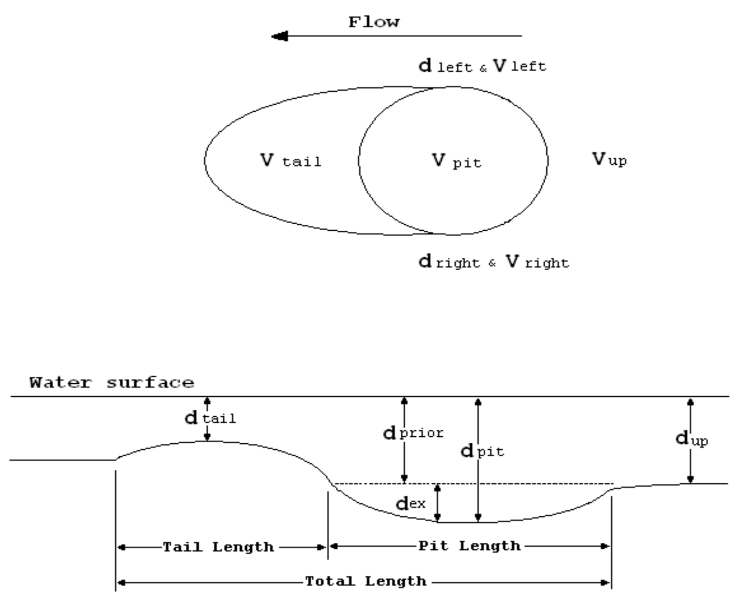


Figure 54. Schematic of measured locations on bull trout redds (*modified* from Schmetterling 1999).

tailspill to the downstream tip of the tailspill. Total redd lengths were calculated from the sum of pit and tail lengths. We measured depths and velocities in the deepest part of the redd pits (d_{pit}); and recorded measurements directly upstream (d_{up} & v_{up}) and downstream on the tailspill crest (d_{tail}) and to the right (d_{right}) and left (d_{left}) of the each redd. To estimate water depth prior (d_{prior}) to redd construction, water depths upstream of redds were average with water depths at tailspill crests ($d_{up} + d_{tail}$) / 2. Pit excavation depths (d_{ex}) in the substrate were estimated by subtracting water pit depth from water depth prior to redd excavation ($d_{pit} – d_{prior}$) (Schmetterling 1999). We located all redds with GPS (Garmin III plus) and noted by which third of the stream channel it was located in (mid, right, left), habitat type (pool, glide, riffle) and estimated distance from nearest overhead cover.

To characterize winter water temperatures at spawning areas for the embryo incubation period, we placed one thermograph (tidbit data logger) in the substrate and one in the water column at each of the four spawning areas. The substrate sensor was placed immediately adjacent to a redd and buried 6” in to the substrate. The second sensor was placed adjacent to the same redd in the water column. Temperature data was recorded from September 2004 through March 2005 at 30-minute intervals. To test the relationship of water temperatures the water column and the substrate, performed a paired *t-test* between the pooled mean monthly data for the primary winter months (December, January and February) with results considered significant at the alpha <0.05 level.

Results

<u>Physiographic setting and reach morphology</u>

The broad-level physiographic features of the study area fall into the “northern rockies aquatic ecoregion” (Omnerick 1988). Within the Blackfoot watershed, this region includes include high, cool and humid mountains with meta-sedimentary (Belt) rock types and inseptisol soils, covered by alpine meadows, subalpine and montane

	Copper Cr	Dunham Cr	Gold Cr	Monture Cr
Bankfull Area (ft^2)	146.1	212.9	85.3	181.1
Bankfull Width (ft)	56.8	93.4	64.2	91.8
Bankfull Depth (ft)	2.6	2.3	1.3	2
Floodprone Width (ft)	64.9	98.7	70	95
Max Depth (ft)	3.7	3.9	2.7	3
Width / Depth Ratio	22.1	40.9	48.3	46.5
Entrenchment Ratio	1.1	1.06	1.09	1.03
D16	6.8	32.9	21.2	11.7
D35	20.2	49.9	39.9	23.7
D50	38	64	51.7	29.3
D84	87	97.5	89.1	57.8
D95	134.1	122.6	119	88.3
Total Slope	0.009	0.012	0.01	0.007
RIffle Slope	0.007	0.012	0.016	0.009
Run Slope	0.005	0.014	0.008	0.01
Pool Slope	0.016	0.015	0.017	0.01
Glide Slope	0.009	0.014	0.01	0.012
Discharge (cfs)	26.9	19.12	32.8	12.8

Table 10. Geomorphic, substrate and discharge measurements of bull trout spawning reaches on Copper, Dunham, Gold and Monture Creeks, fall 2004.

coniferous forests and wood land cover-types. Spawning areas all fall within (type V) valleys formed from glacial scouring processes in which the resultant trough is a relatively wide, U-shaped valley, with valley–floors slopes generally less than 4% (Rosgen 2002). Soils are derived from materials deposit as morainal deposits, glacial outwash and post-glacial alluvium. Geomorphic surveys identified all four spawning areas as C4-type channels (Rosgen 2002). Geomorphic summaries, Wohlman substrates size-classes and discharges measurements for the four study sites are located in Table 10.

<u>Redd measurements</u>

All 37 redds were found in depositional gravel-dominated bedforms, of which a majority (24 or 65 %) were constructed in glide tail-outs in flow convergence zones immediately upstream of riffle crests. The remaining (13 or 35%) redds were constructed in riffles. Within these depositional areas, redd locations varied, with ten redds found in mid-channel, 10 in the right and 17 in the left channel margins. Of those in channel margins, six were in side channels, and two in beaver influenced braided channels. Mid-channel redds recorded the greatest distance from overhead cover averaging 8.9m, compared to 5.6m for redds at other sites.

Summary statistics for measured redds are outlined in Table 11. From the sum of measurements, the "average" redd is constructed in relatively shallow (~21 cm) water of moderate approach velocities (7-8 cm/sec). The total length of the redd is ~192 cm, of which the tailspill forms the majority (59%) and the pit the minority (41%) of the completed redd. The tailspill is constructed 15 cm above the surrounding glide, while the pit is a ~12 cm depression within the glide. Water approach velocity slows from 8.1 cm/sec to 7.0 cm/s within the pit, before accelerating 38% from the pit to the tailspill crest (11.3 cm/s). The shape and velocities operate such that the pit collects "fines" before they access the egg pocket (tailspill), while simultaneously forcing water through the egg pocket.

Attribute	Location in redd	Copper	Dunham	Gold	Monture	Totals
Lengths (cm)	Pit	60 ± 16 (38 - 88)	57 ± 12 (49 - 71)	131 ± 17 (109 - 152)	79 ± 23 (51 - 111)	79 ± 31 (38 - 152)
	Tailspill	90 ± 28 (57 - 142)	73 ± 29 (53 - 107)	133 ± 16 (117 - 160)	137 ± 41 (67 - 230)	113 + 40 (53 - 230)
	Total	150 ± 41 (96 - 229)	130 ± 42 (102 - 178)	265 ± 16 (234 - 277)	216 ± 55 (123 - 338)	192 ± 63 (96 - 338)
Depth (cm)	Upstream of pit (*d* up)	23 ± 6 (14 - 31)	14 ± 10 (3 - 21)	14 ± 4 (9 - 20)	28 ± 8 (17 - 49)	23 + 9 (3 - 49)
	Pit (*d* pit)	31 ± 6 (24 - 40)	21 ± 9 (12 - 29)	26 ± 4 (21 - 32)	35 ± 8 (24 - 55)	31 + 8 (12 - 55)
	Tailspill crest (*d* tail)	17 ± 7 (6 - 29)	11 ± 9 (2 - 18)	11 ± 3 (6 - 15)	17 ± 7 (6 - 31)	16 + 7 (2 - 31)
	Prior to redd construction (*d* prior)	20 ± 6 (10 - 29)	13 ± 9 (2 - 20)	13 ± 1 (11 - 14)	22 ± 7 (14 - 40)	19 + 7 (2 - 40)
	Estimated pit (*d* ex)	10 ± 3 (6 - 15)	9 ± 1 (8 - 10)	14 ± 4 (11 - 21)	13 ± 3 (9 - 20)	12 + 3 (6 - 21)
	Right of pit (*d* right)	24 ± 7 (15 - 40)	16 ± 8 (11 - 24)	13 ± 6 (3 - 20)	24 ± 8 (12 - 38)	21 + 8 (3 - 40)
	Left of pit (*d* left)	22 ± 7 (12 - 34)	12 ± 9 (2 - 18)	17 ± 5 (12 - 26)	22 ± 9 (12 - 43)	20 ± 8 (2 - 43)
Velocity (cm/s)	Upstream of pit (*V* pit)	8 ± 3 (4 - 15)	7 ± 3 (4 - 10)	8 ± 4 (0.5 - 10)	8 ± 2 (5 - 13)	8 ± 3 (0.5 - 15)
	Pit (*V* pit)	7 ± 3 (2 - 11)	6 ± 2 (3 - 7)	5 ± 2 (3 - 7)	8 ± 2 (5 - 12)	7 ± 2 (2 - 12)
	Tailspill crest (*V* tail)	11 ± 3 (5 - 16)	8 ± 3 (4 - 11)	15 ± 9 (7 - 32)	12 ± 3 (7 - 18)	11 ± 5 (4 - 32)
	Right of pit (*V* right)	8 ± 3 (0.7 - 14)	7 ± 3 (5 - 10)	4 ± 3 (0.2 - 9)	9 ± 2 (6 - 13)	7 ± 3 (0.2 - 14)
	Left of pit (*V* left)	8 ± 3 (0.07 - 13)	5 ± 5 (0 - 8)	8 ± 5 (3 - 18)	7 ± 4 (0 - 13)	7 ± 4 (0 - 18)

Table 11. Summary of 37 bull trout redd measurements, fall 2004.

McNeil cores assessment of spawning substrates

Spawning substrate analysis involved 33 McNeil substrate core samples from the four spawning streams (Table 12). Summary statistics for major indices (percent fines <6.35mm, Fredle indices, geometric mean and percent bull trout survival at emergence) show a wide range of values for individual cores, but a very narrow range of mean values among the four spawning areas. This narrow range includes the percentage of fine

Stream	Percent <6.35mm	Fredle Indices	Geometric mean (mm)	Percent bull trout survival
Copper Creek (n=9)	30.7 ± 10.7 (18.9 - 54.5)	4.6 (1.4 - 8.8)	11.4 (4.8-21.3)	32.7 (1.9 - 48)
Dumham Creek (n=6)	29.4 ± 10.8 (16.5 - 47.4)	5.1(1.6 - 9.1)	13.0 (5.5-19.9)	34.4 (11.1 - 51.1)
Gold Creek (n=6)	28.5 ± 9.2 (17.3 - 40.4)	5.3 (2.2 - 9.5)	13.2 (7.4-20.1)	35.5 (20.1 - 50.1)
Monture Creek (n=12)	29.6 ± 9.9 (12 - 43)	5.5 (2.1-14.4)	13.0 (6.9 - 25.6)	34.2 (16.8 - 56.9)
Grand mean	29.6	5.1	12.6	34.2

Table 12. Summary of McNeil core sample results for four bull trout spawning areas in the Blackfoot River watershed, 2004.

sediment (<6.35mm - silt, sand and fine gravel) of ranging from 28.5 to 30.7% and geometric mean particles composed of medium-sized gravel ranging from 11.4 to 13.2 mm.

Water Temperatures

Temperature monitoring of the water column and substrate found a narrow range of temperatures (Table 13). During the primary winter months (December, January and February), Gold Creek recorded the coldest winter water temperatures of all sampled streams, while Monture Creek recorded the highest average water column temperatures. It was also the only tributary in which substrate temperatures were lower than column temperatures, suggesting upwelling was occurring upstream rather than at the actual site of the temperature sensor. A paired t-test analysis of grouped (all streams) mean water column verses the substrate temperatures for the primary winter months (December, January and February) found no relationship (P=0.367).

	Copper Creek		Dunham Creek	
Month	**Water Column**	**Substrate**	**Water Column**	**Substrate**
September	43.8 ± 2.4 (40.2 - 48)	44.5 ± 1.6 (41.6 - 47.7)	42.9 ± 1.7 (40.5 - 46.3)	43.9 ± 1.7 (41.8 - 47.4)
October	40.5 ± 2.6 (34.9 - 45.9)	41.5 ± 2.0 (37.1 - 45.5)	40.4 ± 1.9 (35.3 - 44.7)	41.4 ± 1.8 (36.4 - 45.7)
November	36.8 ± 2.1 (32.2 - 41.8)	37.9 ± 1.6 (33.9 - 41.3)	38.6 ± 0.8 (36.3 - 41.1)	39.6 ± 0.8 937.5 - 42.1)
December	35.3 ± 1.8 (31.2 - 39.7)	36.3 ± 1.4 (33.1 - 39.0)	37.4 ± 1.0 (35.3 - 39.5)	38.5 ± 1.0 (36.1 - 40.7)
January	34.1 ± 2.3 (31.2 - 39.2)	34.9 ± 1.9 (32.5 - 38.5)	35.9 ± 1.3 (32.1 - 39.5)	37 ± 1.3 (33.2 - 40.4)
February	34.5 ± 1.7 (31.2 - 38.1)	35.4 ± 1.1 (33.3 - 37.6)	36.1 ± 1.2 (34.2 - 40)	37.1 ± 1.2 (35 - 40.7)
March	36.3 ± 2.2 (31.7 - 41.3)	37.0 ± 1.5 (33.9-40.4)	36.3 ± 1.2 (34.2 - 40.6)	37.3 ± 1.2 (35.2 - 41.2)

	Gold Creek		Monture Creek	
Month	**Water Column**	**Substrate**	**Water Column**	**Substrate**
September	46.2 ± 2.6 (41.9 - 50.3)	46.4 ± 1.9 (43.3 - 49.2)	44.5 ± 1.8 (42.1 - 48)	42.4 ± 1.7 (39.8 - 46.1)
October	41.6 ± 3.3 (34 - 49.7)	41.9 ± 2.9 (35.6 - 48.7)	42.1 ± 1.7 (38.5 - 46.6)	40 ± 1.7 (36.6 - 44.5)
November	35.6 ± 2.4 (30.8 - 42)	35.9 ± 2.0 (31.3 - 40.8)	39.1 ± 1.1 (36.5 - 42.1)	37 ± 1.1 (34.5 - 39.8)
December	33.5 ± 1.7 (30.8 - 38.3)	33.8 ± 1.5 (31.3 - 37.7)	38 ± 1.0 (34.8 - 40.2)	38.9 ± 1.0 (32.9 - 37.7)
January	32.8 ± 2.0 (30.8 - 38.3)	32.9 ± 1.8 (31.3 - 36.6)	36.9 ± 1.0 (34.2 - 39.6)	34.8 ± 1.0 (32.3 - 37.2)
February	33.3 ± 1.6 (31.3 - 37.8)	33.6 ± 1.3 (31.2 - 36.1)	36.4 ± 1.1 (34.2 - 40.2)	34.5 ± 0.9 (32.3 - 37.2)
March	36.2 ± 2.4 (31.3 - 44)	36.4 ± 1.7 (32.3 - 41.4)	38.1 ± 1.3 (35.9 - 42.4)	36.1 ± 1.1 (33.9 - 39.3)

Table 13. Summay of water temperatures (mean, SD, range) for water column and substrate sites at four bull trout spawning areas.

Discussion

All four spawning areas were remarkably similar at the various spatial scales. All four spawning areas are 3rd-order basin-fed streams located in alluvial (glacio-fluvial) landforms within glacial trough valleys. Observations of springs, and measured groundwater inflows confirm groundwater "upwelling" at all spawning sites (FWP files; Bo Stewart-USFS hydrologist personal communication; *this report*), a pattern identified in other areas (Fraley and Shepard 1989); yet the sources of groundwater appear variably influenced by adjacent valley landforms. At two study sites, upwelling appears upstream of valley constrictions formed from either bedrock or lateral valley morainal constrictions. At the two other locations, concentrated spawning occurs in "gaining" reaches where large inflows of ground-water surface over short distances and both sites are located immediately downstream of seasonally intermittent "losing" reaches. In one such case, groundwater surfaces as the stream begins to track against a bedrock mountain slope. At a fifth site (not considered in this study), a spawning area is located adjacent to two intermittent lateral valleys formed of glacial alluvium, which appear to drain subsurface to the spawning area of the receiving stream.

Bull trout spawned specifically in meandering, gravel-dominated, riffle/pool channels with well-developed, mixed-forest floodplains in all four streams. These streams have gentle gradients (0.009 $\pm$ 0.002), display high width/depth ratios (range 22.1-48.3), and are characterized by point bars and other depositional features, and sinuosities >1.2 (Rosgen 2002). Based on a narrow range of substrate conditions found in C-4 type spawning channels, estimates of percent survival to emergence were likewise similar with a range of 32.7 - 35.5%.

Confirmed in other areas of western Montana (Weaver and Fraley 1991), bull trout spawning areas in the Blackfoot watershed have a component of groundwater upwelling. This moderating influence helps prevent freezing of the egg pocket (Pierce et al. 2004), and forms a stable environment necessary for embryo survival, development and emergence (Thomas 2002; Weaver and Fraley 1991). Although we found no difference ($P=0.37$) between substrate and water column temperatures, other recent studies of bull trout spawning sites found mid-winter temperatures were warmer ($P<0.05$) compared to downstream (non-spawning) areas where channels are more prone to extreme (anchor) ice formation (Pierce et al. 2004). This local warming often forms observable ice-free environments during the core winter months.

Quantified morphological, thermal and visual properties of spawning areas (at various spatial scales) provide a framework for assessing potential (eg. historical) spawning sites for similar valleys within comparable physiographic regions. The narrow range other variables (eg. substrates sizes) may further act as spawning site indicators in lower-order streams, non-glacial valley landforms or upwelling areas found in other physiographic or geomorphic settings.

Restoration applications obviously relate not only to discrete and narrow range of spawning areas properties, but also to the non-spawning spatial requirements of bull trout. In this study, fluvial bull trout spawn in predictable stream environments with substantial base flows (range 13-32 cfs), where connectivity, complexity and cold summer temperatures create the capacity for movement, rearing and refugia. In areas such as upper Nevada Creek where bull trout are (or nearly) extirpated, anthropogenic pressures (conversion of plant communities, instream dams and irrigation practices) have altered flow, temperature and sediment regimes at the watershed scale. In such cases, correcting anthropogenic limiting factors should be considered holistically and regionally before restoration of spawning areas alone can provide any realistic hope of population-level recovery.

McNeil Core spawning site surveys in the Blackfoot River basin

Introduction

The reproductive success of Blackfoot River trout populations often relates to the amount of "fine sediment" in spawning sites. Excessive sediment deposition can effectively smother incubating eggs and entomb alevins and fry, the effects of which can diminish recruitment to trout populations (Waters 1995; Reiser and White 1988). McNeil coring is a standard method used to classify, compare, and monitor spawning substrates (Lotspeich and Everest 1981, McNeil and Ahnell 1964). In western Montana, these coring methods apply not only to the characterization of spawning substrates and evaluations of the survival to emergence for bull trout and WSCT fry (Weaver and Fraley 1993; Fraley and Weaver 1991), but also to the monitoring of sediment producing activities such as road development and livestock-related streambank disturbances and associated corrective measures.

In 2004 and 2005 we collected McNeil core samples at 29 salmonid spawning sites on 22 streams (Figure 55).

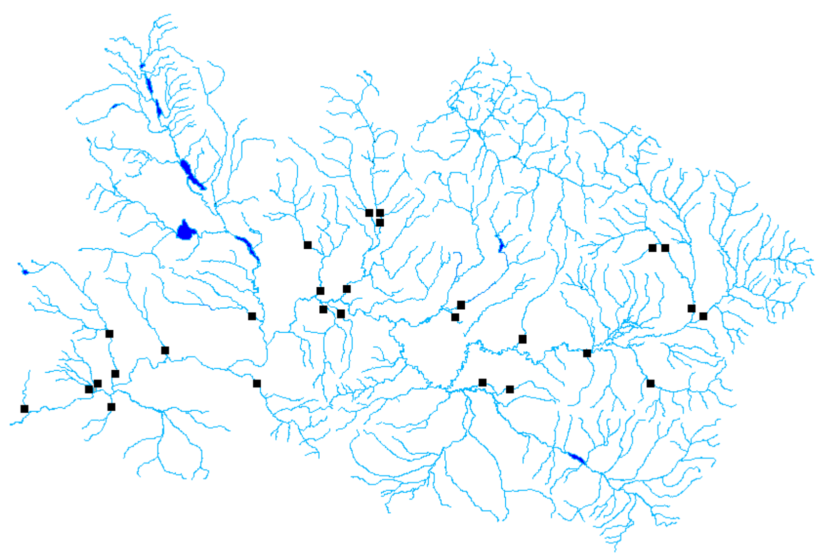


Figure 55. Generalized map of McNeil substrate coring locations in the Blackfoot Watershed, 2004-05.

The 2004 study characterized substrates adjacent to bull trout redds in four separate spawning streams and compared findings to comparable sites (pool tail-outs) in four suspected historical bull trout spawning streams, including three restored spring creeks and one basin-fed stream. Bull trout spawning streams are Gold Creek, Dunham Creek, Monture Creek and Copper Creek. Non-spawning streams include a section of Cottonwood Creek and three recently restored spring creeks (Rock Creek, Kleinschmidt Creek and Nevada Spring Creek). Our purpose was to help determine if suspected historical sites provide and environment conducive to bull trout reproduction. We also compared sediment cores on Monture Creek at two locations – at an unstable site upstream of an undersized bridge and below the bridge in a more geomorphically stable reach (Dave Rosgen, personal communication).

The 2005 core sampling measured spawning substrates at known spawning sites for fluvial salmonids including WSCT, rainbow trout and brown trout of the Blackfoot River. Implications of the combined 2004-5 studies relate to the general role (and existing limitations) of individual streams to spawning success of Blackfoot River fish, and to: 1) ongoing whirling disease research; 2) the recovery of bull trout; 3) the refinement of restoration techniques; and 4) evaluations of sediment producing land disturbance. Montana Fish Wildlife and Parks and Helena National Forest completed these surveys in coordination with the Blackfoot Challenge and the Natural Resource Conservation Service.

Methods

A hollow core sampler similar to the one described by McNeil and Ahnell (1964) was pushed into the streambed to a depth of ~15 cm for the 2004 bull trout studies and 10 cm for the 2004 non-bull trout surveys. For the 2005 non-bull trout surveys the sampler was pushed 10 cm into the streambed. The 15 cm depth is the approximate depth that bull trout deposit their eggs. (Shepard and Graham 1982). The 2004 samples included six to nine individual cores taken adjacent to individual bull trout redds and in pool tail-outs of restored streams thought to possess spawning features for bull trout. The 2005 cores (six per stream) were taken in July and August at known rainbow trout, brown trout and WSCT spawning sites.

The turbid water within the cone was sampled for sediment content utilizing an Imhoff cone as describe in Shepard et al (1984). The water in the core sampler was measured to the nearest half inch to calculate the intracore water volume and to assist in the conversion of the volume of the sediment captured in the cone to dry weight. The substrata was removed from the core area and placed in bags for transport to a USFS lab. Streambed samples were oven dried and shaken through sieve series containing 76.2 50.8, 25.4,12.7 6.3 4.76 2.38, 0.85, 0.074 mm mesh screens. The material retained within each sieve and the pan was weighed to the nearest hundredth of a gram. The estimated dry weight of the sediment within the Imhoff cone was added to the weight of material <0.074. Stream compositions were reported as percentage of each size class by weight.

Average values of geometric means, percent fines and Fredle indices values were computed. For the 2004 samples, we ran a Mann-Whitney statistical test on the average values of the fredle index, geometric mean and percent fines between the individual cores of the spawning the non-spawning sites. This was a test to determine if the samples have been drawn from populations with the same attributes. If the test was significant, then the samples cannot be considered products of populations with the same substrate distributions.

Geometric means, fredle indices and percent fines are measures utilized to evaluate the available substrate and its spawning value. Plants and McHenry (1988) reported the geometric mean diameter is a measure that relates to permeability and porosity of channels sediment. The Fredle index is an indictor of sediment permeability and pore size both of which increase as the index number becomes larger. Percent fines represent the amount of substrate material in categories <0.84 mm and <6.35 mm. Percent fines (<6.35mm) can calculate the percent survival of bull trout and WSCT at emergence (Weaver and Fraley 1991). The bull trout equation is: y = -1.29462x (% fines<6.35) +72.4615 (R^2= 0.91, P=<0.05) and the WSCT equation is y = ((-654812 (%<6.35mm) + 35.6747))*2) (R^2=0.72, P=<0.0005).

To test the difference in the between bull trout spawning locations (Dunham, Copper, Gold and Monture) to spring creek (Nevada Spring Creek, Rock Creek and Kleinschmidt Creek) spawning sites, we use a Mann-Whitney test on the values of percent fines <6.35mm, geometric mean and fredle index at different sites. For the Monture Creek bridge evaluation, we also used the same Mann-Whitney *t-test* to examine the differences in % fines, geometric mean and Fredle index at these two sites. All results were considered significant a P<0.05.

Results

Summary metrics of all McNeil core samples by total stream sample, including survival at emergence calculations for WSCT and bull trout are located in Table 14. Summary results (all streams) of two metrics of central tendency (Fredle index and geometric mean), ranked in ascending order by Fredle index are presented in Figure 56. Summary results (all stream) for two percent metrics of "fine" sediment (<0.84mm and <6.35mm), ranked in ascending order by the sample mean (<0.84mm), are located in Figure 57.

Stream Name	Date	Spp.	Stream Mile	Fredle Indices	Larger particle sizes (mm)			% Fines		% survival	
					Geo Mean	D25	D75	(< 0.84mm)	(< 6.35mm)	WSCT	Bulls
Arrastra Cr	8/4/04	WCT, LL	0.8 - 1.1	3.5 (2.3 - 5.4)	10.8 (7 - 15.7)	4 (2.4 - 5.9)	38.4 (22 - 49.8)	8.2 (3.1 - 11.2)	33.3 (26.1 - 41.4)	28	29
Blackfoot River	11/8/04	WCT,LL, DV	116.5 - 119.9	4.4 (1.8 - 7.3)	11.3 (6.9 - 14.3)	5.3 (2 - 9.3)	36.2 (25.1 - 47.3)	9.6 (6.6 - 15.8)	29.1 (18.8 - 42.3)	33	35
Blackfoot River	11/1/04	LL	104.4 - 105.2	5.2 (2.9 - 8.8)	12.7 (7.7 - 18.1)	6.4 (3.2 - 11.4)	38.3 (21.5 - 53.2)	10 (7.1 - 14.3)	27.2 (18.1 - 36.9)	36	37
Copper Cr	10/7/04	DV	3.3 - 8.5	4.6 (1.4 - 8.8)	11.4 (4.8 - 21.3)	5.4 (1.5 - 6.8)	33.9 (17.2 - 64.6)	8.6 (3.3 - 17.5)	30.7 (18.9 - 54.5)	31	33
Cottonwood Cr.	9/27/04	DV	6.6	3.1 (2 - 6.3)	9.2 (6.3 - 16.4)	3.7 (2.1 - 7.9)	34.1 (21.6 - 53.3)	11.8 (6.7 - 15.8)	37.0 (22.3 - 44.6)	23	25
Dunham Cr	9/21/04	DV	3.4 - 3.8	5.1 (1.6 - 9.1)	13.0 (5.5 - 19.9)	6.0 (1.9 - 11.7)	40.1 (22.9 - 54.2)	8.0 (2.1 - 16.5)	29.4 (16.5 - 47.4)	33	34
Gold Creek	9/14/04	DV	5.7 - 6.1	5.3 (2.2 - 9.5)	13.2 (7.4 - 20.1)	6.5 (2.5 - 12.4)	40.3 (21.3 - 55.9)	7.1 (4.1 - 11.3)	28.5 (17.3 - 40.4)	34	36
Kleinschmidt Cr.	9/28/04	LL	0.5 - 0.6	1.6 (0.4 - 5)	5.6 (2.3 - 12)	2.0 (0.5 - 6.6)	26.0 (11.6 - 44.2)	23.5 (7.1 - 39.9)	47.1 (24.4 - 64.3)	10	11
Monture Cr	9/7/04	DV	13.2 - 13.8	5.0 (2.1 - 14.8)	11.7 (6.9 - 22.2)	6.3 (2.2 - 20.8)	37.0 (23.4 - 54.8)	8.6 (6.3 - 12.5)	32.5 (12 - 43)	29	30
Monture Cr	9/20/04	DV	12.5 - 13.1	6.0 (2.8 - 13.1)	14.4 (7.9 - 25.6)	7.1 (3.1 - 16.3)	42.1 (24.2 - 62)	6.9 (3.3 - 11.1)	26.6 (14 - 36)	37	38
Nevada Spring Cr	9/29/04	LL	3.1 - 3.2	5.9 (0.6 - 26.1)	10.3 (2.1 - 34.1)	7.1 (0.6 - 30.8)	28.9 (7.7 - 52.7)	18.2 (3.1 - 34)	38.3 (3.3 - 71.7)	21	23
Poorman Cr	6/21/04	WCT	4.4 - 12.1	3.8 (2.3 - 5.4)	9.5 (6.2 - 14.3)	4.4 (2.9 - 5.8)	28.6 (17.3 - 40.8)	8.0 (2.5 - 13.6)	32.2 (26.9 - 37.5)	29	31
Rock Cr	9/28/04	RB, LL	1.6	1.9 (0.8 - 3.8)	6.2 (3.5 - 9.6)	2.0 (0.8 - 3.9)	22.5 (13.5 - 33.7)	15.6 (8 - 27.1)	46.3 (32 - 55.5)	11	13
Snowbank Cr	8/17/04	WCT	0.6 - 1.0	3.0 (1.9 - 4.7)	8.0 (5.1 - 12.5)	3.2 (2 - 5.1)	23.4 (13 - 41.1)	7.6 (5.1 - 10.1)	42.2 (28.8 - 54.4)	16	18
Arrastra Cr	8/2/05	WCT, LL	0.9 - 1.1	4.0 (2.1 - 6.2)	10.7 (6.2 - 14.3)	4.7 (2.2 - 7.6)	34.3 (19.8 - 42.6)	9.3 (6.6 - 13.7)	30.5 (22.5 - 39.7)	31	33
Bear Cr	7/23/05	RB, LL	0.7 - 0.8	4.6 (3.4 - 8.3)	11.1 (8.3 - 18.4)	5.3 (3.9 - 9.5)	30.5 (22.9 - 46.9)	5.9 (1.8 - 9.3)	30 (18 - 36.7)	32	34
Belmont Cr	7/30/05	RB, LL	0.2 - 0.4	2.8 (1.8 - 4.1)	7.6 (4.0 -12.9)	3.3 (2.0 - 4.7)	25.9 (10.3 - 50.6)	9.2 (6.3 - 13.2)	44.1 (31 - 57.5)	14	15
Blanchard Cr	7/30/05	RB	1.6 - 1.7	6.8 (2.2 - 11.1)	13.9 (5.7 - 20.3)	8.4 (2.8 - 13.5)	36.5 (18.3 - 49.2)	6.3 (1.8 - 12.8)	22.3 (12 - 43.5)	42	44
Chamberlain Cr	8/1/05	WCT	0.1 - 0.2	7.2 (6.3 - 10.9)	13.7 (6.8 - 19.5)	9.0 (2.5 - 12.6)	32.5 (21.2 - 40.1)	6.6 (1.1 - 12.9)	20.1 (11.8 - 37.6)	45	46
Cottonwood Cr	6/13/05	RB, LL	0.4 - 0.6	6.4 (1.5 - 19.6)	12.9 (5.2 - 28)	7.3 (1.8 - 21.4)	33.1 (21.3 - 47.3)	11.3 (0.9 - 21.2)	27.8 (4.0 - 42.2)	61	36
East Twin Cr	7/16/05	RB	0.1 - 0.2	7.6 (2.6 - 15.4)	15.8 (8.0 - 27.1)	8.9 (3.1 - 16.7)	40.8 (29 - 56.4)	5.9 (0.5 - 10.3)	21.8 (5.6 - 39.4)	43	44
Elk Cr	7/14/05	RB	3.1 - 3.2	0.8 (0.6 - 0.9)	3.2 (2.3 - 4.1)	0.7 (0.6 - 0.9)	12.9 (7.7 - 16.8)	29.1 (24.5 - 33.6)	58.4 (51.1 - 70.3)	-5	-3
Gold Cr	7/23/05	RB, LL	0.4 - 0.5	2.8 (1.4 - 3.3)	8.3 (4.2 - 12.2)	3.2 (1.8 - 4.1)	31 (15.5 - 58.9)	11 (8.8 - 15.6)	39 (32.5 - 53.5)	20	22
Johnson Cr	7/9/05	RB	0.1 - 0.3	3.2 (1.6 - 6.7)	10 (4.5 - 17)	3.6 (1.8 - 7.6)	38.3 (14 - 61.3)	7.9 (2.4 - 13.4)	40.4 (22.4 - 55.4)	18	20
Landers Fork	8/1/05	WCT	1.6 - 3.4	5.0 (3.2 - 5.3)	11.5 (6.8 - 21.1)	5.9 (3.7 - 10.6)	31.4 (16.5 - 58.7)	6.5 (2.1 - 11.9)	28.2 (14.7 - 37.2)	34	36
Monture Cr	7/29/05	WCT, RB, LL	2.0 - 2.5	3.0 (1.7 - 4.7)	8.8 (4.7 - 14.1)	3.6 (2.0 - 5.8)	30.5 (12.1 - 51.6)	12.1 (7.5 - 15.8)	37.5 (26.2 - 51)	22	24
Pearson Cr	8/1/05	WCT	2.0	4.8 (3.6 - 6.8)	9.4 (1.5 - 13.7)	5.7 (4.0 - 8.3)	31.8 (28.4 - 34.2)	8.9 (5.4 - 13)	26.7 (20.9 - 32.2)	36	38
Wasson Cr	7/27/05	WCT	2.4	1.8 (0.9 - 3.2)	4.8 (3.0 - 7.7)	2.0 (0.9 - 3.8)	14.8 (10 - 21.1)	17.3 (12.7 - 24.7)	49.2 (32.2 - 60.9)	7	9
West Twin Cr	7/16/05	RB	0.1 - 0.2	5.6 (3.9 - 11)	13.2 (8.9 - 24.1)	6.5 (4.6 - 12.8)	35.9 (22.6 - 61.5)	5.3 (1.7 - 8.6)	26.6 (14.2 - 31.5)	37	38

Table 14. Summary metrics for 29 McNeil core samples.

Existing bull trout spawning sites had significantly lower percent fines (P=0.0004), significantly higher geometric means (P=0.0004) and Fredle indices (P=0.0001) than the spring creeks (Table 15). We also tested individual spring creeks against the combined bull trout spawning locations. Rock Creek and Kleinschmidt were significantly different from the bull trout spawning sites when tested against the three variables (Table 15), whereas Nevada Spring Creek did not have a significantly different amount of percent fines or Fredle index, but had a significantly lower geometric mean (P=0.037).

	spring creeks verses existing bull trout spawning sites			
	All spring creeks	Nevada Spring	Kleinschmdt	Rock
% Fines (<6.35mm)	0.0004	0.206	0.006	0.002
Geometric mean	0.0004	0.037	0.003	0.002
Fredle Index	0.0001	0.139	0.002	0.002

Table 15. Summary of statistical analysis (P-value) comparing sediment core metrics of existing bull trout spawning sites to restored spring creeks.

For the Monture Creek comparison, we found both a lower percentage of fine sediment (<6.35mm) and a larger particle size (i.e. higher geometric mean) below the bridge than above the bridge, however these differences were not significant (% fines P= 0.336, geometric mean P=0.336, Fredle P=0.297).

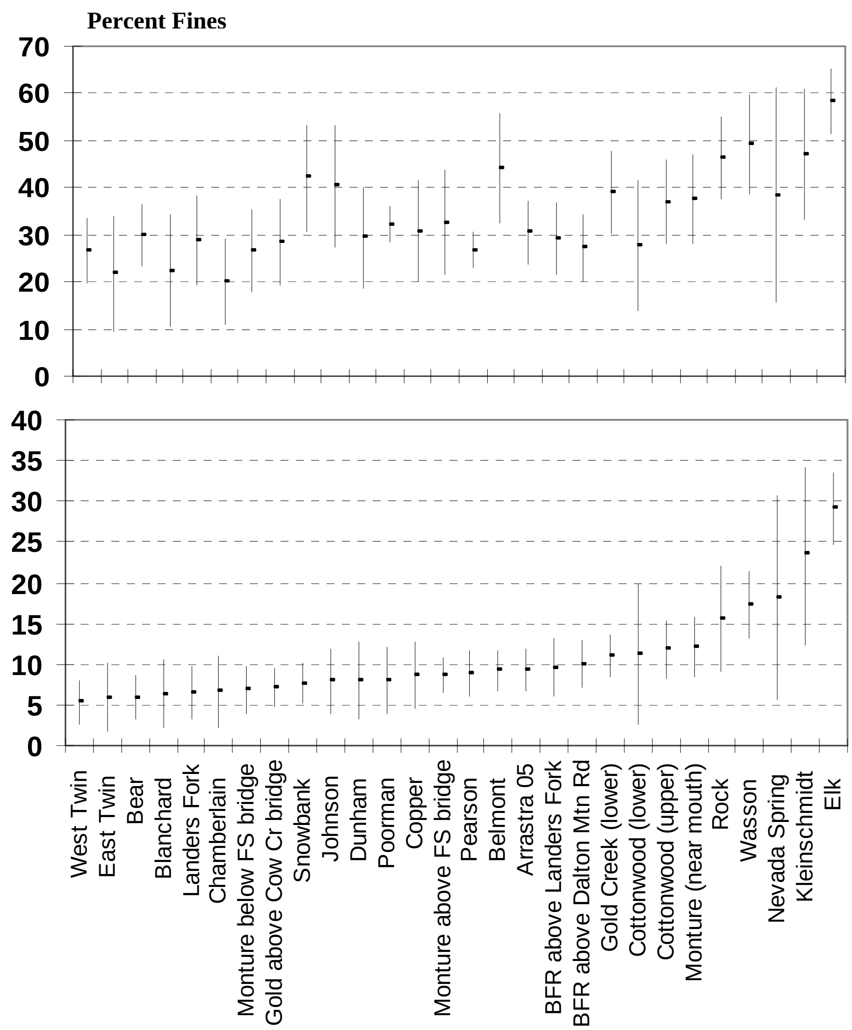


Figure 57. Percent fine sediment (mean + SD) for particles <6.35mm (top) and <0.84mm (bottom) for 28 Blackfoot River spawning streams.

Discussion

The Blackfoot River drains a "geologically young" sediment-rich watershed formed of glacial landforms that is highly subject to natural sediment producing events such as wildfires and landslides. Within a natural setting, flushing flows through vegetatively stable channels performs a sorting and cleansing process of stream substrates that permit fish populations to reproduce and flourish. The Blackfoot Watershed is however also an area highly prone to anthropogenic sediment producing activities from mining, silviculture, roads and grazing. A majority of the 36 TMDL listed stream are at least partially impaired as a result of sediment (Blackfoot Challenge 2005). It is elevated anthropogenic sediment from chronic sources that commonly limits a stream's reproductive capacity. High levels of fine sediment in the Blackfoot River system have significant implications for native fish recovery as well as sport fisheries. Generally, the basin's natural high levels of sediment reduce flexibility of land managers to contribute sediment to the system. In the case of bull trout spawning streams, fine sediment levels (<6.35mm) are near or above threshold limits (30%) above which survival decreases significantly (Shepard et al 1984). Land managers must understand that naturally high levels of sediment in many streams (and spawning sites) provide little room for additional human caused sedimentation.

This baseline provides a potential tool for land managers to interpret the value of existing spawning sites for multiple salmonids of the Blackfoot River and for monitoring future instream sediment changes. However, these data were collected in low flow years and may not fully representative. Interpretation should also be considered within the context of channel slope and channel-type. Certain streams such as spring creeks and E-type channels also naturally support higher levels of fine sediment.

From the perspective of general trout spawning success, the core sample data provides two accepted methods of assessing the value of spawning sites. These are measures of percent fines (<0.84 and <6.35mm) and central tendency (Fredle index and geometric mean diameter) of the sample.

Fine sediments (<0.84mm in diameter) are considered among the most detrimental to incubating eggs (Reiser and White 1988; Hall 1984). It is this material that most often enters important spawning streams as a result of human activities (Reiser and White 1988;

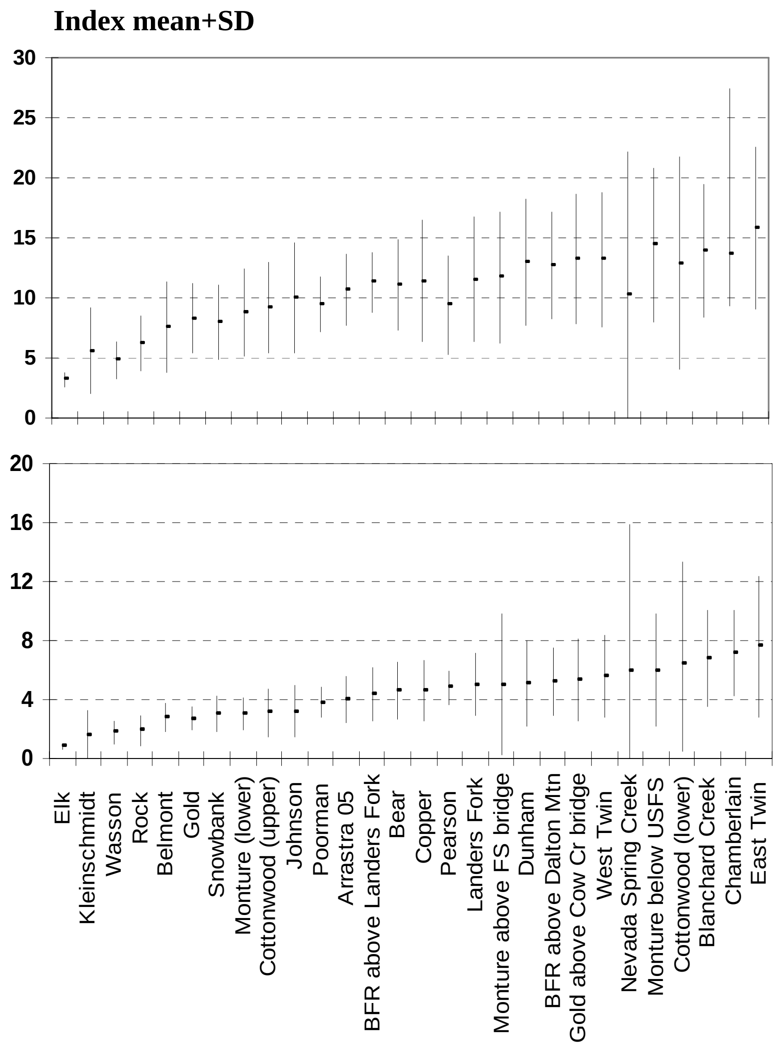


Figure 56. Geometric mean (top in mm) and fredle index mean (bottom) for 29 spawning streams in the Blackfoot Watershed, 2004-05.

Beschta 1982). When these fines exceed 20%, significant mortality of embryos can be expected (Waters 1995). Results of the 2005 study show only two streams (Kleinschmidt Creek and Elk Creek) exceed this 20% value. Both streams are water quality (including sediment) impaired (TMDL 303(d)) due in part to riparian (agricultural) degradation (Blackfoot Challenge 2005). Fine (soft) sediment (and organics) has also been positively correlated with the abundance of *T. tubifex* – an obligate host to the parasite (*Myxobolus cerebralis*) that causes whirling disease in salmonids (Granath and Gilbert 2002). Corresponding with environments conducive to the input and accumulation of fine sediment, both streams are also highly WD infected (*this report,* Table 6).

The percentage of fine sediments (<6.35 mm) has been correlated with the survival of bull trout and WSCT at the time of emergence (Weaver and Fraley 1991; Fraley and Weaver 1993). The percentage of fine sediment in bull trout spawning sites ranged from 26.6 to 32.5, correlating to a range of survival of between 33 and 38%. This percentage of fine sediment appears high, but also approximates the range of "natural" levels in spawning riffles of the Blackfoot (USFS unpublished data, Kramer and Walker 1992). The percentage of fine sediment for nine WSCT spawning sites ranged from 20.1 - 49.2%, correlating to a range of survival of 7 - 45%. The WSCT spawning stream with the lowest predicted survival is lower Wasson Creek. This stream is currently undergoing restoration and grazing–related changes that when completed should substantially improve survival.

Fredle index and geometric mean, both central tendency measures of predicting embryo survival, are also accepted measures of spawning site suitability (Waters 1995, Young et al. 1991). Both show positive relationships between size and embryo survival. Based on these general relationships, a plot of central tendency spawning site "quality" is presented graphically in Figure 56.

Many spring creeks of the Blackfoot Valley historically supported bull trout populations; however, whether these spring creeks actually supported bull trout reproduction is unclear. Recent sampling by FWP has recorded the incremental expansion of bull trout back into several restored streams, including spring creeks, however bull trout reproduction has not been documented to date in any of these areas. Larger spring creeks in particular appear to have some of the site characteristics necessary for successful bull trout reproduction including groundwater upwelling. Despite certain similarities, sediment coring found significantly higher levels of fine sediment (<6.35) in two of three restored spring creeks compared to the bull trout spawning streams. Other disparities involve the broader physiographic and morphological settings in which existing bull trout spawning areas are found (i.e. 3rd order basin-fed glacial trough valleys) in the Blackfoot Watershed (*this report*). In addition these restored streams all exceed 30% fines (<6.35mm) – a level above which survival to emergence rapidly declines (Shepard et al. 1984). Based on survival to emergence equations for bull trout (Fraley and Weaver 1991), predictions of survival are notably lower (range 11-25%) for the restored spring creeks compared to the four bull trout spawning areas (range 33-38%). At the Cottonwood Creek site, the high level of fine sediment, a partial result of excessive livestock streambank damage, confounded our ability to compare and interpret survey results at this site.

It appears unlikely that levels of fines in these and other similar spring creeks will decline due to low energy and low channel gradients characteristic of spring creeks.

From the perspective of restoration, these cores also suggest spring creek restoration methods should correct upstream sediment sources prior to channel construction or placement of instream spawning gravels.

In 2004, we also ran an upstream/downstream comparison at an undersized bridge on Monture Creek (Dave Rosgen, personal communication). The upstream section is geomorphically "unstable" compared to geomorphically stable reach below the bridge (Dave Rosgen, personal communication). Although not statistically significant, the samples recorded a higher percentage of fines (<6.35mm) in the unstable sample compared to the lower sample. Based on prediction equations for percent survival at emergence for bull trout (Fraley and Weaver 1991), core samplings upstream of Monture Creek indicate lower survival (30%) compared to the downstream sample (38%). In this area, a combination of an undersized bridge, historical timber harvest and large concentrations of instream wood all appear to contribute to channel "instability." Interestingly, the channel complexity brought on in part by channel instability (log-jams and beaver activity) also appears to provide a high level of rearing area complexity upstream of the bridge.

Angler Surveys in Native Trout Recovery Areas within the Blackfoot River basin

Background

The Blackfoot River in west-central Montana provides a valuable wild trout fishery comprised of introduced rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*) and native populations of bull trout (*Salvelinus confluentus*) and westslope cutthroat trout (*Oncorhynchus clarki lewisi*) (Pierce et al. 2004). Recent fishery recovery efforts in the drainage have focused on native fluvial stocks.

The distribution and abundance of fluvial bull trout and westslope cutthroat trout (WSCT) in the Blackfoot watershed have been significantly reduced over the past century. Montana Fish, Wildlife and Parks (MFWP) fisheries surveys in 1999-2004 show low to very low populations in the lower 120 miles of the Blackfoot River. Abundance of adult bull trout in the main stem river reflects this scarcity as population estimates on several reaches of the Blackfoot River indicate that average adult densities are <1-5 per river mile (Pierce et al. 2004, MFWP unpublished data). Although fluvial WSCT densities are also far below historic densities, these populations have increased since the institution of catch and release fishing regulations in 1990 and subsequent habitat restoration (Pierce et al. 2004). Factors contributing to the decline of native trout populations in the Blackfoot River system include physical habitat degradation, loss of stream connectivity, water quality degradation, introduction of non-native salmonids and angling.

The impact of angling mortality continues to be of particular concern for fluvial bull trout populations in the Blackfoot River system. A series of recent telemetry studies in the Blackfoot and upper Clark Fork Basins indicate that intentional and unintentional harvest is conservatively responsible for 10%-15% of annual fluvial bull trout mortality (Knotek 2004; Pierce 2004; Schmetterling 2003; Swanberg 1997a; Swanberg 1997b). Patterns of angler use, combined with bull trout behavior and life history attributes make fluvial bull trout susceptible to illegal harvest and potentially high rates of delayed (catch and release) mortality. Angler use has increased significantly (140%) since 1989 on the main stem river (Table 16). Angling use has increased 553% in the middle Blackfoot River (reach 2), an area critical

Year	Reach 1	Reach 2	Reach 3	Total
1989	8689	2054	2732	13475
1991	9789	ND	4186	13975
1993	14006	7951	4744	26701
1995	10964	10020	3972	24956
1997	11555	8939	5128	25622
1999	16791	10399	5213	32403
2001	10405	11626	3080	25111
2003	13595	10544	2715	26854

Non-resident anglers (1989-2003)

Year	Reach 1	Reach 2	Reach 3	Total
1989	1672	460	622	2754
1991	1239	655	454	2348
1993	3394	3258	826	7478
1995	5555	3897	1818	11270
1997	3554	2980	3190	9724
1999	5974	5682	2356	14012
2001	2925	6253	1859	11037
2003	4861	5883	1427	12171

Table 16. Angler pressure estimates for the Blackfoot River 1989-2003.

to bull trout recovery and conservation. In this reach, non-resident use has increased 1,179% since 1989 (Table 16).

These trends are exacerbated by expanded public access sites in areas of seasonal bull trout concentrations (spawning, staging and thermal refuge areas). Although bull trout and WSCT comprise only a small proportion of the salmonids inhabiting these areas, they are more susceptible to angling than rainbow trout and brown trout (Schmetterling and Bohnemann 1999, MFWP unpublished data).

With these issues in mind, we developed a user survey that targeted anglers in key fluvial bull trout and WSCT staging and spawning areas in the Blackfoot River drainage in 2004. The survey was designed to assess regulation compliance, fish identification skills, angling methods, angler demographics, basic catch statistics and angler perceptions of crowding and access availability. A parallel, concurrent survey was completed at similar sites in the Clark Fork River drainage (Knotek 2005). The angler creel survey was an attempt to better understand angler use in areas specified by MFWP as *bull trout recovery-recreational conflict areas.*

Methods

In 2001, MFWP identified *bull trout recovery - recreational conflict areas* (Pierce et al. 2004). These *conflict areas* refer to biologically critical sites (key spawning, rearing and staging areas, important migration corridors and areas of thermal refugia) that overlap with recreational developments, increased angler pressure and illegal bull trout harvest problem areas.

Angler surveys of these sites were completed between June 1 and August 31, 2004, at 19 public access sites in the Blackfoot River system using a roving angler creel survey method. Survey locations included seven mainstem Blackfoot locations (including six developed fishing access sites (FAS)) and twelve tributary locations (including 2 developed fishing access sites) on five bull trout spawning streams (Figure 58).

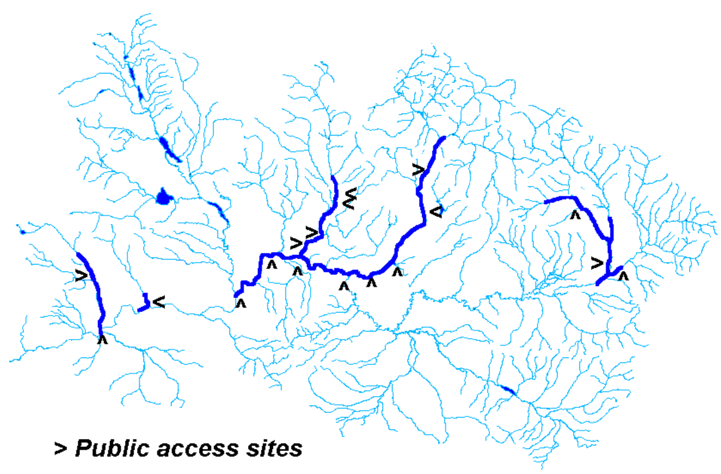


Figure 58. Bull trout recovery/recreational conflict areas. The arrows show angler interview locations.

To keep from surveying the same locations at the same time of day, the direction of survey circuit was reversed every other time the survey was conducted. Heavily used locations were often surveyed twice in one day. We searched an area of approximately 1000 feet upstream and downstream of each location for possible survey participants. Anglers were approached by MFWP fisheries personnel in uniform and asked if they were willing to be interviewed. All individuals that were fishing or intending to fish were interviewed.

Because we did not intend to estimate the amount of use, it was not necessary to conform to a structured randomized or stratified sampling scheme typically used in traditional creel surveys or recreation use surveys. Although we attempted to visit each site on each sampling day, survey technicians were scheduled to maximize the number of angler contacts. All interviews were conducted from shore. This biased our sample toward bank anglers at sites on the main stem where float fishing is common. However, many float anglers were interviewed when they stopped to fish our sampling locations. Bank anglers were those that accessed the river by walking or wading from the bank. Float anglers were those that accessed the river with some type of boat. All surveyed anglers were asked if they intended to harvest fish. Those that did not were assumed to be catch-and-release anglers.

Angler interviews consisted of five major components: 1) background and demographic information; 2) fishing methods; 3) fish identification; 4) knowledge of regulations and compliance; 5) catch information; and 6) perceptions of access and level of use (crowding). A copy of the actual survey form is to the end of this paper. For the fish identification portion of the survey, we developed a single sheet with five colored illustrations depicting the five common trout species in western Montana: westslope cutthroat trout, rainbow trout, bull trout, brown trout and brook trout (see attached survey form). These are the same color plates used in the Montana fishing regulations. Anglers were given the sheet and asked to identify each of the trout species. The survey technician recorded a correct or incorrect response for each species. Hooks were visually inspected to assess whether the angler was fishing with barbed or barbless hooks. Finally, anglers and guide/outfitters licenses were checked for regulation compliance.

Table 17. Survey locations and number of interviews in 2004 Blackfoot River angler survey.

Site	Number of interviews (%)
Upper Gold Creek	0 (0)
Johnsrud (FAS)	19 (7.3)
Belmont Creek (mouth)	11 (4.2)
Clearwater River (FAS)	35 (13.4)
Russell Gate (FAS)	27 (10.3)
Scotty Brown bridge	46 (17.6)
River Junction (FAS)	40 (15.3)
Monture Creek (FAS)	21 (8)
Monture Creek @Hwy 200	1 (0.3)
Monture Creek bridge	4 (1.5)
Monture Creek trailhead	1 (0.3)
NFBLKFT @ Harry Morgan (FAS)	16 (6)
NFBLKFT @ Ovando-Helmville Rd bridge	1 (0.3)
NFBLKFT @ Hwy 200	4 (1.5)
NFBLKFT @ USFS bridge	18 (7)
NFBLKFT trailhead	9 (3.4)
Landers Fork @ Hwy 200	2 (0.8)
Copper Creek bridge	3 (1.2)
BLKFT @ Aspen Grove	4 (1.5)

Results

The 19-location circuit was surveyed 29 times over a 14-week period between June 1 and August 31, 2004, averaging twice per week. Two hundred and sixty two interviews were conducted (Table 17). We interviewed a total of 237 (90.6%) anglers, of which 101(42.6%) were resident Montana anglers, 136 (57.4%) non-resident anglers and 25 (9.5%) guides/outfitters. Two anglers and three guides were repeat interviews and two guides were interviewed four times each. One guide, also fishing, was included as an angler.

The highest numbers of interviews occurred during July with 115 (44%), followed by June with 97 (37%) interviews and August with 50 (19%) interviews. The highest concentration of interviews conducted occurred at MFWP fishing access sites (Table 17).

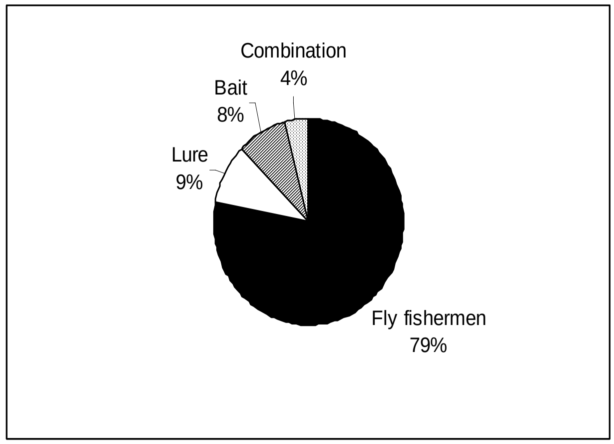


Figure 59. Type of fishing gear used by anglers on Blackfoot River in 2004.

Sixty-seven percent (n=158) of the interviews were with bank/wade anglers, while 33% (n=79) were angling exclusively from a boat. Of the 136 non-resident anglers, 53 (39%) used a guide/outfitter, compared to two of 101(2%) resident anglers. Overall, seventy-nine percent (n=185) of all anglers interviewed were exclusively fly-fishing, followed by 9% (n=22) lure fishing and 8% (n=20) bait fishing. Four percent (n=10) of the anglers used a combination of gear (Figure 59). Eighty-seven percent (118 of 136) of non-resident and sixty-six percent (67 of 101) resident anglers interviewed were using barbless hooks while twenty-three percent (43 of 185) used barbed hooks; seven percent (14 of 185) used both. Seventy-six percent of all lure and bait anglers used barbed hooks.

Fish Identification

Thirty-eight percent (89 of 237) of all anglers interviewed properly identified all five trout species. Fifty-eight percent of resident Montana anglers correctly identified all five trout species compared to only 24% of non-resident anglers. On identifying native trout species, 76% of resident anglers correctly

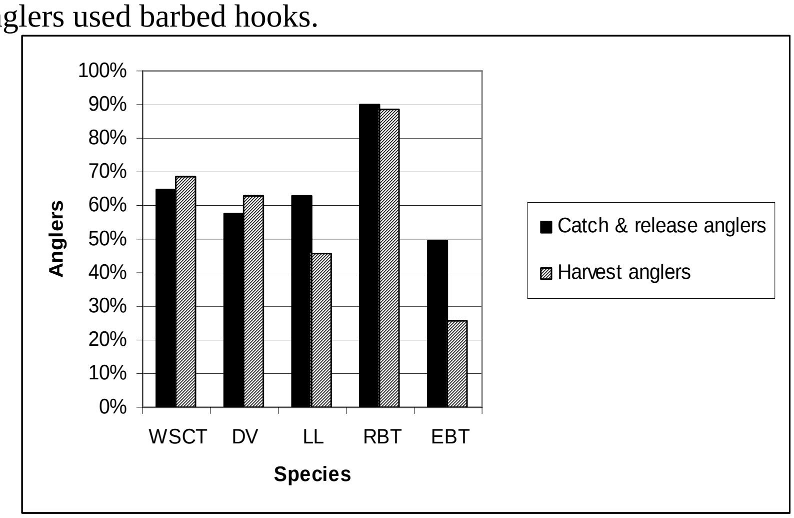


Figure 60. Percent of anglers that identified trout species correctly.

identified bull trout and 85% correctly identified WSCT. For non-resident anglers, 45% correctly identified bull trout and 51% correctly identified WSCT.

Thirty-five of 237 interviewed anglers (15%) expressed a desire to harvest fish. Of the 35 harvest anglers, only 7 (20%) correctly identified all five species of trout, compared to 42% of catch and release anglers. However, a majority (66%) of the harvest anglers identified both WSCT and bull trout correctly, compared to 61% of the catch and release anglers. Fifty-two percent of anglers that attempted to identify WSCT misidentified it as a brown trout. Of all anglers that attempted the fish ID test, 50% misidentified bull trout as brook trout.

Ninety percent of all anglers correctly identified rainbow trout, but only 46% of harvest anglers compared to 63% of the catch & release anglers could correctly identified brown trout (Figure 60). Thirty-six percent of all the harvest anglers misidentified brown trout as brook trout. Brook trout were correctly identified by 50% of the catch & release anglers compared to 26% of harvest anglers.

How anglers learned to identify trout species.

Fifty-nine percent of all anglers who identified four of five trout species correctly answered fishing experience as their means of learning to identify trout (Table 18). Forty-one percent claimed their fish identification knowledge came from fishing regulations and 26% indicated MFWP signs contributed to their knowledge to trout identification. Learning to identify trout species from a parent or family member accounted for 16%. Books, friends, educational programs, and guides contributed $\leq$ 10% to an angler's knowledge of trout identification.

Table 18. How anglers on the Blackfoot River system learned to identify trout.

How Anglers Learned to Identify Trout	Number of Responses
Total number of anglers	**110**
Fishing Regulations	45
Fishing Experience	65
MFWP Signs & Advertisements	29
Friend	5
Book	10
Parent / Family Member	18
School/Education Programs/ Previous Survey	1
Guides	7
Other (Internet, Hatchery)	2

Rating the amount of public access and use by angler

Anglers and guides were asked to rate the availability of public access and the majority (90%) of all participants interviewed rated the amount of access to be about right. Eight percent indicated that there is not enough public access and 2% claimed there is too much access.

Participants interviewed were also asked to rate the amount of use by other anglers or recreationists observed at the location they were fishing. Most survey participants (52%) rated the amount of use as light, 38% rated it very light, and 9% answered slightly crowded. Less than 1% rated use as very crowded (Figure 61).

Results of Regulations Knowledge and Angler Compliance

All anglers and guides surveyed possessed current licenses and regulation compliance was 100%. Most anglers (76%) had a copy of Montana fishing regulations with them (Table 19). A majority of anglers interviewed knew the special angling regulations for bull trout (78%) and WSCT (63%) although differences were noted between resident and non-resident anglers. Ninety-seven percent of resident Montana anglers compared to 64% non-resident anglers knew the special regulations for bull trout and 81% of resident, compared to 49% of non-resident anglers knew special WSCT regulations. Fifteen percent (n=35) of interviewed anglers indicated they were going to harvest fish, of which 80% and 71%, respectively, knew the special angling regulations for bull trout and WSCT, compared to 61% and 77% of all catch & release anglers interviewed.

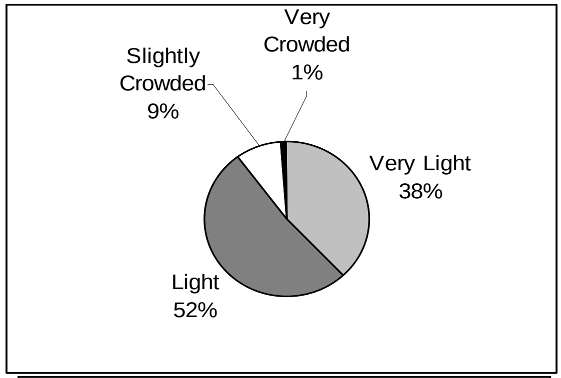


Figure 61. Responses when asked to rate the amount of use by other anglers and recreationists at the present locations they were fishing.

Table 19. Compliance and knowledge of regulations among various angler groups on the Blackfoot River in 2004.

	Have License	Have Regulations	Know Special WSCT Regs	Know Special Bull Trout Regs	Caught Violating Regulations
All Anglers	100%	76.4%	63.0%	78.1%	0%
All Guides	100%	88%	100%	100%	0%
MT Resident Anglers	100%	94.1%	81.2%	97%	0%
Non-resident Anglers	100%	63.4%	49.6%	64%	0%
Anglers Harvesting Fish	100%	89%	71.4%	80%	0%
Catch & Release Anglers	100%	74.2%	61%	77.2%	0%

Creel data

Of the 237 anglers interviewed, 145 (61.2%) had accumulated time fishing. These anglers caught 196 fish in 350 hours for a total catch rate (all fish) of 0.56 fish/hour. Of this the catch rate for trout species of 0.47/hour.

Seventy-nine of 237 anglers surveyed were float anglers. The majority of these (n=47) had not yet begun fishing at the time of the interview. The remaining 32 float anglers accumulated a total of 95 hours of fishing, averaging 2.97 hours/angler. These anglers captured 30 fish (15% of the total catch) for a catch rate of 0.32 fish/hour. We surveyed 158 bank/wade anglers, of which 45 had not yet begun to fish. The remaining

113 bank/wade anglers accumulated 255 total hours of fishing, averaging 2.26 hours/angler. These anglers captured 85 % of the total fish caught (n=166) for a catch rate of 0.65 fish/hour.

WSCT were the most frequently captured fish registering 49% of the total catch (Figure 62). Anglers caught 95 WSCT for a catch rate of 0.27 fish/hour. Fifty seven percent of all anglers that caught fish, reported at least one WSCT. All WSCT were released.

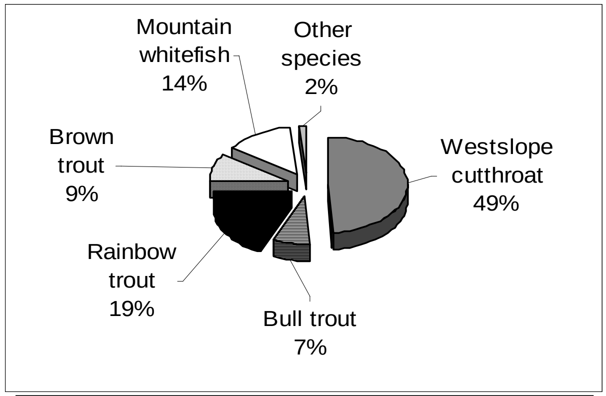


Figure 62. Percent of fish species caught on the Blackfoot River in 2004.

Anglers caught 37 rainbow trout for a catch rate of 0.11 fish/hour. Rainbow trout accounted for 19% of the total catch. Anglers released 97% of all rainbow trout. Ten anglers caught a total of 17 brown trout for a catch rate of 0.05 fish/hour. Brown trout represented 9% of the total catch. Anglers released 88% of all brown trout. Bull trout accounted for 7% of the total catch with a total catch rate of 0.04 fish/hour. Interestingly, five anglers (3% of the total anglers surveyed) caught 14 bull trout, all of which were released. Anglers caught 28 mountain whitefish producing the third highest catch rate of all species caught at 0.08 fish/hour. Mountain whitefish accounted for 14% of the total catch. Twelve percent of all anglers that caught fish, reported catching at least one mountain whitefish. No mountain whitefish were reported harvested. Reportedly, anglers caught three other fish species (e.g. pikeminnow and largescale sucker) making up 2% of the total catch. Ninety-eight percent (n=193) of all caught fish were reportedly released, less than 2% (n=3) were harvested.

Discussion

Creel Data

Total catch rates declined from 0.79 fish/hour in 1996 to 0.56 fish/hour in 2004 (Schmetterling and Bohnemann 2000). Blackfoot River catch rates for trout (0.47 trout/hour) also were lower than 2004 catch rates on the Clark Fork at 0.77 trout/hour (Knotek 2005). These differences may partially reflect differences in the survey methods among these various studies, as well as recent declines in trout densities occurring during the current drought. Unlike the 1996 survey, we did not access the river to maximize the number of float anglers interviewed. All interviews conducted with float anglers were at access sites while anglers were beginning or ending their float trip or waved to shore as they floated passing a location.

WSCT was the most frequently caught species of trout on the Blackfoot River. Five of fifty anglers (10%) that captured trout caught at least one bull trout. Both native species were captured in higher proportions than their relative abundance in the Blackfoot River system. Interestingly, we found a small percentage of anglers capture a high percentage of bull trout. And the majority (12 of 14) of bull trout captured were taken from spawning locations with anglers using bait. One bait angler alone captured nine bull trout. Although all bull trout caught by anglers were released, bait and lure anglers with barbed hooks accounted for 78% of all bull trout caught.

Angler Data

Catch and release fly-fishing continues to be the most popular type of angling on the Blackfoot River. In 1994, forty two percent of anglers exclusively fly-fished (Peters and Workman 1996), compared to 69% in 1999 (Schmetterling and Bohnemann 2000) and 79% in 2004. Regardless of gear type, Blackfoot anglers released 98 % of all fish caught, compared to 95% in 1999 (Schmetterling and Bohnemann 2000) and 84% in 1994 (Peters and Workman 1996). In 2004, eight percent of all Blackfoot anglers surveyed used bait compared to 30% in 1994 (Peters and Workman 1996).

These increases in fly-fishing and catch and release reflect a parallel trend in the 2004 Clark Fork River angler surveys (Knotek 2005). Catch and release for trout were 98 % and 97% for the 2004 Blackfoot River and Clark Fork surveys and 38% more Blackfoot fly anglers used barbless hooks compared to Clark Fork fly anglers. Overall, the number of Blackfoot anglers using barbless hooks (all gear types) decreased from 65% in 1999 (Schmetterling and Bohnemann 2000) to 58% in 2004. The 1999 survey of barbed/barbless hooks was based on a questionnaire, while the 2004 results were based on visual inspection of the hooks.

Fish Identification

The intended effect of fishing regulations relies on anglers knowing and understanding regulations as well as their fish identification abilities. Bull trout are often the least identifiable to anglers in Montana. Although fishery managers have implemented protective regulations for native trout, unintentional harvest is occurring because of angler inability to identify the trout species (Schmetterling and Long 1999, FWP unpublished data).

Most anglers surveyed easily identified rainbow trout. However, identification of native bull trout and WSCT was less successful. Angler identification skills of native trout species were relatively consistent between catch-and-release and harvest anglers with a 63% success rate. Non-resident anglers were 41% less successful at identifying both native trout than resident anglers. Cumulatively, only 51% of the angler sub-categories (resident vs. non-resident and catch-and-release vs. harvest anglers) correctly identified both bull trout and WSCT. Overall, angler ability to identify trout species was poor, with only 38% correctly identifying all five species. Anglers intending to harvest fish had more difficulty identifying all five trout species with a 20% success rate compared to 42% of catch-and-release anglers. The success rate by Montana resident anglers on our fish identification test increased 19%, while non-resident anglers showed a 1.3% increase in fish identification skills compared to a 1996 study.

Brook trout were the most often-misidentified trout species, followed by bull trout. All anglers that misidentified bull trout most often confused the species with brook trout and vice versa. Bull trout were also misidentified as brown trout. Anglers who misidentified WSCT often confused the species with brown trout.

The inability of anglers to identify most trout species on western Montana waters is well documented (Schmetterling and Long 1999; Schmetterling et al. 2000). The general results from this study, coupled with the results of these previous studies, suggest the need for continuation and enhancement of angler education efforts in bull trout recovery-recreational conflict areas.

Anglers that successfully identified 4 of 5 trout in our survey were asked how they learned identify these species. Most anglers responded through angling experience followed by MFWP provided information, fishing regulations and posted signs at fishing access sites have contributed significantly to educating anglers to fish identification and regulations. Schmetterling and Long (1999) also reported that angler fish identification skills are positively related to angling experience.

Regulations and Compliance

During this study, no fishing violations were observed. All anglers and guides interviewed were in compliance with fishing regulations and possessed licenses. However, warnings were issued to five anglers not carrying their licenses on them at time of their fishing activities. Non-resident anglers accounted for 57% of all anglers surveyed. The majority of non-resident anglers fly-fished and practiced catch-and-release, but only 63% possessed a copy of fishing regulations and an average of 57% knew the special angling regulations for bull trout and WSCT. Future management action may include increasing efforts toward educating non-resident anglers.

Amount of public access

When asked to rate the amount of public access on the Blackfoot River or tributary stream they were fishing, results indicate that the majority of anglers surveyed were satisfied with the level of availability of public access.

Amount of Angling and Recreation Use at All Locations

Anglers and guides in our survey were asked to rate the amount of use by other anglers and recreationists at the location they were fishing and quantify the number of each type they observed. Results show that most survey participants rated the amount of use as light (Table 20). This perception of low crowding was likely influenced by angling restrictions and other attempts to discourage use of the Blackfoot River and bull trout spawning streams during the summer of 2004 due to drought concerns.

		Total and (Average) Number of Users Observed by Surveyed Anglers and Guides		
Level of Use Reported	***Number Responses***	**Bank Anglers**	**Float Anglers**	**Other Recreationists**
Very light	98	29 (0.3)	60 (0.6)	74 (0.8)
light	134	107 (0.8)	541 (4.0)	216 (1.6)
Slightly crowded	23	17 (0.7)	158 (6.9)	35 (1.5)
Very crowded	1	0	0	25 (25)

Table 20. Number of different types of recreationists observed by anglers and guides asked to rate the level of use at the location they were fishing during 2004 Blackfoot River creel survey.

Project Summary and Management Implications

Small sample size due in part to emergency drought angling restrictions during the study period limits our ability to fully interpret study results from a management perspective. Regardless, the impact of angling mortality continues to be a concern as managers attempt to recover fluvial bull trout and WSCT trout populations. In this survey, we found that a significant shift to catch-and-release fly-fishing is occurring among the angling constituency. Overall regulation compliance was high and anglers that we surveyed harvested no native trout. However, fish identification continues to be a problem, particularly for anglers intending to harvest fish. Most anglers that we surveyed were satisfied with the level of current angling use and public access, but results may not be representative of normal years given angling restrictions imposed during the study period.

Despite high regulation compliance in our survey and trends of increased catch-and-release fly fishing, telemetry data and continued enforcement cases involving illegally harvested native trout indicate that efforts to discourage harvest should continue. The basis of the perceived problem involves increasing numbers of anglers that are provided access and are focused on native trout staging and spawning areas (traditionally premier fishing locations for all trout species). Native fluvial trout, particularly bull trout, are concentrated in these areas when angling pressure is highest (summer/early fall) and are extremely vulnerable to angling relative to other trout species. Because of low overall densities, bull trout and WSCT are still a minority of trout caught at main stem sites. Though caught infrequently, catch rates for both species are high relative to actual abundance. A small percentage of angler captures were responsible for the majority of the bull trout catch, perhaps indicating some “recreational targeting” of the species, despite regulations against targeting of bull trout. The highest bull trout catch occurred in a bull trout spawning area by anglers using bait and barbed hooks, which leads to higher post-capture mortality than other forms of angling. In the case of adult fluvial bull trout, angled fish are generally large. This is believed to subject the fish to a higher likelihood of harvest or likely a longer period of stress during capture and release. The indirect impact (mortality) due to catch-and-release angling needs to be evaluated.

This survey and other fisheries data collected on the Blackfoot River system suggest that angler education and enforcement efforts should focus on specific angler groups and locations. Specifically, anglers harvesting fish on bull trout spawning streams should be targeted. Native fish issues also need to be better incorporated into river recreation planning, river management and development of public access sites. Without this coordinated approach, ongoing native fish restoration and recovery actions may be compromised.

Appendix I: **2004 ANGLER SURVEY**

Site ______________ **Location**___________ **Date**________ **Time**________ **Interviewer**__________

Notes: ____

Gender: M F
Age:
Bank-fishing Float fishing

Do you have a fishing license? Yes / No **Outfitters license?** Yes / No

Noncompliance Information:

Name ____

Conservation License # / Drivers License #____

Address and Phone ____

Angler Surveyed Previously? Yes / No **If so, how many times**? __________

Are you a resident of Montana? Resident / Nonresident

Are you fishing with a guide today? Yes / No Guide **Guide's name** ________________**Outfitter** ________________

Gear Type: Fly Bait Lure
Hook size:
Hook types: single / multiple barbed / barbless single / multiple barbed / barbless single /multiple barbed/barbless

What time did you begin fishing today? ________________**(# hrs fished** _____)

Do you have a copy of the fishing regulations? Yes / No

Do you intend to keep fish if you catch them? Yes / No

Type and number of fish kept and released:

	<u>Kept</u>	**<u>Released</u>**
Brown trout		
Bull trout		
Rainbow trout		
Brook trout		
<u>Cutthroat trout</u>		
<u>Mountain Whitefish</u>		
<u>Other ____________</u>		

How many times have you fished at this location this year? _________________

Do you know the fishing regulations for cutthroat trout at this location? Yes / No

Do you know the fishing regulations for bull trout at this location? Yes / No

<u>Fish ID Skills</u>	**<u>Correct Answer</u>**	(Use attached sheet)
Brown Trout	yes / no	
Bull Trout	yes / no	
Rainbow Trout	yes / no	
Brook Trout	yes / no	
Cutthroat Trout	yes / no	

<u>If WCT and/or bull trout identified correctly, how did you learn to identify these species?</u>

Signs Friend School/ Ed programs Parent

Fishing regs Guide Book

Other_______________________

How would you rate the amount of use by recreationists and anglers <u>at this location today</u>?

very light light slightly crowded very crowded

How many other anglers and recreationists have you seen on your trip today?

Bank anglers_______ Float anglers_______ Other recreationists _______

How would you rate the availability of public access on this river/stream?

Not enough access Access about right Too much access

Do you have any comments for river managers?

Illustrations used in the fish identification portion of the 2004 survey

A summary of an integrated stream restoration and native fish conservation strategy for the Blackfoot River basin (*see* Pierce, Aasheim and Podner 2005 for details)

Since the fisheries restoration initiative began in 1990, restoration projects have become more inclusive of native fish, water quality, instream flows, landscape protection and many other watershed-level concerns. As a result, the need for a more clearly defined comprehensive, watershed-wide, restoration strategy has emerged. This need originates from 1) an expanded number (and scope) of watershed interest groups, 2) a cadre of recent federal, state and regional fisheries management directives, 3) the development of total maximum daily load (TMDL) plans, and 4) the initiation of a watershed-level long-term drought planning process, among other actions. While undertaking these various programs, it became apparent that consolidating stream restoration, native fish recovery and other supporting activities was necessary. Our rationale for generating a comprehensive restoration strategy was that by integrating all fisheries-related restoration programs into a single guiding document, the Blackfoot Cooperators could better meet a common suite of conservation goals.

At the request of the Blackfoot Challenge, FWP updated a restoration prioritization matrix established by Pierce et al. (2002). The new prioritization incorporating 1) all 102 inventoried tributaries, 2) six reaches of the Blackfoot River, 3) the DEQ *303(d)* list of water quality impaired streams, and 4) the FWP *dewatered stream list*. Our purpose was to develop a cohesive restoration strategy that directs stakeholder involvement to common priorities involving the needs of native and recreational fisheries, improvements to water quality and instream flow. To this end, the plan provides a comprehensive, native fisheries-based, priority-driven template for restoration projects and expands upon the gains of the existing Blackfoot River Restoration Program.

Our prioritization scheme attempts to guide the limited resources of the Blackfoot Cooperators to biologically important tributaries located primarily on private lands. Although the prioritization is intended to guide restoration activities, as new information becomes available and as additional limiting factors are identified low priorities may be elevated potentially triggering restoration action. We recognize unique restoration opportunities may be presented, and that continued input from landowners and managers will help guide the Blackfoot River restoration initiative.

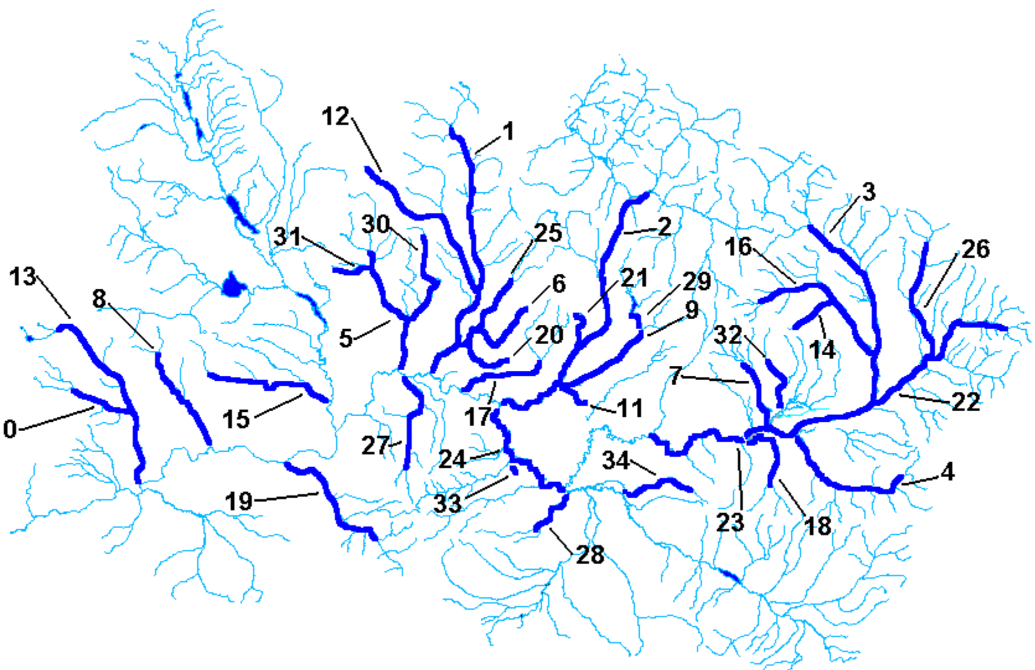
High priority streams

Of the 108 stream bodies, thirty-four received a high total priority rank (Figure 63). Projects in these watersheds will be high priorities for fisheries funding and project development under this restoration strategy. Streams bodies in this category include 1) three reaches of the mainstem Blackfoot River, 2) all major bull trout spawning streams, and 3) other direct tributaries to the Blackfoot River including several from the Garnet Mountains. These streams are biologically connected to the Blackfoot River, and generally support the strongest native fish populations.

Tributaries originating in the northern mountains within the watershed are generally the larger streams. Headwaters range from USFS lands with wilderness designation to intensively managed private industrial forestlands. To varying degrees, these streams represent some of the best opportunities to protect, restore and manage essential habitats occupied by communities of fluvial WSCT and bull trout. In lower stream reaches, several also support important recreational rainbow and brown trout fisheries, as well as brook trout. From a planning perspective, projects for these streams should be consistent with bull trout recovery plans and fluvial WSCT conservation plans unless site-specific measures suggest other actions.

Garnet Mountain streams ranked high due to in part water quality, flow enhancement potential and social considerations. These streams all possess human-induced limiting factors related to habitat problems. Streams in this category generally contain fluvial WSCT and other species important to the Blackfoot River sport fishery.

Listed 303(d) streams in the high priority category are 1) Monture Creek, 2) Poorman Creek, 3) Belmont Creek, 4) Rock Creek, 5) Kleinschmidt Creek, 6) Blanchard Creek, 7) Warren Creek, 8) Elk Creek 9) Blackfoot River reaches 1, 2 and 4, 10) Chamberlain Creek, and 11) McElwain Creek.



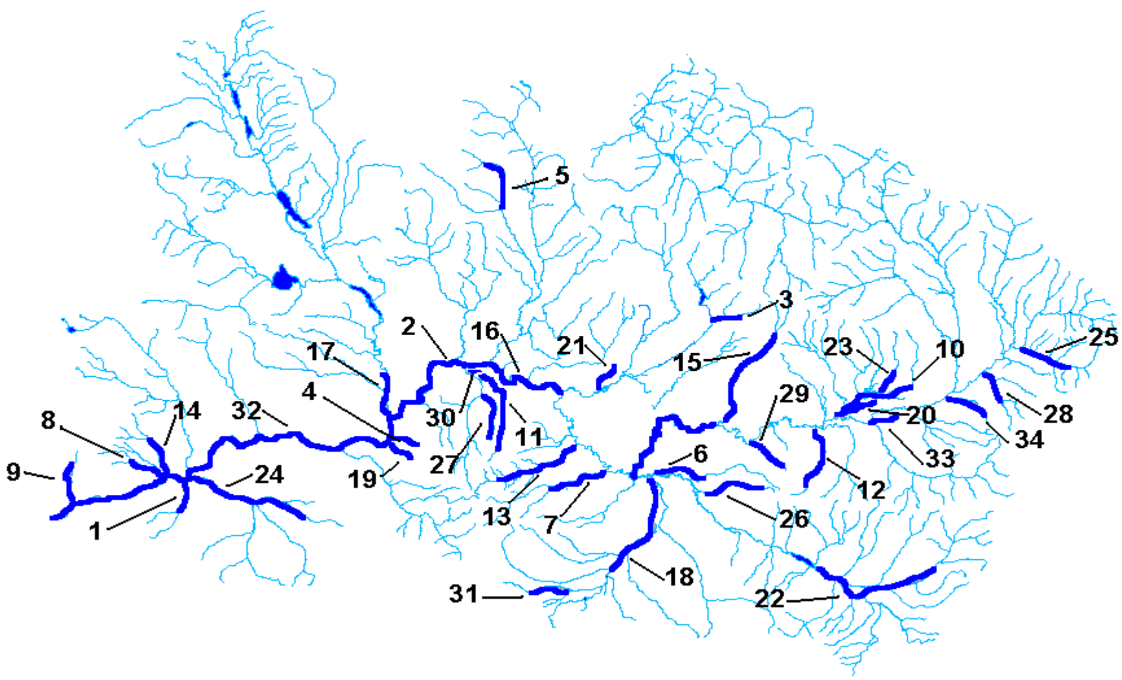
Stream ID #	Stream Name	Total Rank	Stream ID #	Stream Name	Total Rank	Stream ID #	Stream Name	Total Rank
1	Monture Creek	1	12	Dunham Creek	6	23	Blackfoot River 2	9
2	N.F. Blackfoot R.	1	13	Gold Creek	6	24	Blackfoot River 4	9
3	Landers Fork	2	14	Snowbank Creek	6	25	McCabe Creek	9
4	Poorman Creek	2	15	Blanchard Creek	7	26	Alice Creek	10
5	Cottonwood Cr. (R.M.43)	3	16	Copper Creek	7	27	Chamberlain Creek	10
6	Dick Creek	3	17	Warren Creek	7	28	McElwain Creek	10
7	Beaver Creek	4	18	Willow Cr. (lower)	7	29	Salmon Creek	10
8	Belmont Creek	4	19	Elk Creek	8	30	Shanley Creek	10
9	Rock Creek	4	20	Hoyt Creek	8	31	Spring Cr.(Cottonwood)	10
10	Gold Creek, W,F	5	21	Spring Creek (N.F.)	8	32	Stonewall Creek	10
11	Kleinschmidt Cr.	5	22	Blackfoot River 1	9	33	Wales Spring Creek	10
						34	Wasson Creek	10

Figure 63. High priority stream of the Blackfoot River Watershed.

Moderate Priority Streams

Thirty-four stream reaches fall in to the "moderate priority" category (Figure 64). Streams in this category would receive a moderate level of consideration for funding of fisheries-related restoration. Streams include three reaches of the upper Blackfoot River, many low-elevation tributaries to the Blackfoot River including several spring creeks, as well as a few outliners, including disjunct streams located higher in the watershed.

Most of the reaches that we consider moderate priorities are small direct tributaries to the Blackfoot River. Most of these are biologically and hydrologically (surface water) connected to the main stem Blackfoot River continually or during high flow periods. These tributaries support fluvial and stream resident WSCT and most support WSCT spawning and rearing. Restoration of these tributaries should be



Stream ID #	Stream Name	Total Rank	Stream ID #	Stream Name	Total Rank	Stream ID #	Stream Name	Total Rank
1	Bear Creek (R.M.12.2)	11	12	Saurekraut Creek	12	23	Sucker Creek	14
2	Blackfoot River 3	11	13	Wales Creek	12	24	Union Creek	14
3	Little Fish Creek	11	14	West Twin Creek	12	25	Willow Cr. (upper)	14
4	Dry Creek	11	15	Arrastra Creek	13	26	Wilson Creek	14
5	Lodgepole Creek	11	16	Blackfoot River 5	13	27	Chamberlain EF	15
6	Nevada Spring Cr.	11	17	Clearwater River	13	28	Hogum Creek	15
7	Yourname Creek	11	18	Douglas Creek	13	29	Moose Creek	15
8	East Twin Creek	12	19	Fish Creek	13	30	Basin Spring Creek	16
9	Johnson Creek	12	20	Lincoln Spring Cr.	13	31	Black Bear Creek	16
10	Keep Cool Creek	12	21	Jacobsen Spring Creek	14	32	Blackfoot River 6	16
11	Pearson Creek	12	22	Nevada Cr.(upper)	14	33	Grantier Spring Cr.	16
						34	Seven up Pete Cr.	16

Figure 64. Moderate priority streams of the Blackfoot River Watershed.

generally viewed from a WSCT metapopulation conservation perspective. The lower portions of these tributaries variably contain rainbow trout, brown trout and brook trout. Streams generally support genetically unaltered WSCT in the upper watershed and introgressed WSCT in tributaries of the lower Blackfoot Watershed. With one exception

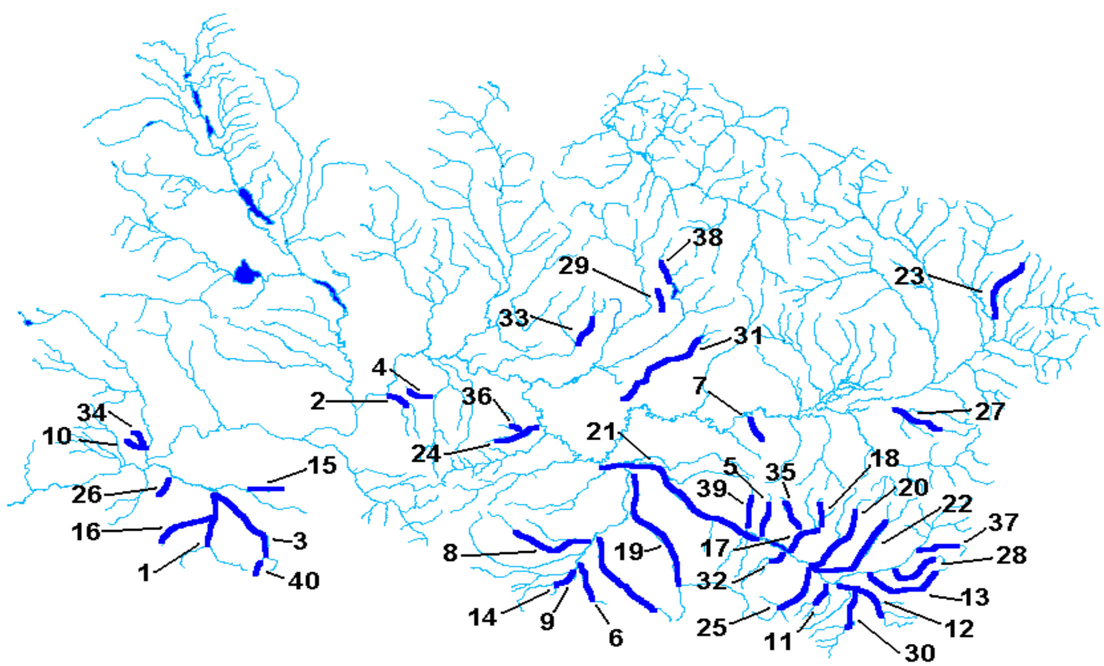
(Arrastra Creek), these tributaries lack bull trout reproduction although many support limited bull trout rearing.

Other moderate priority streams are found both north and south of the general distribution pattern. The northern streams include lower priority bull trout core area streams. Stream on the south include several with potential for water quality and flow improvement or are ranked high with respect to social considerations.

Most streams in this moderate priority category support human-induced limiting factors and many controllable sources of fish mortality, such as entrainment of fish in irrigation ditches and stream dewatering. Most habitat-related problems can be reasonably corrected with sufficient commitment from landowners and resource managers. We have already begun to implement restoration project on many of these streams. Streams on the 303(d) list considered moderate priority include: 1) Blackfoot River reaches 3, 5 and 6, 2) Nevada Spring Creek, 3) Yourname Creek, 4) Pearson Creek 5) Wales Creek, 6) Arrastra Creek, 7) Clearwater River, 8) Douglas Creek, 9) upper Nevada Creek, 10) Union Creek, 11) upper Willow Creek, and 12) Black Bear Creek.

Low Priority streams

Forty streams ranked in the "low priority" category (Figure 65). Low-priority



Stream ID #	Stream Name	Total Rank	Stream ID #	Stream Name	Total Rank	Stream ID #	Stream Name	Total Rank
1	Ashby Creek	17	14	Sturgeon Creek	18	27	Humbug Creek	20
2	Bear Creek (R.M.37.5)	17	15	Washoe Creek	18	28	Shingle Mill Creek	20
3	Camas Creek	17	16	Arkansas Creek	19	29	Bear Creek trib. to N.F.	21
4	Chamberlain WF	17	17	Buffalo Gulch	19	30	Strickland Creek	21
5	Chicken Creek	17	18	California Gulch	19	31	Ward Creek	21
6	Chimney Cr. (Douglas)	17	19	Cottonwood Cr. (Nev.)	19	32	Indian Creek	22
7	Little Moose Creek	17	20	Jefferson Creek	19	33	Warren Creek,Doney Lake	22
8	Murray Creek	17	21	Nevada Cr. (lower)	19	34	Burnt Bridge Creek	23
9	Sheep Creek	17	22	Washington Creek	19	35	Clear Creek	23
10	Warm Springs Cr.	17	23	Bartlett Creek	20	36	Frazier Creek, NF	23
11	Finn Creek	18	24	Frazier Creek	20	37	Gleason Creek	23
12	Halfway Creek	18	25	Gallagher Creek	20	38	McDermott Creek	23
13	Mitchell Creek	18	26	Game Creek	20	39	Chimney Cr. (Nevada)	24
						40	Smith Creek	24

Figure 65. Low priority streams of the Blackfoot River Watershed.

streams will not receive the same level of fisheries restoration consideration as high or moderate priority streams without a concerted local effort. However, despite a low ranking, most low priority streams possess locally valuable fisheries or potential for recovery. The majority (28) of low priority streams fall into two large sub-basins (Union Creek and Nevada Creek) of the Blackfoot watershed. In these areas, reservoirs, subdivision and agriculture have either greatly reduced, or eliminated the biological connection with the mainstem. These streams no longer support fluvial native fish or contribute significantly to sport fisheries of the Blackfoot River. Rather, these are generally small headwater streams supporting stream resident WSCT or are degraded reaches that no longer support salmonids.

Several low priority streams possess site-specific stream resident WSCT concerns that will be considered before restoration activities involving fish passage are implemented. Where WSCT populations are physically isolated, restoration measures should preserve the genetic integrity of "pure" populations, fully consider downstream influences, and avoid exposure to hybridizing and invasive species. Where fisheries restoration is pursued, it should generally be conducted from the headwaters in a downstream direction. These methods would focus on expanding the size of individual populations by improving habitat conditions in headwater areas. This approach should improve populations, while providing sufficient time to evaluate: 1) the influence of climate change, 2) expansion potential of unwanted species, 3) disease risks, and 4) the efficacy of differing restoration methods implemented on similar streams. In all cases involving resident WSCT streams, FWP fisheries biologists should be involved in restoration planning from the onset.

Streams on the 303(d) list considered low priority include: 1) Ashby Creek, 2) Camas Creek, 3) Murray Creek, 4) Washoe Creek, 5) Buffalo Creek, 6) Cottonwood Creek (trib. of Nevada Creek), 7) Jefferson Creek, 8) lower Nevada Creek, 9) Washington Creek, 10) Frazier Creek, 11) Gallagher Creek, and 12) Ward Creek.

A preliminary summary of lake surveys in the backcountry of the Blackfoot River basin

Introduction

During the summer of 2005, FWP biologists assessed fisheries in 13 "backcountry" lakes located in the Lolo and Helena National Forests. These lakes are located in remote areas of the upper Blackfoot watershed in areas designated as either "roadless" or "wilderness." These lake surveys represent initial phases towards a comprehensive inventory of backcountry fisheries that when completed will cover both lakes and streams. Information generated from lakes will provide the basis for a backcountry high mountain lakes management plan.

<u>Study area</u>

Wilderness areas of the Blackfoot River, all located in the northern region of the Blackfoot watershed, cover vast tracts of glaciated mountains. These mountains represent the southern extension of a large contiguous wilderness complex that extends from Glacier National Park south through the Bob Marshall Wilderness. On the southern extension of these wildlands, wilderness waters of the upper Blackfoot watershed generally begin in glacial cirques, lead south through glacial trough valleys before exiting the mountains as larger, colder tributaries of the Blackfoot River. These streams are critical native fish streams supporting migratory populations of Blackfoot River bull trout and WSCT. Lakes in the region have not been sampled in at least 20 years. For the 2005 surveys, we selected four lake clusters containing a total of 13 headwater lakes. Lakes are located the upper Monture, North Fork and Landers Fork watersheds (Figure 66). A majority of lakes were subject to historical fish plants and subsequent gillnet surveys in the 1960's and 1970s. A comprehensive inventory of tributary fisheries has yet to be fully initiated in this region.

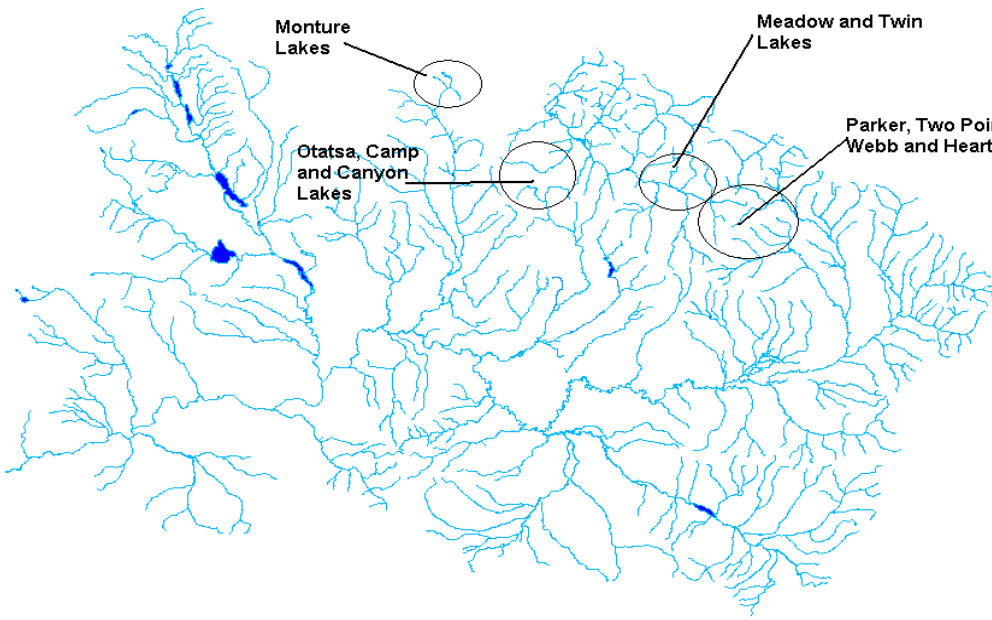


Figure 66. Generalized location map of the 2005-backcountry lake surveys.

Methods

Using packhorses and mules, fisheries crews established four remote base camps near high mountain lakes during the summer of 2005. Over the course of four weeks, we mapped lake bathymetry, set experimental sinking overnight gillnet sets in each of 13 lakes and performed related assessments. Where possible, we placed nets at previous survey locations. From netted fish, we collected measurements of total length, weight, scales, fin clips and recorded observed diet items. From these data, we assessed relative abundance, size distribution, growth, condition factor and *Oncorhynchus* genetic composition and food habits information. Using GPS locations and water depths (sonic depth finders) at discrete points, we mapped the bathymetry of lakes from transect, and the 5' contour surveys using an inflatable canoe. We mapped lake perimeters by foot using GPS units. All lake location data were entered into EXCEL spreadsheet and bathymetry mapped using the GIS ArcView spatial analyst module. During lake transects, we also collected water chemistry (ph, total dissolved solids and conductivity) and secchi disc measurements and Wisconsin zooplankton tow samples. While mapping lake perimeters, we recorded observations related to the presence of juvenile fish, amphibians, macro-invertebrates, plant communities, noteworthy wildlife, etc., and we identified camping areas and trails in the area.

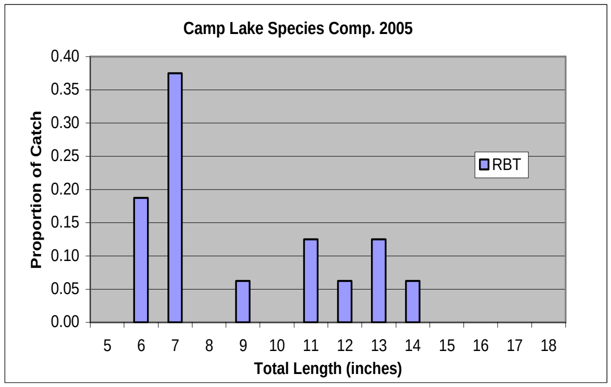
Preliminary Results

A preliminary summary of results is found in Table 1. For this report, we also include preliminary summary results from a single lake (Camp Lake) as a specific example of information collected and analyses performed.

Table 1. Blackfoot River Lake Surveys Summary Sheet for 2005

Lake	Survey Date	Location	Trailhead	Miles in	Lake features				Recreation		Fisheries				Water Chemistry			
					Morph.	Elev.	Acres	Max Depth	Camp Sites	Use	# of Fish	Fish/Hr	Genetics	Size Range (in)	Secchi depth	TDS	PH	Conduc.
Camp Lake	Jul-05	Lolo NF, T17N R11W S32.	North Fork Blackfoot River	8	Glacial Valley	6161'	15.5	13.9'	1, Hardly Discernable	Light	16 RBT	1 gill net, 14.5 Hr = 1.1	Pending	5.9-13.8 Avg = 9.0	13.9	49	8.4	97
Canyon Lake	Jul-05	Lolo NF, T17N R11W S28/33.	North Fork Blackfoot River	8.5	Glacial Valley	5741'	11.2	6.8'	1, Marginal	Light	18 WCT	1 gill net, 18.5 Hr = 0.97	Only WSCT detected.	6.5-13.5 Avg = 10.2	6.8	83	8.8	170
Heart Lake	Jul-05	Helena NF, 16N R8W S17C/18D/19A	Indian Meadows	4.2	Glacial Valley	6424'	28.3	55.8'	4, Well Established	Heavy	17 WCT	2 gill nets 26.8 Hr = 0.63	Planted WCT	13.6-18.5 Avg = 16.1	37.5	108	8.7	216
Lake Otatsy	Jul-05	Lolo NF, T17N R11W S32 / T16N R11W S18	North Fork Blackfoot River	7	Glacial Valley	6069'	19.1	32.6'	2, Well Established 1, Marginal	Moderate	21 RBT	1 gill net, 14 Hr = 1.5	Pending	6.1-11.5 Avg = 9.7	21.5	44	8.1	89
Lower Twin Lake	7/1/2005	Helena NF, T16N R9W S6.	Option 1: Meadow Creek Option 2: Indian Meadows	Option 1: 13.75 Option 2: 12	Glacial valley	5900'	6.6	11.6'	None	Light	25 Trout	1 gill net, 7 Hr = 3.66	Hybrids YCT x WCT x RBT	5.7-23.6 Avg = 12.7	6.6	112	8.7	226
Meadow Lake	Jun-05	Helena NF, T16N R9 S18.	Option 1: Meadow Creek Option 2: Indian Meadows	Option 1: 10 Option 2: 11.7	Glacial valley	5800'	4.4	15'	1, Well Established	Medium	2 RBT	1 gill net, 16 Hr = 0.13	Pending	8.1-14.5 Avg = 10.3	4.4	91	8	181
Monture Lake #1	Jun-05	Lolo NF, T18N R12W S17.	Monture Creek	14.5	Glacial Cirque	7217'	5.5	48.7'	A few places to pitch a tint on eastern shore	Very Light	2 WCT	1 gill net 17 Hr = 0.12	Pending	7.6 and 9.1	2.3.5	3	6.8	5
Monture Lake #2	Jun-05	Lolo NF, T18N R12W S17.	Monture Creek	15.25	Glacial Cirque	7709'	6.9	18.4'	None	None	None	1 gill net 17.5 Hr = 0 fish	N/A	N/A	9.3	1	7.6	5
Monture Lake #3	Jun-05	Lolo NF, T18N R12W S18.	Monture Creek	16.75	Glacial Cirque	7641'	4.5	18.4'	None	None	None	1 gill net 17.5 Hr = 0	N/A	N/A	12	2	6.6	5
Parker Lake	Jul-05	Helena NF, T16N R9W S9	Indian Meadows	8.5	Glacial Valley	6000'	18.9	6.2'	2, one at the base of each peninsula	Moderate	54 YCT	1 gill net, 18 Hr = 4.17	Primarily YCT hybrids with WCT and RBT	5.9-14.9 Avg = 10.6	6.2	142	8.4	291
Two Point Lake	Jul-05	Helena NF, T16N R9W S10	Indian Meadows	8.5	Glacial Valley	6187'	9.5	10.5'	None	Very Light	None	1 gill net 19 Hr = 0	N/A	N/A	10.5	129	9	258
Upper Twin Lake	Jun-05	Helena NF, T16N R9W S5/8.	Option 1: Meadow Creek Option 2: Indian Meadows	Option 1: 13 Option 2: 10.75	Glacial valley	5969'	6.3	10.4'	1, open area on west shore	Light	None	1 gill net 13.25 Hr = 0	N/A	N/A	10.4	150	8.6	300
Webb Lake	Jul-05	Helena NF, T16N R9WS14	Indian Meadows	6.5	Glacial Valley	6079'	6	5.5'	Plenty of places to pitch tents around Webb Lake Guard Station	Heavy	5 WCT	2 gill nets 32.5 Hr = 0.15	WCT with some RBT markers	6.5-14.5 Avg = 8.5	5.5	109	9.2	216

Camp Lake Fish Data 2005



DATE	7/12-13/2005	
# NETS	1	Sinker 1/2"-2"
SET LOCATION(S)	N47.18076 W113.03780 NE Shore Near Outlet	
SET TIME	7/12/2005 19:10	
PULL TIME	7/13/2005 9:30	
DURATION	14.5 hrs	
SET DEPTHS	0-11.8'	
SPECIES CAPTURED	RBT	16
TOTAL TROUT/NET/HR	1.10345	

REPRODUCTION Many springy inlets plus 2 larger ones that could support spawning. Three possible redds seen in . lake itself. Outlet approximately 4 cfs

SIZE DISTRIBUTION Gill net Only

GENETIC SAMPLES 16 Analysis pen

Length (mm	Length (in)	Median (in)	Number RBT	Proportion RBT
114-140	4.5-5.5	5	0	0.00
141-165	5.5-6.5	6	3	0.19
166-190	6.5-7.5	7	6	0.38
191-216	7.5-8.5	8	0	0.00
217-241	8.5-9.5	9	1	0.06
242-267	9.5-10.5	10	0	0.00
268-292	10.5-11.5	11	2	0.13
293-318	11.5-12.5	12	1	0.06
319-343	12.5-13.5	13	2	0.13
344-368	13.5-14.5	14	1	0.06
369-394	14.5-15.5	15	0	0.00
395-419	15.5-16.5	16	0	0.00
420-445	16.5-17.5	17	0	0.00
446-470	17.5-18.5	18	0	0.00
		Totals	16	1.00

	RBT
Max Size (mm)	350
Min Size (mm)	150
Mean Size (mm)	228.38
Age/Growth Info	Yes
Sample Size -Scales	16
	Analysis pending

CONDITION

Total Length	Weight	Log (Ws)	Ws	Wr
177	48	1.82	66.59	72.08
164	78	1.72	53.01	147.13
175	52	1.81	64.37	80.78
240	132	2.22	165.51	79.75
314	348	2.57	369.67	94.14
350	420	2.71	511.40	82.13
328	348	2.62	421.18	82.63
271	220	2.38	238.00	92.44
340	372	2.67	468.95	79.33
292	266	2.47	297.51	89.41
182	56	1.86	72.38	77.37
166	44	1.74	54.97	80.04
171	46	1.78	60.07	76.58
150	36	1.61	40.60	88.67
170	42	1.77	59.03	71.16
164	40	1.72	53.01	75.45

MEAN Wr	86
ST DEV Wr	17.74
MAX Wr	147
MIN Wr	71

Log (Ws) = a' + b * log10 (total length) Ws = Standard Weight Wr = Relative Weight

Murphy, B. R., D. W. Willis, and T.A. Springer. 1991. The relative weight index in fisheries and management: status and needs. Fisheries 16(2):30-38

ANGLING DATA N/A

Camp Lake **7/12-13/2005**

OBSERVERS Ron Pierce, Craig Podner, Michael Davidson

LEGALS T 17 R 11 S 32

TRAIL Trail in good condition and accessible from west side of Lake Otatsy on pack trail via
Lake Creek Trail at North Fork Blackfoot River trailhead. Approx. 15 min hike.
Trail numbers 61,1404,16. The trail shown on map that connects Camp and Canyon Lakes has been decommissioned.

CAMP SITES 1 marginal site near southernmost inlet on W Shore.

EVIDENCE OF USE Very Light

ELEVATION	6161'				
MORPHOLOGY	Glacial Valley				
H2O CHEMISTRY	**TDS** = 49		**PH** = 8.40	**Conductivity** = 97	**Secchi Disk** = 13.9
SURFACE TEMP	17.0 C				
MAX DEPTH	13.9'				
APPROX AREA	15.5 acres				
APPOX VOLUME					
BATHYMETRIC MAP	Yes				
PHOTOS TAKEN	Yes				

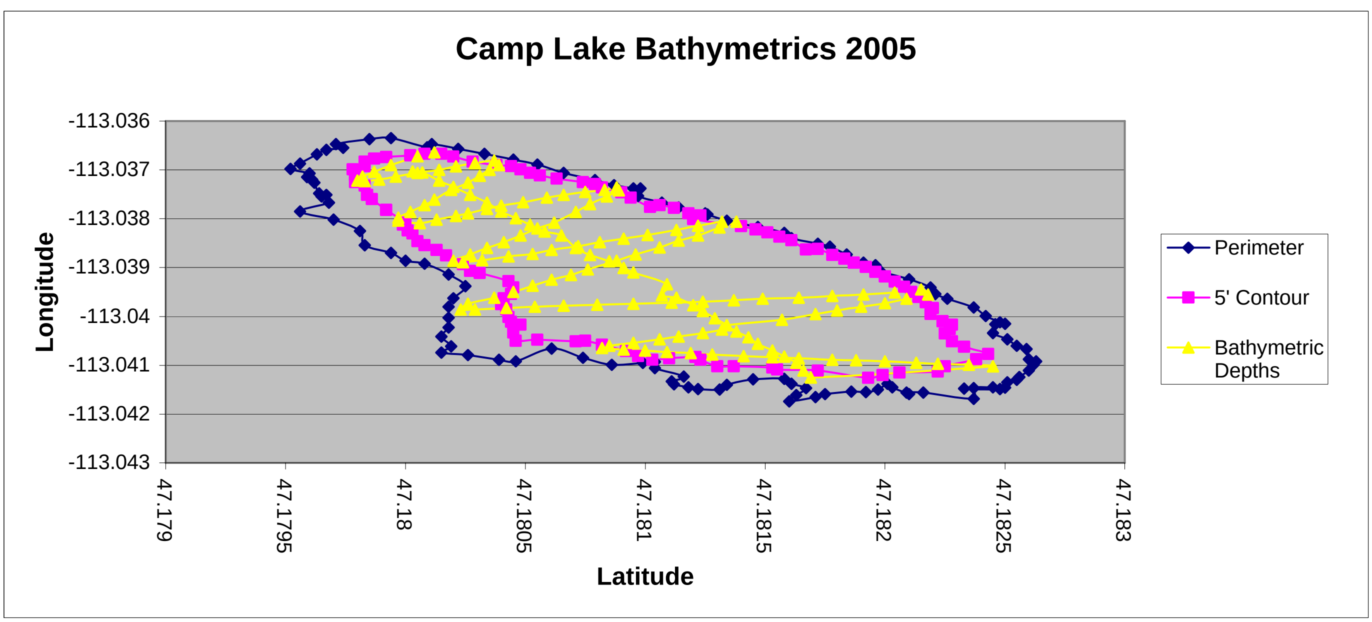
ZOOPLANKTON

		DEPTH	
2 TOWS	**TOW 1**	13.4'	N 47.18090 W113.03856
	TOW 2	13.4'	N 47.18090 W113.03856

AMPHIBIANS Entire shoreline surveyed. Little evidence of amphibians.

SPOTTED FROG	
Adult	3
Larvae	0

NOTES All inlets occur on ENE Shore and the lake in this area is deep slit. Majority of the inlets to this lake are seeps and boggy trickles. Fo
inlets makeup the rest of the inflow approx. 3 cfs (N47.18237 W113.04169, N47.18192 W113.04155, N47.18160 W113.04174, N47.1
Outlet mouth entirely blocked by LWD and outflow is approx. 4 cfs. (WER N47.17971 W113.03647 WEL N47.17985 W113.03637). T
of the lake substrate is a mix of light silt, small boulders/cobble/gravel. There is a big rock shelf and misc. boulders in lake along S sh
Multiple families of Ring-necked Ducks. One Common Loon sighted. Very few aquatic insects. Some Callibaetis spinners and caddi
No sightings of damselflies or dragonflies.



Camp Lake

Location: Lewis and Clark County, Lolo National Forest, Spread Mountain Quadrangle Montana 7.5 Minute Series (Topographical), T17N R11W S32.

Trails: From North Fork Blackfoot River Trailhead, take trail #61 McCabe-Lake Creek Trail (pack) west approximately 4 miles to the junction with trail #1404 Lake Otatsy Trail (pack). Head north on #1404 approximately 3 miles to Lake Otatsy. At trail #16 Canyon Trail (pack)/Camp Pass-Camp Lake Trail (pack) fork (southern tip of Lake Otatsy) take the western fork to Camp Pass-Camp Lake. Follow for approximately 15 minutes past the northern end of Lake Otatsy. Trails are in good condition and well maintained. First 4 miles are a low gradient climb through a glacial valley. From the junction to Lake Otatsy the trail gains 1000 feet in the first mile, through heavily burned forest from 1988, before gradually leveling out and dropping into Lake Otatsy. Lake Otatsy to Camp Lake is an easy walk through thick lodgepole pine, sub-alpine fir, and spruce forests.

The trail shown on map that connects Camp and Canyon Lakes has been decommissioned. To access these two lakes you have to circumnavigate Lake Otatsy.

Acreage: 15.5
Max Depth: 13.9 feet
Usage: Light
Elevation: 6161 feet
Camp Sites: 1 marginal site near southernmost inlet on west shore. This site has not been used in a long time and is barely discernable.

Fish Data: Camp Lake was last sampled on July 12-13, 2005 by Montana Fish Wildlife and Parks. An overnight gillnet was set for a total duration of 14.5 hours. 16 rainbow trout were caught. Fish sizes ranged from 5.9 inches to 13.8 inches and averaged 9 inches. No angling data was taken.

Historical Fish Data: On July 16, 1968 this lake was surveyed Montana Department of Fish and Game. This survey found, in a 24.5 hour gillnet set, 26 rainbow trout ranging in length from 5.8 inches to 12.4 inches and averaging 8.6 inches.

Topography: The immediate shoreline is brushy and heavily timbered, but not steep. Surrounding topography is heavily timbered with lodgepole pine, sub-apline fir and spruce forests and is steep. Trail #16 runs about 20 feet above the northeast shoreline for the entire length of the lake.

Notes: Camp Lake drains about 2 square miles of area primarily through small springs and a couple of unnamed inlets. The outlet drains to the east to East Fork of Lake Creek which feeds into Lake Creek and then to the North Fork of the Blackfoot River. The lake bottom is made up of thick mud and silt with patches of gravel in several areas. The water is clear and has some vegetation growing in the eastern portion of the lake. Wildlife was observed throughout the area including a sighting of a Common Loon and multiple families of Ring-Necked Ducks.

Camp Lake aerial photo

Shoreline view

Outlet area

General view

RECOMMENDATIONS

- Identify a sustainable fisheries technician-funding source in order to continue restoration-related fisheries monitoring and related-assessments as outlined in this report.

- Encourage watershed groups and resource agencies that promote and develop restoration projects to implement monitoring and ensure maintenance needs for their projects.

- Expand *on the ground restoration* to the upper Blackfoot and Clearwater River basins with support provided through watershed groups including the Big Blackfoot Chapter of Trout Unlimited, the North Powell Conservation District, Northwestern Energy, the Blackfoot Challenge as well as other supporting agencies and organizations.

- Complete restoration projects in all bull trout “core areas” and current restoration streams. Expand restoration to the upper Blackfoot watershed, with emphasis placed on “priority” water bodies.

- Focus restoration and protection on migration corridors, spawning and rearing areas, and tributaries that have a high proportion of their stream length in higher elevations and basin-fed stream with steeper gradients. These habitat types have been found to be less susceptible to *T. tubifex* and whirling disease infection.

- Continue to monitor the spread and impacts of whirling disease and the results of restoration on infection rates. Complete the rainbow trout – whirling disease risk assessment and examine the susceptibility of whirling disease on mountain whitefish. Incorporate pertinent results into the restoration program.

- Increase landscape protection on critical fish and wildlife habitat in cooperation with the Montana Land Reliance, Nature Conservancy, US Fish and Wildlife Service, Montana Fish, Wildlife and Parks, Blackfoot Challenge and Plum Creek Timber Company.

- Continue fish populations monitoring at the Johnsrud and Scotty Brown Bridge section of the Blackfoot River, and major tributary restoration projects as funding allows.

- Complete fisheries inventories (lakes and streams) to wilderness areas and complete a mountain lakes management plan.

- Increase FWP enforcement efforts in bull trout spawning and staging areas.

- Address fish passage and northern pike issues at Milltown Dam and continue to mitigate for Milltown Dam within the geographic range of fish population impacts.

- Complete the cleanup of contaminated sediments at the Mike Horse mine and on Helena National Forest in a manner that allows the recolonization of WSCT.

- Adopt a conservative approach to recreational planning in native fish recovery areas.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix A: catch and size statistics for tributaries to the Blackfoot River

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Arrastra Creek	0.7	14N,10W,29B	9-Sep-04	385	CT	54	43	29	1.6-10.6	3.5	11.2	7.5
					EB	14	10	7	2.0-6.2	3.6	2.6	1.8
					LL	36	34	25	2.4-21.6	4.3	8.8	6.5
	1.1	14N,10W,29B	9-Sep-04	425	DV	2	2	0	9.2-9.7	9.5	0.5	0.0
					CT	52	35	26	1.5-9.1	3	8.2	6.1
					EB	39	35	26	2.1-7.2	4.7	8.2	6.1
					LL	14	9	3	2.5-14.4	5.8	2.1	0.7
	2.4	14N,10W,17D	9-Sep-04	250	CT	10	8	4	1.8-10.9	5.9	3.2	1.6
					LL	2	2		7.0-9.1	8.0	0.8	0.0
					EB	2	2		5.8-6.3	6.1	0.8	0.0
					LNS	1	1		6.9	6.9	0.4	0.0
Ashby Creek	3	13N,16W,35B	8-Aug-05	300	CT	36	33	3	1.5 - 7.7	4.8	11.0	1.0
	4	12N,16W,3A	8-Aug-05	300	CT	61	37	19	098 - 7.6	3.99	12.3	6.3
					EB	1	1	0	5.2	5.2	0.3	0.0
Bear Creek	1.1	13N,16W,18B, 13N,16W,7C	10-Aug-04	379	RB	188	144	67	1.8-10.1	3.5	38.0	17.7
					LL	22	15	3	2.4-5.3	3.3	4.0	0.8
					WCT	1	1	0	4.1	4.1	0.3	0.0
					Sculpins	abundant						
			4-Aug-05	374	RB	174	111	66	1.5 - 7.9	3.5	29.7	17.6
					LL	33	27	2	2.4 - 10.1	5.8	7.2	0.5
					EB	6	6	0	4.6 - 7.9	5.5	1.6	0.0
					Sculpins	abundant,	Spotted Frog	present				
Blackfoot Riv H2-0 ditch	83.7	14N,11W,26B	31-Aug-04	1000	LL	15	15	10	3.3-4.2	3.7	1.5	1.0
					MWF	12	12	10	2.7-3.7	3.3	1.2	1.0
					RSS	54	54		1.5-3.3	2.6	5.4	0.0
					LNS	6	6				0.6	0.0
					Sculpin	present						
Blackfoot River	86.4	14N,11W,25C	30-Jul-04	1000	LL	2	2	2	2.4-2.8	2.6	0.2	0.2
Pocha Ditch					NPM	present	SCUL	common				

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Cabin Creek trib to	ear mou	17N,11W,13B	13-Jul-04	3700	DV	5	5	0	4.7-25	9.0	0.1	0.0
Dry Fork @ NF 25.2		& 12C			CT	33	33	8	3.5-8.1	4.8	0.9	0.2
					Tailed	frogs	present					
Chamberlain Creek	0.1	15N,13W,32A	30-Sep-04	440	CT	151	119	70	2.0-7.2	3.5	27.0	15.9
					LL	6	3	1	3.6-7.2	5.0	0.7	0.2
					RB	7	5	1	3.5-5.3	4.4	1.1	0.2
					EB	1	1		5.6	5.6	0.2	0.0
			22-Sep-05	440	CT	182	141	30	1.69 - 7.9	3.4	32.0	6.8
					LL	36	26	21	2.76 - 6.81	3.5	5.9	4.8
					SCUL & R	abundant,	potted frog	present				
Clearwater Ditch	r diver	14N,14,W,4B	22-Sep-05	567	RB	5	5	4	2.9 - 4.7	3.4	0.9	0.7
					LL	11	11	11	2.9 - 4.0	3.4	1.9	1.9
					RSS, MW	present	NP	present				
Copper Creek	1.1	15N,8W,25C	2-Sep-04	555	DV	1	1		7.6	7.6	0.2	0.0
		&26A			CT	6	6		5.1-13.0	9.2	1.1	0.0
					MWF	1	1		7.4	7.4	0.2	0.0
					SCUL	common						
	6.2	15N,8W,9A	4-Sep-04	512	DV	14	14	0	4.3-17.9	6.0	2.7	0.0
					CT	16	16	4	1.9-10.9	5.5	3.1	0.8
					SCUL abundant							
			25-Aug-05	512	DV	27	27	12	2.0 - 7.52	3.5	5.3	2.3
					CT	60	60	33	1.1 - 11.5	4.5	11.7	6.4
					SCUL abundant							
	8.9	15N,8W,5B	2-Sep-04	454	DV	14	14	0	4.8-10.6	6.1	3.1	0.0
					CT	9	9	5	3.1-10.0	5.1	2.0	1.1
	10.8	15N,9W,1B	4-Sep-04	350	DV	6	6	0	4.9-8.1	5.9	1.7	0.0
					CT	3	3	0	6.2-7.5	6.7	0.9	0.0
					SCUL present							

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Cottonwood Creek	12.0	16N,14W,24D	6-Oct-04	500	DV	3	3	1	3.0-5.7	4.7	0.6	0.2
					CT	55	41	16	1.8-14.6	5.0	8.2	3.2
					EB	14	13	1	3.5-10.9	7.3	2.6	0.2
					SCUL	abundant						
			21-Sep-05	500	DV*	4	4	0	5.1 - 8.5	7.1	0.8	0.0
					CT	123	99	59	1.3 - 11	5.1	19.8	11.8
					EB	15	13	7	2.2 - 6.8	3.9	2.6	1.4
					LL	4	4	0	2.2 - 3.1	2.7	0.8	0.0
					SCUL	abundant						
Dry Fork @ NF 25.2	2.5	17N,11W,24D	13-Jul-04		CT	5	5	0	6.0-12.0	9.0		
These three sites	3.5	17N,11W,33C	13-Jul-04		DV	1	1	0	20	20.0		
are hook & line	7.9	17N,11W,3B	13-Jul-04		CT	1	1	0	4.9	4.9		
surveys												
Dunham Creek	2.3	16N,12W,19B	12-Aug-04	615	DV	77	55	19	2.4-15.7	5.2	8.9	3.1
					CT	73	53	13	2.7-16.1	6.0	8.6	2.1
					EB	11	7	2	2.7-6.6	4.9	1.1	0.3
					RB	1	1	0	7.5	7.5	0.2	0.0
			24-Aug-05	615	DV	16	14	0	2.8 - 8.46	6.0	2.3	0.0
					CT	51	36	2	1.5 - 14.3	5.6	5.9	0.3
					EB	10	9	0	1.9 - 10.8	5.6	1.5	0.0
Hoyt Creek	0.5	15N,12W,19B	1-Sep-05	300	EB	65	57	25	2.2 - 9.6	4.3	19.0	8.3
					LL	4	4	1	3.1 - 7.3	5.9	1.3	0.3
					SCUL	abundant						
	1.2	15N,12W,19C	1-Sep-05	300	EB	2	2	0	4.1	4.1	0.7	0.0
					LL	2	2	0	7.6	7.6	0.7	0.0
					SCUL	present						
	3.4	15N,12W,29D	1-Sep-05	300	EB	7	7	1	2.7 - 6.3	5.2	2.3	0.3
	3.9	15N,12W,28C	1-Sep-05	300	EB	21	15	11	2.2 - 5.6	3.4	5.0	3.7

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Jacobson Spring Cr	0.1	14N,12W,12B	9-Jun-04	400	LL	8	8	5	1.7-5.5	3.1	2.0	1.3
wide-shallow lower spring creek					RB	1	1	1	3	3.0	0.3	0.3
					EB	3	3	2	2.2-5.1	3.6	0.8	0.5
					Sculpin:	present						
	0.6	14N,12W,1C,I	9-Jun-04	400	LL	3	3	0	4.3-4.7	4.5	0.8	0.0
					EB	4	4	2	2.2-4.5	3.7	1.0	0.5
					Sculpin:	common						
			17-Aug-05	425	CT	1	1	0	6.3	6.3	0.2	0.0
					RB	1	1	0	3.9	3.9	0.2	0.0
					EB	93	72	12	2.0 - 9.1	3.4	16.9	2.8
					LL	23	18	15	2.8 - 6.4	3.4	4.2	3.5
					SCUL	common						
Feeder spring entering at mile 0.6	0.1	14N,12W,1D	9-Jun-04	600	LL	8	8	2	1.7-5.1	4.0	1.3	0.3
at mile 0.6					EB	5	5	3	3.3-5.5	4.1	0.8	0.5
					LNS	present,	Sculpins	common				
	1.1	14N,12W,1A	9-Jun-04	225	LL	3	3	1	3.7-7.3	5.8	1.3	0.4
					RB	1	1	0	4.5	4.5	0.4	0.0
					EB	4	4	2	2.9-6.6	4.4	1.8	0.9
					Sculpin:	present						
	1.45	14N,11W,6B	10-Jun-04	369	LL	1	1	0	4.6	4.6	0.3	0.0
					EB	1	1	0	5.2	5.2	0.3	0.0
Corral spr enters	0.1	14N,11W,6B	10-Jun-04	90	EB	10	10	9	1.77-5.1	2.3	11.1	10.0
at mile 1.5					Sculpin:	present						
Jacobson Spr Cr	0.5	14N,11W,6B	10-Jun-04	300	LL	1	1	0	4.1	4.1	0.3	0.0
East Channel					EB	22	22	19	1.8-4.6	2.5	7.3	6.3

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
East Channel (cont.)					Sculpins	present						
Keep Cool Cr	1.8	14N,9W,14C	14-Jun-04	360	LL	6	6	0	7.4-14.2	11.5	1.7	0.0
					Sculpins	present						
Kleinschmidt Creek	0.5	14N,11W,5C	23-Aug-04	500	LL	20	20	12	2.5-11.0	4.9	4.0	2.4
			29-Aug-05	500	LL	49	33	23	2.5 - 16.1	4.8	6.6	4.6
					EB	3	2	2	3.7 - 4.1	4.0	0.4	0.4
					SCUL	abundant						
	0.8	14N,11W,5C	23-Aug-04	500	DV	1	1		5.7	5.7	0.2	0.0
					LL	56	28	13	2.4-18.2	5.9	5.6	2.6
					EB	2	1		2.6-7.7	5.2	0.2	0.0
CPUE based on year class for 04 and 05			29-Aug-05	500	CT	2	2	0	6.9 - 7.3	7.1	0.4	0.0
					LL	146	130	87	2.1 - 11.3	4.3	26.0	17.4
					EB	14	9	9	2.9 - 6.5	3.8	1.8	1.8
					SCUL	abundant	Spotted Frog	present				
	2	14N,11W,8A	30-Aug-05	300	EB	5	5	0	6 - 8.3	7.5	1.7	0.0
					SCUL	abundant,	RSS & LNS	common,	Spotted Frog present			
Lincoln Spring Cr.	1.5	14N,9W,23B	15-Jun-04	525	LL	27	27	12	1.4-13.6	4.4	5.1	2.3
					Sculpins	common						
McCabe Creek	2.2	15N,12W,5C	19-Aug-04	340	CT	52	43	16	1.2-11.7	5.1	12.6	4.7
					EB	57	51	33	2.0-7.2	3.2	15.0	9.7
					SCUL	common						
Monture Creek	0.4	15N,13W,27C	22-Aug-05	450	RB*	88	88	85	1.2 - 8.3	2.0	19.6	18.9
					LL	11	11	9	2.2 - 9.0	3.6	2.4	2.0
					SCUL	abundant	LND	present				
	2.2	15N,13W,22D	22-Aug-05	350	DV	6	6	0	6.8 - 8.7	7.9	1.7	0.0

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Monture Creek (cont.)	2.2	15N,13W,22D	22-Aug-05	350	RB*	95	95	91	1.0 - 15.5	2.1	27.1	26.0
					LL	25	25	21	2.3 - 12.2	3.7	7.1	6.0
						SCUL	abundant	Spotted Frogs	common			
	5.4	15N,13W,13A	18-Aug-05	460	RB*	59	59	59	1.0 - 2.1	1.6	12.8	12.8
					LL	15	15	13	2.1 - 8.9	3.2	3.3	2.8
					SCUL	abundant	MWF	present				
	8.6	15N,12W,6C	18-Aug-05	680	DV	15	15	11	2.5 - 8.1	3.6	2.2	1.6
					CT*	87	87	81	1.3 - 5.3	2.0	12.8	11.9
					LL	18	18	16	2.0 - 7.9	2.9	2.6	2.4
					EB	4	4	3	2.4 - 6.3	3.5	0.6	0.4
					SCUL	abundant						
	12.9	16N,12W,29B	22-Aug-05	375	DV	39	39	38	2.5 - 4.4	2.8	10.4	10.1
					CT*	94	94	93	1.1 - 6.3	1.8	25.1	24.8
					EB	42	42	25	2.3 - 6.8	3.6	11.2	6.7
					SCUL	abundant	potted Frog	present				
Nevada Creek	.5 - 5.	13N,11W,9C	29-Sep-05	6336	DV	1	1	0	9.4	9.4	0.0	0.0
					CT	3	3	0	10.1 - 14.8	13.0	0.0	0.0
					RB	1	1	0	7.6	7.6	0.0	0.0
					LL	17	17	0	7.2 - 12.2	9.0	0.3	0.0
					LSS	34	34	0	7.7 - 16.3	11.4	0.5	0.0
					LNS	3	3	2	2.4 - 6.3	3.8	0.0	0.0
					NPM	136	136	1	3.7 - 11.9	7.7	2.1	0.0
					MWF	60	60	3	3.3 - 8.8	4.7	0.9	0.0
Nevada Spring Cr.	.8 (1.1	13N,11W,10C	21-Sep-04	500	DV	1	1	0	9.6	9.6	0.2	0.0
					CT	2	2	0	6.4-11.5	8.8	0.4	0.0
new channel					LL	13	11	0	3.9-12.2	6.3	2.2	0.0
					MWF	1	0	0	5.2	5.2	0.0	0.0
					NPM	2	2	0	4.8-7.3	6.1	0.4	0.0
					RSS	1	1	0	2.8	2.8	0.2	0.0
			15-Sep-05	500	CT	7	6	0	7.4 - 13.3	10.4	1.2	0.0

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Nevada Spring Cr. (cont.)	.8 (1.1	13N,11W,10C	15-Sep-05	500	LL	13	10	0	3.6 - 15.5	9.7	2.0	0.0
					RB	1	1	1	3.7	3.7	0.2	0.2
					MWF	1	1	0	4.1	4.1	0.2	0.0
					NPM	2	2	0	6.3 - 8.7	7.5	0.4	0.0
					RSS	1	1					
	3.0(3.5	13N,11W,11D	21-Sep-04	470	LL	55	44	15	3.3-16.6	6.5	9.4	3.2
					CT	4	4	0	5.3-7.9	6.6	0.9	0.0
					RSS	present						
			15-Sep-05	470	LL	79	68	7	2.8 - 21.8	8.3	14.5	1.5
					CT	2	1	0	8.7 - 9.5	9.1	0.2	0.0
North Fork	2.6	14N,12W,11C	23-Aug-05	560	DV	1	1	0	17.1	17.1	0.2	0.0
Blackfoot River					CT*	1	1	0	9.1	9.1	0.2	0.0
at NF xing					RB	85	85	66	1.0 - 6.9	2.1	15.2	11.8
					LL	29	29	21	2.5 - 3.7	2.9	5.2	3.8
					SCUL	common	LND	present				
above Ryan Bridge	7.9	15N,11W,29C	23-Aug-05	810	DV	18	18	16	2.2 - 5.5	2.8	2.2	2.0
					LL	1	1	0	6.3	6.3	0.1	0.0
					EB	1	1	1	3.3		0.1	0.1
					SCUL	abundant	Spotted Frog	present				
Jacobsen Ditch at N.F.mile	8.7	15N,11W,29B	23-Aug-05	300	No	salmonids,	SCUL	abundant				
Weaver Ditch at N.F.mile	10.4	15N,11W,21C	23-Aug-05	300	salmon:	SCUL	common					
Rangitch Ditch at N.F. mile	11.6	15N,11W,21A	23-Aug-05	300	DV	3	3	3	2.5 - 3.0	2.7	1.0	1.0
					MWF	1	1	1	2.8	2.8	0.3	0.3
					SCUL	present						

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
N.F. at fish camp	12	15N,11W,15C	24-Aug-05	816	DV	18	18	17	1.9 - 7.9	2.8	2.2	2.1
					CT	3	3	0	5.2 - 6.9	6	0.4	0.0
					LL	1	1	0	5.2	5.2	0.1	0.0
					SCUL	abundant						
Roe Ditch at N.F. mile	12.5	15N,11W,15D	23-Aug-05	250	salmoni	SCUL	present					
Lund Ditch at N.F.mile	15.5	15N,11W,2C	24-Aug-05	310	DV	2	2	2	1.9 - 2.9	2.4	0.6	0.6
					EB	4	4	0	4.5 - 5.7	5.3	1.3	0.0
					MWF	8	8	8	2.3 - 2.9	2.6	2.6	2.6
	17.2	16N,11W,35B	24-Aug-05	285	DV	27	27	19	2.2 - 6.6	3.4	9.5	6.7
					CT	2	2	1	1.4 - 7.9	4.6	0.7	0.4
					RB	2	2	0	4.2 - 7.9	6.1	0.7	0.0
					SCUL	abundant	Spotted Frog	present				
	25.7	17N,10W,29C	14-Jul-04	550	DV	14	14	14	1.7-2.4	1.9	2.5	2.5
					RB	2	2	1	3.2-4.0	3.6	0.4	0.2
					Sculpins	present						
NF above falls	27	17N,10W,28C	14-Jul-04		RB	11	11	0	5.0-12.0	8.0		
hook & line survey												
Pearson Creek	0.5	15N,13W,33D	8-Sep-05	300	CT	22	18	0	3.5 - 7.7	4.7	6.0	0.0
CPUE based on year class					EB	4	4	1	3.1 - 3.9	3.6	1.3	0.3
					Spotted Fr	present						
	1.1	14N,13W,3B	21-Sep-04	450	CT	182	154	84	1.8-6.3	3.0	34.2	18.7
					EB	8	7	5	3.1-6.5	3.9	1.6	1.1
			8-Sep-05	405	CT	146	119	65	1.3 - 6.9	3.3	29.4	16.0
					EB	6	6	4	3.3 - 6.8	3.3	1.5	1.0
					LL	1	1	0	6	6.0	0.2	0.0

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Pearson Creek (cont.)	1.1	14N,13W,3B	8-Sep-05	405	›tted Fr	present						
Poorman Creek	1.3	14N,9W,36A	11-Aug-04	450	No fish							
Below lower ditch			10-Aug-05	490	CT	3	1	0	1.2 - 1.6	1.3	0.2	0.0
					LL	19	13	11	2.5 - 4.3	3.2	2.7	2.2
					SCUL	present						
Above upper ditch	1.5	14N,9W,36A	11-Aug-04	270	LL	7	6	1	3.8-11.9	8.4	2.2	0.4
					EB	2	2	0	7.9-11.2	9.6	0.7	0.0
					SCUL	present						
			10-Aug-05	270	CT	3	3	0	1.6 - 2.0	1.8	1.1	0.0
					LL	53	38	34	2.1 - 7.2	3.1	14.1	12.6
					EB	2	0	2	2.9 - 3.1	3.0	0.0	0.7
					SCUL	present						
Rock Creek	1.6	14N,11W,5A	11-Aug-04	510	LL	30	23	9	2.4-11.2	5.6	4.5	1.8
					RB	3	3	3	2.3-3.3	2.5	0.6	0.6
					EB	15	11	9	2.6-7.9	3.8	2.2	1.8
			9-Aug-05	510	LL	58	43	22	1.8 - 11.6	4.6	8.4	4.3
					EB	42	32	26	1.8 - 8.9	3.6	6.3	5.1
					SCUL	abundant						
Snowbank Creek	0.1	15N,8W,9A	25-Aug-05	140	No	fish	sampled					
below diversion	0.4	15N,8W,9A	16-Aug-05	450	CT	23	16	11	1.2 - 7.8	2.6	3.6	2.4
					DV	13	11	0	43. - 5.1	4.7	2.4	0.0
above diversion	0.41	15N,8W,9A	2-Sep-04	454	CT	5	5	1	1.6-9.6	5.3	1.1	0.2
					DV	2	2		6.1-7.0	6.5	0.4	0.0
			16-Aug-05	500	CT	17	15	6	3.6 - 9.9	5.5	3.0	1.2
					DV	1	1	0	4.7	4.7	0.2	0.0

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Spring Creek,	0.6	15N,11W,21B	7-Sep-05	385	DV	2	2	0	4.7 - 7.5	6.1	0.5	0.0
Trib. to N.F.					CT	76	63	56	1.3 - 5.9	2.4	16.4	14.5
above culvert					EB	14	10	10	2.2 - 5.1	2.7	2.6	2.6
					SCUL	common						
Stonewall Cr	0.1	14N,9W,14C	14-Jun-04	405	LL	2	2	0	16.8-21.3	19.1	0.5	0.0
					EB	3	3	0	5.7-6.1	5.9	0.7	0.0
	3	14N,9W,2B	18-Jun-04	246	CT	1	1	0	5.7	5.7	0.4	0.0
					EB	9	9	6	1.4-6.6	3.3	3.7	2.4
					Sculpins	present						
	0.65	14N,9W,14B	27-Jul-04	390	CT	1	1	0	4.13	4.1	0.3	0.0
					EB	4	4	0	8.7-9.2	9.0	1.0	0.0
					Sculpins	abundant,	Spotted	frogs	present			
	4.3	15N,9W,34A	14-Jun-04	275	CT	8	8	3	2.6-5.7	4.2	2.9	1.1
					Tailed	frogs	present					
Warren Creek	1.1	15N,12W,31C	8-Sep-04	345	LL	12	10	2	3.6-8.7	5.4	2.9	0.6
					RSS	12	5	5	2.5-4.0	3.4	1.4	1.4
					LNS	5	4	0	4.0-5.9	4.7	1.2	0.0
					MWF	1	0	1	3.7	3.7		
					Sculpins	common	LND	present	Spotted	frogs	present	
			6-Sep-05	345	LL	30	27	15	3.3 - 5.04	4.5	7.8	4.3
					SCUL & LI	abundant	Spotted frog	present				
	2.1	15N,12W,31A	8-Sep-04	345	LL	7	6	3	3.4-6.7	4.3	1.7	0.9
					Sculpins	common						
			6-Sep-05	345	LL	22	19	2	3.6 - 5.3	4.3	5.5	0.6
					EB	1	1	0	7.9	7.9	0.3	0.0
					SCUL	common						
	3.6	15N,12W,32C	8-Sep-04	468	EB	51	45	4	3.4-8.7	4.9	9.6	0.9
					LNS	2	1	0	4.1-4.7	4.4	0.2	0.0
					Sculpins	present						

Appendix A: catch and size statistics for tributaries to the Blackfoot River (cont.)

Stream	River Mile	Location (T, R, S)	Date Sampled	Section Length (ft)	Spp.	Total Number Captured	Number Captured 1st Pass	YOY(<4.0") 1st Pass	Range of Lengths (in)	Mean Length (in)	CPUE (#/100') 1st Pass	YOY CPUE (#/100') 1st Pass
Warren Creek (cont.)	3.6	15N,12W,32C	6-Sep-05	468	EB	67	56	7	3.6 - 8.6	4.8	12.0	1.5
					LNS	9	9	2	3.3 - 5.1	4.2	1.9	0.4
					SCUL	abundant						
pre-project	6.7	15N,12W,35B	8-Sep-04	280	ONC	1	1	1	2.4	2.4	0.4	0.4
post-project			8-Sep-05	387	EB	6	5	5	2.9 - 3.8	3.4	1.3	1.3
					LNS	17	17	15	1.4 - 4.8	2.3	4.4	3.9
	8.2	15N,12W,25C	7-Sep-05	345	CT*	15	11	0	5.3 - 11.4	8.0	3.2	0.0
					EB	204	165	118	2.0 - 13.4	4.0	47.8	34.2
					LNS	19	19	3	3.1 - 7.7	5.5	5.5	0.9
					SCUL & LI	common	RSS	common				
Wasson Creek pre-project	0.1	13N,11W,11D	18-Aug-04	366	RSS	4	4					
posr-project			17-Aug-05	500	CT	2	2	0	4.8 - 6.2	5.5	0.4	0.0
					LL	3	3	2	2.6 - 6.6	3.9	0.6	0.4
					LNS	6	4	2	3.2 - 5.2	4.0	0.8	0.4
	0.6	13N,11W,13B	15-Aug-05	300	CT	35	24	0	4.4 - 11.5	6.4	8.0	0.0
					LNS	3	1	0	4.7 - 6.9	5.4	0.3	0.0
Below lower ditch	2.4	13N,10W,7C	18-Aug-04	300	CT	6	6	0	4.3-9.8	6.0	2.0	0.0
			15-Aug-05	300	CT	21	15	2	3.2 - 8.3	5.2	5.0	0.7
Above upper ditch	2.6	13N,10W,7C	18-Aug-04	282	CT	24	24	15	1.8-7.2	3.5	8.5	5.3
			15-Aug-05	300	CT	58	55	9	3.6 - 9.6	4.9	18.3	3.0

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Arrastra Creek	0.7	14N,10W,29	9-Sep-04	385	CT	<4.0	29	8		0.72	40 ± 6.3	10.4 ± 1.6
						>4.0	13	3		0.77	16.9 ± 3.1	4.4 ± 0.8
					EB	>4.0	3	3		0.00		
					LL	>4.0	9	1		0.89	10.1 ± 0.9	2.6 ±0.2
	1.1	14N,10W,29B	9-Sep-04	405	CT	<4.0	27	14		0.48	56.1 ± 28.1	13.8 ± 6.9
						>4.0	10	3		0.70	14.3 ± 4.3	3.5 ± 1.1
					LL	<4.0	3	3		0.00		
						>4.0	6	2		0.67	9.0 ± 4.2	2.2 ± 1.0
					EB	<4.0	18	9		0.50	36 ± 20.4	8.9 ± 5.0
						>4.0	17	5		0.71	24.1 ± 5.4	5.9 ± 1.3
					DV	>4.0	2	0		1.00	2.0 ± 0.0	0.5 ± 0.0
	2.4	14N,10W,17D	9-Sep-04	250	CT	<4.0	4	0		1.00	4.0 ±0.0	1.6 ± 0.0
						>4.0	4	2		0.50		
					EB	>4.0	2	0		1.00	2.0 ± 0.0	0.8 ± 0.0
					LL	>4.0	2	0		0.67	2.0 ±0.0	0.0 ± 0.0
Ashby Creek	3	12N,16W,35B	8-Aug-05	300	CT	<4.0	3	0		1.00	3.0 ± 0.0	1.0 ± 0.0
						>4.0	30	3		0.90	33.3 ± 1.4	11.1 ± 0.5
	4	12N,16W,3A	8-Aug-05	300	CT	<4.0	19	15		0.21	90.25 ± 203.6	30.1 ± 67.9
						>4.0	18	9		0.50	36.0 ± 20.4	12.0 ± 6.8
					EB	>4.0	1	0		1.00	1.0 ± 0.0	0.3 ± 0.0
Bear Creek	1.1	13N,16W,18B &7C	10-Aug-04	379	CT	<4.0	0	0			±	±
						>4.0	1	0		1.00	1.0±0.0	0.3±0.0
					RB	<4.0	77	28		0.64	121 ± 18	31.9±4.8
						>4.0	67	16		0.76	88 ± 7.4	23.2±1.9
					Age1+RB		79	25		0.68	116±13.5	30.5±3.6
					LL	<4.0	12	6		0.50	24.4±16.6	6.3±4.4

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Bear Creek (cont.)	1.1	13N,16W,18B &7C	10-Aug-04	379	LL	>4.0	3	1		0.67	4.5±2.9	1.2±0.8
					EB	<4.0	1	1		0.00		
						>4.0	4	1		0.75	5.3±1.9	1.4 ±0.5
					All	<4.0	90	35		0.61	147 ± 22.8	38.9± 6.0
						>4.0	75	18		0.76	98.7±7.9	26± 2.1
			4-Aug-05	374	RB	<4.0	66	45		0.32	207.4 ± 139.1	55.5 ± 37.2
						>4.0	45	18		0.60	75.0 ± 17.3	20.1 ± 4.6
					Age1+RB		73	33		0.55	133.2 ± 30.4	35.6 ± 8.1
					LL	<4.0	2	1		0.50	4.0 ± 6.8	1.1 ± 1.8
						>4.0	25	5		0.80	31.2 ± 3.4	8.4 ± 0.9
					EB	>4.0	6	0		1.00	6.0 ± 0.0	1.6 ± 0.0
					All	<4.0	68	46		0.32	210.2 ± 135.2	56.2 ± 36.2
						>4.0	76	23		0.70	108.9 ± 12.	29.1 ± 3.2
Chamberlain Creek	0.1	15N,13W,32A	30-Sep-04	440	CT	<4.0	70	22		0.69	102.1±12.6	23.2±2.9
						>4.0	49	10		0.80	61.6±4.9	14.0±1.1
					RB	<4.0	1	0		1.00	2.0±0.0	0.5±0.0
						>4.0	4	2		0.50		
					LL	<4.0	1	1		0.00		
						>4.0	2	2		0.00		
					All	<4.0	72	23		0.68	105.8±13.2	24.0±3.0
						>4.0	55	14		0.75	73.78±7.5	16.8±1.7
			22-Sep-05	440	CT	<4.0	85	30		0.65	131.4 ± 17.7	29.9 ± 4.0
						>4.0	56	11		0.80	69.69 ± 4.9	15.8 ± 1.1

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
						>4.0	5	0		1.00	5.0 ± 0.0	1.1 ± 0.0
					All	<4.0	106	40		0.62	170.24 ± 23.1	38.7 ± 5.2
						>4.0	61	11		0.82	74.42 ± 4.5	16.9 ± 1.0
Cottonwood Creek	12.0	16N,14W,24D	6-Oct-04	500	CT	<4.0	16	9		0.44	36.6 ± 28.8	7.3 ± 5.8
						>4.0	25	5		0.80	31.2 ± 3.4	6.3 ± 0.7
					DV	<4.0	1	0				
						>4.0	2	0		1.00	2.0 ± 0.0	0.4 ± 0.0
					EB	<4.0	1	0				
						>4.0	12	1		0.92	13.1 ± 0.7	2.6 ± 0.1
					All	<4.0	18	9		0.50	36 ± 20.4	7.2 ± 4.1
						>4.0	39	6		0.85	46.1 ± 2.8	9.2 ± 0.6
			21-Sep-05	500	CT	<4.0	59	15		0.75	79.1 ± 15.8	15.8 ± 1.5
						>4.0	40	9		0.78	51.6 ± 5.1	10.3 ± 1.0
					DV	<4.0	0	0				
						>4.0	4	0		1.00	4.0 ± 0.0	0.8 ± 0.0
					EB	<4.0	7	1		0.86	8.2 ± 1.1	1.6 ± 0.2
						>4.0	6	1		0.83	7.2 ± 1.2	1.4 ± 0.2
					LL	<4.0	4	3		0.25	16.0 ± 62.2	3.2 ± 12.4
						>4.0	0	0				
					All	<4.0	70	19		0.73	96.1 ± 9.5	19.2 ± 1.9
						>4.0	50	10		0.80	62.5 ± 4.7	12.5 ± 0.9
Dunham Creek	2.3	16N, 12W, 19B	12-Aug-04	615	CT	>4.0	40	12		0.70	57.1±8.7	9.3±1.4
					DV	>4.0	36	14		0.61	58.9±14.4	9.6±2.3
					EB	>4.0	5	3		0.40		
					All	>4.0	81	29		0.64	126±18.9	20.5±2.9
			24-Aug-05	615	CT	<4.0	18	2		0.89	20.2 ± 1.2	3.3 ± 0.2

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Dunham Creek (cont.)	2.3	16N, 12W, 19B	24-Aug-05	615	CT	>4.0	18	13		0.28	64.8 ± 102.1	10.5 ± 16.6
					DV	<4.0	3	0		1.00	3.0 ± 0.0	0.5 ± 0.0
						>4.0	11	2		0.82	13.4 ± 1.9	2.2 ± 0.3
					EB	<4.0	2	0		1.00	2.0 ± 0.0	0.3 ± 0.0
						>4.0	7	1		0.86	8.2 ± 1.1	1.3 ± 0.2
					All	<4.0	23	2		0.91	25.2 ± 1.0	4.1 ± 0.2
						>4.0	36	16		0.56	64.8 ± 20.4	10.5 ± 3.3
Hoyt Creek	0.5	15N,12W,19B	1-Sep-05	300	EB	<4.0	25	3		0.88	28.4 ± 1.6	9.5 ± 0.5
						>4.0	32	5		0.84	37.9 ± 2.6	12.6 ± 0.9
					LL	<4.0	1	0		1.00	1.0 ± 0.0	0.3 ± 0.0
						>4.0	3	0		1.00	3.0 ± 0.0	1.0 ± 0.0
	1.2	15N,12W,19C	1-Sep-05	300	EB	>4.0	2	0		1.00	2.0 ± 0.0	0.7 ± 0.0
					LL	>4.0	2	0		1.00	2.0 ± 0.0	0.7 ± 0.0
	3.4	15N,12W,29D	1-Sep-05	300	EB	<4.0	1	0		1.00	1.0 ± 0.0	0.3 ± 0.0
						>4.0	6	0		1.00	6.0 ± 0.0	2.0 ± 0.0
	3.9	15N,12W,28C	1-Sep-05	300	EB	<4.0	11	6		0.45	24.2 ± 21.3	8.1 ± 7.1
						>4.0	4	0		1.00	4.0 ± 0.0	1.3 ± 0.0
Jacobson Spring Creek	0.6	14N,12W,1C, D	17-Aug-05	425	CT	>4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.0
					RB	>4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.0
					EB	<4.0	60	19		0.68	87.8 ± 11.8	20.7 ± 2.8
						>4.0	12	2		0.83	14.4 ± 1.8	3.4 ± 0.4
					LL	<4.0	15	5		0.67	22.5 ± 6.6	5.3 ± 1.5
						>4.0	3	0		1.00	3.0 ± 0.0	0.7 ± 0.0
Kleinschmidt Creek	0.5	14N,11W,6D, 5C	23-Aug-04	500	LL	[<4.3]	12	0		1.00	12.0± 0.0	2.4 ± 0.0

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Kleinschmidt Creek	0.5	14N,11W,6D, 5C	23-Aug-04	500	LL	[>4.3]	8	0		1.00	8.0 ± 0.0	1.6 ± 00
			29-Aug-05	500	LL	[<4.3]	23	12		0.48	48.1 ± 26.4	9.6 ± 5.3
woodless section						[>4.3]	10	4		0.60	16.7 ± 8.1	3.3 ±1.6
					EB	[<4.3]	2	1		0.50	4.0 ± 6.8	0.8 ± 1.4
						[>4.3]	0	0				
					All	[<4.3]	25	13		0.48	52.1 ± 27.3	10.4 ± 5.5
						[>4.3]	10	4		0.60	16.7 ± 8.1	3.3 ± 1.6
	0.8	14N,11W,5C	23-Aug-04	500	LL	[<4.3]	13	6		0.54	24.1 ± 13.6	4.8 ± 2.7
						[>4.3]	15	10	4	0.33		6.6
			29-Aug-05	500	LL	[<4.3]	87	10		0.89	98.3 ± 2.8	19.7 ± 0.6
wood section						[>4.3]	43	6		0.86	49.9 ± 2.6	10 ± 0.5
					CT	[<4.3]	0	0				
						[>4.3]	2	0		1.00	2.0 ± 0.0	0.4 ± 0.0
					EB	[<4.3]	9	4		0.56	16.2 ± 10.2	3.2 ± 2.0
						[>4.3]	0	1				
					All	[<4.3]	96	14		0.85	112.4 ± 4.1	22.5 ± 0.8
						[>4.3]	60	7		0.88	67.9 ± 2.4	13.6 ± 0.5

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Kleinschmidt Creek	2.0	14N,11W,8A	30-Aug-05	300	EB	[<4.3]	0	0				
						[>4.3]	5	0		1.00	5.0 ± 0.0	1.7 ± 0.0
McCabe Creek	2.2	15N, 12W, 5C	19-Aug-04	340	CT	<4.0	16	2		0.88	18.3 ± 1.4	5.4 ± 0.4
						>4.0	27	7		0.74	36.4 ± 5.4	10.7 ± 1.6
					EB	<4.0	33	6		0.82	43.3 ± 3.3	11.9 ± 1.0
						>4.0	18	0		1.00	18 ± 0.0	5.3 ± 0.0
					All	<4.0	49	8		0.84	58.6 ± 3.5	17.2 ± 1.0
						>4.0	45	7		0.84	53.3 ± 3.1	15.7 ± 0.9
Nevada Spring Creek	0.8 (1.1)	13N, 11W, 10C	21-Sep-04	500	DV	<4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.4
					CT	<4.0	2	0		1.00	2.0 ± 0.0	0.4 ± 0.0
					LL	<4.0	11	2		0.82	13.4 ± 1.9	2.7 ± 0.4
			15-Sep-05	500	CT	>4.0	6	1		0.83	7.2 ± 1.2	
					RB	<4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.0
					LL	<4.0	0	1				
						>4.0	10	2		0.80	12.5 ± 2.1	2.5 ± 0.4
					NPM	>4.0	2	0		1.00	2.0 ± 0.0	0.4 ± 0.0
					MWF	>4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.0
					All	>4.0	19	3		0.84	22.6 ± 2.0	4.5 ± 0.4
	3.0(3.5)	13N, 11W, 11D	21-Sep-04	470	LL	<4.0	15	3		0.80	18.7 ± 2.6	4.0 ± 0.6
						>4.0	29	8		0.72	40 ± 6.3	8.5 ± 1.3
					CT	<4.0	0	0				
						>4.0	4	0		1.00	4.0 + 0.9	0.9 + 0.0
					All	>4.0	33	8			43.6± 5.3	9.3 ± 1.1
			15-Sep-05	470	LL	<4.0	7	4		0.43	16.3 ± 20.2	3.5 ± 4.3
						>4.0	61	7		0.89	68.9 ± 2.4	14.7 ± 0.5
					CT	<4.0	0	0				
						>4.0	1	1				
					All	>4.0	62	8		0.87	71.2 ± 2.8	15.1 ± 0.6

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Pearson Creek	0.5	15N,13W,33D	8-Sep-05	300	CT YOY	<3.2	0	0				
					age 1+	>3.2	18	4		0.78	23.1 ± 3.4	7.7 ± 1.1
					EB	<4.0	1	0		1.00	1.0 ± 0.0	0.3 ± 0.0
						>4.0	3	0		1.00	3.0 ± 0.0	1.0 ± 0.0
	1.1	14N,13W,3B	21-Sep-04	450	CT YOY	<3.2	84	18		0.79	106.91±6.9	23.8±1.5
					age 1+	>3.2	70	10		0.86	81.67±3.4	18.1±0.8
					EB	<4.0	5	1		0.80	6.25±1.5	1.4±0.3
						>4.0	2	0		1.00	2.0±0.0	0.4±0.0
			8-Sep-05	405	CT YOY	<3.2	65	19		0.71	91.8 ± 10.5	22.7 ± 2.6
					age 1+	>3.2	54	8		0.85	63.3 ± 3.2	15.7 ± 0.8
					EB	<4.0	4	0		1.00	4.0 ± 0.0	1.0 ± 0.0
						>4.0	2	0		1.00	2.0 ± 0.0	0.5 ± 0.0
					LL	>4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.0
Poorman Creek	1.3	14N,9W,36A	10-Aug-05	490	CT	<4.0	1	2				
						>4.0	0	0				
(Downstream of lower diversion)					LL	<4.0	11	5		0.55	20.2 ± 12.0	4.1 ± 2.4
						>4.0	2	1		0.50	4.0 ± 6.8	0.8 ± 1.4
					All	<4.0	12	7		0.42	28.8 ± 28.7	5.9 ± 5.9
						>4.0	2	1		0.50	4.0 ± 6.8	0.8 ± 1.4
	1.5	14N,9W,36A	11-Aug-04	270	LL	<4.0	1	0		1.00	1.0 ± 0.0	0.4 ± 0.0
(Upstream of upper diversion)						>4.0	5	1		0.80	6.25 ± 1.5	2.3 ± 0.6
					EB	>4.0	2	0		1.00	2.0 ± 0.0	0.7 ± 0.0
			10-Aug-05	270	CT	<4.0	3	0		1.00	3.0 ± 0.0	1.1 ± 0.0
						>4.0	0	0				
					LL	<4.0	34	12		0.65	52.5 ± 11.2	19.5 ± 4.2
						>4.0	4	3		0.25	16.0 ± 62.2	5.9 ± 23.0
					EB	<4.0	0	2				
						>4.0	0	0				

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Poorman Creek	1.5	14N,9W,36A	10-Aug-05	270	All	<4.0	7	5		0.29	24.5 ± 59.4	9.1 ± 22.0
						>4.0	34	14		0.59	57.8 ± 16.2	21.4 ± 6.0
Rock Creek	1.6	14N,11W,5A	11-Aug-04	510	LL	<4.0	9	1		0.89	10.1 ± 0.9	3.3 ± 0.2
						>4.0	14	6		0.57	24.5 ± 11.5	4.0 ± 2.3
					EB	<4.0	9	2		0.78	11.6 ± 2.4	3.4 ± 0.5
						>4.0	2	2				
					RB	<4.0	3	0		1.00	3.0 ± 0.0	0.6 ± 0.0
					All	<4.0	21	3		0.86	36.0 ± 8.3	7.1 ± 1.6
						>4.0	16	8		0.50	32 ± 19.2	6.3 ± 3.8
			9-Aug-05	510	LL	<4.0	22	11		0.50	44.0 ± 22.5	8.6 ± 4.4
						>4.0	21	4		0.81	25.9 ± 2.8	5.1 ± 0.6
					EB	<4.0	26	7		0.73	35.6 ± 5.7	7.0 ± 1.1
						>4.0	6	3		0.50	12.0 ± 11.8	2.4 ± 2.3
					All	<4.0	48	18		0.63	76.8 ± 15.3	15.1 ± 3.0
						>4.0	27	7		0.74	36.5 ± 5.4	7.1 ± 1.1
Snowbank Creek below diversion	0.4	15N,8W,9A	16-Aug-05	450	CT	<4.0	11	7		0.36	30.2 ± 40.0	6.7 ± 8.9
						>4.0	5	0		1.00	5.0 ± 0.0	1.1 ± 0.0
					DV	<4.0	0	0				
						>4.0	11	2		0.82	13.4 ± 1.9	3.0 ± 0.4
					All	<4.0	11	7		0.36	30.3 ± 40.0	6.7 ± 8.9
						>4.0	16	2		0.88	18.3 ± 1.4	4.1 ± 0.3
above diversion	0.41	15N,8W,9A	16-Aug-05	500	CT	<4.0	6	0		1.00	6.0 ± 0.0	1.2 ± 0.0
						>4.0	9	2		0.78	11.6 ± 2.4	2.3 ± 0.5
					DV	<4.0	0	0				
						>4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.0
					All	<4.0	6	0		1.00	6.0 ± 0.0	1.2 ± 0.0
						>4.0	10	2		0.80	12.5 ± 2.1	2.5 ± 0.4
Spring Creek (Murphy)	0.6	15N,11W,21B	7-Sep-05	385	DV	<4.0	0	0				

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Spring Creek (Murphy) (cont.)	0.6	15N,11W,21B	7-Sep-05	385	CT	<4.0	56	11		0.80	69.7 ± 4.9	18.1 ± 1.3
						>4.0	7	2		0.71	9.8 ± 3.3	2.5 ± 0.9
					EB	<4.0	10	2		0.80	12.5 ± 2.1	3.2 ± 0.6
						>4.0	0	2				
					All	<4.0	66	13		0.80	82.2 ± 5.3	21.3 ± 1.4
						>4.0	9	4		0.56	16.2 ± 10.2	4.2 ± 2.6
Warren Creek	1.1	15N,12W, 31C	8-Sep-04	345	LL	<4.0	1	0		1.00	1.0 ± 0.0	0.3 ± 0.0
						>4.0	9	2		0.78	11.6 ± 2.4	3.4 ± 0.7
			6-Sep-05	345	LL	<4.0	15	2		0.87	17.36 ± 1.4	5.0 ± 0.4
						>4.0	12	1		0.92	13.1 ± 0.7	3.8 ± 0.2
	2.1	15N,12W,31A	8-Sep-04	468	EB	<4.0	4	0		1.00	4.0 ± 0.0	0.9 ± 0.0
						>4.0	41	6		0.85	48.0 ± 2.7	10.3 ± 0.6
			6-Sep-05	468	EB	<4.0	7	0		1.00	7.0 ± 0.0	1.5 ± 0.0
						>4.0	49	11		0.78	63.2 ± 5.7	13.5 ± 1.2
pre-project	6.7	15N,12W,35B	8-Sep-04	280	Onc.	<4.0	1	0		1.00	1.0 ± 0.0	0.4 ± 0.0
post-project			8-Sep-05	387	EB	<4.0	5	1		0.80		
						>4.0	0	0				
	8.2	15N, 12W, 25C	7-Sep-05	345	CT*	<4.0	0	0				
						>4.0	11	4		0.64	17.3 ± 6.8	5.0 ± 2.0
					EB	<4.0	118	35		0.70	167.8 ± 14.5	48.6 ± 4.2
						>4.0	47	4		0.91	51.4 ± 1.4	14.9 ± 0.4
					All	<4.0	118	35		0.70	167.8 ± 14.5	48.6 ± 4.2
						>4.0	58	8		0.86	67.3 ± 3.0	19.5 ± 0.9
Wasson Creek	0.1	13N, 11W, 11D	17-Aug-05	500	CT	<4.0	0	0				
						>4.0	2	0		1.00	2.0 ± 0.0	0.4 ± 0.0
					LL	<4.0	2	0		1.00	2.0 ± 0.0	0.4 ± 0.0
						>4.0	1	0		1.00	1.0 ± 0.0	0.2 ± 0.0

Appendix B: Two-pass depletion estimates for tributaries of the Balckfoot River (cont.)

Stream	River Mile	Location (T,R,S)	Date Sampled	Section Length (ft)	Species	Size Class (in)	1st Pass	2nd Pass	3rd Pass	Prob. of Capture	Total Estimate ± CI	Estim/100' ± CI
Wasson Creek (cont.)	0.6	13N,11W,13B	15-Aug-05	300	CT	<4.0	0	0				
						>4.0	24	11		0.54	44.3 ± 18.1	14.8 ± 6.0
	2.4	13N,10W,7C	15-Aug-05	300	CT	<4.0	2	0		1.00	2.0 ± 0.0	0.7 ± 0.0
						>4.0	13	6		0.54	24.1 ± 13.6	8.0 ± 4.5
	2.6	13N,10W,7C	15-Aug-05	300	CT	<4.0	9	0		1.00	9.0 ± 0.0	3.0 ± 0.0
						>4.0	46	3		0.93	49.2 ± 1.0	16.4 ± 0.3

Appendix C: Mark and recapture estimates for the Blackfoot River

Location	River Mile Mid-point	Date Sampled	Section Length (ft)	Spp.	Size Class (in)	M	C	R	Efficiency (R/C)	Total Estim ± 95% CI	Estim/1000' ± 95% CI
Johnsrud Section	13.5	13-May-04	18700	CT	>6.0	54	37	7	0.19	260±151	13.9±8.1
					6.0-11.9	36	29	7	0.24	138±77	7.4±4.1
					>12.0	18	8	0	0.00	170±222	9.1±11.9
				DV	>6.0	12	6	1	0.17	45±43	2.4±2.3
				LL	>6.0	104	47	13	0.28	359±153	19.2±8.2
					6.0-11.9	33	20	4	0.20	142±99	7.6±5.3
					>12.0	73	27	9	0.33	206±98	11.0±5.2
				RB	5.0-9.9	200	210	29	0.14	1413±461	75.5±24.6
					10.0-11.9	38	17	4	0.24	139±95	7.5±5.1
					>12.0	90	46	11	0.24	355±167	19.0±8.9
					rb>6.0	306	236	43	0.18	1647±434	88.1±23.2
				All	>6.0	476	326	64	0.20	2394±517	128.3±27.7
Scotty Brown	43.9	12-May-04	20064	CT	6.0-11.9	57	71	22	0.31	181±60	9.0±30
					>12.0	48	53	14	0.26	175±73	8.7±3.6
					>6.0	105	124	36	0.29	357±95	17.8±4.7
				DV	>6.0	13	20	5	0.25	48±30	2.4±1.5
				LL	6.0-11.9	26	52	10	0.19	129±65	6.4±3.2
					>12.0	29	47	18	0.38	75±25	3.1±1.3
					>6.0	55	99	28	0.28	192±58	9.6±2.9
				RB	4.0-10.9	39	45	5	0.11	306±211	15.2±10.5
					11.0-13.9	15	16	6	0.38	38±20	1.9±1.0
					>14.0	41	61	13	0.21	185±82	9.2±4.1
					RB>6.0	89	108	24	0.22	380±125	18.9±6.2
				All	>6.0	262	352	94	0.27	976±167	48.7±8.3
Wales Creek	63	10-May-04	31635	CT	>6.0	8	7	3	0.43	17 ± 11	0.5 ± 0.3
				DV	>6.0	1	3	0			
				LL	>6.0	46	51	8	0.16	271±152	8.6±4.8
				RB	>6.0	0	0	0			
				ALL	>6.0	55	61	11	0.18	288±141	9.1±4.4

Appendix D: Summary of stream discard measurement for 2004 and 2005

Summary for stream discharge measurements for 2004 and 2005.

Stream	Legal Description	Stream Mile	Date	Discharge ft^3/s	Staff gauge reading	Lat	Long	Location
Ashby Creek	12N,15W,35B	2.7	8-Aug-05	0.857		N46.8467	W113.5898	Above Arkansas bypass ditch
	12N,16W,3A	4	8-Aug-05	2.57		N46.8320	W113.5964	at road xing
Clearwater River	14N,14W,16D	0.1	22-Jun-04	376.12		N46.9649	W113.3791	300ft upstream from mouth
	14N,14W,4B	3.5	22-Jun-04	378.9		N47.0014	W113.3813	300ft upstream of diversion
Clearwater (Potter) Ditch	14N,14W,4B		6-May-04	25.4		N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4C		6-May-04	20.4		N46.9913	W113.3857	at fish trap located on state land
	14N,14W,16B		6-May-04	14.2		N46.9728	W113.3802	in lower pasture
	14N,14W,4B		22-Jun-04	20.28		N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		23-Jun-04	19.4		N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4C		23-Jun-04	19.1		N46.9913	W113.3857	at fish trap located on state land
	14N,14W,9B		23-Jun-04	16.9		N46.9859	W113.3816	at county rd xing
	14N,14W,16B		23-Jun-04	12.7		N46.9728	W113.3802	in lower pasture
	14N,14W,4B		3-Aug-04	13.4		N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		16-Aug-04	9.62	0.93	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater campground
	14N,14W,4B		27-May-05	20.76	1.4	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		30-May-05	35.25	1.83	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		13-Jun-05	30.4	1.73	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		21-Jun-05	29.16	1.65	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		27-Jul-05	22.2	1.46	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		2-Aug-05	14.71	1.18	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		2-Aug-05	12	1.0	N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground
	14N,14W,4B		29-Aug-05	1.895		N47.0010	W113.3817	Near headgate & staff gauge at Clearwater FAS campground

Summary for stream discharge measurements for 2004 and 2005.

Stream	Legal Description	Stream Mile	Date	Discharge ft³/s	Staff gauge reading	Lat	Long	Location
Dreyer Irrigation Ditch from Cottonwood Creek	16N,14W,24D		22-Jun-04	10.1	0.26	N47.1251	W113.3034	Measurements taken ~20ft above staff gauge
	16N,14W,24D		8-Jul-04	4.56		N47.1251	W113.3034	Old meter used -suspect data, compare to rating curve with the new meter
	16N,14W,24D		4-May-05	6.24	0.18	N47.1251	W113.3034	Measurements taken ~20ft above staff gauge
			4-May-05	7.05	0.2			
			4-May-05	4.09	0.14			
			4-May-05	2.41	0.09			
			10-May-05	11.9	0.3			
East Twin Creek	13N,17W,2D	0.1	3-Jun-04	17		N46.91473	W113.71026	~ 0.1miles upstream from mouth
Gold Creek	13N,16W,6B	0.1	3-Jun-04	143.5		N46.91990	W113.67726	~ 100ft upstream from mouth
Hoyt Creek	15N,12W,19B	0.5	31-Aug-05	0.378		N47.04663	W113.17015	~25ft upstm of spring
Spring Cr trib to lower Hoyt Creek	15N,12W,19B	0.5	31-Aug-05	0.3		N47.04660	W113.17002	~20ft upstm from confluence
Hoyt Creek	15N,12W,29D	4.1	31-Aug-05	0.301		N47.02099	W113.13590	above project area
Jacobsen Spring Creek at mouth	14N,12W,1C	0.1	3-May-04	10.66	n/a	N46.9916	W113.0620	Pivot irrigation system off
			9-Jun-04	11.36	0.8	N46.9916	W113.0620	Pivot irrigation system off
			25-Jun-04	9.52	0.73	N46.9916	W113.0620	Pivot irrigation system on
			2-Jul-04	8.83	0.74	N46.9916	W113.0620	Pivot irrigation system on
			30-Jul-04	6.56	0.68	N46.9916	W113.0620	Pivot irrigation system on
			16-Aug-04	4.41	0.67	N46.9916	W113.0620	Pivot irrigation system on
			26-Aug-04	7.74	0.7	N46.9916	W113.0620	Pivot irrigation system off
			6-Oct-04	7.59	0.66	N46.9916	W113.0620	Pivot irrigation system off
Jacobsen Spring Creek at mile 0.6	14N,12W,1D	0.6	9-Jun-04	4.03	0.66	N46.9950	W113.0603	Pivot irrigation system off
			25-Jun-04	2.45	0.56	N46.9950	W113.0603	Pivot irrigation system on
			2-Jul-04	2.49	0.62	N46.9950	W113.0603	Pivot irrigation system on
			30-Jul-04	1.74	0.56	N46.9950	W113.0603	Pivot irrigation system on
			16-Aug-04	1.79	0.51	N46.9950	W113.0603	Pivot irrigation system on
			26-Aug-04	2.79	0.59	N46.9950	W113.0603	Pivot irrigation system off
			6-Oct-04	2.51	0.58	N46.9950	W113.0603	Pivot irrigation system off

Summary for stream discharge measurements for 2004 and 2005.

Stream	Legal Description	Stream Mile	Date	Discharge ft^3/s	Staff gauge reading	Lat	Long	Location
Johnson Creek	13N,18W,14C	0.1	3-Jun-04	31.74		N46.8882	W113.8409	~25ft upstream from mouth
Keep Cool Creek	14N,9W,14D	1.9	14-Jun-04	39.87		N46.9598	W112.7097	~ 0.2mile upstream of Beaver Cr Rd
Kleinschmidt Creek @ mouth	14N,11W,6A	0.1	10-Mar-04	9.63	n/a	N46.9999	W113.0354	upstream of confluence with Rock Creek
			25-Mar-04	12.09	n/a	N46.9999	W113.0354	
			21-Apr-04	9.09	n/a	N46.9999	W113.0354	
			24-May-04	8.85	n/a	N46.9999	W113.0354	
			27-May-04	9.8	0.77	N46.9999	W113.0354	
			14-Jun-04	11.19	0.9	N46.9999	W113.0354	
			2-Jul-04	12.98	1.12	N46.9999	W113.0354	
			15-Jul-04	13.26	1.2	N46.9999	W113.0354	
			30-Jul-04	14.28	1.22	N46.9999	W113.0354	
			26-Aug-04	13.92	1.19	N46.9999	W113.0354	
			21-Sep-04	14.89	1.17	N46.9999	W113.0354	
			27-Oct-04	12.33	1.04	N46.9999	W113.0354	
			28-Jan-05	10.62	0.82	N46.9999	W113.0354	
Kleinschmidt Creek @ fenceline	14N,11W,5C	0.5	10-Mar-04	9.89		N46.9976	W113.0283	fenceline between Freide and Rue properties
			25-Mar-04	11.56		N46.9976	W113.0283	
			21-Apr-04	9.13		N46.9976	W113.0283	
			24-May-04	9.03		N46.9976	W113.0283	
			27-May-04	n/a		N46.9976	W113.0283	
			14-Jun-04	10.28		N46.9976	W113.0283	
			2-Jul-04	12.75		N46.9976	W113.0283	
			15-Jul-04	14.43		N46.9976	W113.0283	
			30-Jul-04	14.8		N46.9976	W113.0283	
			26-Aug-04	13.94		N46.9976	W113.0283	
			21-Sep-04	13.37		N46.9976	W113.0283	
			27-Oct-04	12.84		N46.9976	W113.0283	
			28-Jan-05	8.26		N46.9976	W113.0283	
Kleinschmidt Creek @ mile 1.2	14N,11W,5C	1.2	10-Mar-04	9.5	n/a	N46.9933	W113.0186	near Tom Rue's house
			25-Mar-04	9.84	n/a	N46.9933	W113.0186	
			21-Apr-04	7.59	n/a	N46.9933	W113.0186	
			24-May-04	8.11	n/a	N46.9933	W113.0186	
			27-May-04	8.06	1.38	N46.9933	W113.0186	
			14-Jun-04	9.2	1.42	N46.9933	W113.0186	
			2-Jul-04	11.41	1.52	N46.9933	W113.0186	
			15-Jul-04	11.95	1.6	N46.9933	W113.0186	
			30-Jul-04	12.05	1.62	N46.9933	W113.0186	
			26-Aug-04	12.53	1.65	N46.9933	W113.0186	
			21-Sep-04	12.38	1.64	N46.9933	W113.0186	
			27-Oct-04	11.16	1.54	N46.9933	W113.0186	
			28-Jan-05	8.14	1.38	N46.9933	W113.0186	
Kleinschmidt Creek @ Hwy 200	14N,11W,8A	1.9	10-Mar-04	2.42	n/a	N46.9885	W113.0098	
			25-Mar-04	4.22	n/a	N46.9885	W113.0098	
			21-Apr-04	2.51	n/a	N46.9885	W113.0098	
			24-May-04	3.15	n/a	N46.9885	W113.0098	
			27-May-04	3.06	0.93	N46.9885	W113.0098	
			14-Jun-04	2.73	1	N46.9885	W113.0098	
			2-Jul-04	2.53	1.2	N46.9885	W113.0098	
			15-Jul-04	2.54	1.23	N46.9885	W113.0098	
			30-Jul-04	2.4	1.28	N46.9885	W113.0098	
			26-Aug-04	3.03	1.3	N46.9885	W113.0098	
			21-Sep-04	3.28	1.31	N46.9885	W113.0098	
			27-Oct-04	3.09	1.15	N46.9885	W113.0098	
			28-Jan-05	2.09	0.9	N46.9885	W113.0098	

Summary for stream discharge measurements for 2004 and 2005.

Stream	Legal Description	Stream Mile	Date	Discharge ft^3/s	Staff gauge reading	Lat	Long	Location
Moose Creek	14N,10W,34B	0.6	28-Jul-04	0.44		N46.92282	W112.85421	~150ft downstream of USFS Rd xing
N.F.Blackfoot River	17N,10W,29C	25.5	15-Jul-04	172.02		N47.19194	W112.90897	100ft below USFS cabin
Rue Irrigation Ditch from NFBLKFT	15N,11W,21C		8-Jul-04	10.4		N47.0365	W113.0050	Measurement taken at headgate
	14N,11W,5D		8-Jul-04	0.357		N46.9966	W113.0073	Measurement taken at county rd xing near Rue's pivot irrigation system.
Sauerkraut Creek	14N,9W,29B	0.1	28-Jul-04	1.93		N46.93240	W112.76771	~25ft upstream from mouth, base flow
Spring Cr trib to NFBLKFT	15N,11W,21B	0.5	7-Sep-05	0.455		N47.04305	W113.00674	below culvert
Spring Creek	14N,9W,23B	0.4	15-Jun-04	25.63		N46.9548	W112.7101	at Hwy 200 (Lincoln,MT)
	14N,9W,23A	1.8	15-Jun-04	18.24		N46.9564	W112.6899	below 3 culverts at 1st st xing
Stonewall Creek	14N,9W,14D	0.1	14-Jun-04	2.425		N46.9613	W112.7043	mouth, at confluence to Keep Cool Cr
Sucker Creek	14N,8W,7B	5.9	15-Jun-04	2.01		N46.98127	W112.66136	
Union Creek	13N,16W,6C	0.1	3-Jun-04	11.436		N46.91186	W113.67501	upstream from mouth
Warren Creek	15N,12W,35B	6.7	14-Sep-05	1.24		N47.01417	W113.08279	below diversion
		6.8	14-Sep-05	2.06		N47.01450	W113.0822	above diversion
West Twin Creek	13N,17W,2C	0.1	3-Jun-04	39.2				~ 0.1 miles upstream of mouth
Willow Creek below Lincoln,MT	14N,9W,28A	1.5	28-Jul-05	0.31		N46.93744	W112.73829	~ 50 downstream of Dalton Mtn Rd, base flow

Appendix E: Restoration Streams and Table of Activities

Stream Name	Fish passage improvement	Prevent Irrigation ditch losses	Spawning habitat protection	Channel restoration	Fish habitat improvement	Riparian vegetation improve.	Improve instream flows	Improve wetlands	Improve range/ riparian habitat	Improve irrigation	Conserv. easements	Remove streamside feedlots
Alice Creek												
Arkansas Creek												
Arrastra Creek	X											
Ashby Creek	X	X		X	X	X	X	X	X	X	X	
Bartlett Creek												
Basin Spring Creek				X	X	X	X	X	X	X	X	X
Bear Creek (lower River)	X			X	X	X	X		X	X		X
Bear Creek (middle River)												
Bear Creek (North Fork)												
Beaver Creek	X	X						X		X	X	
Belmont Creek	X		X						X			
Black Bear Creek												
Blackfoot River(mouth to Clearwater)							X				X	
Blackfoot River(Clearwater to N.F)							X		X		X	
Blackfoot River(NF to Nevada)								X	X		X	
Blackfoot River(Nevada to Arrastra)								X	X	X	X	X
Blackfoot River(Arrastra to Lincoln)												
Blackfoot River(Lincoln to Headwaters)												
Blanchard Creek	X					X			X	X		
Buffalo Gulch												
Burnt Bridge Creek												
California Gulch												
Camas Creek												
Chamberlain Creek	X	X	X	X	X	X	X	X	X	X	X	X
Chamberlain Creek, east fork												
Chamberlain Creek, west fork									X			
Chicken Creek												
Chimney Creek (trib to Douglas)												
Chimney Creek (Nevada drain.)												
Clear Creek												
Clearwater River							X					
Copper Creek												
Cottonwood Creek (lower trib.)	X	X				X	X	X	X	X	X	X
Cottonwood Creek (Nevada drain.)	X			X		X			X	X		X

Appendix E: Restoration Streams and Table of Activities

Stream Name	Fish passage improvement	Prevent Irrigation ditch losses	Spawning habitat protection	Channel restoration	Fish habitat improvement	Riparian vegetation improve.	Improve Instream flows	Improve wetlands	Improve range/ riparian habitat	Improve irrigation	Conserv. easements	Remove streamside feedlots
Dick Creek	X	X		X	X	X	X	X	X	X	X	X
Douglas Creek	X					X						
Dry Creek						X			X			
Dunham Creek		X		X	X	X				X	X	
Elk Creek				X	X			X				
East Twin Creek	X											
Finn Creek												
Fish Creek												
Frazier Creek												
Frazier Creek, north fork												
Gallagher Creek												
Game Creek												
Gleason Creek												
Gold creek					X							
Gold Creek, WF												
Grantier Spring Creek	X		X	X	X	X		X	X			
Halfway Creek												
Hogum Creek												
Hoyt Creek	X					X			X	X	X	
Humbug Creek												
Indian Creek												
Jacpbsem Spring Creek				X	X	X			X		X	
Jefferson Creek												
Johnson Creek	X											
Keep Cool Creek						X						
Kleinschmidt Creek	X		X	X	X	X		X	X		X	
Landers Fork												
Lincoln Spring Creek				X	X	X			X			
Little Fish Creek												
Lodgepole Creek												
McElwain Creek												
McCabe Creek	X	X		X	X	X	X		X	X		
Mitchell Creek												

Appendix E: Restoration Streams and Table of Activities

Stream Name	Fish passage improvement	Prevent Irrigation ditch losses	Spawning habitat protection	Channel restoration	Fish habitat improvement	Riparian vegetation improve.	Improve Instream flows	Improve wetlands	Improve range/ riparian habitat	Improve irrigation	Conserv. easements	Remove streamside feedlots
Monture Creek			X	X	X	X	X	X	X	X	X	
Moose Creek												
Murray Creek												
Nevada Creek (lower)	X			X	X	X			X	X	X	
Nevada Creek (upper)												
Nevada Spring Creek	X		X	X	X	X	X	X	X		X	X
North Fork Blackfoot River		X		X	X	X	X		X	X	X	
Pearson Creek	X	X	X	X	X	X	X	X	X	X	X	X
Poorman Creek	X	X				X	X		X	X		
Rock Creek	X	X		X	X	X	X	X	X	X	X	X
Salmon Creek	X	X	X	X	X	X	X	X	X	X	X	X
Seven up Pete Creek												
Sauerkraut Creek												
Shanley Creek		X				X	X		X	X	X	
Sheep Creek												
Shingle Mill Creek												
Snowbank Creek												
Spring Creek (upper Cottonwood)												
Spring Creek (North Fork)	X									X		
Stonwall Creek												
Strickland Creek												
Sturgeon Creek												
Union Creek												
Wales Creek									X			
Wales Spring Creek												
Ward Creek												
Warm Springs Creek												
Warren Creek	X		X	X	X	X	X	X	X	X	X	X
Washington Creek												
Washoe Creek												
Wasson Creek	X	X	X	X	X	X	X	X	X	X	X	X
Wilson Creek												
West Twin Creek	X											

Appendix E: Restoration Streams and Table of Activities

Stream Name	Fish passage improvement	Prevent Irrigation ditch losses	Spawning habitat protection	Channel restoration	Fish habitat improvement	Riparian vegetation improve.	Improve Instream flows	Improve wetlands	Improve range/ riparian habitat	Improve irrigation	Conserv. easements	Remove streamside feedlots
Willow Creek (above Lincoln)												
Willow Creek (below Lincoln)												
Yourname Creek												

Appendix F: Table of Potential Restoration Projects

Stream Name	Road Crossings	Irrigation Impacts	Channel alterations	Lacks Complexity	Riparian vegetation	Instream flow	Road drainage	Feedlots, Grazing	Recreation Impacts	Whirling Disease	Mining	Residential
Alice Creek				X	X				X			
Arkansas Creek			X				X	X				
Arrastra Creek	X						X		X	X		
Ashby Creek	X	X	X	X	X	X	X	X				
Bartlett Creek					X				X			
Basin Spring Creek												
Bear Creek (R.M. 12.2)					X		X					
Bear Creek (R.M. 37.5)	X											
Bear Creek (trib to N.F)		X				X						
Beaver Creek		X			X	X		X		X		
Belmont Creek							X		X	X		
Black Bear Creek	X					X		X				
Blackfoot River (N.F. to Nevada Creek)						X		X		X		
Blackfoot River (Nevada Cr. to Arrastra Cr.)		X		X	X	X		X		X		
Blackfoot River(Arrastra Cr. to Lincoln)		X	X	X	X	X		X	X	X		
Blackfoot River(Clearwater to N.F)			X		X			X	X	X		
Blackfoot River(Lincoln to Headwaters)		X	X	X		X			X	X	X	
Blackfoot River(mouth to Clearwater)			X	X			X	X	X	X		
Blanchard Creek		X	X	X	X	X	X	X				
Buffalo Gulch	X			X	X			X			X	
Burnt Bridge Creek	X	X	X		X	X	X					
California Gulch	X			X	X			X				
Camas Creek			X	X				X				
Chamberlain Creek				X	X		X			X		
Chamberlain Creek, east fork							X					
Chamberlain Creek, west fork							X					
Chicken Creek	X		X	X	X			X				
Chimney Creek (Nevada drain.)	X	X	X			X		X				
Chimney Creek (trib to Douglas)		X	X	X	X			X				
Clear Creek	X		X		X			X				X
Clearwater River		X	X			X						
Copper Creek	X								X			
Cottonwood Creek (Nevada drain.)	X	X	X	X	X	X		X				X

Appendix F: Table of Potential Restoration Projects (cont.)

Stream Name	Crossings	Impacts	alterations	Complexity	vegetation	flow	drainage	Grazing	Impacts	Disease	Mining	Residential
Cottonwood Creek (R.M. 43)	X		X	X	X	X	X	X		X		
Dick Creek	X	X		X	X	X		X				
Douglas Creek		X	X	X	X	X	X	X				
Dry Creek				X				X				
Dunham Creek					X	X						
East Twin Creek												
Elk Creek	X	X	X	X	X	X	X	X		X	X	
Finn Creek		X		X		X		X				
Fish Creek		X	X									
Frazier Creek		X	X			X		X				
Frazier Creek, North fork			X			X		X				
Gallagher Creek	X							X				
Game Creek	X							X				
Gleason Creek	X										X	
Gold Creek									X	X		
Gold Creek, W.F.												
Grantier Spring Creek												
Halfway Creek				X	X			X				
Hogum Creek	X				X			X				
Hoyt Creek		X	X	X	X	X		X		X		
Humbug Creek		X	X		X	X		X			X	
Indian Creek				X								
Jacobsen Spring Creek			X	X	X			X		X		
Jefferson Creek	X		X	X		X					X	
Johnson Creek												
Keep Cool Creek	X	X	X	X	X	X		X			X	
Kleinschmidt Creek			X		X			X		X		
Landers Fork			X	X	X	X			X			
Lincoln Spring Creek	X	X		X	X	X		X		X		X
Little Fish Creek	X				X		X	X				
Little Moose Creek												
Lodgepole Creek												
McCabe Creek	X				X							
McDermott Creek												
McElwain Creek	X	X			X	X	X	X				
Mitchell Creek	X			X				X				

Appendix F: Table of Potential Restoration Projects (cont.)

Stream Name	Road Crossings	Irrigation Impacts	Channel alterations	Lacks Complexity	Riparian vegetation	Instream flow	Road drainage	Feedlots, Grazing	Recreation Impacts	Whirling Disease	Mining	Residential
Monture Creek	X		X	X	X			X	X	X		X
Moose Creek	X										X	
Murray Creek	X	X		X	X	X	X	X				
Nevada Creek (lower)		X	X	X	X	X		X				
Nevada Creek (upper)	X	X			X		X	X			X	
Nevada Spring Creek												
North Fork Blackfoot River			X	X	X	X			X	X		
Pearson Creek			X		X		X	X				
Poorman Creek	X		X	X	X	X	X	X			X	
Rock Creek	X	X	X	X	X	X		X		X		X
Salmon Creek		X		X		X						
Sauerkraut Creek	X		X	X	X		X	X			X	
Seven up Pete Creek	X								X		X	
Shanley Creek		X			X			X				
Sheep Creek						X		X				
Shingle Mill Creek		X						X				
Smith Creek												
Snowbank Creek	X	X	X			X			X			
Spring Creek (upper Cottonwood)		X	X		X	X						
Spring Creek (Murphy-North Fork)		X				X						
Strickland Creek				X	X			X				
Stonewall Creek	X		X			X		X			X	
Sturgeon Creek			X		X	X		X				
Sucker Creek	X	X	X	X	X	X		X				
Union Creek	X	X		X	X	X		X				
Wales Creek		X	X		X	X		X				
Wales Spring Creek			X		X			X				
Ward Creek	X	X	X	X	X	X		X				
Warm Springs Creek	X	X				X	X					
Warren Creek	X	X	X	X	X	X		X		X		
Warren Creek, Doney Lake trib.												
Washington Creek	X	X	X	X				X			X	
Washoe Creek				X				X				
Wasson Creek	X	X	X	X	X	X		X				
West Twin Creek												

Appendix F: Table of Potential Restoration Projects (cont.)

Stream Name	Road Crossings	Irrigation Impacts	Channel alterations	Lacks Complexity	Riparian vegetation	Instream flow	Road drainage	Feedlots, Grazing	Recreation Impacts	Whirling Disease	Mining	Residential
Willow Creek (lower)	X	X			X	X		X			X	
Willow Creek (upper)					X			X				
Wilson Creek	X	X				X						
Yourname Creek		X	X	X	X	X		X				

Appendix G. Table of Restoration Streams and Cooperators

Stream Name	State					Federal					Private						
	FWP	MDT	NPCD	DEQ	DNRC	USFWS	BLM	NRCS	BOR	USFS	BC	TU	PL	CF	NFWF	NW	PCT
Alice Creek																	
Arkanas Creek																	
Arrastra Creek	X			X					X		X	X				X	
Ashby Creek	X					X		X			X	X	X	X		X	
Bartlett Creek																	
Basin Spring Creek	X					X						X	X				
Bear Creek (lower River)	X				X	X		X				X	X			X	X
Bear Creek (middle River)																	
Bear Creek (North Fork)																	
Beaver Creek						X						X	X				
Belmont Creek	X						X					X					X
Black Bear Creek																	
Blackfoot River(Arrastra to Lincoln)																	
Blackfoot River(Clearwater to N.F)	X					X						X	X				
Blackfoot River(Lincoln to Headwaters)																	
Blackfoot River(mouth to Clearwater)							X										X
Blackfoot River(Nevada-Arrastra)	X					X						X	X				
Blackfoot River(NF-Nevada)													X				
Blanchard Creek	X				X	X	X					X	X				
Buffalo Gulch																	
Burnt Bridge Creek																	
California Gulch																	
Camas Creek																	
Chamberlain Creek	X					X	X					X	X		X		X
Chamberlain Creek, east fork	X					X	X										X
Chamberlain Creek, west fork							X										X
Chicken Creek																	
Chimney Creek (trib to Douglas)																	
Chimney Creek (Nevada drain.)																	
Clear Creek																	
Clearwater River	X					X					X	X	X				
Copper Creek																	
Cottonwood Creek (lower trib.)	X				X	X	X		X	X		X	X			X	
Cottonwood Creek (Nevada drain.)						X											
Dick Creek	X					X		X				X	X				X
Douglas Creek	X		X			X		X	X		X	X	X				
Dry Creek																	
Dunham Creek	X					X				X	X	X	X	X		X	

Appendix G. Table of Restoration Streams and Cooperators

Stream Name	State					Federal					Private						
	FWP	MDT	NPCD	DEQ	DNRC	USFWS	BLM	NRCS	BOR	USFS	BC	TU	PL	CF	NFWF	NW	PCT
East Twin Creek	X	X															
Elk Creek	X					X	X		X		X	X	X		X	X	
Finn Creek																	
Fish Creek																	
Frazier Creek																	
Frazier Creek, north fork																	
Gallagher Creek																	
Game Creek																	
Gleason Creek																	
Gold Creek	X				X	X	X					X	X			X	X
Gold Creek, West Fork																	
Grantier Spring Creek	X					X						X	X				
Halfway Creek																	
Hogum Creek																	
Hoyt Creek	X					X		X	X		X	X	X	X			
Humbug Creek																	
Indian Creek																	
Jacobsen Spring Creek	X					X		X	X		X	X	X	X			
Jefferson Creek																	
Johnson Creek	X					X						X	X			X	
Keep Cool Creek	X		X			X		X	X		X	X	X	X			
Kleinschmidt Creek	X	X	X			X		X			X	X	X	X	X		
Landers Fork																	
Lincoln Spring Creek	X		X						X								
Little Fish Creek																	
Little Moose Creek																	
Lodgepole Creek																	
McCabe Creek	X					X		X		X	X	X	X			X	
McDermott Creek																	
McElwain Creek	X					X						X	X				
Mitchell Creek																	
Monture Creek	X					X		X		X		X	X		X		
Moose Creek										X		X		X			
Murray Creek																	
Nevada Creek (above reservoir)	X		X			X		X			X		X		X		
Nevada Creek (below reservoir)	X		X				X	X				X	X				
Nevada Spring Creek	X		X			X		X	X		X	X	X	X			
North Fork Blackfoot River	X				X	X					X	X	X	X	X		X

Appendix G. Table of Restoration Streams and Cooperators

	State					Federal					Private						
Stream Name	**FWP**	**MDT**	**NPCD**	**DEQ**	**DNRC**	**USFWS**	**BLM**	**NRCS**	**BOR**	**USFS**	**BC**	**TU**	**PL**	**CF**	**NFWF**	**NW**	**PCT**
Pearson Creek	X		X			X	X	X			X	X	X			X	X
Poorman Creek	X				X	X		X		X	X	X	X	X		X	
Rock Creek	X	X	X	X	X	X		X			X	X	X	X	X	X	
Salmon Creek	X					X						X	X	X	X		
Saurekraut Creek																	
Seven up Pete Creek																	
Shanley Creek	X					X						X	X				
Sheep Creek																	
Shingle Mill Creek																	
Smith Creek																	
Snowbank Creek																	
Spring Creek (Murphy North Fork)	X				X	X		X			X	X	X				X
Spring Creek (upper Cottonwood)																	
Stonewall Creek																	
Strickland Creek																	
Sturgeon Creek																	
Sucker Creek																	
Union Creek																	
Wales Creek	X										X		X			X	
Wales Spring Creek																	
Ward Creek			X	X		X					X	X	X	X			
Warm Springs Creek																	
Warren Creek	X		X	X		X		X	X		X	X	X	X			X
Warren Creek -trib from Doney Lake																	
Washington Creek																	
Washoe Creek																	
Wasson Creek	X		X	X		X		X	X		X	X	X			X	
West Twin Creek	X	X															
Willow Creek (above Lincoln)																	
Willow Creek (below Lincoln)																	
Wilson Creek																	
Yourname Creek																	

restoration project stream in Blue

FWP-Montana Fish, Wildlife and Parks
MDT-Montana Department of Transportion
NPCD-North Powell Conservation District
DEQ-Department of Environmental Quality
DNRC-Dept. of Natural Resources and Conserv.
USFWS-U.S. Fish and Wildlife Service
BLM-Bureau of Land Management
USFS-U.S. Forest Service
BC-Blackfoot Challenge
TU-Trout Unlimited
PL-Private Landowners
CF-Chutney Foundation
NFWF-National Fish and Wildlife Foundation
NWE-Northwestern Energy
PCT-Plum Creek Timber Company

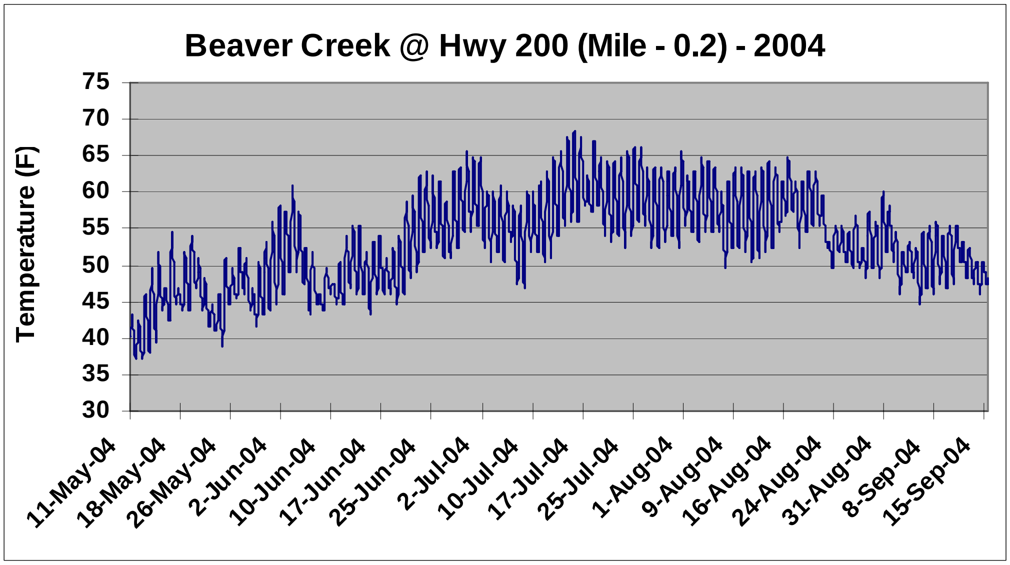
Appendix H: Temperatures sensor locations in the Blackfoot drainage, 2004

Stream Name	Location (stream mile)	Legal Description	Duration	Sensor Type	Recording Interval
Beaver Creek @ Hwy 200	1	14N,9W,22B	5/11/04-9/16/04	Hobo	72min.
Belmont Creek @ mouth	0.1	14N,16W,24C	3/2/04-9/15/04	Hobo & Tidbit	72min, 50min.
Blackfoot River above Belmont Cr	21.8	14N,16W,24C	5/3/04-9/15/04	Tidbit	50min.
Blackfoot River @ Cuttoff Rd Bridge	72.2	14N,11W,32D	5/5/04-8/5/04	Tidbit	50min.
Blackfoot River @ Dalton Mtn Rd Bridge	104.5	14N,9W,28B	5/4/04-9/15/04	Tidbit	50min.
Blackfoot River @ Raymond Bridge	60	14N,12W,28D	5/5/04-9/15/04	Tidbit	50min.
Blackfoot River @ Scotty Brown Bridge	46.1	15N,13W,33A	3/1/04-8/5/04	Hobo & Tidbit	72min, 50min.
Blackfoot River @ USGS	7.9	13N,17W,9B	5/3/04-9/15/04	Tidbit	50min.
Chamberlain Creek	1.8	14N,13W,4A	3/1/04-5/30/04	Hobo	72min.
Clearwater River @ mouth	0.1	14N,14W,16C	3/1/04-5/31/04	Hobo	72min.
Copper Creek @ Sucker Cr Rd Bridge	1.1	15N,8W,25C	5/4/04-9/15/04	Tidbit	50min.
Cottonwood Creek @ Hwy 200	1	15N,13W,29B	3/1/04-9/15/04	Hobo, Tidbit	72min, 50min.
Gold Creek	1.6	14N,16W,30C	5/3/04-9/16/04	Tidbit	50min.
Jacobsen Spring Creek @ mouth	0.1	14N,12W,1C	5/3/04-8/26/04	Hobo	72min
Jacobsen Spring Creek (middle)	0.6	14N,12W,1C	5/3/04-8/26/04	Hobo	72min
Jacobsen Spring Creek (pump house)	1.5	14N,11W,6B	5/3/04-8/26/04	Hobo	72min
Keep Cool Cr @ Beaver Cr Rd	1.7	14N,9W,15D	5/11/04-9/16/04	Hobo	72min
Keep Cool Cr @ Sucker Cr Rd	4.6	14N,9W,13A	5/11/04-9/16/04	Hobo	72min
Kleinschmidt Creek	0.4	14N,11W,6A	5/4/04-9/15/04	Tidbit	50min.
Landers Fork @ Copper Cr Rd Bridge	4.2	15N,8W,36B	5/4/04-9/15/04	Tidbit	50min.
Lincoln Spring Creek @ Hwy 200	1.4	14N,9W,23B	5/11/04-9/15/04	Hobo	72min
Lincoln Spring Creek @ 1st Ave	2.8	14N,9W,23A	5/11/04-9/15/04	Hobo	72min
Monture Creek @FAS	1.8	15N,13W,22D	3/1/04-9/15/04	Hobo,Tidbit	72min, 50min.
Nevada Creek above Nevada Spr Cr	5.5	13N,11W,9C	5/3/04-10/15/04	Hobo	72min
Nevada Creek below Nevada Spr Cr	4.5	13N,11W,8D	5/4/04-10/15/04	Hobo	72min
Nevada Spring Creek @ mouth	0.1	13N,11W,9C	5/4/04-10/17/04	Hobo	16min
Nevada Spring Creek @ lower bridge	0.8 (1.1)	13N,11W,10B	5/10/04-9/30/04	Hobo	72min
Nevada Spring Creek @ lower fenceline	1.9 (2.1)	13N,11W,10A	5/3/04-10/17/04	Hobo	16min
Nevada Spring Creek @ upper fenceline	3.1 (3.5)	13N,11W,11C	5/11/04-9/23/04	Hobo	60min
Nevada Spring Creek @ source	3.3 (4.0)	13N,11W,11D	5/3/04-10/19/04	Hobo	72min
North Fork Blackfoot River	2.6	14N,12W,10D	3/1//04-9/15/04	Tidbit	50min.
Stonewall Creek @ mouth	0.1	14N,9W,14C	5/11/04-9/16/04	Hobo	72min
Stonewall Creek (middle)	1	14N,9W,14B	5/11/04-9/16/04	Hobo	72min
Warren Creek @ Hwy 200	7.5	15N,12W,35A	5/5/04-8/1/04	Hobo	72min
Warren Creek @ lower bridge	1.1	15N,12W,31C	5/5/04-9/15/04	Hobo	72min
Warren Creek @ Ovando- Helmville Rd	4.4	15N,12W,33C	5/5/04-9/15/04	Hobo	72min
Wasson Creek @ mouth	0.1	13N,11W,11D	5/3/04-10/20/04	Hobo	16min
Wasson Creek @ Hwy 141	1.3	13N,11W,13B	5/3/04-10/20/04	Hobo	16min

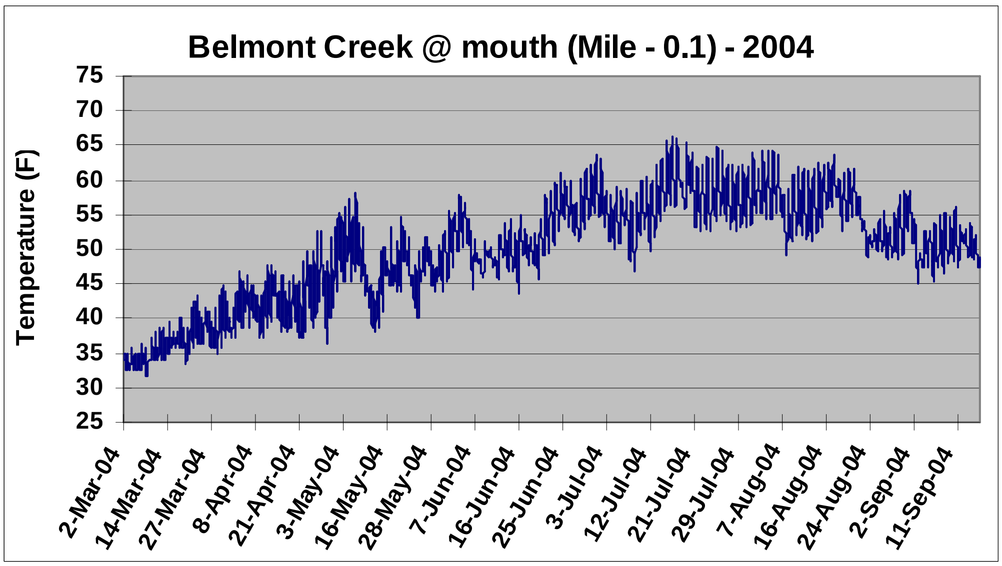
Temperatures sensor locations in the Blackfoot drainage, 2005.

Arrastra Creek	0.6	14N,10W,30A	7/6/05-8/30/05	Hobo	72min.
Bear Creek	1	13N,16W,18B	3/1/05-8/30/05	Hobo	72min.
Belmont Creek	0.1	14N,16W,24C	2/28/05-8/31/05	Hobo	72min
Blackfoot River above Belmont Cr	21.8	14N,16W,24C	7/7/05-9/28/05	Tidbit	50min.
Blackfoot River @ Cuttoff Rd Bridge	72.2	14N,11W,32D	7/6/05-9/29/05	Tidbit	50min.
Blackfoot River @ Dalton Mtn Rd Bridge	104.5	14N,9W,28B	7/6/05-9/29/05	Tidbit	50min.
Blackfoot River @ Raymond Bridge	60	14N,12W,28D	7/6/05-9/29/05	Tidbit	50min.
Blackfoot River @ Scotty Brown Bridge	46.1	15N,13W,33A	3/1/05-9/29//05	Hobo & Tidbit	72min, 50min.
Blackfoot River @ USGS	7.9	13N,17W,9B	2/28/05-8/8/05	Hobo & Tidbit	72min, 50min.
Blanchard Creek	1.1	14N,14W,5B	7/6/05-8/30/05	Hobo	72min
Chamberlain Creek	0.1	15N,13W,32A	7/6/05-8/31/05	Hobo	72min.
Clearwater River	0.1	14N,14W,16C	3/1/05-8/30/05	Hobo	72min.
Cottonwood Creek @ Hwy 200	1	15N,13W,29B	3/1/05-8/31/05	Hobo	72min
East Twin Creek	0.1	13N,17W,2C	7/7/05-8/31/05	Hobo	72min
Elk Creek @ Sunset Hill Rd	3	14N,14W,32C	7/6/05-8/31/05	Hobo	72min.
Gold Creek	1.6	14N,16W,30C	2/28/05-8/31/05	Hobo	72min.
Hoyt Creek	1.2	15N,12W,19C	7/6/05-8/31/05	Hobo	72min
Hoyt Creek	4.3	15N,12W,28C	7/6/05-8/31/05	Hobo	72min
Johnson Creek	0.1	13N,18W,14B	7/7/05-8/31/05	Hobo	72min
Landers Fork @ Hwy 200	1	14N,8W,12C	7/6/05-8/31/05	Hobo	72min
Monture Creek @ mouth	0.1	15N,13W,27C	3/1/05-8/31/05	Hobo	72min
Nevada Creek above Nevada Spr Cr	5.5	13N,11W,9C	6/27/05-10/15/05	Hobo	72min
Nevada Creek below Nevada Spr Cr	4.5	13N,11W,8D	6/27/05-10/15/05	Hobo	72min
Nevada Spring Creek @ mouth	0.1	13N,11W,9C	10/20/04-9/23/05	Tidbit	50min.
Nevada Spring Creek @ lower bridge	0.8 (1.1)	13N,11W,10B	10/20/04-10/10/05	Hobo	210min
Nevada Spring Creek @ upper fenceline	3.1 (3.5)	13N,11W,11C	10/20/04-6/21/05	Tidbit	50min.
North Fork Blackfoot River	2.6	14N,12W,10D	3/1/05-8/31/05	Hobo	72min
Wasson Creek @ mouth	0.1	13N,11W,11D	6/27/05-9/23/05	Hobo	16min
Wasson Creek @ Hwy 141	1.3	13N,11W,13B	6/27/05-9/23/05	Hobo	16min
West Twin Creek	0.1	13N,17W,2D	7/7/05-8/31/05	Hobo	72

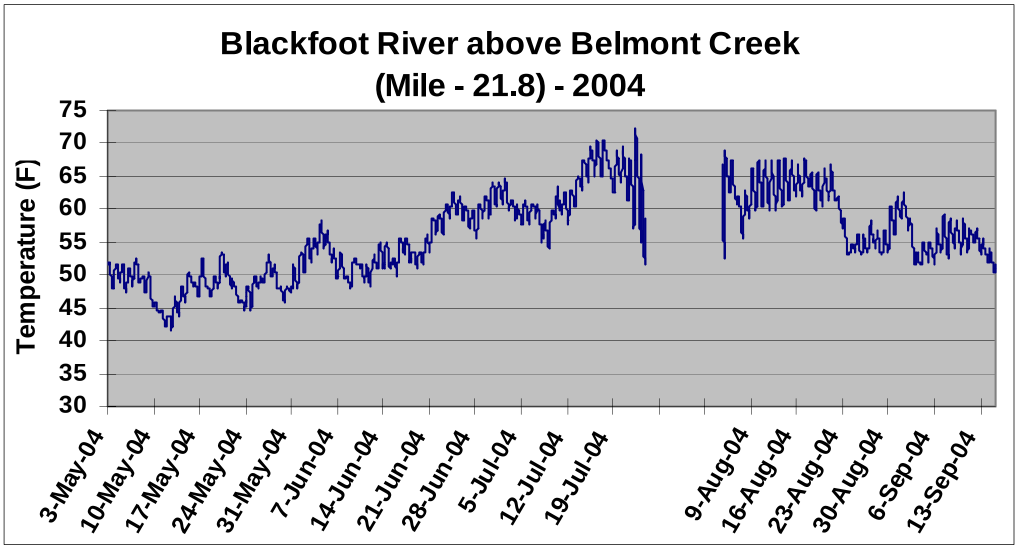
( ) Post channel reconstruction stream mileage



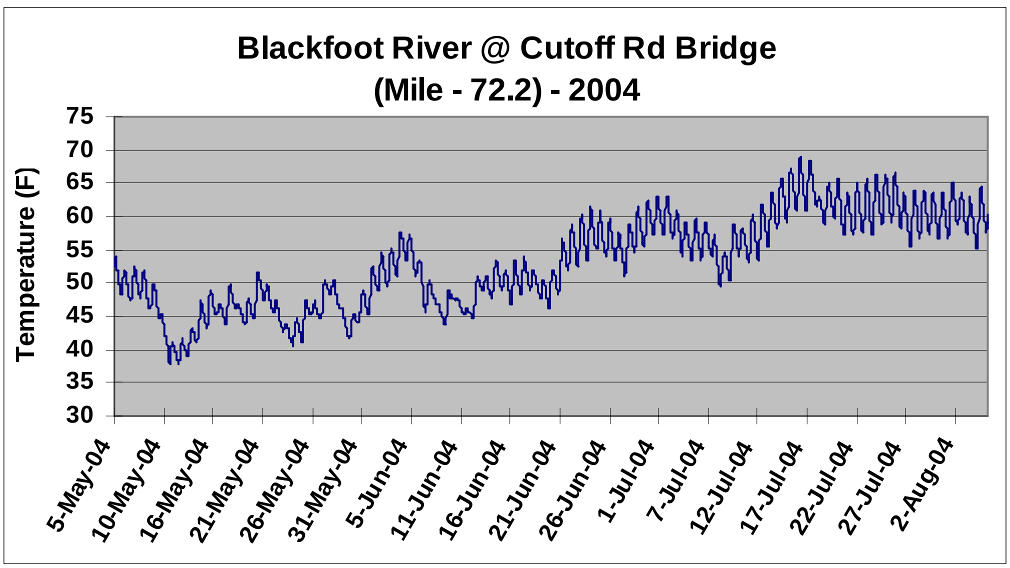
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	54.58	37.20	45.55	3.77	14.21
June	65.59	43.19	51.54	4.97	24.66
July	68.33	46.82	58.24	4.39	19.25
August	65.59	48.25	56.71	4.17	17.43
September	58.04	44.65	50.89	2.76	7.62



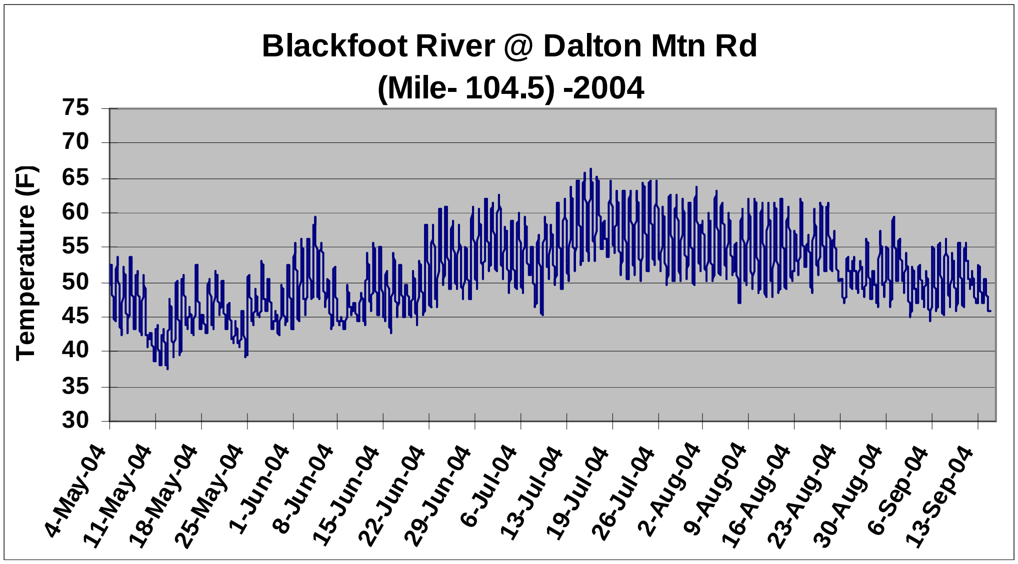
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	44.70	31.70	36.44	2.68	7.19
April	52.50	36.40	42.47	3.26	10.60
May	58.00	38.00	47.24	3.66	13.42
June	62.28	43.75	51.76	3.93	15.43
July	66.35	46.83	57.09	3.72	13.87
August	64.30	48.49	55.75	3.86	14.87
September	58.57	45.15	50.75	2.70	7.29



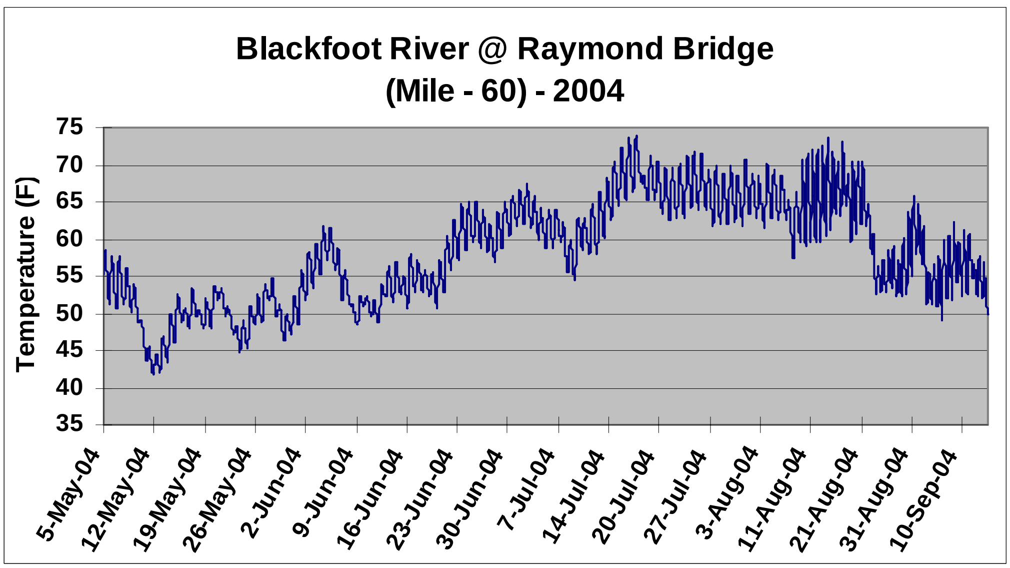
Month	Max TempF	Min Temp F	Avg Temp	StDev Temp	Var Temp
May	53.51	41.59	48.32	2.43	5.90
June	64.03	47.82	54.78	3.84	14.73
July	72.23	51.44	62.75	4.27	18.25
August	67.80	52.99	60.57	4.28	18.35
September	62.42	50.40	55.11	2.44	5.95



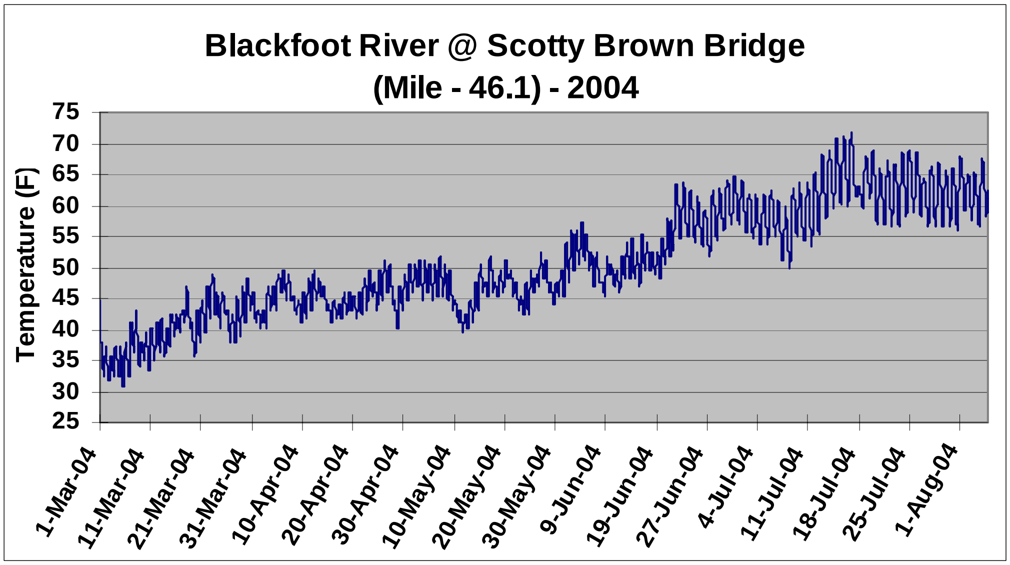
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	54.04	37.92	45.81	3.30	10.88
June	62.43	43.66	51.94	4.22	17.84
July	68.91	49.37	59.80	3.78	14.29
August	65.12	55.08	60.20	2.53	6.39



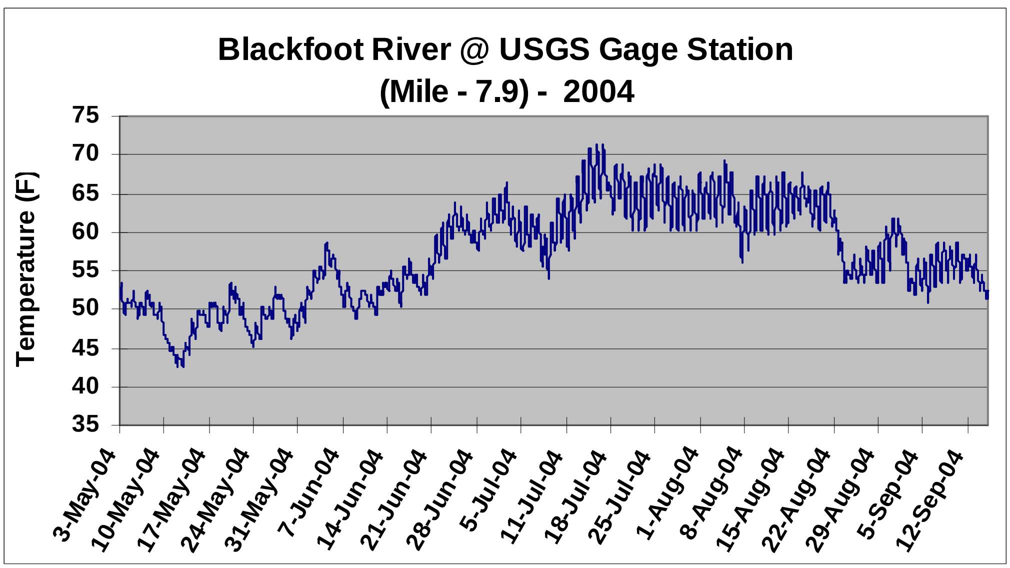
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	53.68	37.55	45.57	3.60	12.94
June	62.07	42.78	50.22	4.49	20.15
July	66.35	45.38	56.22	4.43	19.59
August	63.67	46.43	53.88	4.06	16.51
September	56.28	44.34	50.06	2.89	8.35



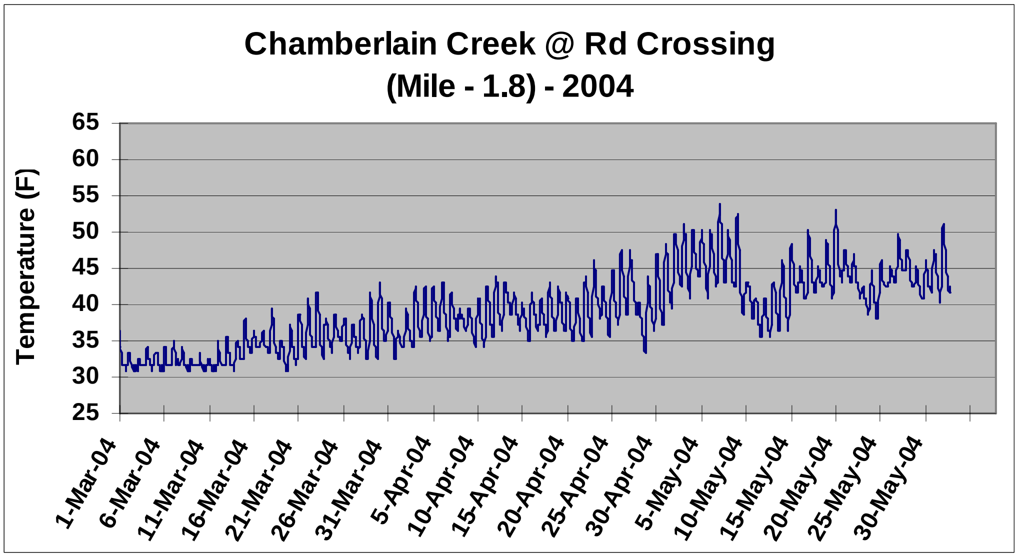
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	58.52	41.77	49.80	3.36	11.29
June	65.69	48.47	56.25	4.29	18.37
July	73.99	54.33	64.89	3.88	15.05
August	73.60	52.41	63.20	5.11	26.09
September	64.78	49.07	55.87	3.24	10.50



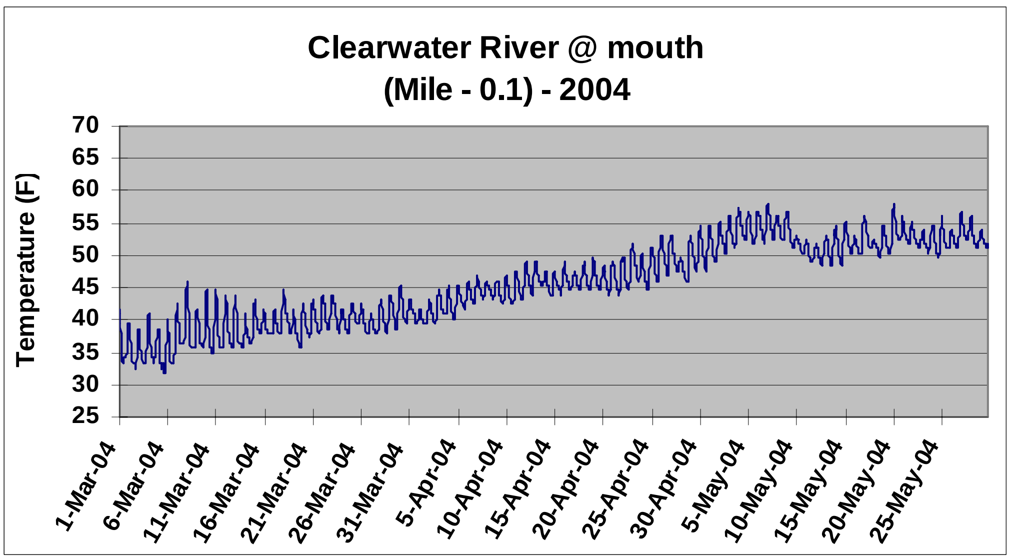
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	48.96	30.91	39.88	4.16	17.29
April	51.08	40.23	45.12	2.37	5.62
May	52.49	39.48	46.79	2.69	7.22
June	63.94	45.38	53.42	4.54	20.59
July	71.62	49.80	61.33	4.34	18.85
August	68.02	55.96	62.08	3.32	11.05



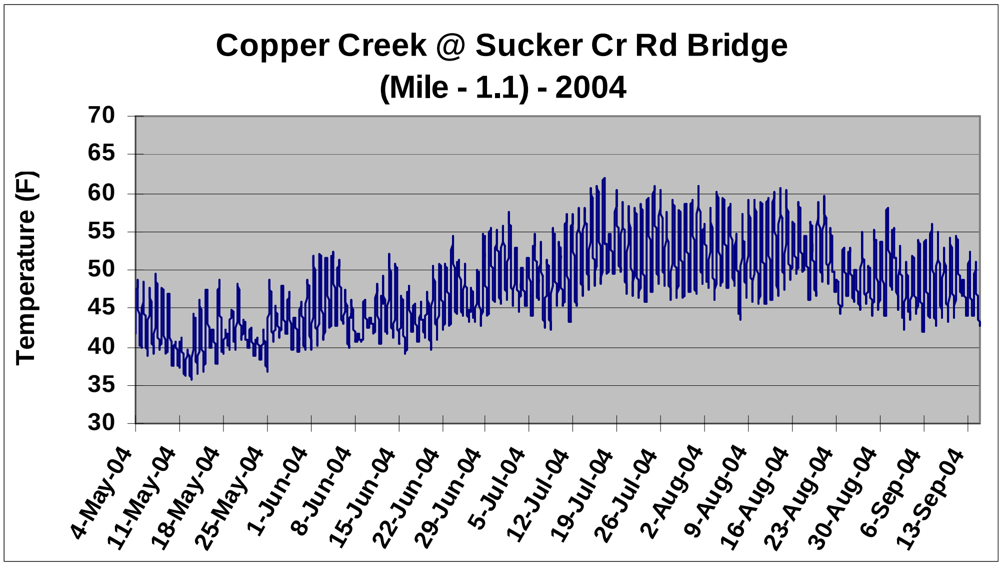
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	53.35	42.46	48.73	2.37	5.62
June	64.40	48.18	55.23	3.91	15.30
July	71.48	53.87	63.41	3.43	11.75
August	69.26	53.35	61.52	4.15	17.20
September	61.72	50.76	55.47	2.31	5.33



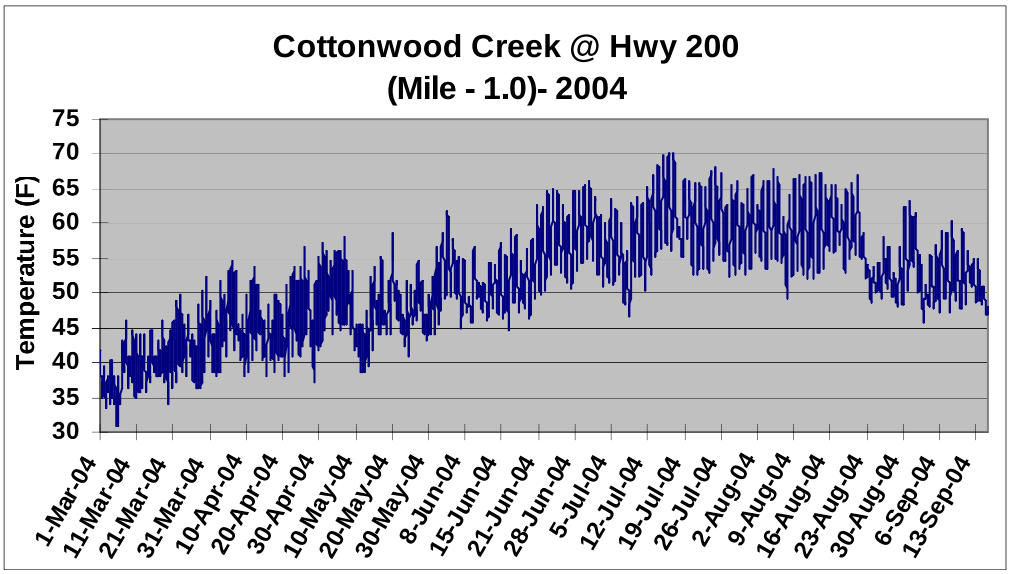
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	43.19	30.91	34.04	2.55	6.50
April	47.53	32.52	38.93	2.95	8.70
May	53.89	35.66	43.72	3.45	11.89
June	51.08	40.23	44.65	3.43	11.74



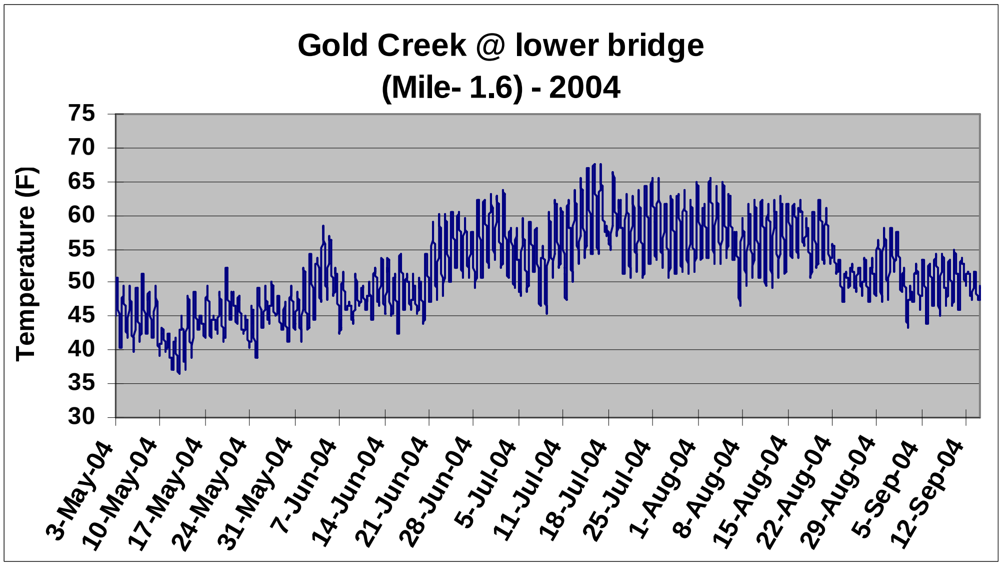
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	46.10	31.70	38.76	2.94	8.66
April	54.60	39.50	45.84	3.08	9.52
May	58.00	47.60	52.60	2.05	4.20



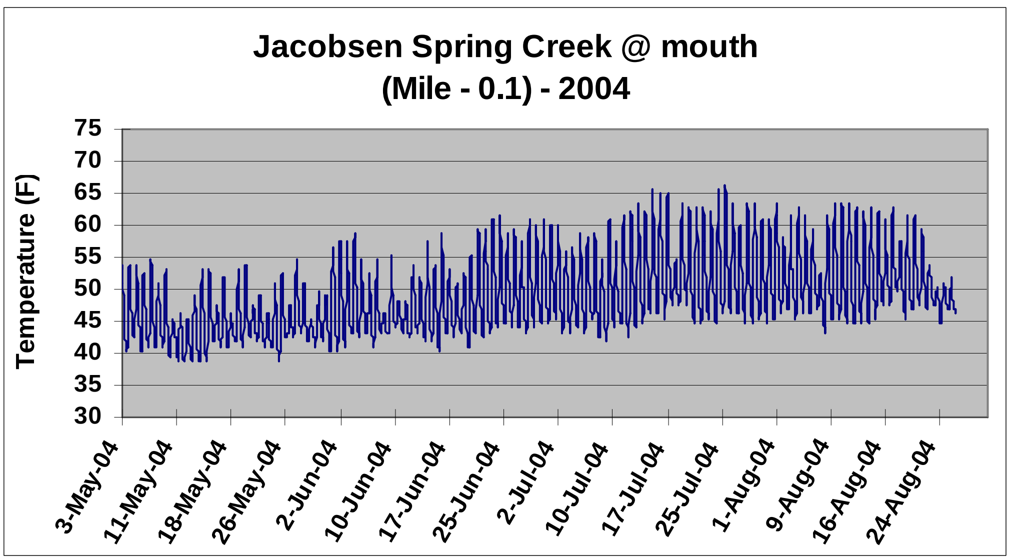
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	49.38	35.64	41.91	3.04	9.27
June	55.53	39.04	45.42	3.59	12.91
July	62.02	42.13	51.51	4.39	19.24
August	60.87	43.53	51.37	4.14	17.15
September	56.08	41.85	48.02	3.42	11.67



Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	52.49	30.91	40.24	3.92	15.35
April	56.66	37.20	45.46	4.16	17.31
May	58.73	38.72	47.91	4.02	16.13
June	65.47	43.92	53.43	4.85	23.52
July	70.18	46.50	58.93	4.67	21.81
August	67.82	48.17	57.50	4.84	23.40
September	61.41	45.66	52.25	3.37	11.36

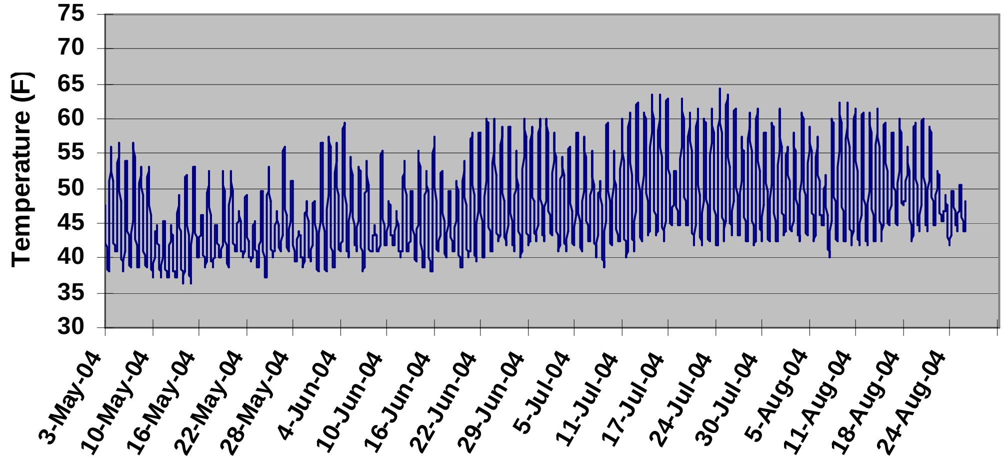


Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	52.26	36.64	44.43	3.19	10.17
June	63.27	41.36	50.88	4.72	22.33
July	67.58	45.52	57.09	4.59	21.07
August	65.42	46.57	55.39	4.38	19.15
September	57.46	43.44	50.27	2.88	8.27



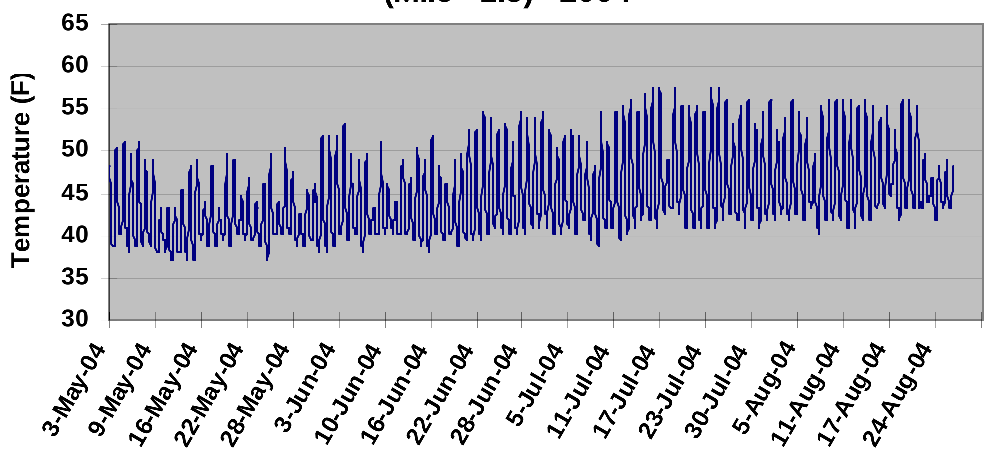
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	54.58	38.72	44.74	3.76	14.13
June	61.48	40.23	48.03	5.10	26.06
July	66.28	41.72	51.71	5.90	34.86
August	63.54	43.19	51.62	5.07	25.72

Jacobsen Spring Creek upstream of unnamed trib (Mile - 0.6) - 2004

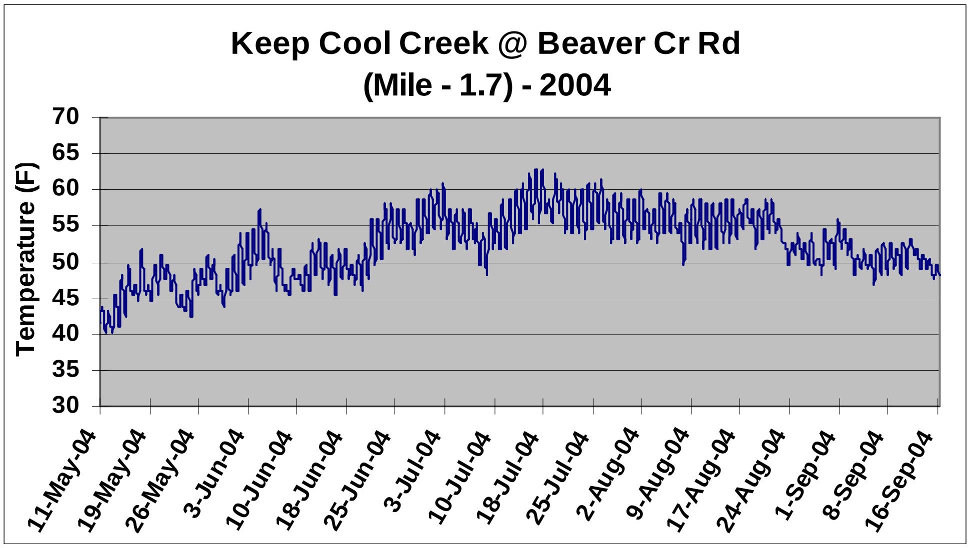


Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	56.66	36.43	43.54	4.59	21.04
June	60.11	37.97	46.26	5.73	32.87
July	64.22	38.72	49.59	6.46	41.67
August	62.17	40.23	49.37	5.56	30.93

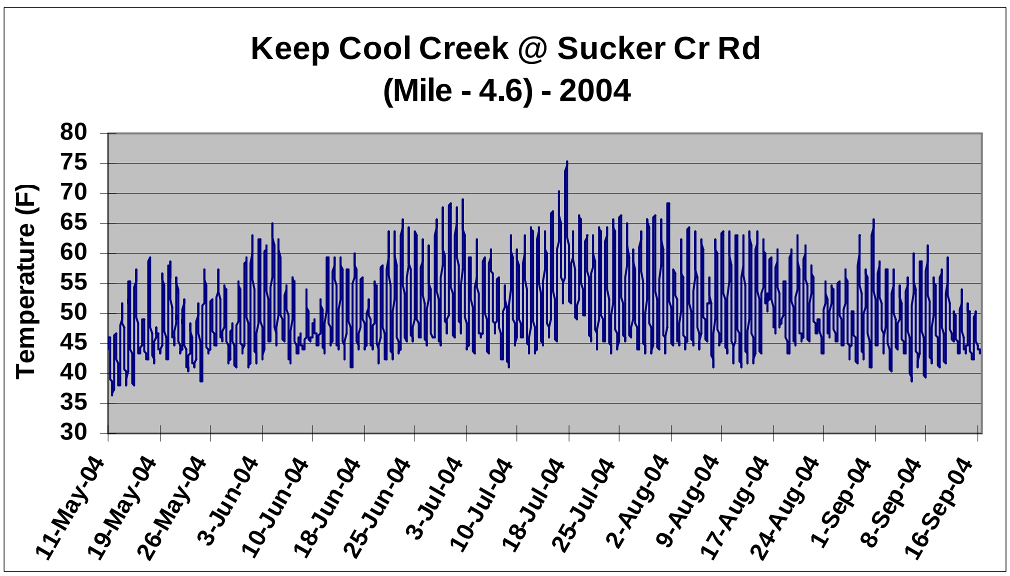
Jacobsen Spring Creek near pump house (Mile - 1.5) - 2004



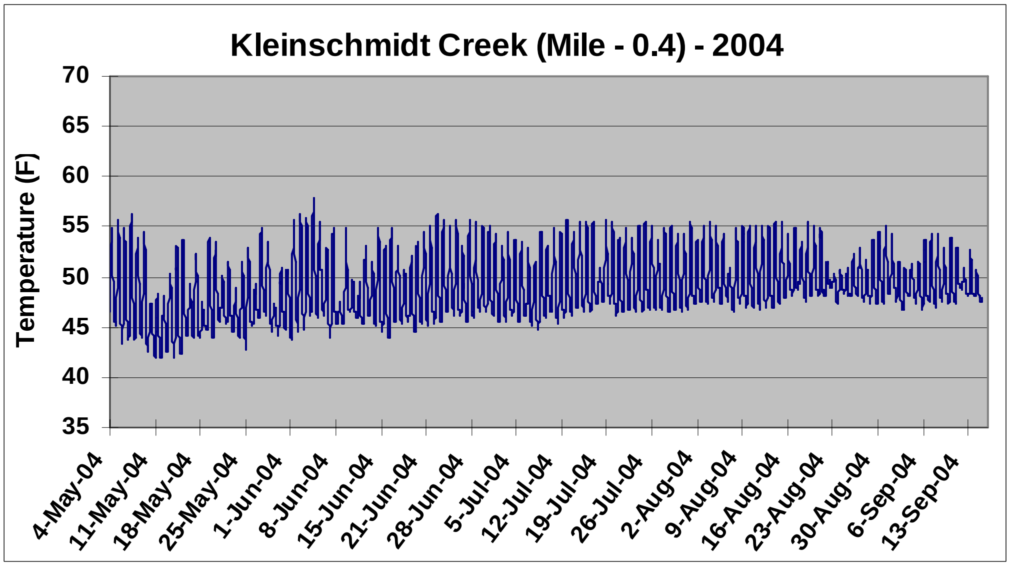
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	51.08	37.20	41.86	3.18	10.14
June	54.58	37.97	43.69	4.11	16.89
July	57.35	38.72	46.30	4.87	23.67
August	55.97	40.23	46.66	4.24	18.01



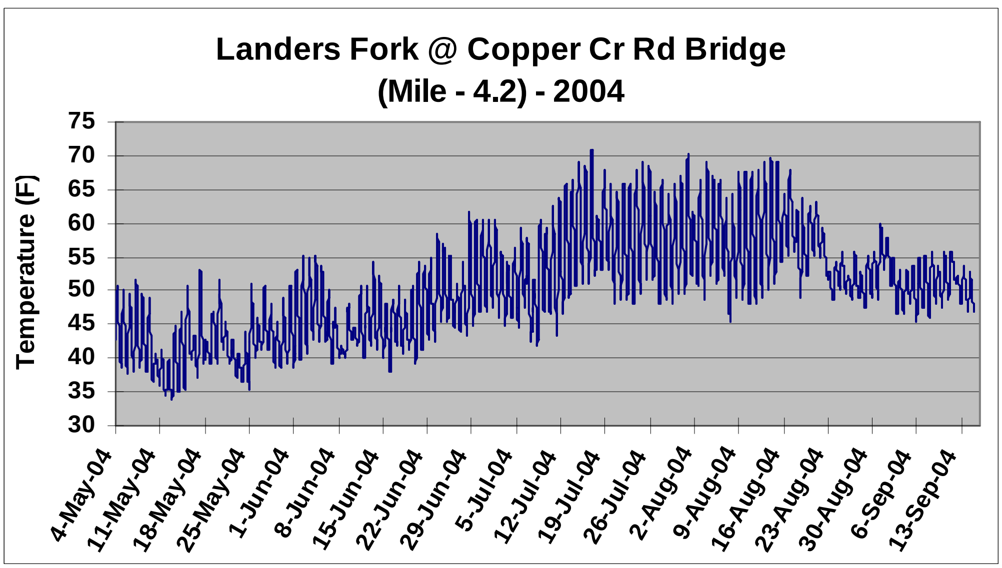
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	51.79	40.23	46.23	2.61	6.80
June	60.11	45.38	51.22	3.48	12.10
July	62.85	48.25	56.47	2.84	8.05
August	60.11	48.25	54.63	2.67	7.12
September	55.28	46.82	50.67	1.68	2.83



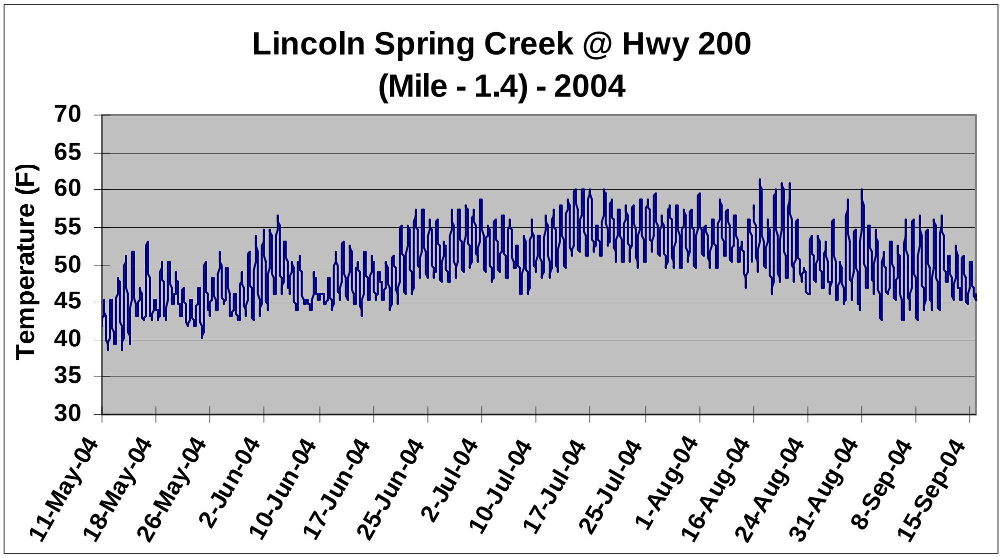
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	59.42	36.43	46.56	5.06	25.58
June	68.33	40.97	50.59	6.30	39.67
July	75.22	40.97	53.30	7.17	51.40
August	68.33	40.97	50.96	6.20	38.42
September	61.48	38.72	47.94	5.21	27.19



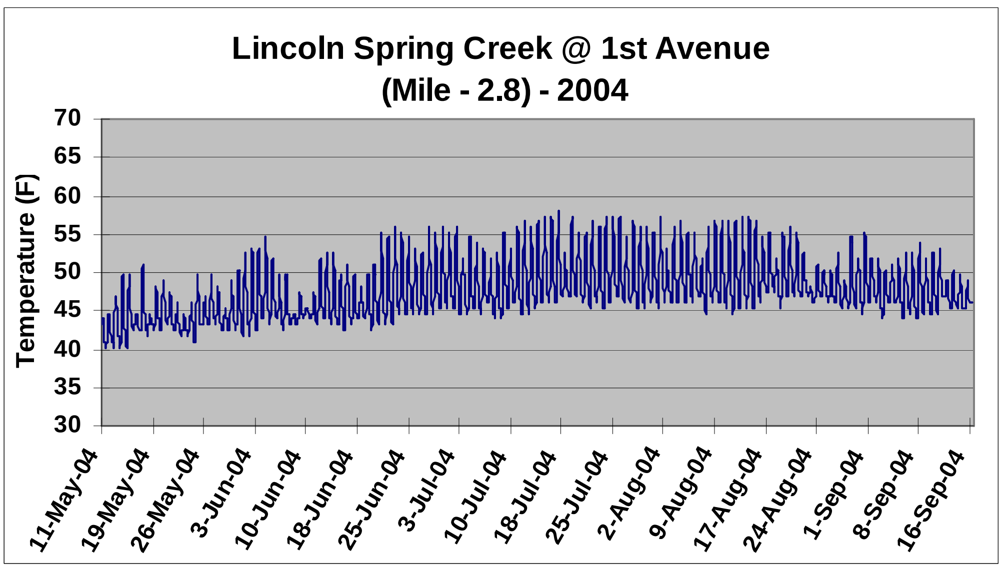
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	56.23	41.99	47.16	3.20	10.24
June	57.90	43.67	48.75	3.27	10.67
July	55.67	44.79	49.40	2.92	8.52
August	55.39	46.47	49.94	2.36	5.59
September	54.27	46.75	49.40	1.81	3.26



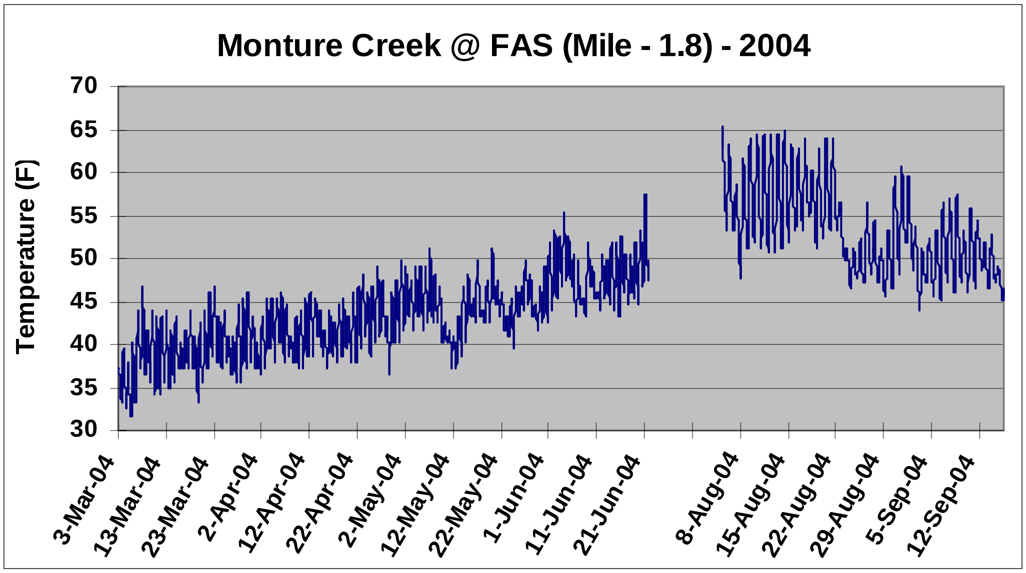
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	53.19	33.85	42.06	4.05	16.43
June	61.55	38.11	46.72	4.81	23.14
July	70.75	41.78	55.52	6.37	40.54
August	70.20	45.41	56.42	5.59	31.29
September	58.40	45.41	51.33	2.84	8.08



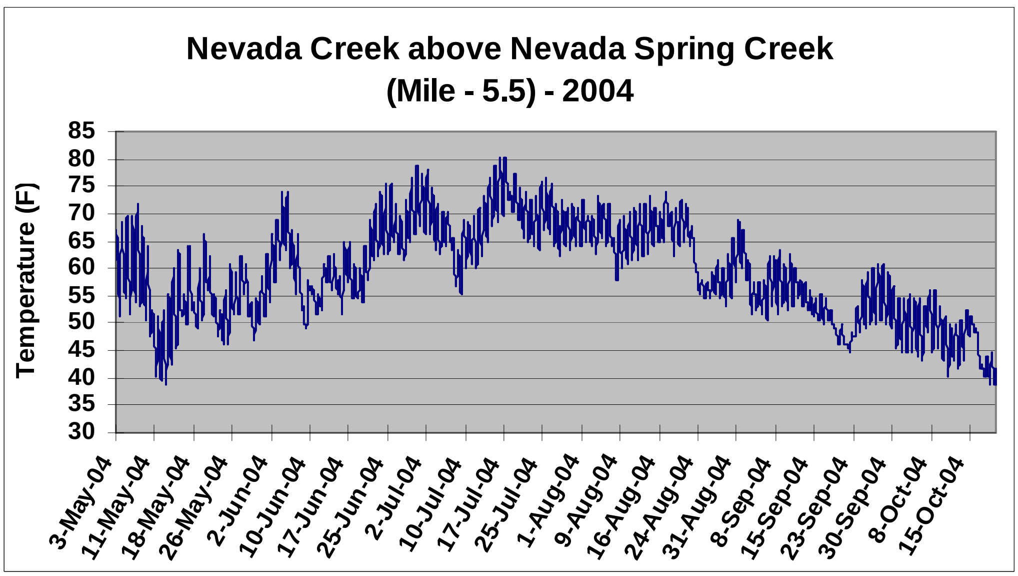
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	53.20	38.70	45.12	3.01	9.06
June	58.00	42.50	49.09	3.59	12.86
July	60.10	46.10	53.63	3.19	10.15
August	61.50	43.90	52.03	3.84	14.71
September	56.70	42.50	48.90	3.51	12.29



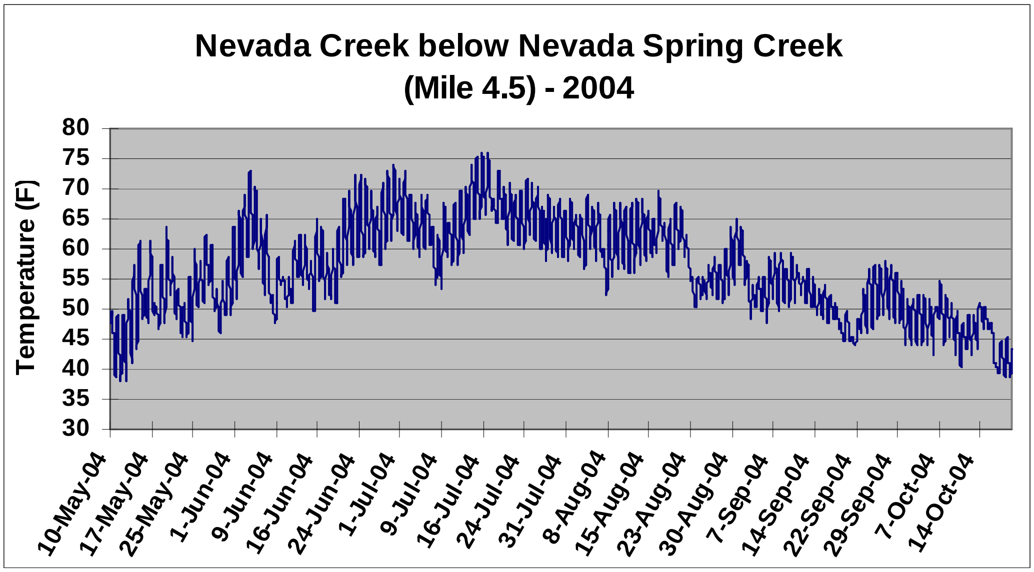
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	51.08	40.23	44.16	2.26	5.13
June	55.97	41.72	46.74	3.26	10.65
July	58.04	43.92	49.34	3.53	12.43
August	57.35	44.65	49.19	3.04	9.23
September	53.89	43.92	47.47	2.21	4.87



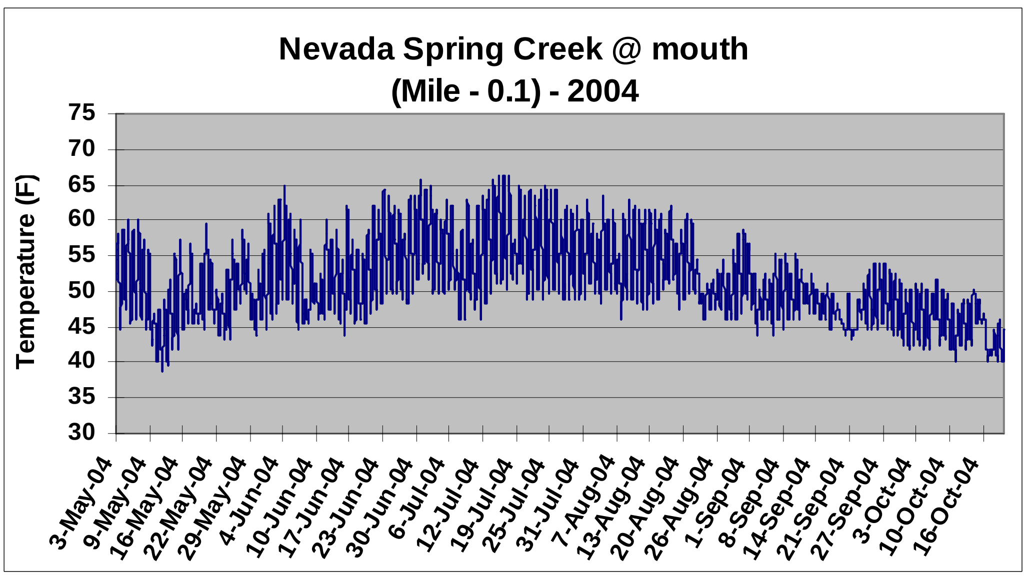
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	46.82	31.72	39.13	3.19	10.15
April	48.96	36.43	41.97	2.76	7.64
May	51.08	37.20	44.41	2.72	7.39
June	57.35	42.46	56.75	13.87	192.39
August	65.45	45.53	55.02	4.93	24.29
September	59.59	43.97	50.31	3.17	10.03



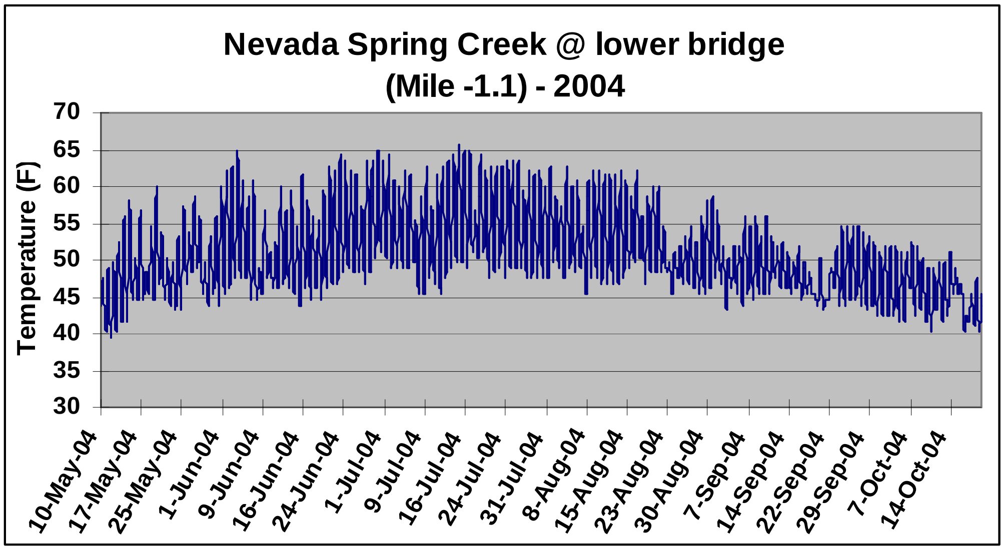
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	71.80	38.70	54.37	6.36	40.48
June	78.80	49.00	61.65	6.28	39.45
July	80.20	55.30	68.90	4.77	22.77
August	73.90	53.20	64.70	5.10	26.01
September	67.00	44.70	54.22	4.67	21.80
October	56.00	38.70	47.63	4.26	18.17



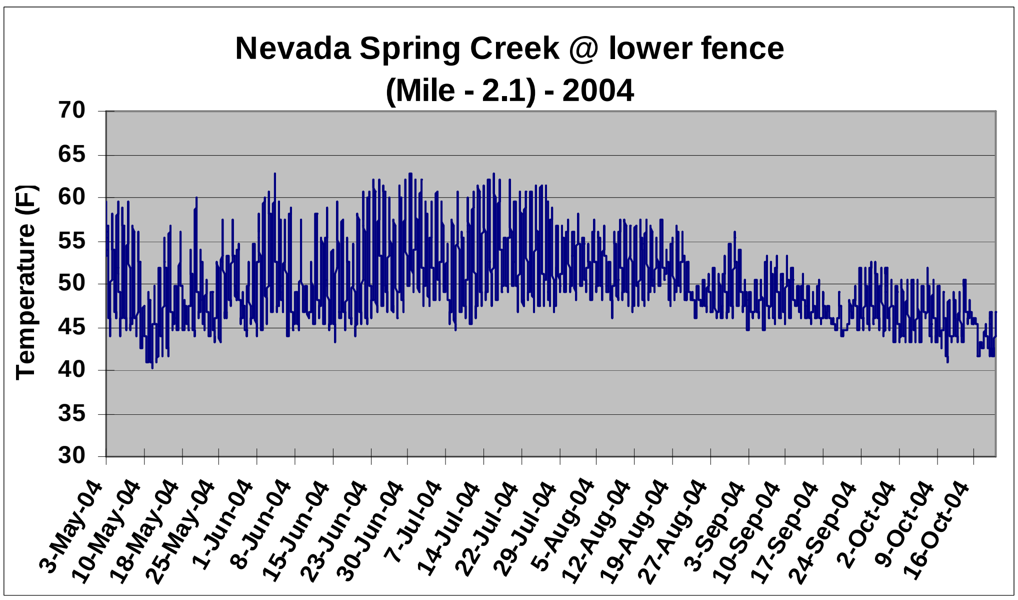
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	63.54	37.97	51.15	5.16	26.64
June	73.84	47.53	59.73	5.96	35.50
July	75.92	53.19	65.27	4.32	18.65
August	69.71	50.38	60.26	4.55	20.69
September	63.54	43.92	52.29	3.96	15.66
October	54.58	38.72	46.64	3.60	12.94



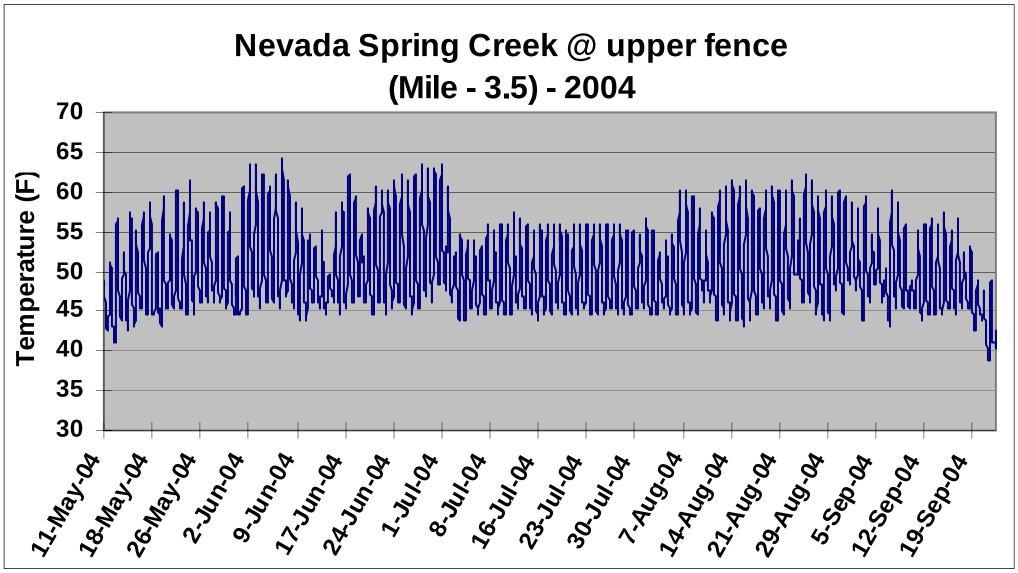
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	60.11	38.72	49.64	4.58	20.99
June	65.59	43.92	53.44	5.21	27.17
July	66.28	46.10	56.37	4.91	24.12
August	63.54	46.10	53.62	4.34	18.87
September	56.66	43.19	48.81	2.96	8.74
October	51.79	40.23	45.64	3.03	9.20



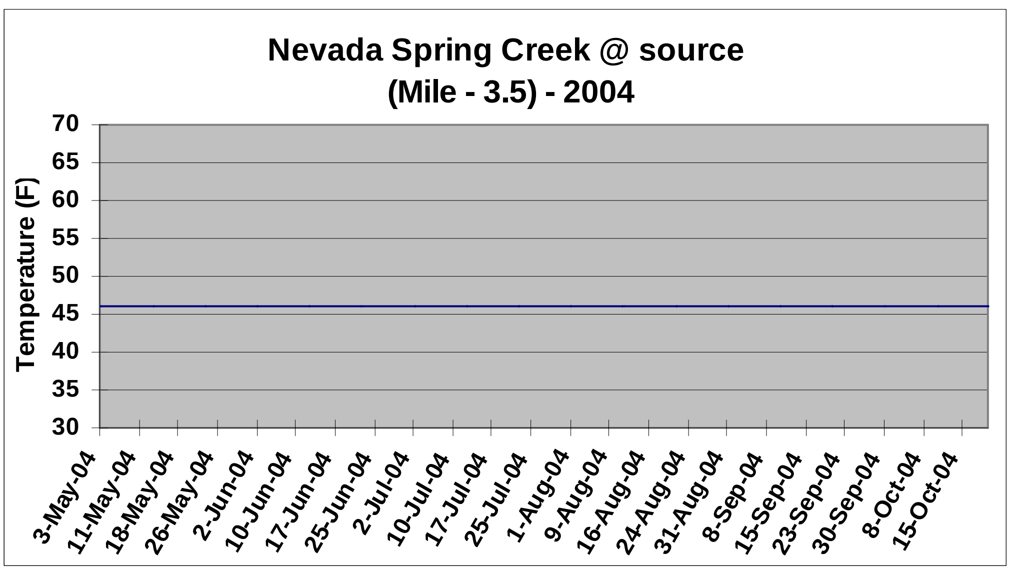
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	60.10	39.50	48.54	4.21	17.76
June	64.90	43.90	52.54	5.35	28.61
July	65.60	45.40	55.05	5.06	25.65
August	62.80	45.40	52.62	4.53	20.51
September	56.70	43.20	48.44	3.10	9.62
October	52.50	40.20	45.74	3.18	10.11



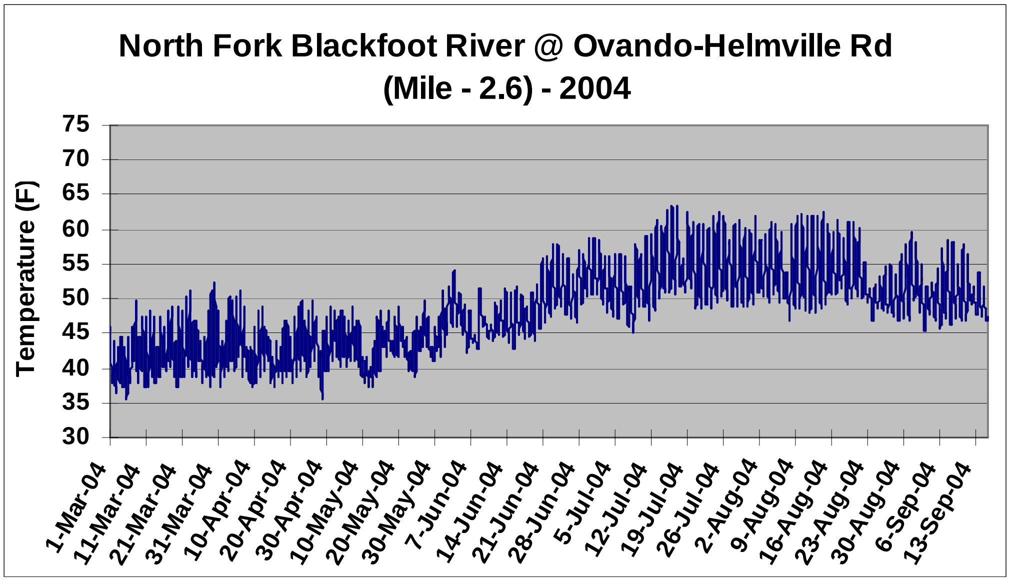
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	60.11	40.23	48.50	4.20	17.62
June	62.85	43.19	51.04	4.88	23.84
July	62.85	44.65	52.99	4.49	20.18
August	58.04	46.10	51.05	3.00	9.00
September	53.89	43.92	47.73	2.19	4.79
October	51.79	40.97	45.56	2.39	5.69



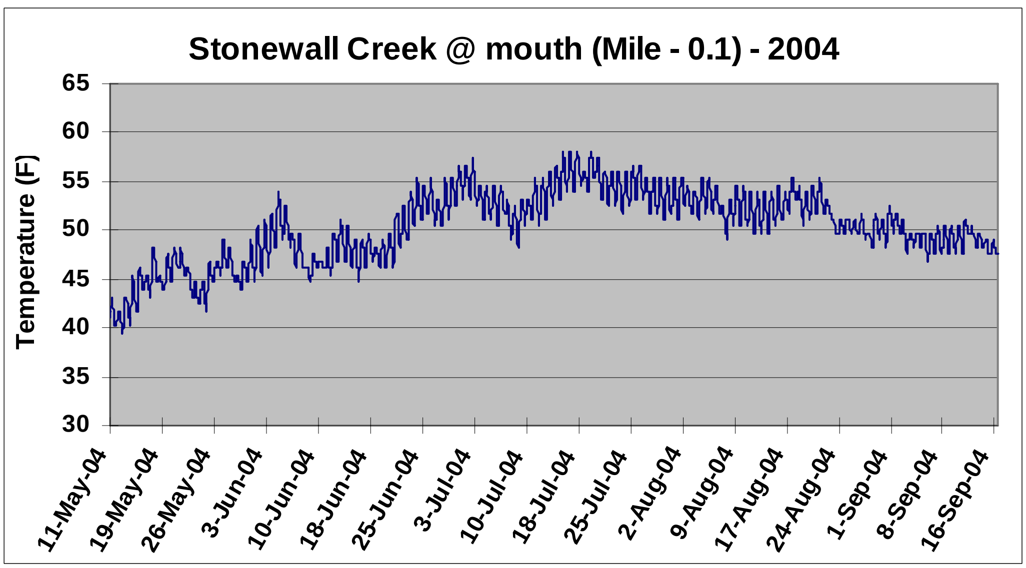
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	54.58	43.19	46.69	2.05	4.21
June	53.19	44.65	47.42	1.91	3.64
July	53.19	45.38	48.20	1.73	2.98
August	51.08	45.38	47.35	1.34	1.79
September	48.96	44.65	46.29	1.00	1.00
October	48.25	43.19	45.26	1.06	1.13



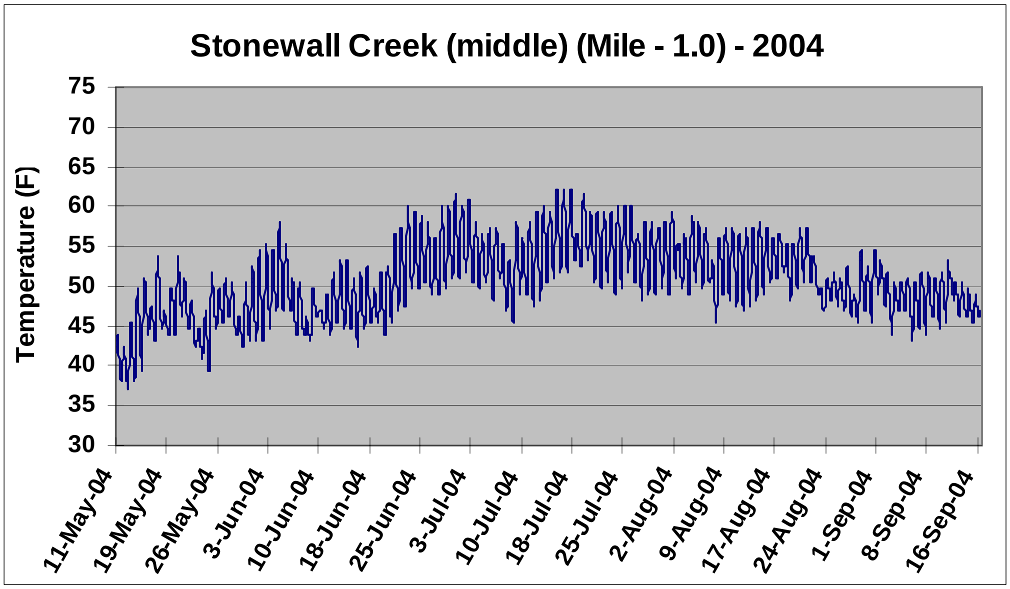
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	46.10	46.10	46.10	0.00	0.00
June	46.10	46.10	46.10	0.00	0.00
July	46.10	46.10	46.10	0.00	0.00
August	46.10	46.10	46.10	0.00	0.00
September	46.10	46.10	46.10	0.00	0.00
October	46.10	46.10	46.10	0.00	0.00



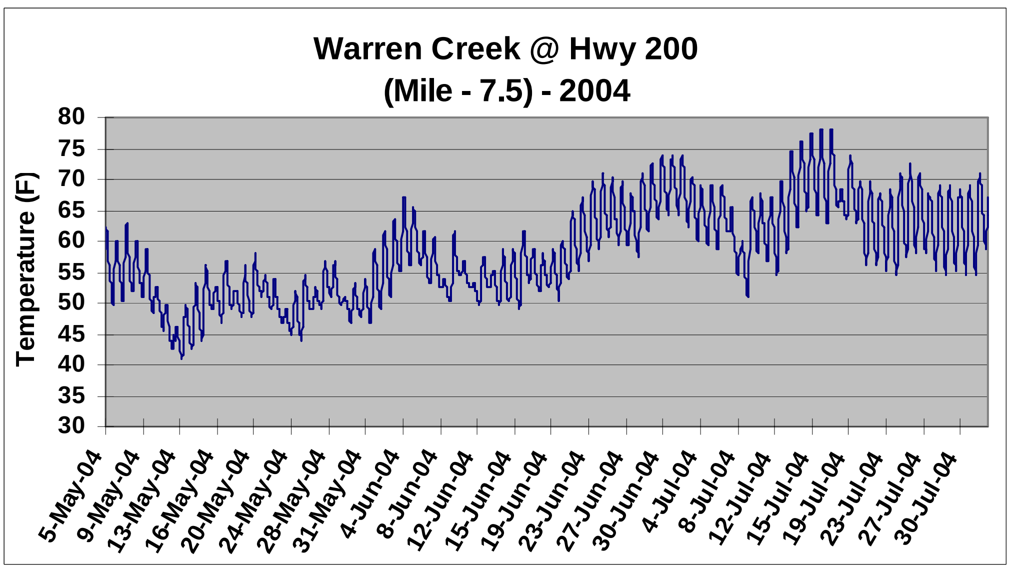
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	52.49	35.66	41.85	3.40	11.56
April	51.08	35.66	42.53	3.10	9.63
May	49.67	37.20	43.36	2.56	6.54
June	58.61	41.72	48.48	3.56	12.66
July	63.47	45.20	53.72	4.03	16.23
August	62.61	46.87	53.09	3.93	15.42
September	58.33	45.48	50.41	2.91	8.48



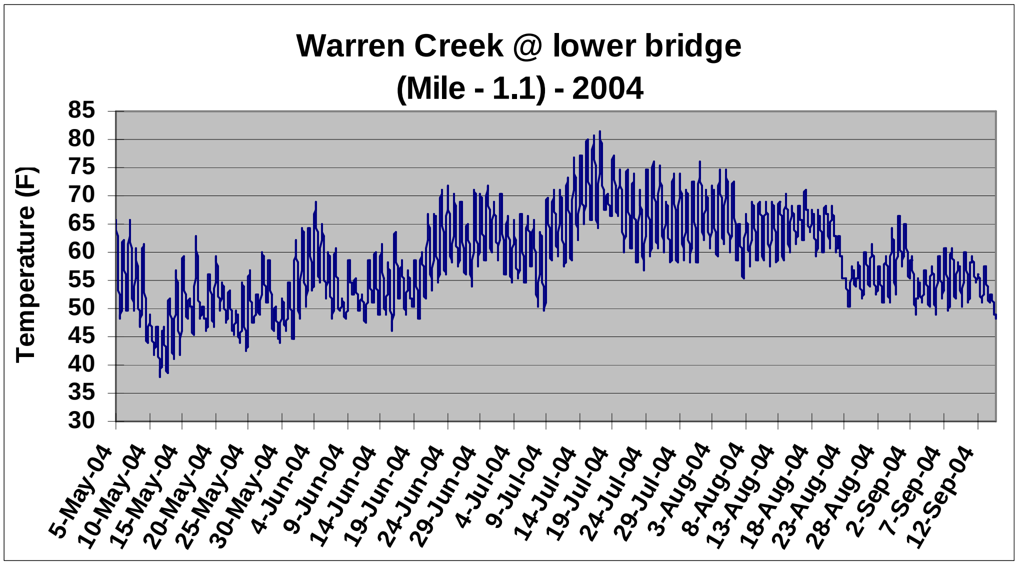
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	48.96	39.48	44.79	2.10	4.42
June	56.66	44.65	49.41	2.76	7.62
July	58.04	48.25	53.98	1.92	3.69
August	55.28	48.25	52.00	1.67	2.79
September	51.79	46.82	49.21	1.08	1.16



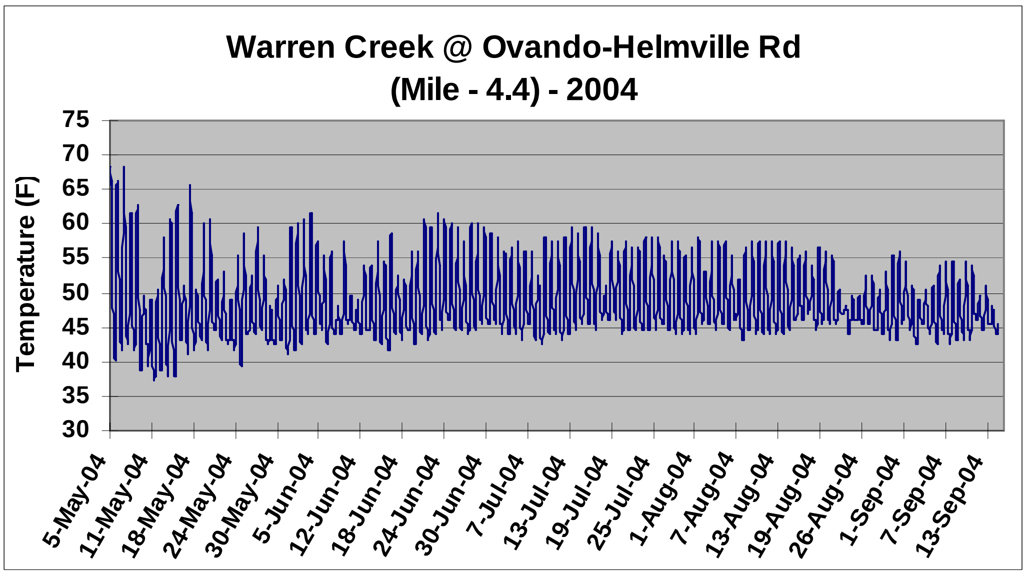
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	53.89	37.20	45.62	3.48	12.11
June	61.48	42.46	49.86	4.33	18.73
July	62.17	45.38	54.56	3.62	13.13
August	59.42	45.38	52.18	3.27	10.69
September	53.19	43.19	48.61	2.23	4.97



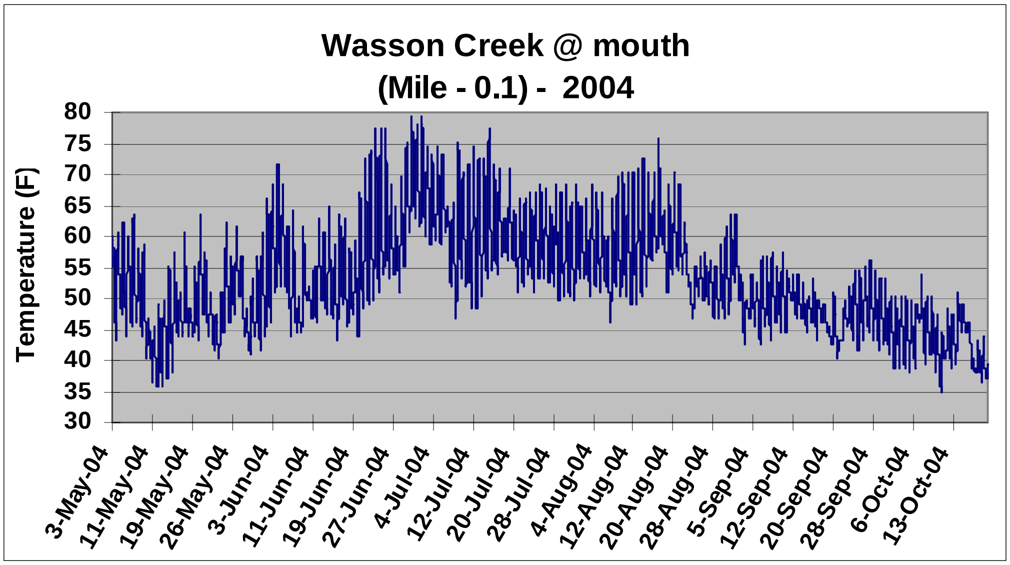
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	62.80	41.00	50.79	4.00	16.00
June	73.90	46.80	58.15	5.72	32.77
July	78.10	51.10	64.69	5.41	29.25
August	71.10	54.60	62.69	4.96	24.59



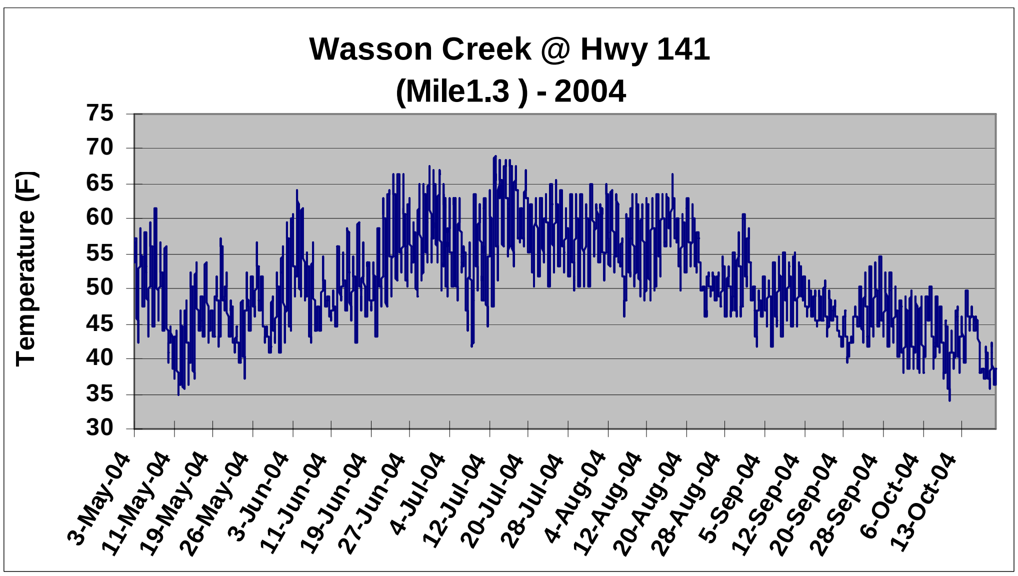
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	65.59	37.97	50.54	5.31	28.21
June	71.77	44.65	57.10	6.05	36.61
July	81.53	49.67	65.63	6.21	38.53
August	75.92	50.38	62.31	5.47	29.95
September	64.91	48.25	55.27	3.55	12.60



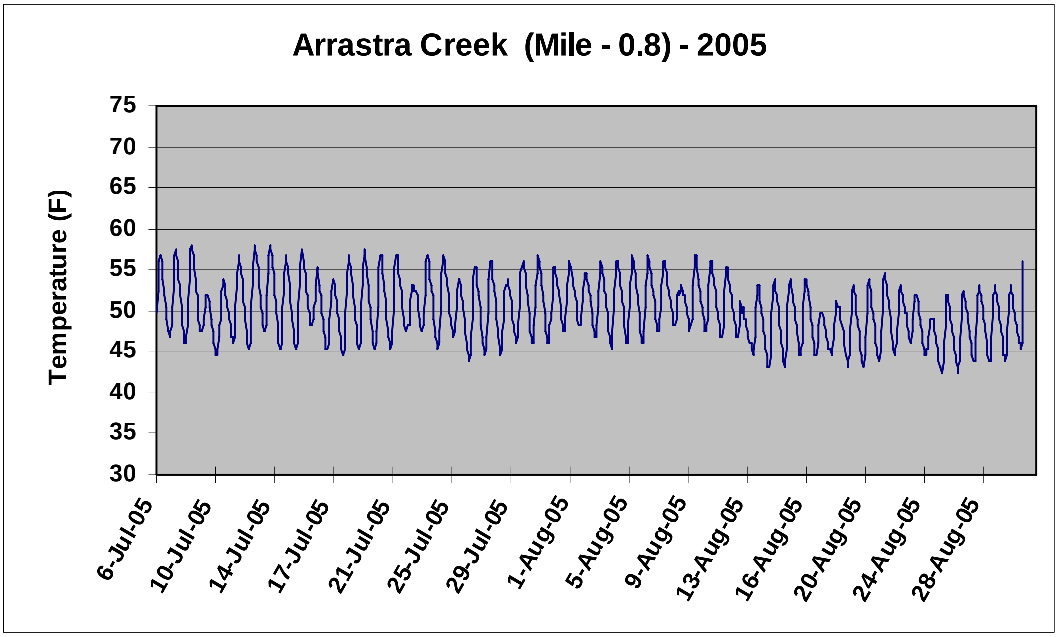
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	68.33	37.20	47.62	6.42	41.26
June	61.48	40.97	48.73	5.11	26.13
July	59.42	42.46	49.36	4.53	20.48
August	58.04	43.19	48.64	3.76	14.14
September	54.58	42.46	47.09	3.03	9.19



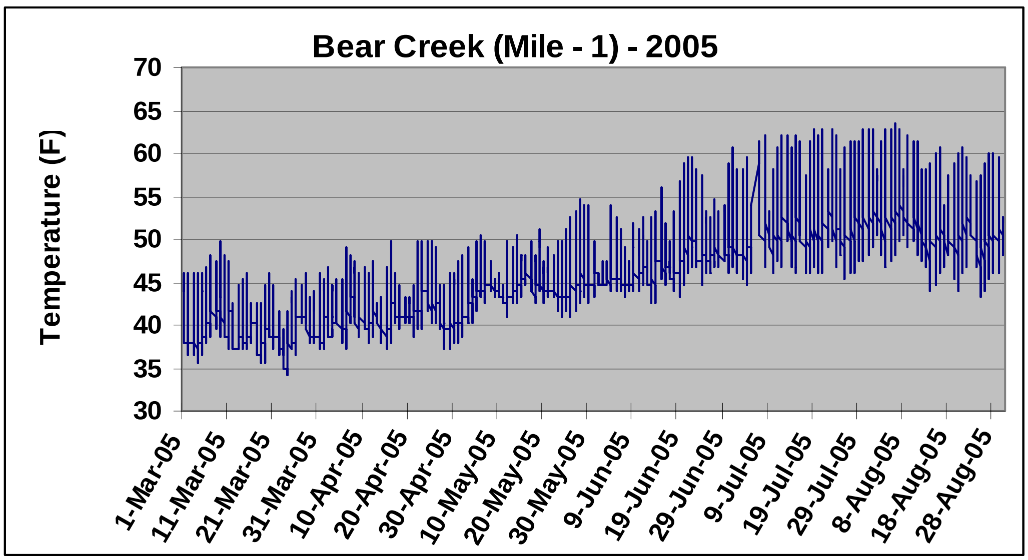
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	63.54	35.66	48.56	5.86	34.33
June	79.41	41.72	55.89	7.93	62.90
July	79.41	46.82	61.18	6.72	45.14
August	75.92	46.10	57.03	6.04	36.46
September	63.54	40.23	48.65	3.80	14.43
October	53.89	34.88	43.50	3.84	14.71



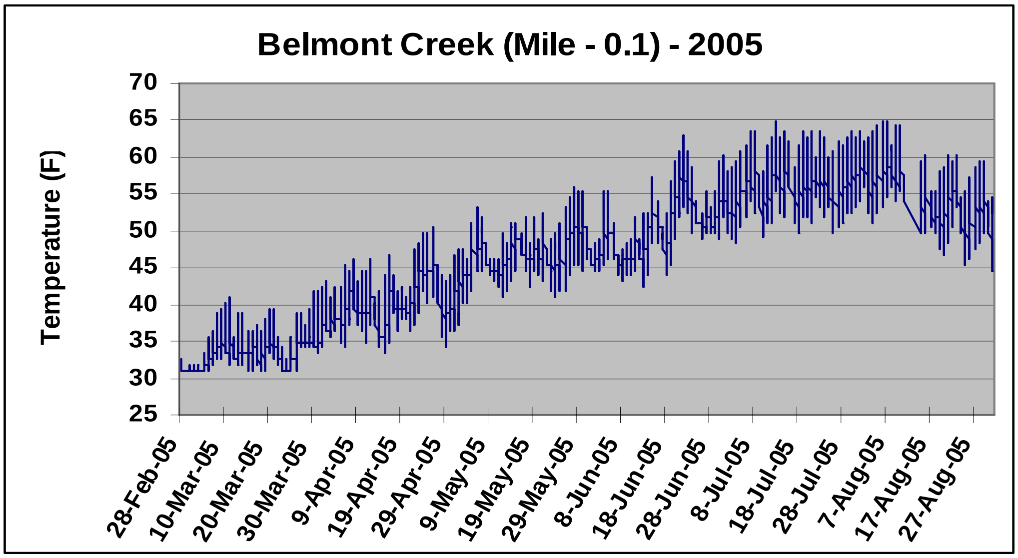
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
May	61.48	34.88	46.79	5.28	27.91
June	67.65	40.97	52.55	5.77	33.29
July	69.02	41.72	57.58	5.34	28.50
August	66.28	46.10	55.39	4.97	24.74
September	58.73	39.48	47.61	3.66	13.38
October	50.38	34.10	42.71	3.81	14.50



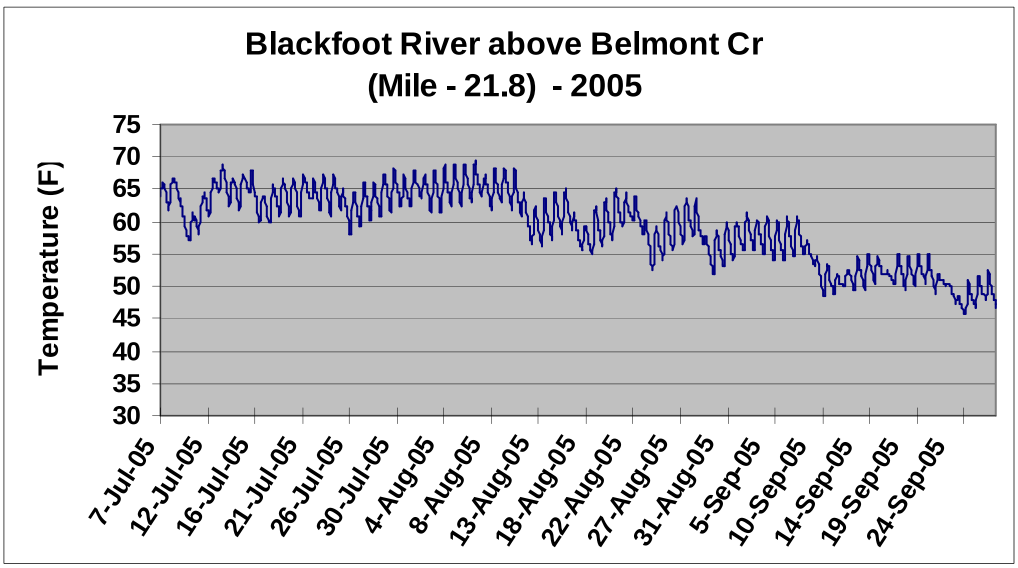
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	58	43.9	50.89	3.63	13.19
August	56.7	42.5	49.46	3.38	11.45



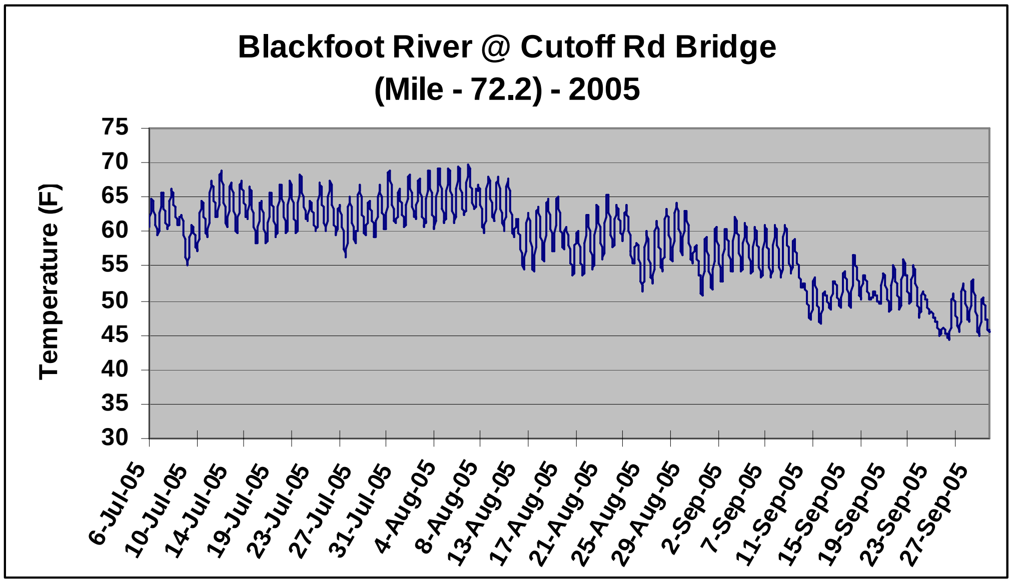
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	49.67	34.1	40.16	2.89	8.4
April	49.67	37.2	41.95	2.71	7.36
May	54.58	37.97	45.02	2.82	7.93
June	59.42	42.46	48.08	3.42	11.73
July	62.85	44.65	52.14	4.88	23.82
August	63.54	43.19	52.22	4.71	22.2



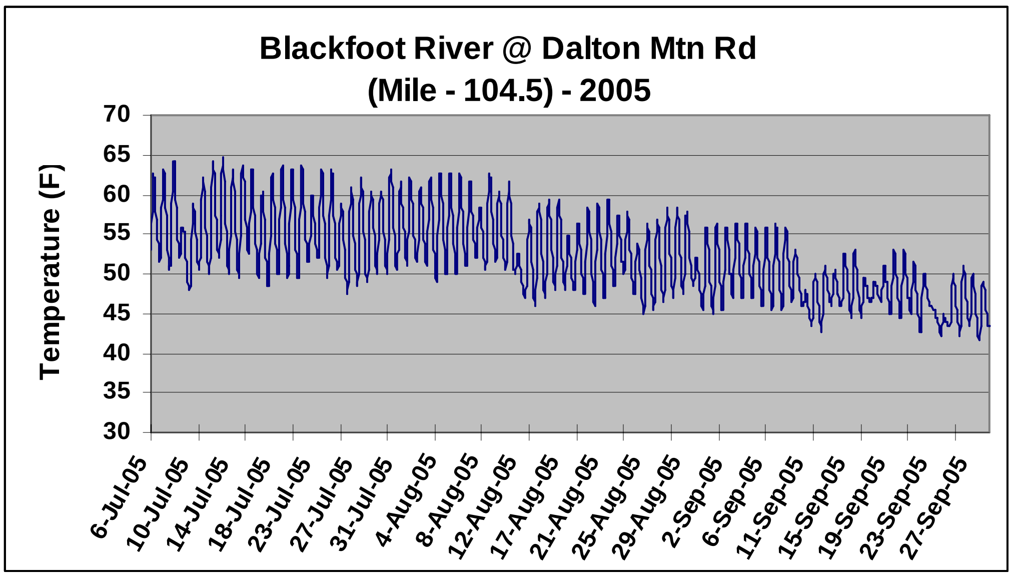
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
February	32.52	30.91	31.01	0.4	0.16
March	41.72	30.91	33.79	2.52	6.38
April	50.38	33.31	40.11	3.35	11.26
May	55.97	36.43	46.36	3.32	11.04
June	62.85	42.46	50.03	4.05	16.44
July	64.9	48.25	55.76	3.69	13.6
August	64.9	44.65	54.79	4.42	19.59



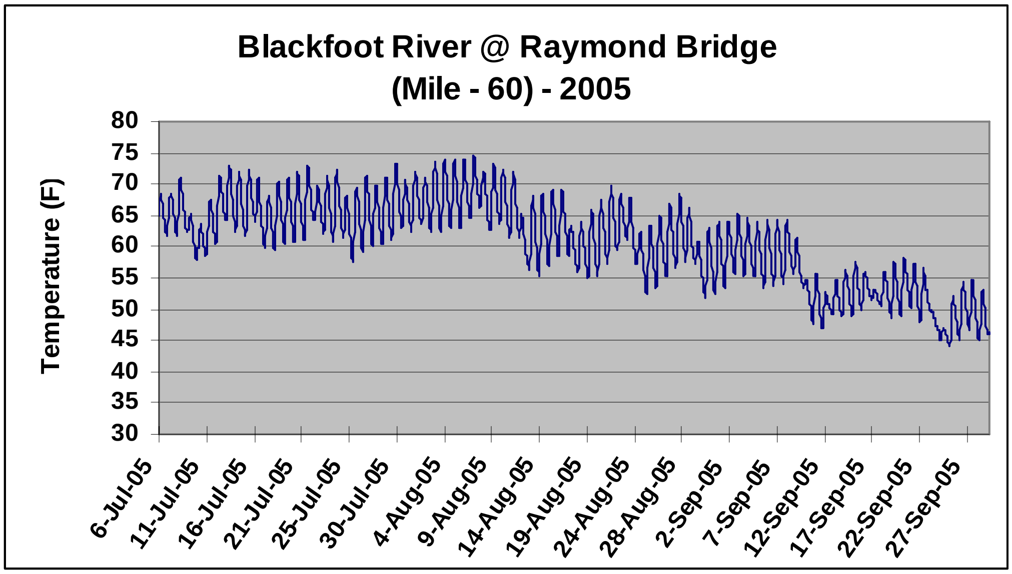
Month	Max Temp	Min Temp	Avg Temp	St Dev Temp	Var Temp
July	68.9	57.2	63.7	2.4	5.7
August	69.4	51.9	61.4	3.8	14.3
September	61.4	45.7	53.1	3.6	12.8



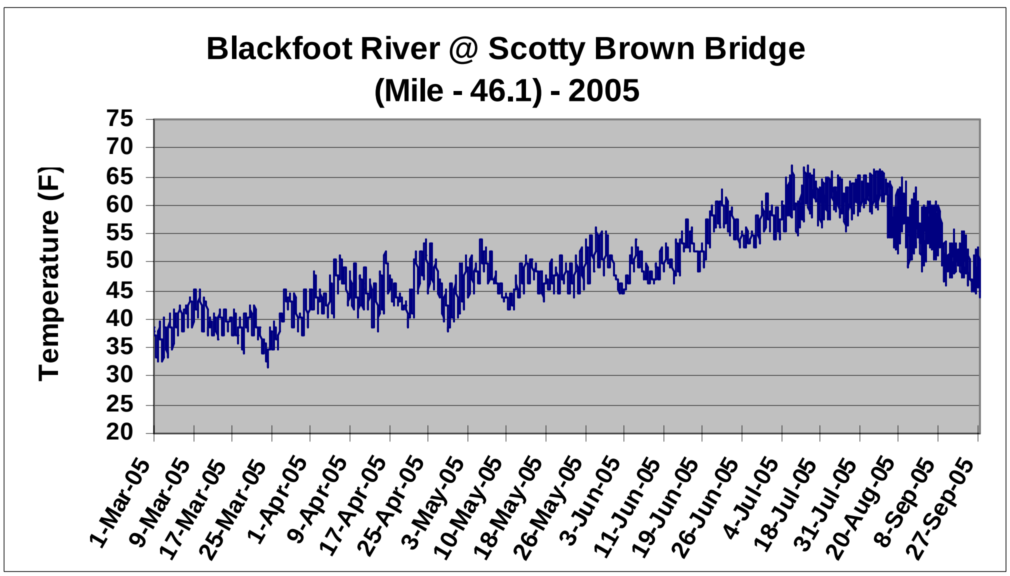
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	68.97	55.21	62.75	2.75	7.56
August	69.86	50.74	60.92	4.14	17.11
September	62	44.31	52.42	4.14	17.11



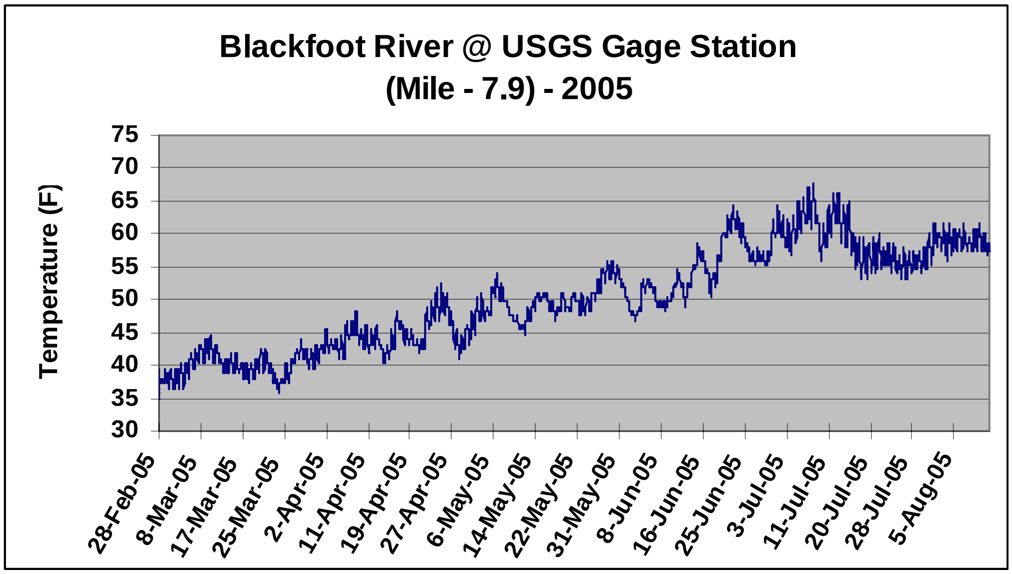
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	64.74	47.47	55.92	4.35	18.89
August	62.6	44.86	53.39	4.19	17.58
September	56.28	41.75	48.25	3.39	11.5



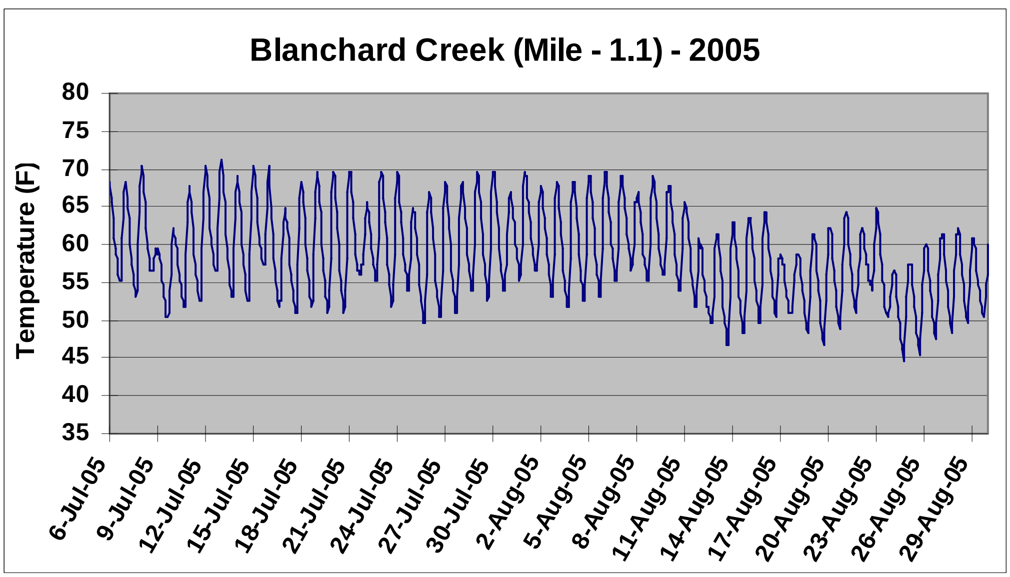
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	73.38	57.67	65.57	3.61	13.02
August	74.6	51.83	63.62	5.01	25.14
September	65.11	44.02	53.74	4.88	23.79



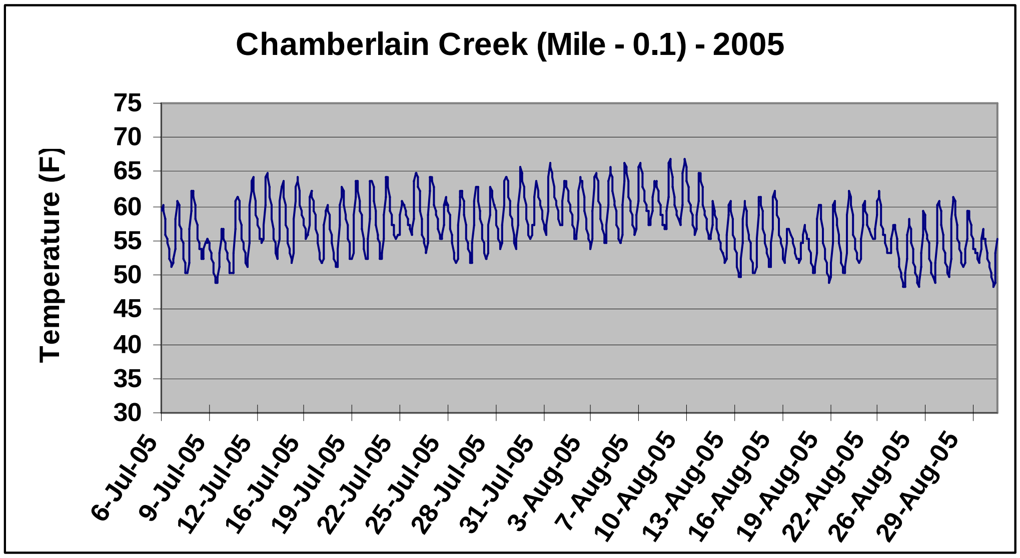
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	45.38	31.72	39.33	2.91	8.48
April	53.89	37.97	45.1	3.35	11.26
May	55.97	40.23	47.83	3.08	9.47
June	62.85	44.65	52.22	4.25	18.05
July	66.81	53.89	60.53	3.09	9.6
August	66.2	48.54	59.7	4.06	16.45
September	60.49	43.85	52.01	3.87	15



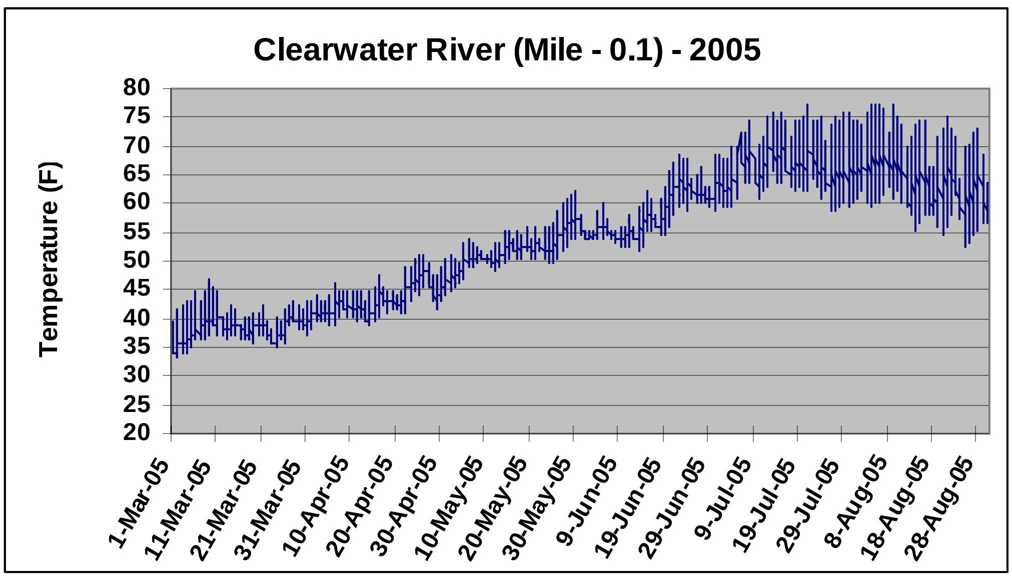
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
February	37.2	34.88	36.93	0.74	0.55
March	44.65	35.66	39.99	1.81	3.29
April	52.49	40.23	44.63	2.41	5.79
May	55.97	43.19	49.72	2.54	6.45
June	64.22	46.82	54.31	4.19	17.53
July	67.65	53.19	58.93	3.32	10.99
August	61.48	55.28	58.95	1.29	1.69



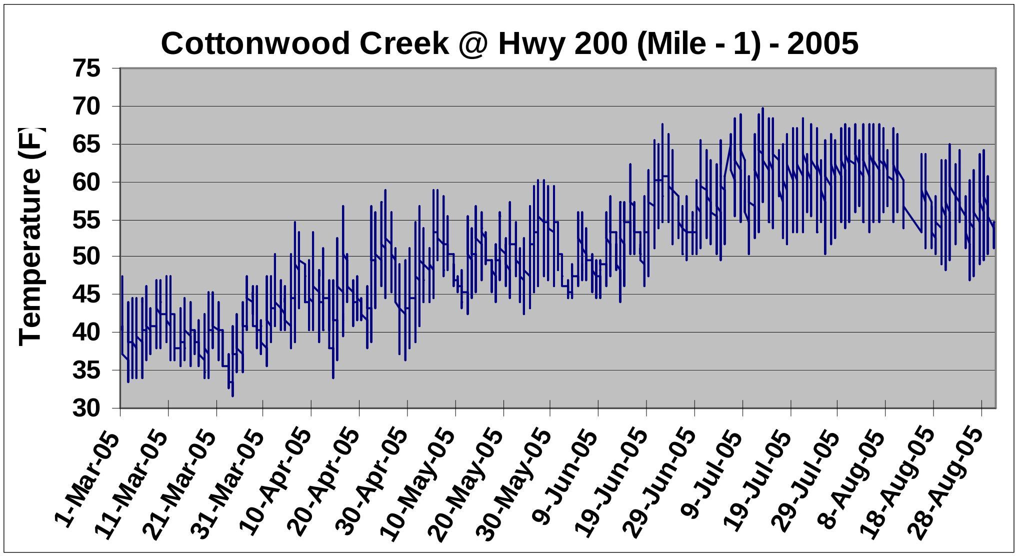
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	71.08	49.67	60.18	5.61	31.57
August	69.71	44.65	57.48	5.59	31.22



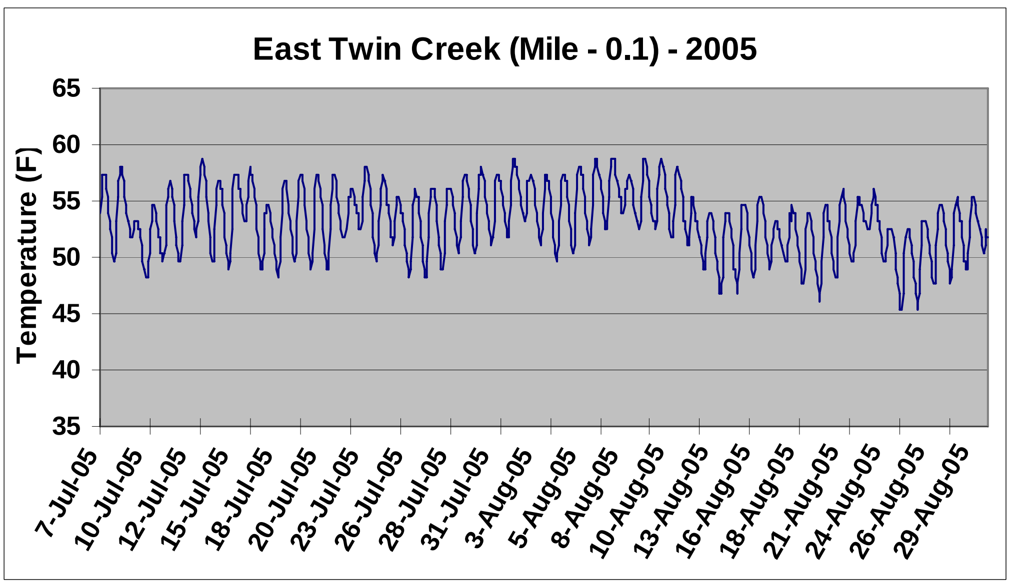
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	65.59	48.96	57.36	3.89	15.18
August	66.96	48.25	56.82	4.27	18.22



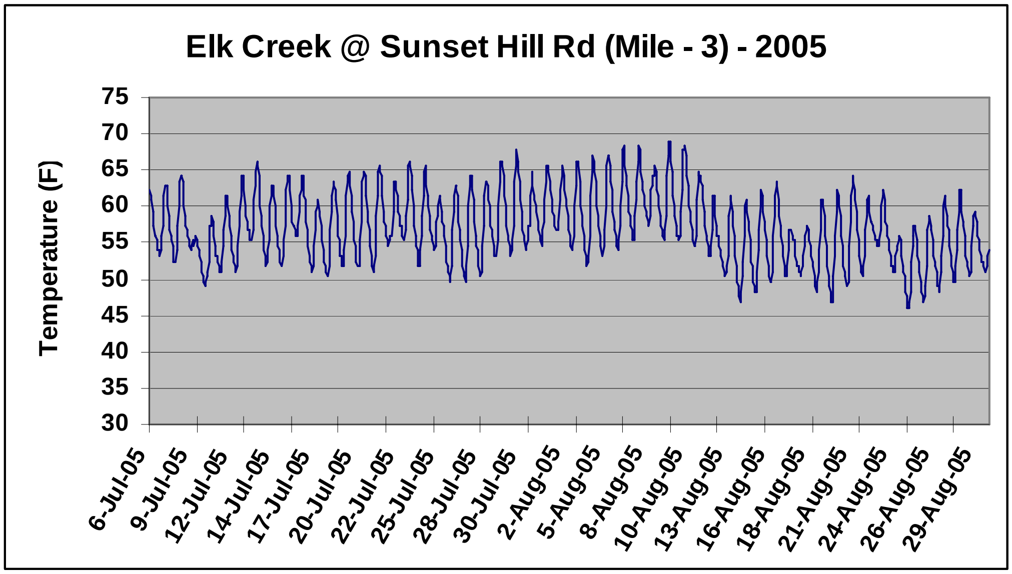
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	46.82	33.31	38.73	2.27	5.16
April	51.08	37.97	43.34	2.73	7.48
May	62.17	43.92	52.11	3.27	10.71
June	68.33	51.79	58.19	3.93	15.42
July	77.31	58.73	66.3	4.37	19.1
August	77.31	52.49	64.48	5.811	33.77



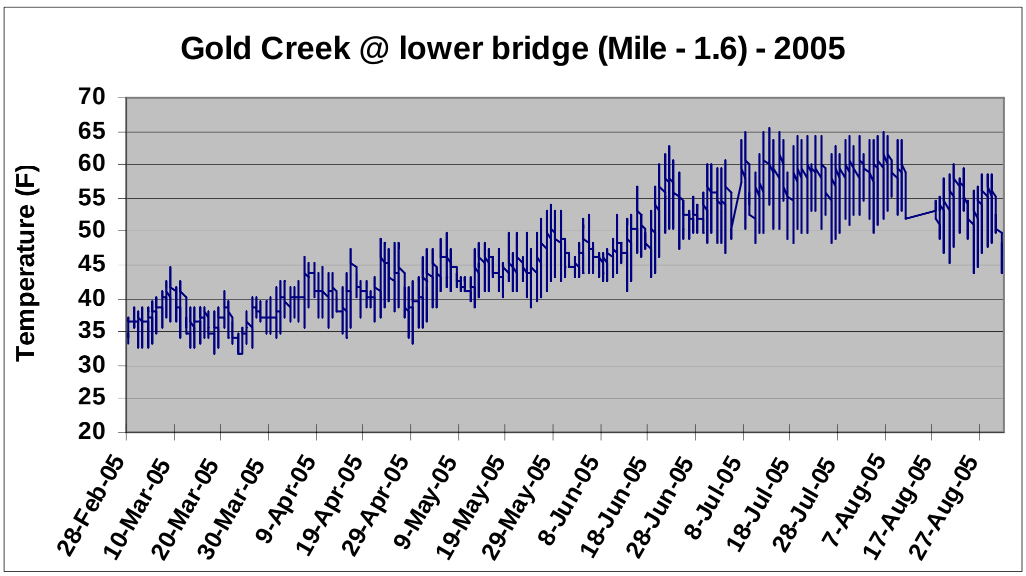
Month	Max temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	47.53	31.72	39.8	3.44	11.82
April	58.73	34.1	45.33	4.67	21.86
May	60.11	38.72	50	4.19	17.6
June	67.65	43.92	52.7	5.28	27.91
July	69.71	49.67	59.06	4.75	22.54
August	67.65	46.82	57.72	4.91	24.12



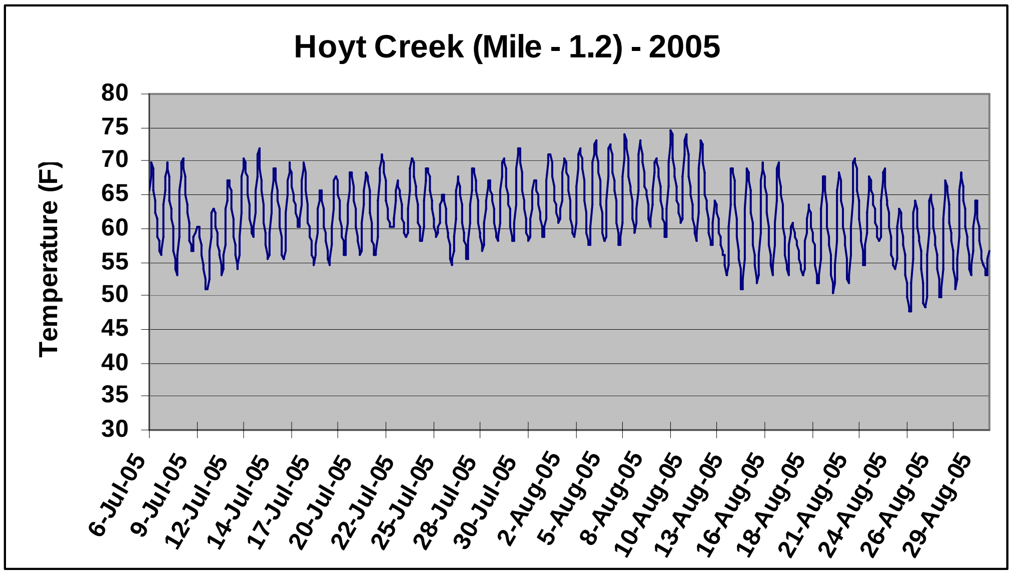
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	58.7	48.3	53.65	2.71	7.32
August	58.7	45.4	52.98	2.95	8.72



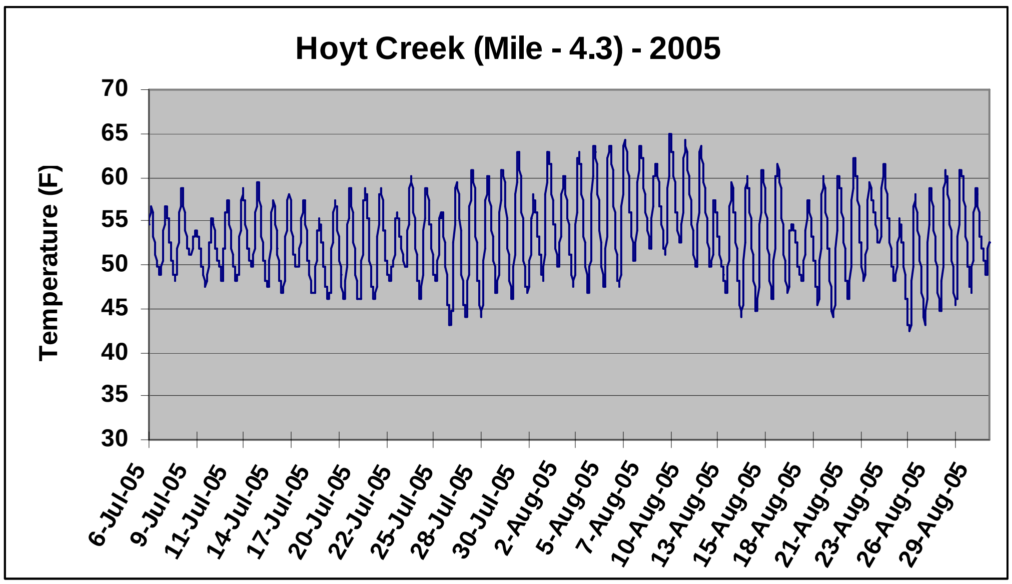
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	67.7	49	57.55	4.27	18.25
August	69	46.1	56.69	5.12	25.23



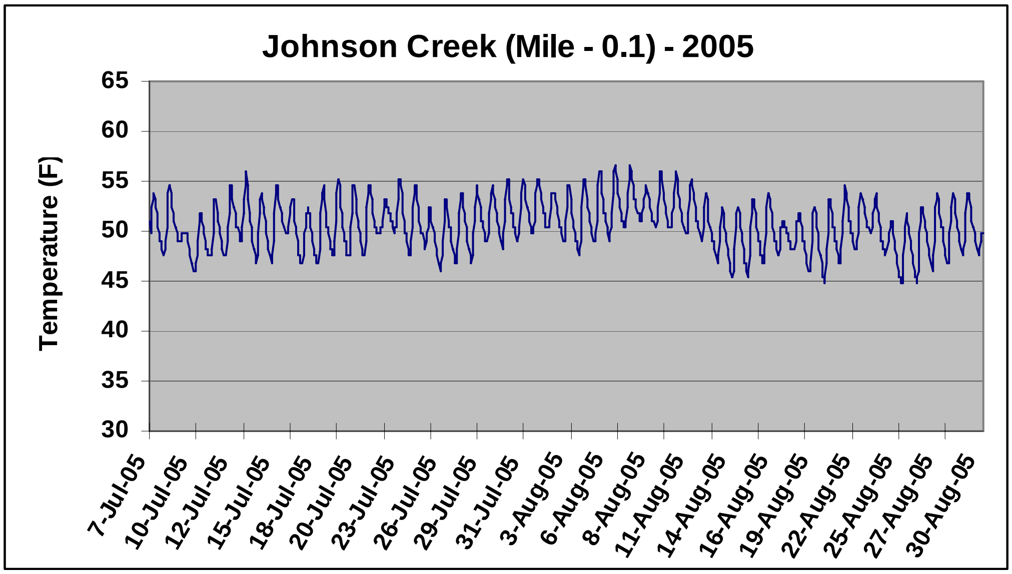
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
February	37.2	33.31	35.71	1.48	2.19
March	44.65	31.72	36.81	2.55	6.5
April	48.96	33.31	40.45	3.14	9.87
May	53.89	35.66	44.24	3.39	11.51
June	62.85	40.97	49.44	4.62	21.33
July	65.56	46.82	55.83	4.57	20.9
August	64.91	43.9	54.91	4.72	22.29



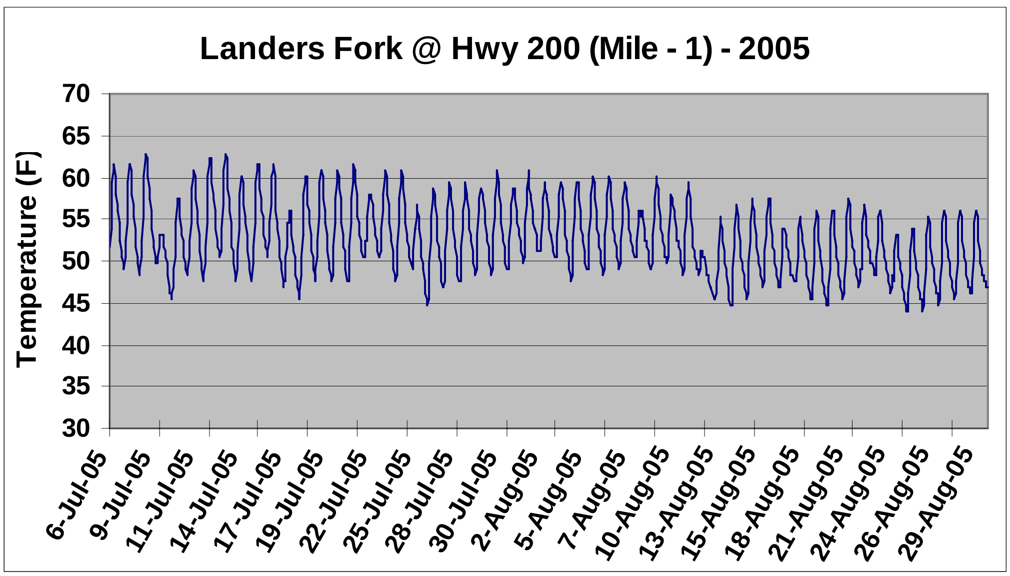
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	71.8	51.1	62.27	4.68	21.87
August	74.6	47.6	61.61	5.97	35.61



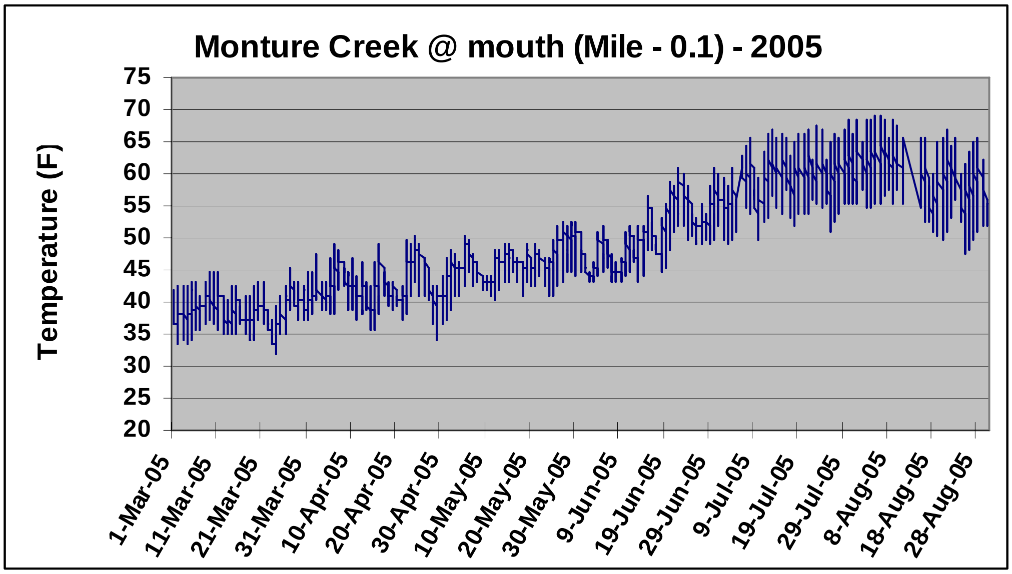
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	62.85	43.19	52.31	4.13	17.04
August	64.91	42.46	53.93	5.14	26.44



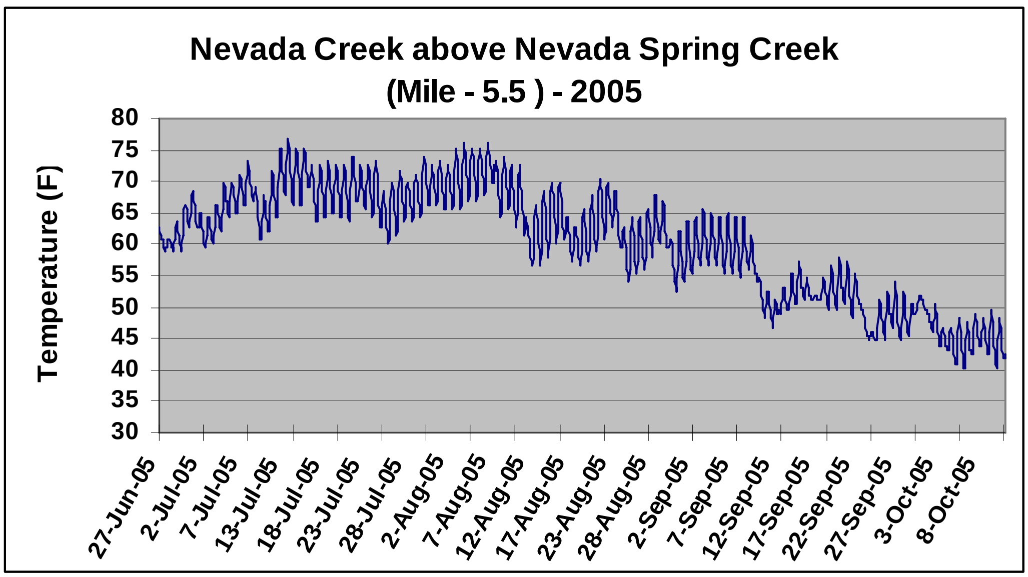
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	56	46.1	50.63	2.33	5.45
August	56.7	44.7	50.63	2.54	6.48



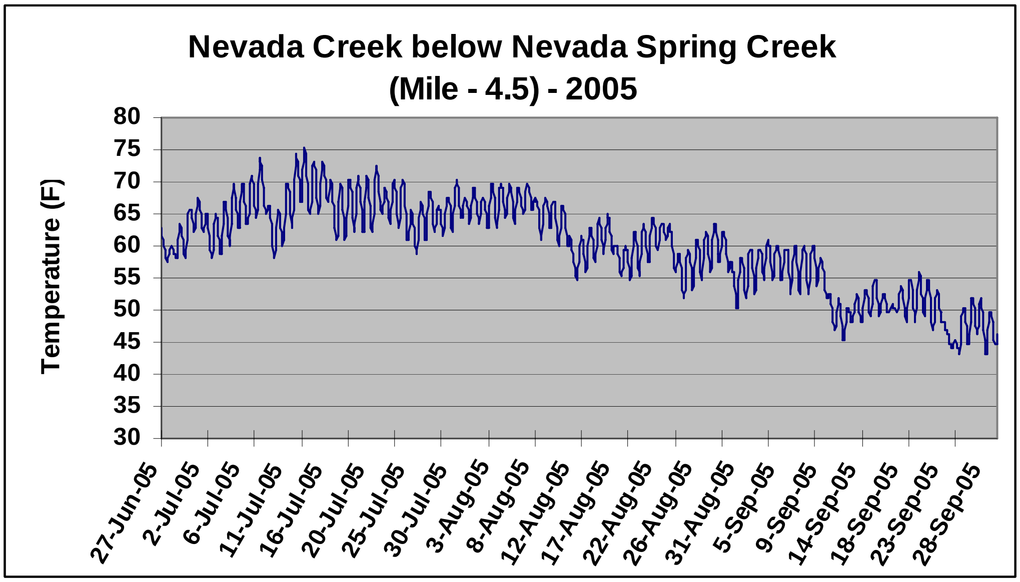
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	62.8	44.7	53.81	4.25	18.1
August	60.8	43.9	51.56	3.86	14.89



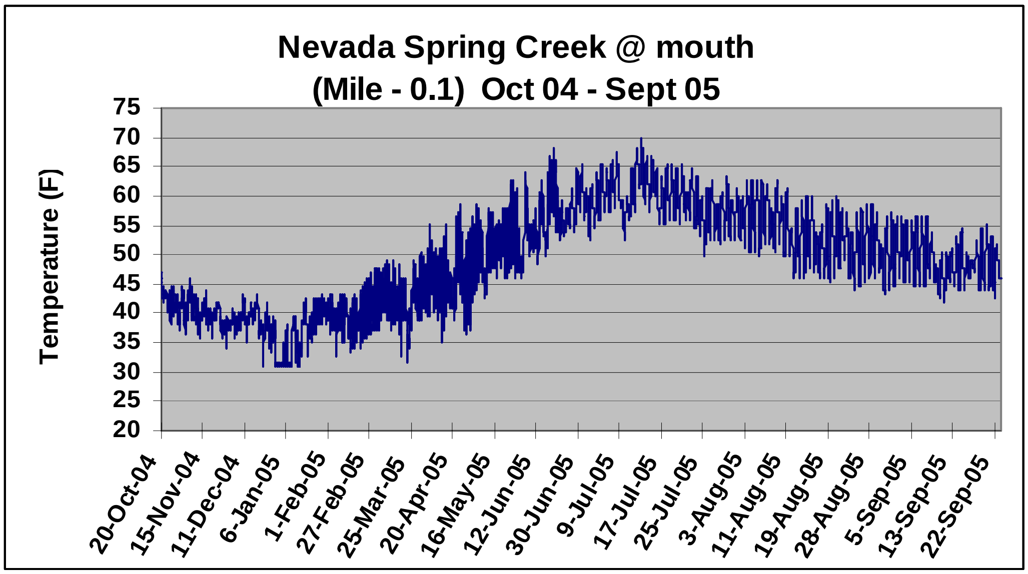
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	45.38	31.72	38.6	2.81	7.91
April	50.38	34.1	42.12	3.16	9.99
May	52.49	37.2	45.45	2.83	8
June	60.8	43.19	49.8	4.42	19.6
July	68.33	48.96	57.94	4.47	19.97
August	69.02	47.53	58.88	4.93	24.27



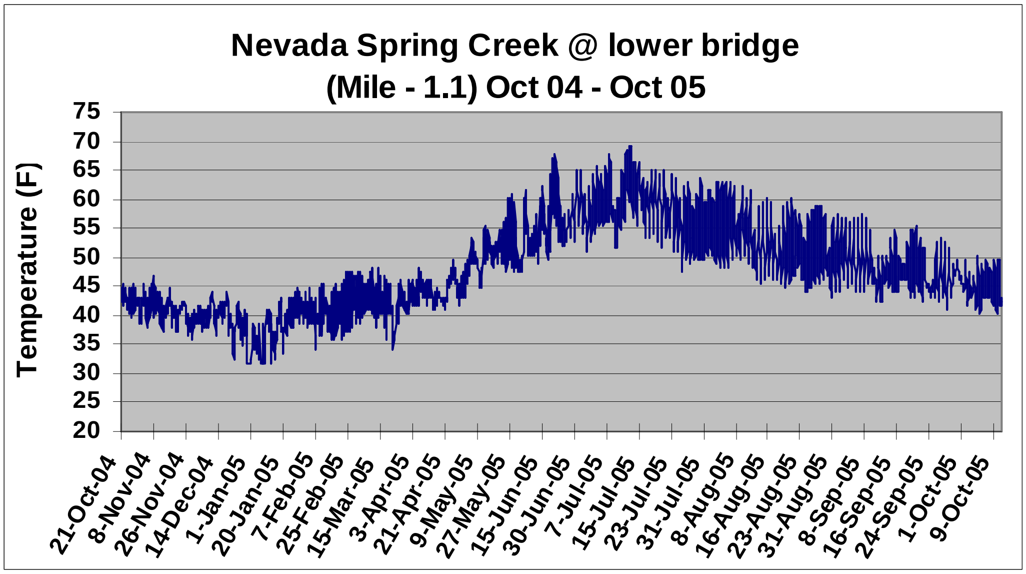
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
June	66.3	58.7	61.19	2.09	4.36
July	76.7	59.4	67.65	3.62	13.09
August	76	52.5	64.95	5.3	28.1
September	65.6	44.7	53.4	5.06	25.61
October	51.1	40.2	45.51	2.71	7.36



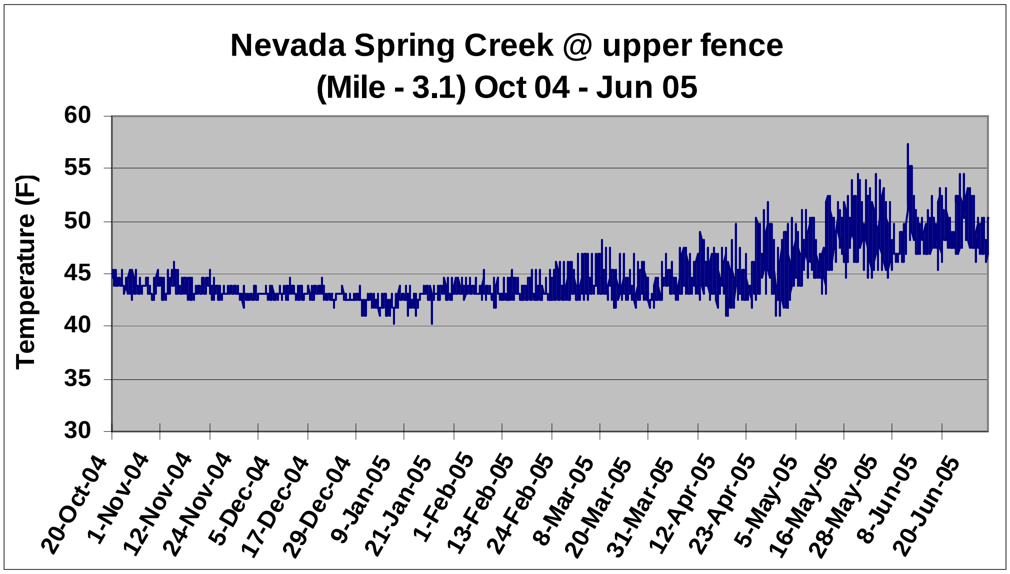
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
June	65.59	57.35	60.44	2.32	5.38
July	75.22	58.04	65.96	3.49	12.2
August	69.71	50.38	61.67	4.27	18.21
September	60.8	43.19	52.07	4.42	19.58



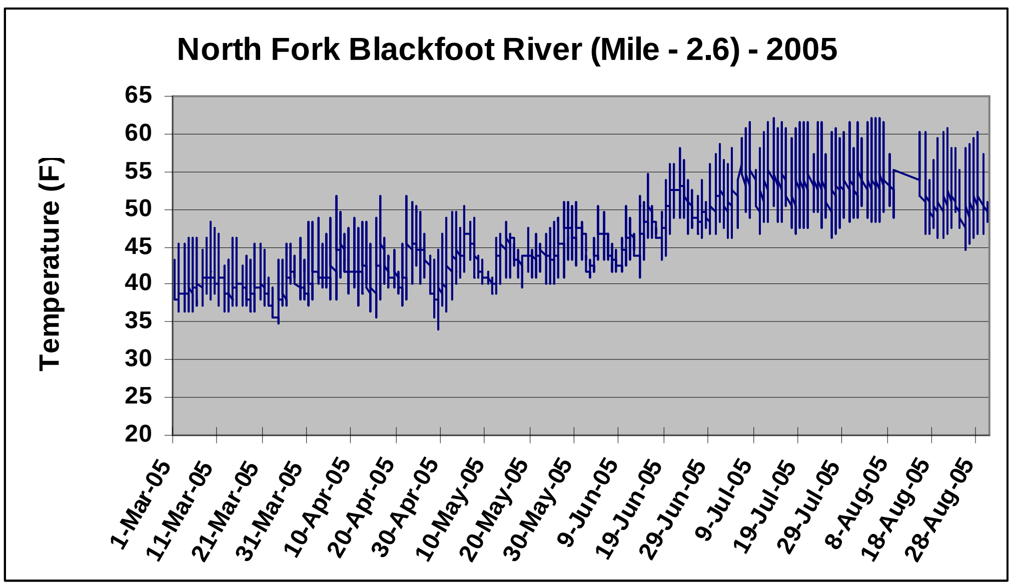
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
October	46.82	37.97	41.92	1.88	3.55
November	46.1	34.1	40.04	2.21	4.87
December	43.19	30.91	38.35	2.48	6.17
January	43.19	30.91	36.34	3.81	14.5
February	46.82	32.52	39.33	2.91	8.48
March	50.38	31.72	41.98	3.69	13.64
April	58.73	34.88	45.5	4.6	21.2
May	62.85	37.2	51.25	4.76	22.7
June	68.33	46.1	56.1	4.53	20.5
July	69.71	49.67	59.83	3.77	14.21
August	62.85	43.19	53.78	4.71	22.22
September	57.35	41.72	49.1	3.71	13.8



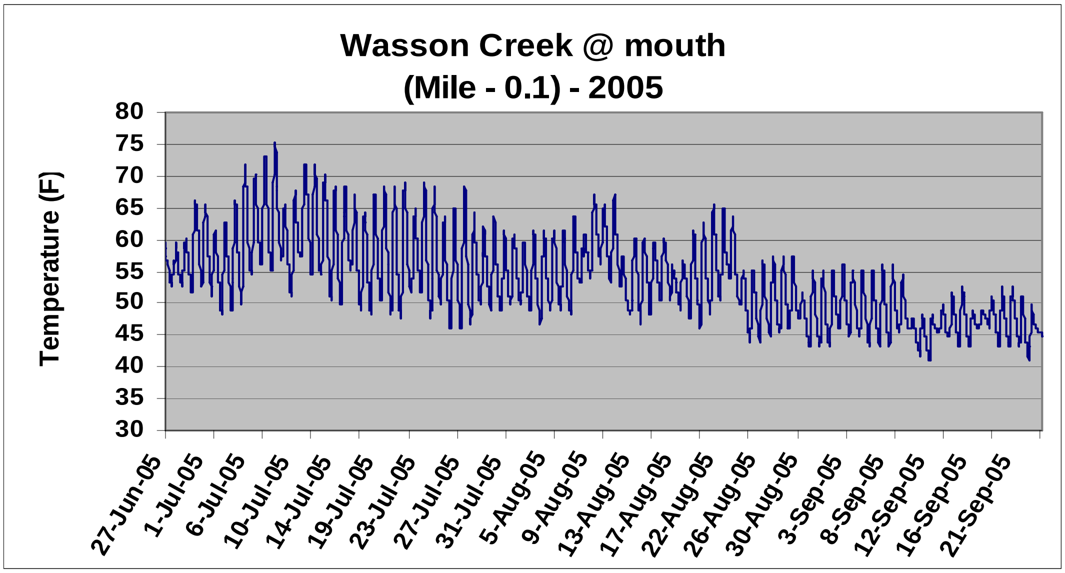
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
October	45.4	38.7	42.37	1.59	2.54
November	46.8	35.7	40.89	2.07	4.27
December	43.9	31.7	39.33	2.46	6.06
January	44.7	31.7	37.6	3.55	12.58
February	47.6	34.1	40.28	2.89	8.38
March	48.3	34.1	42.1	2.79	7.76
April	49.7	41	44.23	1.87	3.51
May	60.8	43.2	50.67	3.35	11.21
June	67.7	47.6	55.45	4.4	19.36
July	69.02	47.53	58.63	4.37	19.09
August	62.85	43.19	52.7	4.87	23.7
September	57.35	40.97	47.97	3.72	13.88
October	50.38	40.23	44.95	2.55	6.51



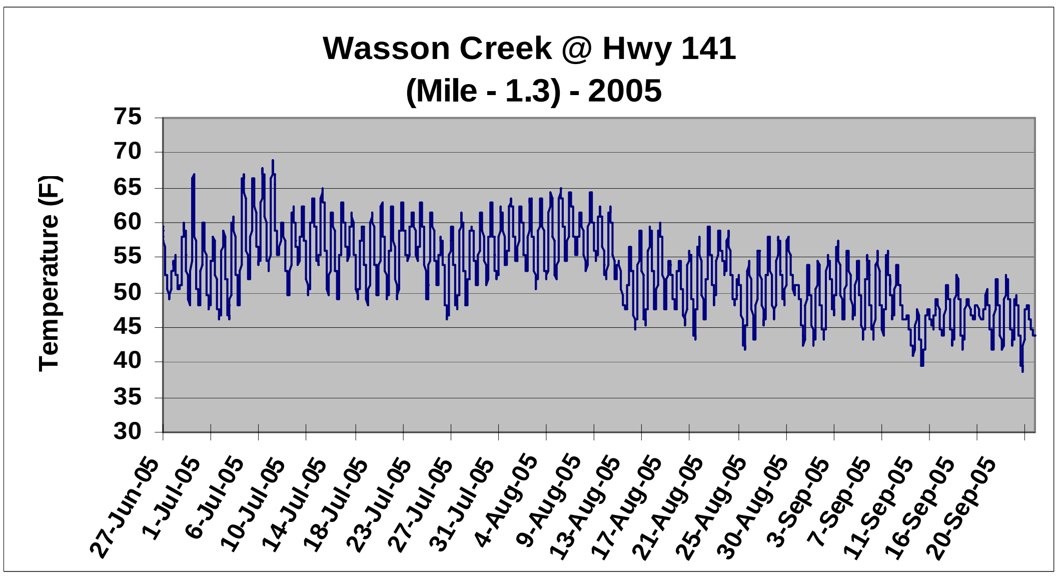
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
October	45.38	42.46	43.91	0.69	0.47
November	46.1	41.72	43.43	0.72	0.52
December	44.65	40.97	43.01	0.59	0.35
January	44.65	40.23	42.78	0.86	0.75
February	46.1	41.72	43.29	0.89	0.81
March	48.25	41.72	43.87	1.29	1.66
April	51.79	40.97	44.78	2.04	4.18
May	54.58	41.72	47.88	2.67	7.11
June	57.35	45.38	49.09	2.15	4.61



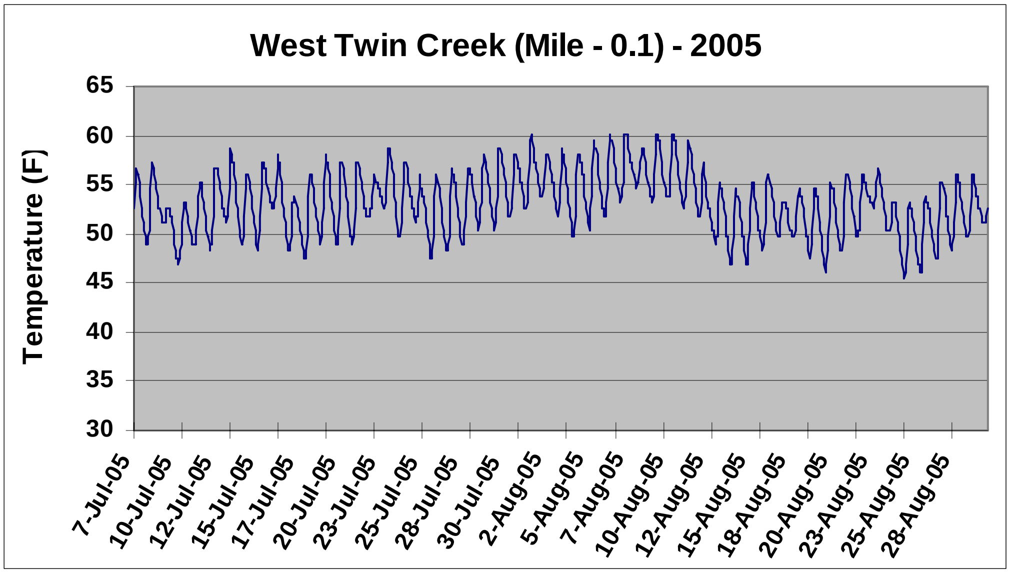
Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
March	48.25	34.88	40.33	2.853	8.14
April	51.79	34.1	42.48	3.56	12.68
May	51.08	36.43	43.84	2.86	8.2
June	58.04	40.97	47.55	3.79	14.37
July	62.17	46.1	53.01	4.15	17.19
August	62.17	44.65	52.61	4.25	18.07



Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
June	66.28	51.79	56.93	3.63	13.21
July	75.22	46.1	58.29	6.36	40.41
August	66.96	43.19	54.05	4.98	24.8
September	55.97	40.97	47.6	3.28	10.76

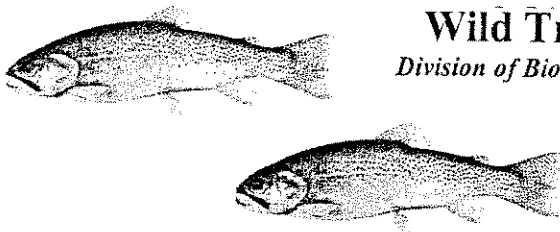


Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
June	66.96	48.25	54.32	4.55	20.69
July	69.02	46.1	56.07	4.81	23.19
August	64.91	41.72	53.84	5.07	25.71
September	57.35	38.72	47.73	3.73	13.93



Month	Max Temp	Min Temp	Avg Temp	StDev Temp	Var Temp
July	58.73	46.82	53.04	2.85	8.12
August	60.11	45.38	53.27	3.26	10.65

Appendix I: Westslope cutthroat trout genetic sampling sites and results



Wild Trout and Salmon Genetics Laboratory

*Division of Biological Sciences * University of Montana * Missoula, MT 59812*

(406)243-5503/6749 Fax (406)243-4184

December 21, 2004

Ron Pierce
Genetics Contact, Region 2
Mt. Dept. of Fish, Wildlife, and Parks
3201 Spurgin Road
Missoula, MT 59801

Dear Ron:

The paired interspersed nuclear DNA elements (PINE) technique has been used to analyze DNA from the following trout samples:

Table 1. Summary of results.

Sample #	Water Name/Location/Collection Date/ Collector	N [a]	# markers [b]	Species ID [c]	Power (%) [d]	% WCT [e]	Individuals [f]
2924	**North Fork Frazier Creek** 14N12W32 9/5/2002 Ron Pierce	28	xxx	WCT	R94 Y85	100	xx

[a]Number of samples successfully analyzed; if combined with previous sample (Indicated in "Location" column). number indicates the combined sample size; if present, the number in () is the average number successfully analyzed per locus (some individuals do not amplify for all marker loci).
[b]Number of markers analyzed that are diagnostic for the non-native species.
[c]Codes WSCT = westslope cutthroat trout (*Oncorhynchus clarki lewisi*); RBT = rainbow trout (*O. mykiss*); YSCT = Yellowstone cutthroat trout (*O. clarki bouvieri*). Only one species code is listed when the entire sample possessed alleles from that species only. However, it must be noted that we cannot definitively rule out the possibility that some or all of the individuals are hybrids; we merely have not detected any non-native alleles at the loci examined (see Power %). Species codes separated by "x" indicate hybridization between those species.
[d]Number corresponds to the percent chance we have to detect 1% hybridization given the number of individuals successfully analyzed and the number of diagnostic markers used (e.g., 25 individuals are required to yield a 95% chance to detect 1% hybridization of rainbow or Yellowstone cutthroat trout into a westslope cutthroat trout population). Not reported when hybridization is detected.
[e]Indicates the genetic contribution of westslope cutthroat trout to the sample assuming Hardy-Weinburg proportions. This number is reported only if samples appear to come from a random mating population and can be analyzed at the population level.
[f]Indicates number of individuals with genotypes corresponding to the species code column when the sample can be analyzed on the individual level only; this occurs when alleles are not randomly distributed and hybridization appears to be recent and/or if the sample appears to consist of an admixture of populations
*See the **"Sample Details"** section below.

Methods and Data Analysis

The PINE technique uses short synthetically made segments of DNA called primers, in pairs, to search for relatively small segments of organismal DNA flanked by particular, often viral, DNA inserts. During the polymerase chain reaction (PCR), the primers bind to the ends of the inserts and many copies of the organismal DNA between the primers are made. While the DNA from some organisms may have two appropriately spaced inserts to which the primers can attach, the DNA from other organisms may have only one or none of the appropriately spaced inserts in particular regions. During PCR we will fail to copy DNA in the latter two cases.

Thus, the PINE technique coupled with PCR is used to search for evidence of genetic variation based on the presence or absence of particular DNA fragments. The fragments are labeled by the primers used to produce them and their length in terms of the number of nucleotides in the fragment.

The fragments are made using dye labeled nucleotides and after PCR are separated from each other via electrophoresis in polyacrylamide gels. Smaller fragments move through the gels at a faster rate than larger fragments. The use of dye labeled nucleotides allows one to visualize the position of the fragments in the gels after electrophoresis using a spectrophotometer and the size of the fragments is determined by comparison to the position of synthetic fragments of known size that were also migrated into the gel.

When DNA from westslope cutthroat trout, *Oncorhynchus clarki lewisi,* and rainbow trout, *O. mykiss,* is compared with PINE analysis and three different pairs of primers seven fragments are characteristic of westslope cutthroat trout and six fragments are usually characteristic of rainbow trout (Table 1). Likewise, when DNA from westslope and Yellowstone cutthroat trout, *O. c. bouvieri,* is compared using the same procedure one fragment is characteristic of westslope cutthroat trout and four fragments are characteristic of Yellowstone cutthroat trout (Table 1).

Fragments produced from the DNA of one taxon and not another are commonly termed diagnostic or marker loci because they can be used to help determine whether a sample came from a non-hybridized population of one of the taxa or a population in which hydridization between them has or is occurring. Individuals from a non-hybridized population will possess fragments characteristic of only that taxon. In contrast, since half the DNA of first generation hybrids comes from each of the parental taxa the DNA from such individuals will yield all the fragments characteristic of the two parental taxa. In later generation hybrids, the amount and particular regions of DNA acquired from the parental taxa will vary among individuals. Thus, DNA from later generation hybrid individuals will yield only a subset of the parental fragments and the particular subset will vary among individuals. In a sample from a random mating hybrid swarm, that is a population in which the genetic material (i.e. fragments) of the parental taxa is randomly distributed among individuals such that essentially all of them are of hybrid origin, the frequency of the fragment producing allele from the non-native taxon is expected to be nearly equal among the diagnostic loci since their presence can all be traced to a common origin or origins. Thus, if a sample contains variation at only a single marker locus where the presence of the fragment is usually characteristic of a non-native taxon and lacks such fragments at all other markers this is probably not indicative of hybridization. Rather, it much more likely represents the existence of genetic variation for the presence or absence of the fragment within this particular population of the native taxon.

An important aspect of PINE marker loci is that individuals homozygous for the presence allele (*pp*) or heterozygous (*pa*) will both yield the fragment. That is, *p* is dominant to *a*. Thus, in order to estimate the genetic contribution of the native taxon to a hybrid swarm we concentrate on the marker loci at which the *p* allele is characteristic of the non-native taxon. Furthermore, we must assume that genotypic distributions in the population reasonably conform to expected random mating proportions. Under this assumption the frequency of the native *a* allele is approximately the square root of the frequency of individuals in the population lacking the fragment (*aa*). The frequency of the non-native allele then is one minus this value. We focus on the *p* alleles characteristic of the non-native taxon because with low levels of hybridization it is the presence of these alleles that are likely to provide evidence of hybridization. With low levels of hybridization, it is likely all individuals in the sample will genotypically be *pp* or *pa* where the *p* allele is characteristic of the native taxon. Thus, like in non-hybridized populations all individuals in the sample will yield the fragment providing no evidence of hybridization.

Failure to detect evidence of hybridization in a sample does not necessarily mean the population is non-hybridized because there is always the possibility that we would not detect evidence of hybridization because of sampling error. In order to assess the likelihood the population is non-hybridized, we determine the chances of not detecting as little as a one percent genetic contribution of a non-native taxon to a hybrid swarm. This is simply 0.99^{2NX} where N is the number of fish in the sample and X is the number of marker loci where the *p* allele is characteristic of the non-native taxon.

In samples showing evidence of hybridization, that is; fragments characteristic of a non-native taxon were detected at two or more marker loci, we used two approaches to determine if the population appeared to be a hybrid swarm. First, contingency table chi-square analysis was used to test for heterogeneity of allele frequencies among the marker loci. Next, we compared the observed distribution of the number of loci per individual at which non-native fragments were detected to the expected random binomial distribution based on the estimated native and non-native genetic contributions to the population. If both analyses were non-significant we concluded the population came from a hybrid swarm.

Heterogeneity of allele frequencies among marker loci could arise from a couple of factors. In very old hybrid swarms the frequencies over time may diverge from each other due to genetic drift or the sample may have contained individuals from multiple populations with different amounts of hybridization. These possibilities are generally distinguishable from each other. Under the first scenario, the non-native fragments will still be randomly distributed among individuals while in the latter scenario they will not.

Another factor that can result in a non-random distribution of non-native fragments among individuals is relatively recent hybridization. Unlike in mixed population samples, however, in this situation the allele frequencies among marker loci are expected to be statistically homogeneous because they can all still be traced to a common origin or origins.

Results and Discussion:

Sample # 2924 Details:

PINE fragments characteristic of only Westslope were detected.

TABLE 1

Diagnostic PINE markers for westslope cutthroat, Yellowstone cutthroat, and rainbow trout. **X** indicates the fragment is present in the particular taxon.

Markers	Yellowstone	Westslope	Rainbow
Hpa1 5'/Hpa1 3'			
232	x		
153		x	
72	x	x	
70			x
69	x	x	
66			x
Fok1 5'/Tc1			
369			x
366	x	x	
230			x
159	x		

138	x		
110		x	
Hpa1 5'/33.6+2			
395			x
388	x	x	
266			x
248	x		
148	x	x	

Wild Trout and Salmon Genetics Laboratory

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April 18, 2005

Ron Pierce
Genetics Contact, Region 2
Mt. Dept. of Fish, Wildlife, and Parks
3201 Spurgin Road
Missoula, MT 59801

Ron:

The paired interspersed nuclear DNA elements (PINE) technique has been used to analyze DNA from the following trout samples:

Summary of results.

Sample #	Water Name/Location/Collection Date/ Collector	N[a]	# markers[b]	Species ID[c]	Power (%)[d]	% WCT[e]	Individuals[f]
2977	**Cabin Creek** 17N11W13 7/13/2004 Ron Pierce	26	R6Y4	WCT X RBT,WCT			xx

[a]Number of fish successfully analyzed. If combined with a previous sample (Indicated in "Location" column), the number indicates the combined sample size. If present, the number in () is the average number of individuals successfully analyzed per locus (some individuals do not amplify for all marker loci).
[b]Number of markers analyzed that are diagnostic for the non-native species (R=rainbow trout, W=westslope cutthroat trout, Y=Yellowstone cutthroat trout).
[c]Codes: WCT = westslope cutthroat trout (*Oncorhynchus clarki lewisi*); RBT = rainbow trout (*O. mykiss*); YCT = Yellowstone cutthroat trout (*O. clarki bouvieri*). Only one species code is listed when the entire sample possessed alleles from that species only. However, it must be noted that we cannot definitively rule out the possibility that some or all of the individuals are hybrids. We may not have detected any non-native alleles at the loci examined because of sampling error (see Power %). Species codes separated by "x" indicate hybridization between those species.
[d]Number corresponds to the percent chance we have to detect 1% hybridization given the number of individuals successfully analyzed and the number of diagnostic markers used. For example, 25 individuals are required to yield a 95% chance to detect 1% hybridization with rainbow or an 87% chance to detect 1% hybridization with Yellowstone cutthroat trout into what once was a westslope cutthroat trout population. Not reported when hybridization is detected.
[e]Indicates the genetic contribution of the hybridizing taxa in the order listed under c to the sample assuming Hardy-Weinburg proportions. This number is reported if the sample appears to have come from a hybrid swarm. That is, a random mating population in which species markers are randomly distributed among individuals.
[f]Indicates number of individuals with genetic characteristics corresponding to the species code column when the sample can be analyzed on the individual level. This occurs when marker alleles are not randomly distributed among individuals and hybridization appears to be recent and/or if the sample appears to consist of a mixture of populations.

Methods and Data Analysis

The PINE technique uses short synthetically made segments of DNA called primers, in pairs, to search for relatively small segments of organismal DNA flanked by particular, often viral, DNA inserts. During the polymerase chain reaction (PCR), the primers bind to the ends of the inserts and many copies of the organismal DNA between the primers are made. While the DNA from some organisms may have two appropriately spaced inserts to which the primers can attach, the DNA from other organisms may have only one or none of the appropriately spaced inserts in particular regions. During PCR we will fail to copy DNA in the latter two cases.

Thus, the PINE technique coupled with PCR is used to search for evidence of genetic variation based on the presence or absence of particular DNA fragments. The fragments are labeled by the primers used to produce them and their length in terms of the number of nucleotides in the fragment.

The fragments are made using dye labeled nucleotides and after PCR are separated from each other via electrophoresis in polyacrylamide gels. Smaller fragments move through the gels at a faster rate than larger fragments. The use of dye labeled nucleotides allows one to visualize the position of the fragments in the gels after electrophoresis using a spectrophotometer and the size of the fragments is determined by comparison to the position of synthetic fragments of known size that were also migrated into the gel.

When DNA from westslope cutthroat trout, *Oncorhynchus clarki lewisi,* and rainbow trout, *O. mykiss,* is compared with PINE analysis and three different pairs of primers seven fragments are characteristic of westslope cutthroat trout and six fragments are usually characteristic of rainbow trout (Table 1). Likewise, when DNA from westslope and Yellowstone cutthroat trout, *O. c. bouvieri,* is compared using the same procedure one fragment is characteristic of westslope cutthroat trout and four fragments are characteristic of Yellowstone cutthroat trout (Table 1).

Fragments produced from the DNA of one taxon and not another are commonly termed diagnostic or marker loci because they can be used to help determine whether a sample came from a non-hybridized population of one of the taxa or a population in which hybridization between them has or is occurring. Individuals from a non-hybridized population will possess fragments characteristic of only that taxon. In contrast, since half the DNA of first generation hybrids comes from each of the parental taxa the DNA from such individuals will yield all the fragments characteristic of the two parental taxa. In later generation hybrids, the amount and particular regions of DNA acquired from the parental taxa will vary among individuals. Thus, DNA from later generation hybrid individuals will yield only a subset of the parental fragments and the particular subset will vary among individuals. In a sample from a random mating hybrid swarm, that is a population in which the genetic material (i.e. fragments) of the parental taxa is randomly distributed among individuals such that essentially all of them are of hybrid origin, the frequency of the fragment producing allele from the non-native taxon is expected to be nearly equal among the diagnostic loci since their presence can all be traced to a common origin or origins. Thus, if a sample contains substantial variation at only a single marker locus where the presence of the fragment is usually characteristic of a non-native taxon and lacks such fragments at all other markers this is probably not indicative of hybridization. Rather, it much more likely represents the existence of genetic variation for the presence or absence of the fragment within this particular population of the native taxon.

An important aspect of PINE marker loci is that individuals homozygous for the presence allele (*pp*) or heterozygous (*pa*) will both yield the fragment. That is, *p* is dominant to *a*. Thus, in order to estimate the genetic contribution of the native taxon to a hybrid swarm we concentrate on the marker loci at which the *p* allele is characteristic of the non-native taxon. Furthermore, we must assume that genotypic distributions in the population reasonably conform to expected random mating proportions. Under this assumption the frequency of the native *a* allele is approximately the square root of the frequency of individuals in the population lacking the fragment (*aa*). The frequency of the non-native allele then is one minus this value. We focus on the *p* alleles characteristic of the non-native taxon because with low levels of hybridization it is the presence of these alleles that are likely to provide evidence of hybridization. With low levels of hybridization, it is likely all individuals in the sample will genotypically be *pp* or *pa* where the *p* allele is characteristic of the native taxon. Thus, like in non-hybridized populations all individuals in the sample will yield the fragment providing no evidence of hybridization.

Failure to detect evidence of hybridization in a sample does not necessarily mean the population is non-hybridized because there is always the possibility that we would not detect evidence of hybridization because of sampling error. In order to assess the likelihood the population is non-hybridized we determine the chances of not detecting as little as a one percent genetic contribution of a non-native taxon to a hybrid swarm. This is simply 0.99^{2NX} where N is the number of fish in the sample and X is the number of marker loci where the *p* allele is characteristic of the non-native taxon.

In samples showing evidence of hybridization, that is; fragments characteristic of a non-native taxon were detected at two or more marker loci, we used two approaches to determine if the population appeared to be a hybrid swarm. First, contingency table chi-square analysis was used to test for heterogeneity of allele frequencies among the marker loci. Next, we compared the observed distribution of the number of loci per individual at which non-native fragments were detected to the expected random binomial distribution based on the estimated native and non-native genetic contributions to the population. If both analyses were non-significant we concluded the population came from a hybrid swarm.

Heterogeneity of allele frequencies among marker loci can arise in very old hybrid swarms as the frequencies over time diverge from each other due to genetic drift. In this case, however, the non-native fragments will still be randomly distributed among individuals.

There are two likely reasons why a non-random distribution of non-native fragments may be observed among individuals in a sample. It may contain individuals from genetically divergent populations with different amounts of hybridization or hybridization may have only recently occurred in the population. Based on genetic data alone, these two situations will generally be difficult to distinguish from each other. Regardless of the explanation, when the non-native fragments are not randomly distributed among individuals in a sample estimating a mean level of hybridization has little, if any, biological meaning and, therefore, is often not estimated.

Results and Discussion

Cabin Creek 2977

PINE fragments characteristic of westslope cutthroat and rainbow trout were detected at three of the six diagnostic markers between these fishes that were analyzed in the sample. Although the frequency of rainbow trout alleles among the marker loci was statistically homogeneous ($P>0.50$), the markers characteristic of rainbow trout were not randomly distributed ($P<0.001$) among the fish in the sample. In contrast, all the rainbow trout markers were detected in only one fish. All the other fish possessed markers characteristic of only westslope cutthroat trout. These results suggest this population is a mixture of hybridized and non-hybridized westslope cutthroat trout. The vast predominance of what appear to be non-hybridized westslope cutthroat trout in the sample and the relatively high frequency of rainbow trout fragments (0.30) in the fish definitely of hybrid origin suggest the latter is a recent migrant into the population. Thus, interbreeding between non-hybridized westslope cutthroat trout and fish of hybrid origin may not have begun at the time of sampling. The presence of fish of hybrid origin in the population, however, seriously threatens the continued genetic integrity of the non-hybridized fish.

Sincerely,

Ben Wright
Robb Leary

TABLE 1

Diagnostic PINE markers for westslope cutthroat, Yellowstone cutthroat, and rainbow trout. **X** indicates the fragment is present in the particular taxon.

Markers	Yellowstone	Westslope	Rainbow
Hpa1 5'/Hpa1 3'			
232	x		
153		x	
72	x	x	
70			x
69	x	x	
66			x
Fok1 5'/Tc1			
369			x
366	x	x	
230			x
159	x		
138	x		
110		x	
Hpa1 5'/33.6+2			
395			x
388	x	x	
266			x
248	x		
148	x	x	

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October 10, 2005

Ladd Knotek
Montana Department of Fish, Wildlife, and Parks
3201 Spurgin
Missoula, Montana 59801

Ladd;

Following is my assessment of the high priority samples you wanted checked for accuracy of data interpretation:

Union Creek (#2047)

This sample collected June 5, 2000 was originally reported as appearing to have come from a hybrid swarm containing about a 92% westslope cutthroat and an 8% rainbow trout genetic contribution. This does not really appear to be the case, but from a management perspective the discrepancy in interpretation is moot.

There appeared to be some problem with obtaining DNA from the samples and/or in the polymerase chain reaction (PCR) used to copy the DNA as data are really available from only four of the six diagnostic loci that we normally analyze that usually distinguish rainbow trout from westslope cutthroat trout. PINE fragments characteristic of rainbow trout were detected at three of the four diagnostic loci from which data were obtainable. The rainbow trout fragments, however, do not appear to be randomly distributed among the fish in the sample (Poisson distribution; Chi-square, $P<0.05$). In contrast, significantly more fish than expected by chance (N=15) possessed markers characteristic of only westslope cutthroat trout at all loci analyzed and significantly more fish (1) possessed markers characteristic of rainbow trout at three of the diagnostic loci analyzed. Furthermore, significantly fewer individuals than expected by chance (4) possessed a rainbow trout marker at only one diagnostic locus. This nonrandom distribution of rainbow trout markers among the fish in the sample at the diagnostic loci suggests that at the time of sampling the population contained a mixture of non-hybridized westslope cutthroat trout and hybrid individuals between westslope cutthroat and rainbow trout. In this situation, conclusively determining which individuals are non-hybridized will be extremely problematic. This will require a large number of markers because the hybrid individuals collected were definitely later than first generation hybrids. Thus, with a relatively small number of markers many hybrids will be indistinguishable from westslope cutthroat trout. From a management perspective, therefore, based on this sample the population should simply be considered to have been hybridized with rainbow trout.

Game Creek (#2261)

This tributary to Union Creek sampled June 22, 2002 was initially reported as appearing to have come from a non-hybridized westslope cutthroat trout population. I strongly disagree with this conclusion.

Again, there appeared to be some problem with obtaining DNA from the samples and/or in the polymerase chain reaction (PCR) used to copy the DNA as data are really available from only four of the six diagnostic loci that we normally analyze that usually distinguish rainbow trout from westslope cutthroat trout. The sample originally was erroneously reported as containing two individuals with a fragment characteristic of rainbow trout at only one, and the same, diagnostic locus. The other 23 fish in the sample possessed PINE fragments characteristic of only westslope cutthroat trout. In this situation, there are two possible interpretations of the data. The population could be slightly hybridized with rainbow trout or the variation detected could simply be westslope cutthroat trout genetic variation that is electrophoretically indistinguishable from that usually characteristic of rainbow trout. Because of the uncertainty about whether or not the sample came from a hybridized population, conservatively it was suggested it be considered to be non-hybridized westslope cutthroat trout.

Rechecking the data revealed that the two fish in the sample reported as possessing a PINE fragment characteristic of rainbow trout at one of the four diagnostic loci analyzed actually possessed PINE fragments characteristic of rainbow trout at two diagnostic loci. These two fish, therefore, were almost undoubtedly of hybrid origin. The PINE fragments characteristic of rainbow trout, however, were not randomly distributed $P<0.001$) among the fish in the sample suggesting that at the time of sampling the population most likely contained a mixture of non-hybridized westslope cutthroat trout and fish of hybrid origin. For the same reasons as in the Union Creek population, conclusively determining which individuals are non-hybridized in Game Creek will be extremely problematic. From a management perspective, therefore, based on this sample the population should simply be considered to have been hybridized with rainbow trout.

Fish Creek (#2277)

This sample collected September 10, 2001 was initially reported as having come from a hybrid swarm with about a 98% westslope cutthroat and a 2% rainbow trout genetic contribution. I do not completely agree with this interpretation, but again this disagreement probably will not change how the population is viewed genetically from a management perspective.

PINE fragments characteristic of rainbow trout were detected at four of the six diagnostic loci analyzed that usually distinguish rainbow trout from westslope cutthroat trout. As in the previous two samples, however, the fragments characteristic of rainbow trout were not randomly distributed (P<0.001) among the fish in the Fish Creek sample. Rather, they were detected in only three fish. Of these, two possessed a rainbow trout fragment at only one locus, but the particular locus differed between the two. The other fish definitely of hybrid origin possessed rainbow trout fragments at three diagnostic loci. The remaining 22 fish in the sample possessed PINE fragments characteristic of westslope cutthroat trout at all loci analyzed. The simplest explanation compatible with these data is the sample contained individuals from two genetically different populations. The majority of the fish appear to have come from a westslope cutthroatXrainbow trout hybrid swarm with a predominant westslope cutthroat trout genetic contribution. A small proportion of the fish appear to have come from a hybridized population of westslope cutthroat and rainbow trout with a much more substantial rainbow trout genetic contribution than the former population. These latter fish may well be recent migrants or the progeny of recent migrants into the population.

Skalkaho Creek (#537, #899, #2312, and #2923)

The first two samples collected from Skalkaho Creek (537, collected September 3, 1991, N10; and 899, May 3, 1994, 10; both from T5N R19W S27) came from the very upper reaches. Allozyme analysis indicated no evidence of hybridization and, therefore, the samples were reported as appearing to have come from non-hybridized westslope cutthroat trout. There was no evidence of genetic differences between the samples (contingency table Chi-square, P>0.05) so they were combined into one. With the combined sample size of 20, there was about a 91% chance of detecting as little as a one percent rainbow trout and a 98% chance of detecting as little as a one percent Yellowstone cutthroat trout genetic contribution to a hybrid swarm. At the time these samples were collected, therefore, upper Skalkaho Creek very likely contained a non-hybridized westslope cutthroat trout population.

The fish in sample 2312 (September 10, 2002, 25) were collected from Ward Ditch. PINE fragments characteristic of rainbow trout were detected at four of the six diagnostic loci analyzed that usually distinguish rainbow trout from westslope cutthroat trout. In the original report, the sample was considered to have come from a westslope cutthroatXrainbow trout hybrid swarm. This, however, does not appear to be the case as the rainbow trout PINE fragments were not randomly distributed (P<0.001) among the fish in the sample. In contrast, they were detected in only two individuals with one possessing rainbow trout markers at three diagnostic loci and the other at one. The remaining fish in the sample possessed PINE fragments characteristic of only westslope cutthroat trout. These results are compatible with at least a couple of explanations. First, the fish sampled may have been a mixture of non-hybridized westslope cutthroat trout and some fish of hybrid origin. Conversely, the fish may have been a mixture of individuals from a westslope cutthroatXrainbow trout hybrid swarm with a small rainbow trout genetic contribution and migrants from a hybridized population between westslope cutthroat and rainbow trout with a much more substantial rainbow trout genetic contribution.

Sample 2923 suggests of the above two explanations the latter is more likely. This sample (N=68) consisted mainly of migratory adults collected from above and below Ward Ditch in 2003 and 2004. PINE fragments characteristic of rainbow trout were detected at three of the six diagnostic loci analyzed that usually distinguish rainbow trout from westslope cutthroat trout. The rainbow trout markers appeared to be randomly distributed (P>0.05) among the fish in the sample suggesting these fish came from a hybrid swarm between westslope cutthroat trout and rainbow trout with about a 99.5% westslope cutthroat trout genetic contribution. The previous Ward Ditch sample, therefore, may have been a mixture of Skalkaho Creek migratory fish and possibly a migrant individual from a more heavily hybridized population, possibly the Bitterrroot River.

The question remaining in Skalkaho Creek, therefore, is whether or not the very upper reaches of the stream actually still contain a non-hybridized westslope cutthroat trout population or not. This possibility exists as samples 2312 and 2923 all came from lower reaches of the drainage and these upper reach fish are suspected to mainly express a resident life history characteristic (Chris Clancy, Montana Department of Fish, Wildlife, and Parks, personal communication).

West Fork Bitterroot River (#710, #948, #1031?, #1032, and #2259)

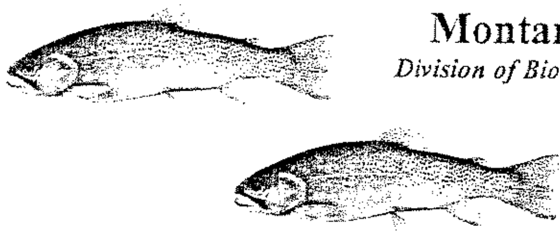
Samples 710 (collected September 6, 1992, N=3, T3S R22W S16) and 948 (July 18, 1994, 16, T3S R22W S4) were collected above Painted Rocks Reservoir. Allozyme analysis indicated no evidence of hybridization. There was no evidence of genetic differences between the samples (P>0.05) so they were combined into one. With the combined sample size of 19, there is about a 90% chance of detecting as little as a one percent rainbow trout and a 98% chance of detecting as little as a one percent Yellowstone cutthroat trout genetic contribution to a hybrid swarm. At the time these samples were collected, therefore, the upper West Fork Bitterroot River very likely contained a non-hybridized westslope cutthroat trout population.

Samples 1302 (September 21, 1998, 6, T2N R21W S24) and 2259 (September 17, 1998, 25, T1S R22W S23) were collected below Painted Rocks Reservoir. Allozyme analysis of the most downstream sample (1302) provided no evidence of hybridization. There appeared to be a problem with DNA quality or extraction from sample 2259 as PINE data were obtainable from only 14 fish. Of these, 12 possessed PINE fragments characteristic of only westslope cutthroat trout, one possessed a PINE fragment at one of the six diagnostic loci that usually distinguish rainbow from westslope cutthroat trout, and the final fish appeared to be a first generation hybrid between westslope cutthroat and rainbow trout as it possessed PINE fragments characteristic of both fishes at all marker loci analyzed. Interpretation of these results is confounded, because the samples do not represent a random collection of fish. Rather individuals that morphologically appeared to be westslope cutthroat trout were specifically collected (Chris Clancy, personal communication). Thus, about the only interpretation that can be made from these data is that there may be some non-hybridized westslope cutthroat trout and there are definitely some hybridized individuals between westslope cutthroat and rainbow trout in the West Fork Bitterroot River below Painted Rocks Reservoir.

There is strong suspicion (Chris Clancy, personal communication) that sample 1301 may not have actually come from the West Fork Bitterroot River drainage. Its purported location of T1S R22W S15 places it below Painted Rocks Reservoir. Allozyme analysis indicated it to be a mixture of non-hybridized westslope cutthroat trout (5) and fish definitely of hybrid origin between westslope and Yellowstone cutthroat trout (4). It is the presence of Yellowstone cutthroat trout alleles in the sample that makes its location suspicious. Hybridization with Yellowstone cutthroat trout appears to be essentially absent from West Fork Bitterroot River tributaries, and thus there does not appear to be a source of such hybridized individuals in the drainage for a mixed population, middle mainstem location.

Sincerely;

Robb Leary



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November 17, 2005

Ladd Knotek
Genetics Contact, Region 2
Mt. Dept. of Fish, Wildlife, and Parks
3201 Spurgin Rd
Missoula, MT 59801

Ladd:

The paired interspersed nuclear DNA elements (PINE) technique has been used to analyze DNA from the following trout samples:

Summary of results.

Sample #	Water Name/Location/Collection Date/ Collector	N [a]	# markers [b]	Species ID [c]	Power (%) [d]	% WCT [e]	Individuals [f]
3087	**Deep Creek** 15N27W23 9/19/2005 Ladd Knotek	15	R6Y4	WCT	R99 Y99	100	xx
3088	**Park Creek** 11N19W1 8/5/2005 Ladd Knotek	22	R6Y4	WCT?	R93 Y83	100	xx
3089	**Blackfoot River** 13N17W8 2/28/2005 Ron Pierce	20	R6Y4	WCT X RBT			xx
3090	**Rattlesnake Creek** 5/1/2004 Ladd Knotek	10	R6Y4	WCT X RBT			xx
3091	**Rattlesnake Creek** 5/1/2004 Ladd Knotek	16	R6Y4	WCT X RBT			xx
3092	**Rattlesnake Creek** 5/1/2004 Ladd Knotek	16	R6Y4	WCT, WCT X RBT			xx
3093	**Thompson Creek** 17N26W32 8/2/2005 Ladd Knotek	30	R6Y4	WCT?	R97 Y91	100	xx
3094	**Cold Creek** 17N28W 8/1/2005 Ladd Knotek	24	R6Y4	WCT?	R94 Y85	100	xx

Sample #	Water Name/Location/Collection Date/ Collector	N	# markers	Species ID	Power (%)	% WCT	Individuals
3095	**Canyon Lake** 7/14/2005 Ladd Knotek	17	R6Y4	WCT?	R87 Y74	100	xx
3096	**Patrick Creek** 18N26W2 7/29/2005 Ladd Knotek	25	R6Y4	WCT?		100	xx
3097	**Webb Lake** 7/20/2005 Ron Pierce	5	R6Y4	WCT X RBT			xx
3098	**Parker Lake** 7/21/2005 Ron Pierce	26	R6Y4	YCT X WCT X RBT			xx
3099	**West Twin Lakes** 6/21/2005 Ron Pierce	25	R6Y4	WCT X YCT X RBT			xx

[a]Number of fish successfully analyzed. If combined with a previous sample (Indicated in "Location" column), the number indicates the combined sample size. If present, the number in () is the average number of individuals successfully analyzed per locus (some individuals do not amplify for all marker loci).
[b]Number of markers analyzed that are diagnostic for the non-native species (R=rainbow trout, W=westslope cutthroat trout, Y=Yellowstone cutthroat trout).
[c]Codes: WCT = westslope cutthroat trout (*Oncorhynchus clarki lewisi*); RBT = rainbow trout (*O. mykiss*); YCT = Yellowstone cutthroat trout (*O. clarki bouvieri*). Only one species code is listed when the entire sample possessed alleles from that species only. However, it must be noted that we cannot definitively rule out the possibility that some or all of the individuals are hybrids. We may not have detected any non-native alleles at the loci examined because of sampling error (see Power %). Species codes separated by "x" indicate hybridization between those species.
[d]Number corresponds to the percent chance we have to detect 1% hybridization given the number of individuals successfully analyzed and the number of diagnostic markers used. For example, 25 individuals are required to yield a 95% chance to detect as little as 1% hybridization with rainbow or an 87% chance to detect as little as 1% hybridization with Yellowstone cutthroat trout into what once was a westslope cutthroat trout population. Not reported when hybridization is detected.
[e]Indicates the genetic contribution of the hybridizing taxa in the order listed under c to the sample assuming Hardy-Weinburg proportions. This number is reported if the sample appears to have come from a hybrid swarm. That is, a random mating population in which species markers are randomly distributed among individuals.
[f]Indicates number of individuals with genetic characteristics corresponding to the species code column when the sample can be analyzed on the individual level. This occurs when marker alleles are not randomly distributed among individuals and hybridization appears to be recent and/or if the sample appears to consist of a mixture of populations.

Methods and Data Analysis

The PINE technique uses short synthetically made segments of DNA called primers, in pairs, to search for relatively small segments of organismal DNA flanked by particular, often viral, DNA inserts. During the polymerase chain reaction (PCR), the primers bind to the ends of the inserts and many copies of the organismal DNA between the primers are made. While the DNA from some organisms may have two appropriately spaced inserts to which the primers can attach, the DNA from other organisms may have only one or none of the appropriately spaced inserts in particular regions. During PCR we will fail to copy DNA in the latter two cases. Thus, the PINE technique coupled with PCR is used to search for evidence of genetic variation based on the presence or absence of particular DNA fragments. The fragments are labeled by the primers used to produce them and their length in terms of the number of nucleotides in the fragment.

The fragments are made using dye labeled nucleotides and after PCR are separated from each other via electrophoresis in polyacrylamide gels. Smaller fragments move through the gels at a faster rate than larger fragments. The use of dye labeled nucleotides allows one to visualize the position of the fragments in the gels after electrophoresis using a spectrophotometer and the size of the fragments is determined by comparison to the position of synthetic fragments of known size that were also migrated into the gel.

When DNA from westslope cutthroat trout, *Oncorhynchus clarki lewisi,* and rainbow trout, *O. mykiss,* is compared with PINE analysis and three different pairs of primers seven fragments are characteristic of westslope cutthroat trout and six fragments are usually characteristic of rainbow trout (Table 1). Likewise, when DNA from westslope and Yellowstone cutthroat trout, *O. c. bouvieri,* is compared using the same procedure two fragments are characteristic of westslope cutthroat trout and four fragments are characteristic of Yellowstone cutthroat trout (Table 1).

Fragments produced from the DNA of one taxon and not another are commonly termed diagnostic or marker loci because they can be used to help determine whether a sample came from a non-hybridized population of one of the taxa or a population in which hybridization between them has or is occurring. Individuals from a non-hybridized population will possess fragments characteristic of only that taxon. In contrast, since half the DNA of first generation hybrids comes from each of the parental taxa the DNA from such individuals will yield all the fragments characteristic of the two parental taxa. In later generation hybrids, the amount and particular regions of DNA acquired from the parental taxa will vary among individuals. Thus, DNA from later generation hybrid individuals will yield only a subset of the parental fragments and the particular subset will vary among individuals. In a sample from a random mating hybrid swarm, that is a population in which the genetic material (i.e. fragments) of the parental taxa is randomly distributed among individuals such that essentially all of them are of hybrid origin, the frequency of the fragment producing allele from the non-native taxon is expected to be nearly equal among the diagnostic loci since their presence can all be traced to a common origin or origins. Thus, if a sample contains substantial variation at only a single marker locus where the presence of the fragment is usually characteristic of a non-native taxon and lacks such fragments at all other markers this is probably not indicative of hybridization. Rather, it much more likely represents the existence of genetic variation for the presence or absence of the fragment within this particular population of the native taxon.

An important aspect of PINE marker loci is that individuals homozygous for the presence allele (*pp*) or heterozygous (*pa*) will both yield the fragment. That is, *p* is dominant to *a*. Thus, in order to estimate the genetic contribution of the native taxon to a hybrid swarm we concentrate on the marker loci at which the *p* allele is characteristic of the non-native taxon. Furthermore, we must assume that genotypic distributions in the population reasonably conform to expected random mating proportions. Under this assumption the frequency of the native *a* allele is approximately the square root of the frequency of individuals in the population lacking the fragment (*aa*). The frequency of the non-native allele then is one minus this value. We focus on the *p* alleles characteristic of the non-native taxon because with low levels of hybridization it is the presence of these alleles that are likely to provide evidence of hybridization. With low levels of hybridization, it is likely all individuals in the sample will genotypically be *pp* or *pa* where the *p* allele is characteristic of the native taxon. Thus, like in non-hybridized populations all individuals in the sample will yield the fragment providing no evidence of hybridization.

Failure to detect evidence of hybridization in a sample does not necessarily mean the population is non-hybridized because there is always the possibility that we would not detect evidence of hybridization because of sampling error. In order to assess the likelihood the population is non-hybridized, we determine the chances of not detecting as little as a one percent genetic contribution of a non-native taxon to a hybrid swarm. This is simply 0.99^{2NX} where N is the number of fish in the sample and X is the number of marker loci where the *p* allele is characteristic of the non-native taxon.

In samples showing evidence of hybridization, that is; fragments characteristic of a non-native taxon were detected at two or more marker loci, we used two approaches to determine if the population appeared to be a hybrid swarm. First, contingency table chi-square analysis was used to test for heterogeneity of allele frequencies among the marker loci. Next, we compared the observed distribution of the number of loci per individual at which non-native fragments were detected to the expected random binomial distribution based on the estimated native and non-native genetic contributions to the population. If both analyses were non-significant we concluded the population came from a hybrid swarm.

Heterogeneity of allele frequencies among marker loci can arise in very old hybrid swarms as the frequencies over time diverge from each other due to genetic drift. In this case, however, the non-native fragments will still be randomly distributed among individuals.

There are two likely reasons why a non-random distribution of non-native fragments may be observed among individuals in a sample. It may contain individuals from genetically divergent populations with different amounts of hybridization or hybridization may have only recently occurred in the population. Based on genetic data alone, these two situations will generally be difficult to distinguish from each other. Regardless of the explanation, when the non-native fragments are not randomly distributed among individuals in a sample estimating a mean level of hybridization has little, if any, biological meaning and, therefore, is often not estimated.

Results and Discussion:

Deep Creek **3087**

PINE fragments characteristic of only westslope cutthroat trout were detected in the sample. A previous allozyme analysis of 26 fish (#422) also detected alleles characteristic of only westslope cutthroat trout. When these two samples are combined, we have better than a 99% chance of detecting as little as a one percent rainbow or Yellowstone cutthroat trout genetic contribution to a hybrid swarm. This population, therefore, is very likely non-hybridized westslope cutthroat trout.

Park Creek **3088**

PINE fragments characteristic of only westslope cutthroat trout were detected in the sample. With a sample size of 22 individuals, we have only a 93% chance of detecting as little as a one percent rainbow trout genetic contribution and an 83% chance of detecting as little as a one percent Yellowstone cutthroat trout genetic contribution to a hybrid swarm. Thus, we cannot reasonably exclude the possibility that this population may be slightly hybridized with rainbow trout, Yellowstone cutthroat trout, or both. Unless future data indicate otherwise, however, the conservative approach would be to consider this a non-hybridized westslope cutthroat trout population.

Blackfoot River **3089**

Genetically, this sample contained three noteworthy fish. Individual 1734 possessed PINE fragments characteristic of rainbow trout at all six diagnostic loci for this fish that were analyzed, and possessed no PINE fragments characteristic of westslope cutthroat trout at the seven diagnostic loci for this fish that were analyzed. This suggests this individual may be a non-hybridized rainbow trout. Individual 1840 possessed all six fragments characteristic of rainbow trout and all seven fragments characteristic of westslope cutthroat trout suggesting it is very likely a first generation hybrid between these fishes. Individual 1950 possessed all seven fragments characteristic of westslope cutthroat trout, but possessed fragments characteristic of rainbow trout at only four of the six diagnostic loci for this species that were analyzed. Thus, individual 1950 appears to be a first generation backcross to westslope cutthroat trout; that is, the progeny of a mating between a first generation hybrid and a westslope cutthroat trout. All the other fish in the sample (1731-1733, 1735-1737, 1838, 1839, 1841-1848, and 1949), possessed fragments characteristic of rainbow trout at five or six diagnostic loci and fragments characteristic of westslope cutthroat trout at one or two diagnostic loci. These individuals, therefore, appear to be late generation hybrids between rainbow and westslope cutthroat trout with a predominant rainbow trout genetic contribution. Thus, overall this sample appears to have contained a mixture of possibly non-hybridized rainbow trout and early and late generation hybrids between rainbow and westslope cutthroat trout.

Rattlesnake Creek "Hybrids" 3090

Of the 10 fish in this sample, nine possessed PINE fragments characteristic of rainbow trout at all six diagnostic loci for this fish that were analyzed. These individuals also possessed PINE fragments characteristic of westslope cutthroat trout at all seven diagnostic loci for this fish that were analyzed. These nine individuals, therefore, appear to be first generation hybrids between rainbow and westslope cutthroat trout. The remaining fish in the sample (20-86) possessed all seven fragments characteristic of westslope cutthroat trout, but only five of the six fragments characteristic of rainbow trout. Thus, this individual could be a first generation backcross to westslope cutthroat trout or it could be a first generation hybrid with rainbow trout PINE genetic variation that is indistinguishable from that usually characteristic of westslope cutthroat trout.

Rattlesnake Creek "Rainbows"3091

All of the fish in this sample except two definitely appear to be late generation hybrids between rainbow and westslope cutthroat trout with a predominant rainbow trout genetic contribution. They possessed PINE fragments characteristic of rainbow trout at five or six of the six diagnostic loci for this fish that were analyzed, and they also possessed PINE fragments characteristic of westslope cutthroat trout at one or two of the seven diagnostic loci for this fish that were analyzed. The two exceptional individuals (21-80 and 21-81) possessed PINE fragments characteristic of only rainbow trout suggesting they may be non-hybridized rainbow trout, but it is also possible that they are simply late generation hybrids that by chance did not possess fragments characteristic of westslope cutthroat trout at the diagnostic loci analyzed.

Rattlesnake Creek "Cutthroat"3092

All of the individuals in this sample except one possessed PINE fragments characteristic of only westslope cutthroat trout suggesting they may be non-hybridized westslope cutthroat trout. The exceptional fish (21-96) possessed PINE fragments characteristic of westslope cutthroat trout at all seven diagnostic loci for this fish that were analyzed, but it also possessed PINE fragments characteristic of rainbow trout at three of the six diagnostic loci for this fish that were analyzed. This fish, therefore, is undoubtedly of hybrid origin between westslope cutthroat and rainbow trout and based on its genetic characteristics it may be a first generation backcross to westslope cutthroat trout.

Thompson Creek 3093

PINE fragments characteristic of only westslope cutthroat trout were detected in the sample. With a sample size of 30 individuals, we have a 97% chance of detecting as little as a one percent rainbow trout genetic contribution and a 91% chance of detecting as little as a one percent Yellowstone cutthroat trout genetic contribution to a hybrid swarm. Although we cannot reasonably exclude the possibility that this population may be slightly hybridized with Yellowstone cutthroat trout, conservatively it should be considered to be non-hybridized westslope cutthroat trout unless further data indicate otherwise.

Cold Creek 3094

PINE fragments characteristic of only westslope cutthroat trout were detected in the sample. With a sample size of 24 individuals, we have a 94% chance of detecting as little as a one percent rainbow trout genetic contribution and an 85% chance of detecting as little as a one percent Yellowstone cutthroat trout genetic contribution to a hybrid swarm. Thus, we cannot reasonably exclude the possibility that this population may be slightly hybridized with rainbow trout, Yellowstone cutthroat trout, or both. Unless future data indicate otherwise, however, the conservative approach would be to consider this a non-hybridized westslope cutthroat trout population.

Canyon Lake 3095

PINE fragments characteristic of only westslope cutthroat trout were detected in the sample. With a sample size of 17 individuals, we have an 87% chance of detecting as little as a one percent rainbow trout genetic contribution and a 74% chance of detecting as little as a one percent Yellowstone cutthroat trout genetic contribution to a hybrid swarm. Thus, we cannot reasonably exclude the possibility that this population may be slightly hybridized with rainbow trout, Yellowstone cutthroat trout, or both. Unless future data indicate otherwise, however, the conservative approach would be to consider this a non-hybridized westslope cutthroat trout population.

Patrick Creek 3096

Sample 1

A PINE fragment usually characteristic of rainbow trout was detected at only one of six diagnostic loci for this species that were analyzed in the sample. The fragment was detected in only one individual. Thus, its presence could indicate a small amount of hybridization with rainbow trout or it could simply be westslope cutthroat trout PINE genetic variation that is electrophoretically indistinguishable from that usually characteristic of rainbow trout. Presently, we cannot distinguish between these possibilities. This will require analyzing additional fish or diagnostic loci. Thus, at this time the status of this population is uncertain, but conservatively it should be considered to be non-hybridized westslope cutthroat trout unless additional information indicates otherwise.

Sample 2

A PINE fragment usually characteristic of rainbow trout was detected at only one of six diagnostic loci for this species that were analyzed in the sample. This fragment, detected at a different locus than the 'rainbow' fragment detected in Sample 1, was present in six of the 11 fish in the sample. Thus, its presence could indicate hybridization with rainbow trout or it could simply be westslope cutthroat trout PINE genetic variation that is electrophoretically indistinguishable from that usually characteristic of rainbow trout. In this situation, we favor the latter interpretation because if its presence was due to hybridization it is highly unlikely (contingency table chi-square; $P<0.001$) that we would not detect evidence of hybridization with rainbow trout at the other five diagnostic loci for this fish that were analyzed. At this time, therefore, this population conservatively should be considered to be non-hybridized westslope cutthroat trout.

Webb Lake 3097

PINE fragments characteristic of rainbow trout were detected in this sample at two of the six diagnostic loci analyzed that are usually characteristic of this species. The rainbow trout fragments were detected in only one of the five fish in the sample. The other four fish possessed PINE fragments characteristic of only westslope cutthroat trout. Thus, this sample appears to have contained a mixture of non-hybridized westslope cutthroat trout and late generation hybrids between westslope cutthroat and rainbow trout. The small sample size, however, precludes making the conclusion the sample contained non-hybridized westslope cutthroat trout with much conviction because we cannot reasonably determine whether or not the rainbow trout fragments are randomly distributed among the fish in the population because of greatly reduced statistical power. Regardless of whether or not the population does contain non-hybridized westslope cutthroat trout, from a practical perspective it should simply be considered to be hybridized. The presence of late generation hybrids makes reliably distinguishing non-hybridized westslope cutthroat trout from hybrid individuals problematic because many of the latter by chance will have just westslope cutthroat trout fragments at the few diagnostic loci that we usually analyze.

Parker Lake 3098

All of the fish in this sample possessed PINE fragments characteristic of Yellowstone cutthroat trout at two or more of the four diagnostic loci for this fish that were analyzed. PINE fragments characteristic of rainbow trout were also detected in the sample at five of the six diagnostic loci for this fish that were analyzed. Finally, PINE fragments characteristic of westslope cutthroat trout were detected in the sample at both of the diagnostic loci for this fish that were analyzed. Neither the Yellowstone cutthroat nor the rainbow trout fragments were randomly distributed among the fish in the sample. Significantly (chi-square; $P<0.001$) more fish possessed Yellowstone cutthroat trout fragments at all the diagnostic loci analyzed and significantly fewer fish lacked or possessed a Yellowstone cutthroat trout fragment at only one locus than expected by chance (Figure 1). Likewise, significantly (chi-square; $P<0.001$) more fish possessed rainbow trout fragments at four or five diagnostic loci and significantly fewer possessed them at only one or two diagnostic loci than expected by chance (Figure 2). Thus, although this population definitely contains individuals of hybrid origin among Yellowstone cutthroat, westslope cutthroat, and rainbow trout it does not appear to be a hybrid swarm. In contrast, the fish in the sample tend to have a higher Yellowstone cutthroat trout or rainbow trout genetic contribution than expected in a hybrid swarm. This suggests that the lake may be inhabited by two somewhat reproductively isolated populations both of which are hybridized. Despite this possibility, from a practical perspective the lake should simply be considered to contain a hybridized population with a predominant Yellowstone cutthroat trout and a relatively minor westslope cutthroat and rainbow trout genetic contribution.

West Twin Lakes 3099

PINE fragments characteristic of Yellowstone cutthroat trout were detected in the sample at all four diagnostic loci for this fish that were analyzed. PINE fragments characteristic of rainbow trout were also detected in the sample at all six of the diagnostic loci for this fish that were analyzed. Finally, PINE fragments characteristic of westslope cutthroat trout were also detected in the sample at both of the diagnostic loci for this fish that were analyzed. The Yellowstone cutthroat trout fragments appeared to be randomly distributed (chi-square; $P>0.025$; Figure 3) among the fish in the sample, but the rainbow trout fragments were not as significantly (chi-square; $P<0.001$; Figure 4) more fish lacked rainbow trout fragments or possessed them at all diagnostic loci than expected by chance. This suggests the lake may be inhabited by two somewhat reproductively isolated populations both of which are hybridized. One population may have a predominant rainbow trout genetic contribution and the other a significant westslope and Yellowstone cutthroat trout genetic contribution. Despite this possibility, since all the fish in the sample were definitely of hybrid origin from a practical perspective the lake should simply be considered to possess a hybridized population of westslope cutthroat, Yellowstone cutthroat, and rainbow trout.

Sincerely,

Ben Wright

Robb Leary

TABLE 1

Diagnostic PINE markers for westslope cutthroat, Yellowstone cutthroat, and rainbow trout. **X** indicates the fragment is present in the particular taxon.

Markers	Yellowstone	Westslope	Rainbow
Hpa1 5'/Hpa1 3'			
232	x		
153		x	
72	x	x	
70			x
69	x	x	
66			x
Fok1 5'/Tc1			
369			x
366	x	x	
230			x
159	x		
138	x		
110		x	
Hpa1 5'/33.6+2			
395			x
388	x	x	
266			x
248	x		
148	x	x	

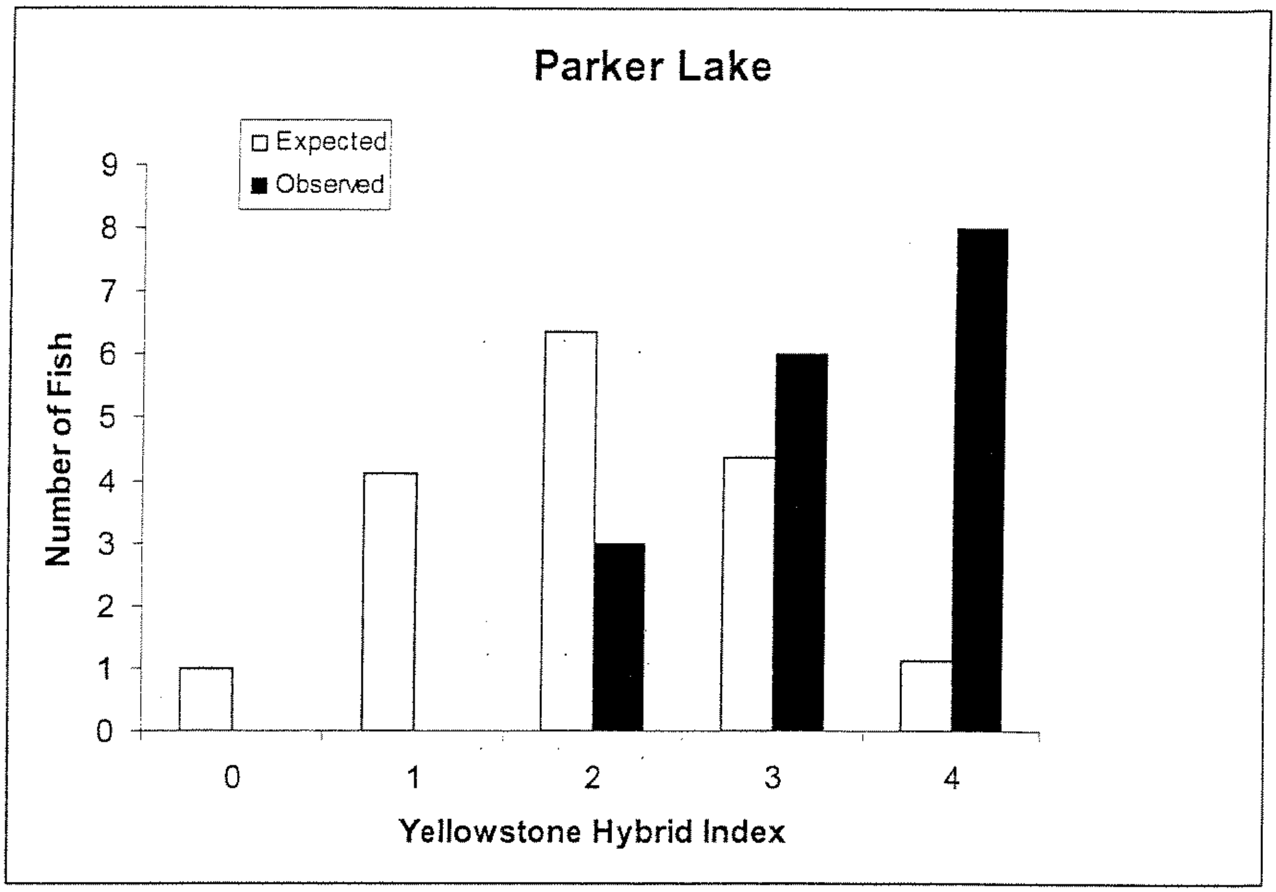

Figure 1. Observed and expected random distributions of Yellowstone hybrid index scores in the sample from Parker Lake. Hybrid index is the number of diagnostic loci out of four at which an individual possessed PINE fragments characteristic of Yellowstone cutthroat trout.

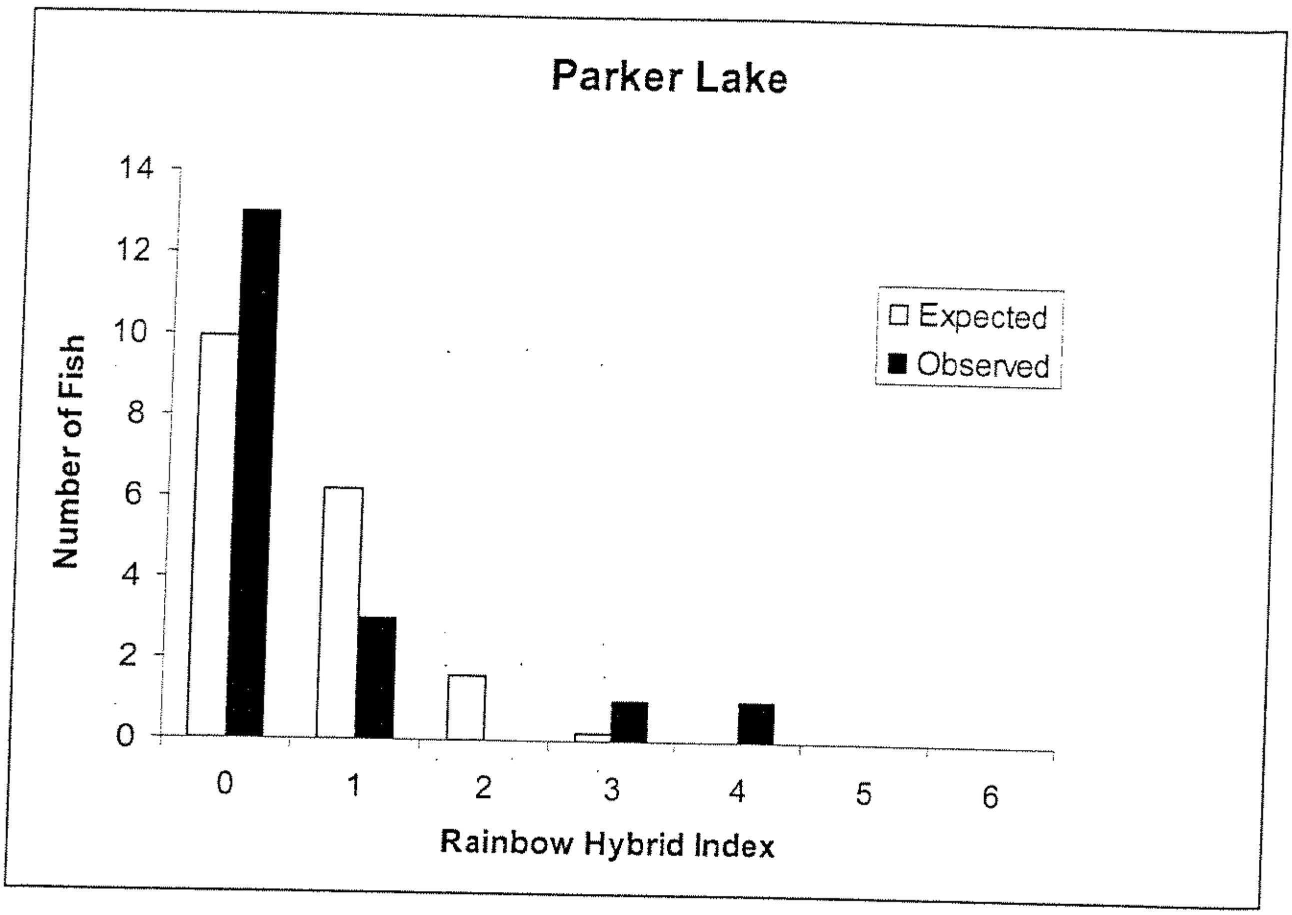

Figure 2. Observed and expected random distributions of rainbow hybrid index scores in the sample from Parker Lake. Hybrid index is the number of diagnostic loci out of six at which an individual possessed PINE fragments characteristic of rainbow trout.

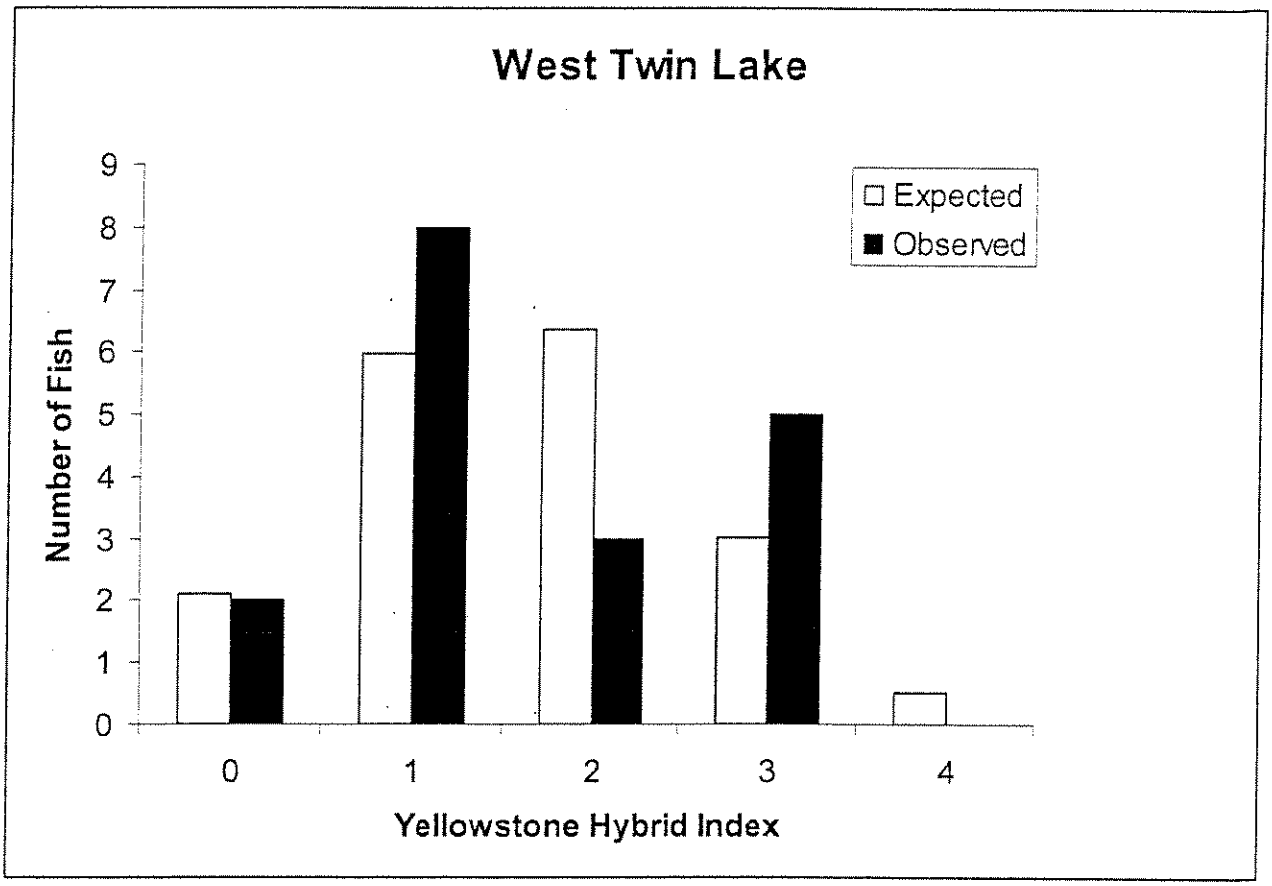

Figure 3. Observed and expected random distributions of Yellowstone hybrid index scores in the sample from West Twin Lake. Hybrid index is the number of diagnostic loci out of four at which an individual possessed PINE fragments characteristic of Yellowstone cutthroat trout.

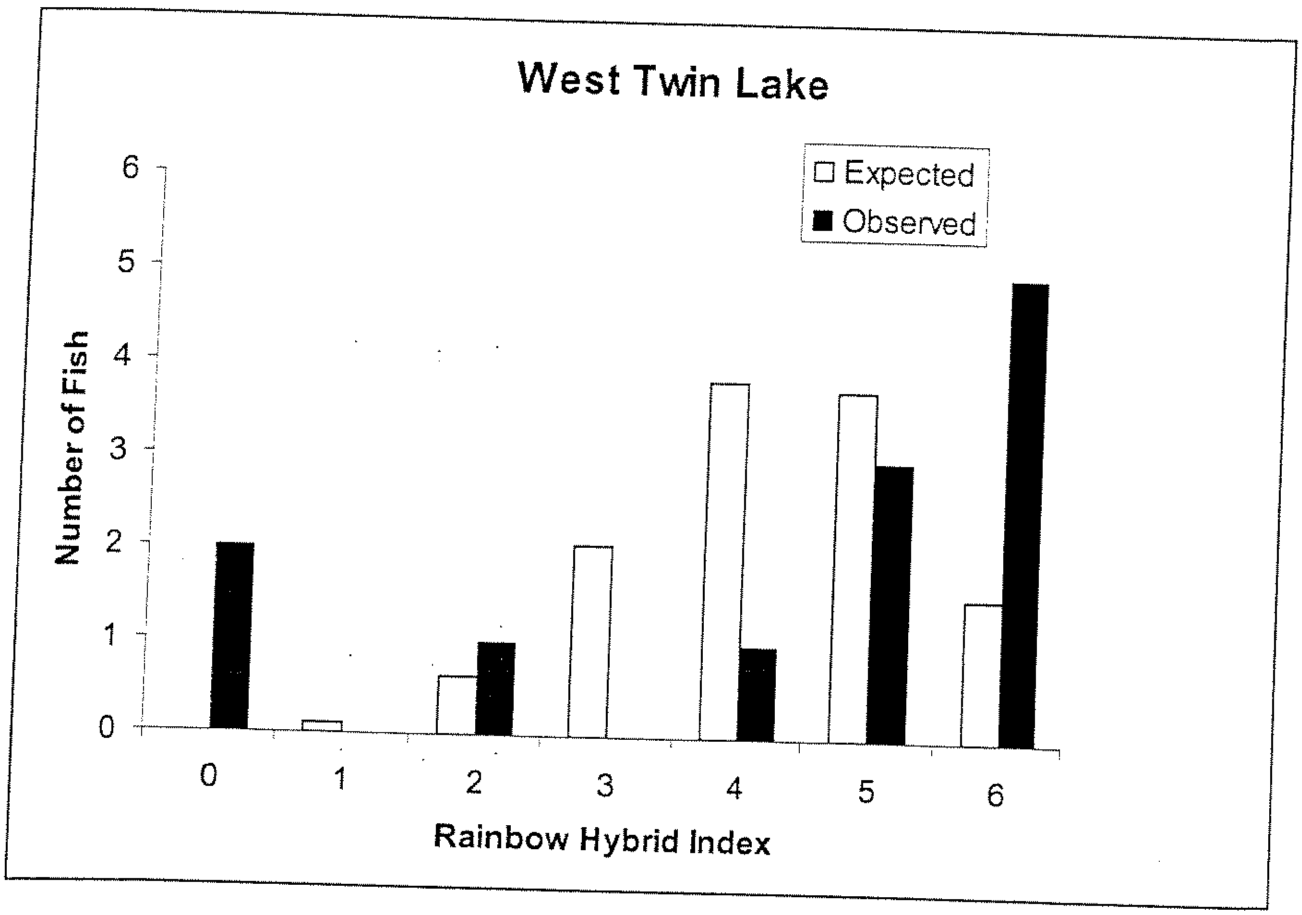

Figure 4. Observed and expected random distributions of rainbow hybrid index scores in the sample from West Twin Lake. Hybrid index is the number of diagnostic loci out of six at which an individual possessed PINE fragments characteristic of rainbow trout.