Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation

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EXECUTIVE SUMMARY

The BPA project entitled "Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation" mitigates for lost fishery resources that are of cultural significance to the Coeur d'Alene Tribe. This project funds management actions, and research, monitoring, and evaluation (RME) activities associated with these actions, which are carried out by the Coeur d'Alene Tribe's Fisheries Program to recover depressed populations of westslope cutthroat trout in the Coeur d'Alene basin. This report summarizes RME data collected during 2011 and 2012 that describe the status and trends of cutthroat trout in target watersheds, the status of physical factors in stream environments that may be limiting recovery objectives, and the response of stream habitats and trout populations to implemented habitat restoration and non-native fish extraction measures. The report also describes the in-stream and riparian restoration actions that were implemented in 2011 and 2012.

Research, monitoring, and evaluation summary

Status and trend of adult fish abundance

In Lake Creek, spawner abundance estimates of 125 (±61) and 410 (±85) were generated for adfluvial cutthroat trout that ascended upstream of the migrant trap in 2011 and 2012, respectively. In 2011, the estimate of adults that ascended above the trap was considerably less than the 230 (±108) adults that were estimated to have approached the trap. The discrepancy in estimates was likely due to difficulties that ascending adults had in negotiating the migrant trap. These problems were addressed in 2012 with modifications to the trap structure. In Benewah Creek, spawner abundance estimates for adfluvial cutthroat trout that ascended upstream of 9-mile bridge were not available in either year. However, 63 (±30) adults were estimated to have approached the 9-mile migrant trap in 2011; the percentage of these adults that ascended upstream of the trap could not be determined. Modifications to the 9-mile adult migrant trap in Benewah Creek, which are similar to those that have been implemented in Lake Creek, are scheduled to be completed prior to the 2013 trapping season.

Status and trend of juvenile fish abundance and productivity

Reliable juvenile outmigrant abundance estimates could not be generated for adfluvial cutthroat trout in either Lake or Benewah Creek watersheds in 2011 and 2012. Because of the high levels of discharge in both years, outmigrant traps could not be deployed early enough to sample the majority of the outmigrant run. In addition, when traps were deployed, juveniles could not be consistently captured because of intermittent high flow periods that severely compromised trap performance. A rotary screw trap is planned to be introduced at the Benewah Creek 9-mile site during the 2013 trapping season to evaluate its effectiveness for capturing and obtaining abundance estimates of adfluvial juvenile outmigrants.

Interrogation data from juveniles that had been PIT-tagged at outmigrant traps in Lake Creek from 2005 to 2010 and in Benewah Creek from 2008 to 2010 indicate that approximately 2% have returned to spawn as adults. This return rate is 8 to 10 times lower than those estimates that have been derived for adfluvial juvenile cutthroat trout in other systems. These findings indicate that processes operating in Lake Coeur d'Alene may be unduly impacting survival of juvenile cutthroat trout and also lend support to the need to examine whether predation is a predominant mechanism regulating survival rates. An ongoing study, which began in the fall of 2011 and is

scheduled for completion in 2013, is assessing the impact of two non-native piscivores, northern pike and smallmouth bass, on cutthroat trout survival in Lake Coeur d'Alene.

Status and trend of spatial distribution of fish

Results from electrofishing surveys conducted at index sites in 2011 and 2012 across target watersheds revealed patterns of cutthroat trout abundance and distribution that were consistent with surveys conducted in previous years. Cutthroat trout of ages one and older were widespread and documented at moderate to high densities (mean of 25.5 fish/100 m) across much of the mainstem habitat in Evans Creek. These results generally reflect the overall suitability of rearing conditions for cutthroat trout in Evans Creek. In contrast, similar aged cutthroat trout in Alder Creek were generally found at densities less than 5 fish/100 m, with fish absent from approximately 70% of the surveyed sites, and were constrained to the lowermost reaches of the watershed. The observed spatial pattern of cutthroat trout distribution in Alder Creek is likely explained by their displacement by non-native brook trout, which were found at high densities (mean of 46 fish/100 m) in much of the upper watershed.

The spatial distribution and densities of age one and older cutthroat trout in tributary habitats of adfluvial watersheds differed between Lake and Benewah creeks in 2011 and 2012. In the upper Benewah watershed, mean densities of cutthroat trout were moderate and ranged from 9.0 to 23.8 fish/100 m and from 9.0 to 15.6 fish/100 m in surveyed tributaries in 2011 and 2012, respectively. Cutthroat trout were fairly evenly distributed across sampled reaches within each of the upper Benewah Creek tributaries. In comparison, age one and older cutthroat trout in the three primary rearing tributaries of the upper Lake Creek watershed (Bozard Creek, West Fork of Lake Creek, and Upper Lake Creek) were disproportionately distributed among surveyed reaches. Densities of cutthroat trout averaged 28.5 fish/100 m in 2011 and 45.1 fish/100 m in 2012 across upper reaches, whereas in lower reaches they were often found at densities less than 10.0 fish/100 m and in some cases, most notably in the West Fork of Lake Creek, found to be absent. The disparity in abundance between upper and lower tributary reaches is likely attributed to differences in habitat suitability, and is intended to be addressed by prospective habitat restoration measures. The higher densities of cutthroat trout documented in upper reaches of Lake Creek tributaries than in Benewah Creek tributaries likely reflect the greater estimated number of adfluvial spawners in Lake than in Benewah Creek.

Status and trend of fish diversity

Over 480 age one and older cutthroat trout were PIT-tagged during summer rearing periods in tributaries of the upper Lake and Benewah creek watersheds in 2012. Only 3 and 6% of these fish moved downstream out of the tributaries in which they were tagged during fall and winter periods in upper Lake and Benewah creeks, respectively. The lack of movement out of tributaries to deeper mainstem habitat during the winter of 2012-2013 may have been due to the mild conditions that were present in these watersheds throughout much of the winter. The continued collection of interrogation data from PIT-tagged fish will indeed inform the degree and regularity of seasonal movements and the locations of in-stream seasonal habitats (e.g., overwintering) used by cutthroat trout under variable winter flow regimes. Furthermore, the interrogation of tagged juvenile cutthroat trout during forthcoming spring outmigration periods will better describe the spatial distribution of the adfluvial life-history variant in these two watersheds.

Limiting habitat conditions

Stream temperatures recorded in Lake and Benewah watersheds in 2011 and 2012 still support the suitability of tributaries over mainstem reaches as cutthroat trout rearing habitats during mid-summer periods. Summer water temperatures rarely exceeded 17°C, an internal performance benchmark, in upper reaches of the Bozard Creek sub-drainage in Lake Creek and in tributaries in the upper Benewah Creek watershed during both years. Though summer water temperatures were higher in mainstem than in tributary habitats, temperatures in the mainstem Benewah reach that has received Phase 2 restoration treatments exceeded 17°C less than 10% of the time in both years. In comparison, water temperatures exceeded this benchmark value more than 50% of the time in contiguous mainstem reaches immediately downriver. The discrepancy observed in temperature signatures between the two upper Benewah mainstem reaches may be due to a greater influence of groundwater inputs in the upper than in the lower reach, and lends support to the aim of our restoration strategies to increase floodplain connectivity and water retention in mainstem reaches of the upper Benewah watershed.

Habitat surveys were conducted across reaches of the South and West Forks of Benewah Creek and Windfall Creek in the upper Benewah watershed to provide baseline data that describe existing conditions in all three tributaries, and that will also serve in future analyses to assess the effectiveness of tributary restoration measures. The overall mean percentage of pool habitat was considerably greater in Windfall Creek (59%) than in the South and West Forks (35-39%) of Benewah Creek. Windfall Creek also had the highest large woody debris loadings (mean, 4.3 m^3/100 m) of all three tributaries surveyed in 2012. The lowest mean large wood volumes (< 2.7 m^3/100 m) were documented in the West Fork of Benewah Creek; this tributary is scheduled to be treated with large wood additions in 2013.

Effectiveness of habitat actions

The engineered log jam analog structures that were installed as part of the overall restoration strategy within the Phase 2 Benewah upper mainstem reach created a much greater proportion of the available backwatered, pool habitat (59%) in this reach than natural beaver dams by 2012. The introduction of these restoration structures was deemed important given that a considerable declining trend was observed in the number of intact natural beaver dams, and the extent of beaver influenced, backwatered channel habitat, in this reach from 2010 to 2012. The decrease in the number of intact natural dams, from 38 in 2010 to 8 in 2012, was likely due to high flow periods during winter and early spring that eliminated natural dam structures, and the lack of rebuilding efforts during subsequent summer periods. Of the remaining dams that were found to be structurally sound and which sustained backwatered pool habitat, most were associated with stable materials (e.g., mid-channel islands, root wads, partially buried large wood). As a result, the current restoration tactics that have been employed in this reach (e.g., driving series of vertical posts to support existing intact natural dam structures) should serve as a stable foundation for future dam re-building efforts and the attendant seasonally-persistent pool habitat that is considered essential for creating suitable rearing conditions for cutthroat trout. Furthermore, in the temporary absence of beaver activity, the stable engineered log jam analogs should impound water during high discharge events and induce extended periods of overbank flooding to enhance floodplain connectivity and water retention in the upper Benewah watershed.

Predator/competitor control implementation

A brook trout removal program was initiated in 2004 to suppress the abundance of brook trout observed in the upper Benewah watershed. Compared with the initial years of our removal efforts, the current approach targets a substantially smaller contiguous mainstem segment, which has been considered to provide the most suitable spawning habitat for brook trout, and includes the deployment of temporary barriers to prevent access to spawning grounds. Thus, we have re-focused tactics toward curbing reproductive success rather than attempting to remove as many fish as possible, and have reduced our annual efforts from approximately three weeks to three to four days. Over 2011 and 2012, a total of 309 brook trout was removed from the upper Benewah watershed during late summer suppression efforts. The number of fish removed in each of these two years was less than 50% of that removed in each of 2009 and 2010, and less than 25% of that which was removed in each of the years from 2005 to 2008. In part, these results were due to a reduction in the length of mainstem habitat addressed by our removal efforts in recent years. However, the number of fish removed in each of the last two years from a 2.0 km index mainstem reach upstream of 12-mile bridge, a reach that has been regularly sampled since 2005, were the lowest values recorded over the last eight years. In addition, single pass density indices of brook trout across tributaries in the upper Benewah watershed averaged 3.9 fish/100 m in 2011 and 2.1 fish/100 m in 2012, which were the lowest values recorded since the commencement of the suppression program. Collectively, these results attest to the effectiveness of our suppression program at regulating brook trout abundance at a manageably low level. Furthermore, the curbed removal efforts that have been implemented since 2009 evidently have not led to substantial reproductive output in brook trout in the upper watershed.

Restoration and enhancement activities

Restoration actions were implemented in the upper mainstem of Benewah Creek, designated as Reach D2, to facilitate greater frequency of floodplain/stream interaction and to increase the diversity of both aquatic and terrestrial habitats. The 439 m of an existing relict channel was activated in 2012 to become the main channel, with the bypassed channel segment functioning as a high flow swale and connected backwater. Completion of this element increased channel length by 197 m and locally reduced stream gradient by 46 percent. A total of nine in-channel structures were constructed to emulate flow obstruction effects of natural wood jams and beaver dams. The structures affect approximately 197 m of mainstem habitats and an additional 105 m of tributary habitats in lower Windfall Creek by increasing residual pool depth and volume at base flow conditions. Approximately 28 cubic meters of wood was added to the stream channel and near bank region within a 467 meter reach to aid beavers in dam construction and increase wood loading and three natural beaver dams were reinforced with vertical uprights. Between 2009 and 2012, treatments have been applied in 30 locations affecting 57 percent of stream habitats within the 3,138m of the D2 reach of upper Benewah Creek. Treatments have improved rearing conditions for native trout by increasing habitat diversity and reducing bank erosion. The more persistent channel obstructions that have been constructed result in overbank flows at discharges equal to the 1.5-year return interval flood and will facilitate stream bed aggradation over time across the larger reach.

A fish passage project was completed in 2012 on the West Fork Benewah Creek. This project involved removing an undersized perched 24” culvert and surrounding road fill. Five grade control structures comprised of 20-25 large boulders were constructed to stabilize the channel

downstream of the crossing once the culvert was removed. This project restored connectivity with the upper West Fork Benewah Creek watershed allowing native trout access to an additional 3,390 m of potential rearing and spawning habitats.

Channel and riparian enhancement measures to address severe channel incision and bank erosion were implemented in the West Fork of Lake Creek in 2011 as part of a strategy to create a new channel segment that is hydraulically connected with the adjacent floodplain. During the final year of the project, 336 m of new channel was constructed increasing the length of restored stream habitats to 1,265 m. Imported gravels and logs were used to create streambed and streambanks in the newly constructed channel. Logs were also placed on the new floodplain to provide roughness to prevent erosion. A new culvert was installed as well as a grade control structure that linked the new stream with the existing channel alignment downstream. A total of 5.76 ha of new floodplain were created, while the former channel was filled and converted back to farmland. Riparian enhancement in 2011 followed the vegetation plan that was developed for the site and involved planting 20,199 herbaceous plugs (sedges and rushes) along 670 m of newly built stream-bank, and 11,291 deciduous trees along 2.83 ha of adjacent floodplain habitat to re-establish native vegetation. Additional plantings were installed in 2012 to complete project work at the site.

Also in the Lake Creek watershed, 97.1 hectares of uplands that variously drain to the lower mainstem were reforested after being converted to agricultural uses prior to 1950. A total of 81,700 conifers were planted with the goal of reestablishing native plant communities and reducing erosion.

1.0 PROJECT BACKGROUND

Historically, the Coeur d'Alene Indian Tribe depended on runs of anadromous salmon and steelhead along the Spokane River and Hangman Creek as well as resident and adfluvial forms of trout and char in Coeur d'Alene Lake for subsistence. Dams constructed in the early 1900s on the Spokane River in the City of Spokane and at Little Falls (further downstream) were the first dams that initially cut-off the anadromous fish runs from the Coeur d'Alene Tribe. These fisheries were further removed following the construction of Chief Joseph and Grand Coulee Dams on the Columbia River. Together, these actions forced the Tribe to rely solely on the resident fish resources of Coeur d'Alene Lake for their subsistence needs.

The Coeur d'Alene Tribe is estimated to have historically harvested around 42,000 westslope cutthroat trout (*Oncorhynchus clarki lewisi*) per year (Scholz et al. 1985). In 1967, Mallet (1969) reported that 3,329 cutthroat trout were harvested from the St. Joe River, and a catch of 887 was reported from Coeur d'Alene Lake. This catch is far less than the 42,000 fish per year the tribe harvested historically. Today, only limited opportunities exist to harvest cutthroat trout in the Coeur d'Alene Basin. It appears that a suite of factors have contributed to the decline of cutthroat trout stocks within Coeur d'Alene Lake and its tributaries (Mallet 1969; Scholz et al. 1985; Lillengreen et al. 1993). These factors included the construction of Post Falls Dam in 1906, major changes in land cover types, impacts from agricultural activities, and introduction of exotic fish species.

The decline in native cutthroat trout populations in the Coeur d'Alene basin has been a primary focus of study by the Coeur d'Alene Tribe's Fisheries and Water Resources programs since 1990. The overarching goals for recovery have been to restore the cutthroat trout populations to levels that allow for subsistence harvest, maintain genetic diversity, and increase the probability of persistence in the face of anthropogenic influences and prospective climate change. This included recovering the lacustrine-adfluvial life history form that was historically prevalent and had served to provide resiliency to the structure of cutthroat trout populations in the Coeur d'Alene basin. To this end, the Coeur d'Alene Tribe closed Lake Creek and Benewah Creek to fishing in 1993 to initiate recovery of westslope cutthroat trout to historical levels.

However, achieving sustainable cutthroat trout populations also required addressing biotic factors and habitat features in the basin that were limiting recovery. Early in the 1990s, BPA-funded surveys and inventories identified limiting factors in Tribal watersheds that would need to be remedied to restore westslope cutthroat trout populations. The limiting factors included: low-quality, low-complexity mainstem stream habitat and riparian zones; high stream temperatures in mainstem habitats; negative interactions with nonnative brook trout in tributaries; and potential survival bottlenecks in Coeur d'Alene Lake.

In 1994, the Northwest Power Planning Council adopted the recommendations set forth by the Coeur d'Alene Tribe to improve the Reservation fishery (NWPPC Program Measures 10.8B.20). These recommended actions included: 1) Implement habitat restoration and enhancement measures in Alder, Benewah, Evans, and Lake Creeks; 2) Purchase critical watershed areas for protection of fisheries habitat; 3) Conduct an educational/outreach program for the general public within the Coeur d'Alene Reservation to facilitate a "holistic" watershed protection process; 4) Develop an interim fishery for tribal and non-tribal members of the reservation through

construction, operation and maintenance of five trout ponds; 5) Design, construct, operate and maintain a trout production facility; and 6) Implement a monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects. These activities provide partial mitigation for the extirpation of anadromous fish resources from usual and accustomed harvest areas and Reservation lands.

Since that time, much of the mitigation activities occurring within the Coeur d'Alene sub-basin have had a connection to the BPA project entitled "Implement of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation" (#1990-044-00), which is sponsored and implemented by the Coeur d'Alene Tribe Fisheries Program. Further, most of the aforementioned limiting factors are being addressed by this project either through habitat enhancement and restoration techniques, biological control, or with monitoring and evaluation that will provide data to refine future management decisions. This annual report summarizes previously unreported data collected during the 2011 and 2012 calendar years to fulfill the contractual obligations for the BPA project. Even though the contract performance period for this project crosses fiscal and calendar years, the timing of data collection and analysis as well as implementation of restoration projects lends itself to this reporting schedule. The report is formatted into two primary sections:

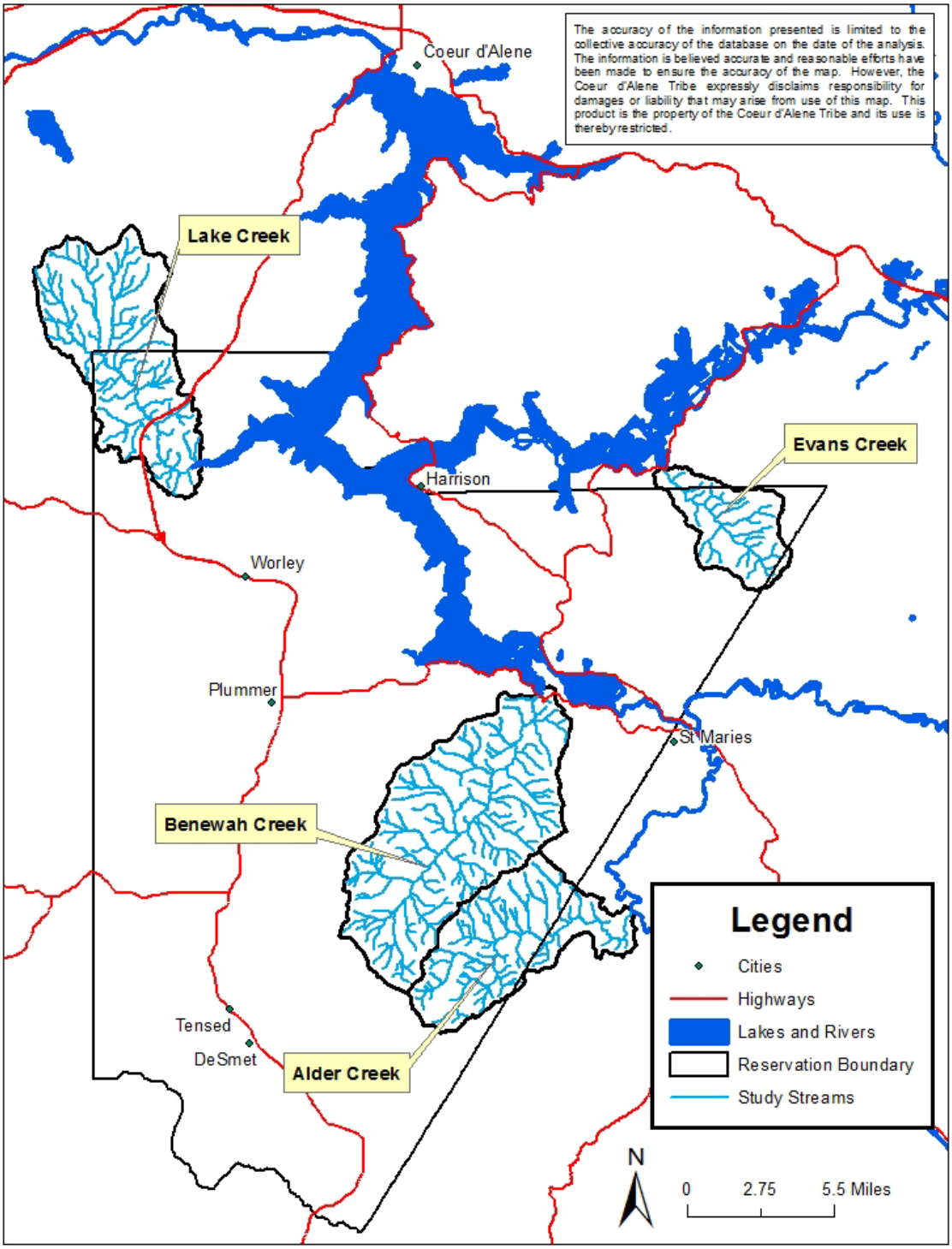
- Monitoring and evaluation. This section comprises monitoring results for biological and physical indicators that describe the status and trends of trout populations and in-stream habitat features in our target watersheds. In addition, this section summarizes data that evaluate the effectiveness of implemented management actions in our watersheds, including recent channel restoration activities and a brook trout suppression program.
- Implementation of restoration and enhancement projects. This section comprises descriptions of the channel and riparian restoration projects that were implemented in 2011 and 2012. Included in the action descriptions are summaries of the immediate effects that the restoration measures had on channel features.

2.0 STUDY AREA

The study area addressed by this report consists of the southern portion of Coeur d'Alene Lake and four watersheds – Alder, Benewah, Evans, and Lake - which feed the lake (Map 1). These areas are part of the larger Coeur d'Alene sub-basin, which lies in three northern Idaho counties Shoshone, Kootenai and Benewah. The basin is approximately 9,946 square kilometers and extends from the Coeur d'Alene Lake upstream to the Bitterroot Divide along the Idaho-Montana border. Elevations range from 646 meters at the lake to over 2,130 meters along the divide. This area formed the heart of the Coeur d'Alene Tribe's aboriginal territory, and a portion of the sub-basin lies within the current boundaries of the Coeur d'Alene Indian Reservation.

Coeur d'Alene Lake is the principle water body in the sub-basin. The lake is the second largest in Idaho and is located in the northern panhandle section of the state. The lake lies in a naturally dammed river valley with the outflow currently controlled by Post Falls Dam. The lake covers 129 square kilometers at full pool with a mean depth of 22 meters and a maximum depth of 63.7 meters.

The four watersheds currently targeted by the Tribe for restoration are located mostly on the Reservation (Map 1), but cross boundaries of ownership and jurisdiction, and have a combined basin area of 34,853 hectares that include 529 kilometers of intermittent and perennial stream channels. The climate and hydrology of the target watersheds are similar in that they are influenced by the maritime air masses from the pacific coast, which are modified by continental air masses from Canada. Summers are mild and relatively dry, while fall, winter, and spring bring abundant moisture in the form of both rain and snow. A seasonal snowpack generally covers the landscape at elevations above 1,372 meters from late November to May. Snowpack between elevations of 915 and 1,372 meters falls within the "rain-on-snow zone" and may accumulate and deplete several times during a given winter due to mild storms (US Forest Service 1998). The precipitation that often accompanies these mild storms is added directly to the runoff, since the soils are either saturated or frozen, causing significant flooding.



Map 1. Locations of the four focal watersheds in the Coeur d'Alene Basin.

3.0 RESEARCH, MONITORING, AND EVALUATION

3.1 Introduction

3.1.1 Fish Population Status Monitoring (RM&E)

Status and trend of adult and juvenile abundance and productivity

The status and trend of adfluvial cutthroat trout populations in Lake and Benewah creeks are monitored by tracking the number of returning adult spawners and outmigrating juveniles at the watershed scale. It is imperative that trajectories in spawners are reliably tracked given that one of the primary objectives of our recovery efforts is to augment the number of returning adult cutthroat to our adfluvial watersheds to support a persistent meta-population structure in the Coeur d'Alene basin and to ultimately provide a sustainable fishery. In combination with spawner estimates, accurate estimates of outmigrating juveniles should also permit the derivation of outmigrant per spawner ratios, metrics that would allow tracking of watershed-wide trajectories in juvenile production. Because juvenile production is monitored downstream of most of the recently implemented and projected habitat restoration projects, outmigrant estimates will aid in the assessment of the collective in-stream population response to restoration actions (Bradford et al. 2005). Survival of juvenile cutthroat trout during lake residence has been considered to be a key vital rate for determining overall population trajectories of adfluvial cutthroat trout in some systems (Stapp and Hayward 2002). This underscores the importance of understanding whether the return rate of juveniles to adults, and hence survival in Lake Coeur d'Alene, is limiting adult production in our adfluvial watersheds. Consequently, in-lake survival rates of both juvenile and adult life stages are tracked annually in both Lake and Benewah creek watersheds.

Status and trend of the spatial distribution of populations

The status and trend of salmonid populations are also monitored annually at sites distributed across tributary and mainstem reaches in our watersheds. Monitoring populations at a spatial scale finer than the watershed (e.g., tributary and reach scale) will permit an examination of whether abundance trajectories differ across sub-drainages or across reaches within sub-drainages. The detection of declining trends or persistently low numbers of fish at the reach scale may signal localized degradation or deficiencies in habitat conditions that need to be addressed and prioritized for prospective habitat improvements. The tracking of temporal changes in the spatial distribution of trout populations will also permit an examination of expansion rates to evaluate whether newly created suitable habitat (e.g., barrier removal) is undergoing colonization. Collectively, monitoring the spatial distribution of trout populations should reveal whether connectivity is improving to transform a patchy distribution to a more robust structure.

Status and trend of population diversity

Examining the diversity of seasonal and life-history behaviors of cutthroat trout in monitored watersheds will improve our understanding of in-stream habitat use and adfluvial production in our watersheds. Monitoring the in-stream movement patterns of trout will provide data on seasonal habitats used, especially during overwintering periods, and could aid in evaluating trout response to restorative actions implemented to improve seasonal habitats or in the identification of reaches that would require further treatment. In-stream, seasonal movement patterns will also

provide data on the extent of exchange of individuals among tributaries and the degree of inter-connectedness among sub-populations which will aid our understanding of the meta-population structure in our watersheds. Monitoring the propensity of cutthroat trout to move out of stream habitats and into the lake will provide data on those tributaries within our adfluvial watersheds that support the migratory life-history strategy. Understanding the current spatial distribution of the adfluvial life-history variant may aid in prioritizing future restoration efforts.

3.1.2 Tributary Habitat RM&E

3.1.2.1 Monitor and evaluate tributary habitat conditions that may be limiting achievement of biological performance objectives

Stream temperature

Summer rearing temperatures has been considered to be a primary factor in explaining distributional patterns of cutthroat trout (Dunham et al. 1999; Paul and Post 2001; Sloat et al. 2001; de la Hoz Franco and Budy 2005). Similarly, in the Lake and Benewah Creek watersheds, cutthroat trout have consistently been found at higher densities in cooler tributary reaches than in warmer mainstem reaches during summer rearing periods. In addition, much of our in-stream restorative actions, such as pool formation and riparian re-vegetation, have been implemented to address sub-optimal summer water temperatures. Given that high summer water temperatures have been considered to be a major factor limiting cutthroat trout production in our watersheds, we annually track trends in both air and stream temperatures to examine changes over time.

Physical habitat

Physical habitat attributes are also monitored in mainstem and tributary reaches of our watersheds to examine additional factors that may be limiting recovery of cutthroat trout populations. In the past, assessments of mainstem habitats identified dysfunctional stream processes that included channel incision, unstable streambanks and accelerated sedimentation, lack of habitat complexity, and elevated summer rearing temperatures from low stream canopy closure and reduced groundwater connection with adjacent floodplains (Vitale et al. 2007, Vitale et al. 2008; Firehammer et al. 2009, Firehammer et al. 2010); many of these impaired processes have been addressed with mainstem restorative efforts implemented from 2005 to 2012. Watershed-wide assessments have also identified a deficiency of habitat complexity in tributary reaches, primarily resulting from a paucity of recruited, channel-forming large pieces of wood and a concomitant lack of pool habitat. This report covers monitoring surveys that describe physical habitat features in three tributaries of the upper Benewah watershed to provide baseline data that will ultimately serve in analyses to assess the effectiveness of tributary restoration measures.

3.1.2.2 Monitor and evaluate the effectiveness of tributary habitat actions relative to environmental, physical, or biological performance objectives.

Effectiveness monitoring is currently being conducted in mainstem reaches of the upper Benewah watershed to evaluate responses to large-scale in-stream and riparian restoration actions. Since 2005, restorative actions have been directed toward approximately 5 km of contiguous mainstem habitat, and associated floodplain and riparian areas, upriver of 9-mile bridge. This mainstem reach was targeted because it had the potential to increase carrying capacity and production of juvenile cutthroat trout given its proximity and connectivity to

important spawning tributaries. Phase 1 restoration proceeded over the first four years, and consisted of the reconstruction of approximately 2500 m of channel habitats, which entailed reactivating meanders previously lost to channel avulsions; elevating riffle streambeds to promote overbank flooding and increase pool volume; adding large wood to in-stream habitats to provide cover, create pools, and aid in bank stabilization; and planting vegetation along channel margins and riparian zones for shade, bank stabilization, and future woody debris recruitment. Phase 2 restoration, which began in 2009, addressed approximately 2400 m of contiguous main-stem habitat upstream of that treated as part of Phase 1 restoration. Phase 2 restoration used a more passive approach than that implemented during Phase 1, encouraging the establishment of persistent beaver dam complexes that will gradually aggrade the streambed over time and, via backwater effects, promote connectivity between the channel and adjacent floodplain habitats. As part of this approach, engineered wood structures were installed in the stream to emulate the flow obstruction effects of natural dams and offer stability to existing natural dam complexes. Throughout both Phase 1 and 2 treated reaches, our monitoring program measures physical attributes linked to the quality of salmonid habitat at representative sites to evaluate whether restored conditions are being maintained or approaching desired conditions and benchmarks. In addition, supplemental effectiveness monitoring is conducted throughout the treated Phase 2 reach, whereby metrics associated with the stability of natural beaver dams (e.g., dam turnover) and the habitat created by these dam complexes are monitored seasonally. This report only covers monitoring efforts associated with beaver dam complexes within the Phase 2 mainstem reach.

3.1.3 Predator/Competitor Control Implementation

Brook trout suppression

A brook trout removal program was initiated in 2004 to suppress the numbers of brook trout found in mainstem and tributary habitats in the upper portion of the Benewah watershed. This control was deemed necessary because brook trout have been shown to negatively impact cutthroat trout when populations of the two species overlap (Griffith 1988; Adams et al. 2001; Peterson and Fausch 2003; Peterson et al. 2004; Shepard 2004). However, unlike other brook trout removal projects that have focused on chemical eradication and subsequent measures to prevent re-colonization (Shepard et al. 2003), we have used less intrusive methods to annually control brook trout. Our approach was tempered by the desire to maintain connectivity with the lake to promote the migratory life-history variant of our cutthroat trout population and its concomitant high productivity potential. We felt that the benefits of unimpeded access and the expression of the cutthroat adfluvial life-history greatly outweighed the benefits of brook trout eradication in isolated tributaries (Peterson et al. 2008). Our suppression strategy entails annually removing fish before fall spawning periods using a single pass electrofishing effort in contiguous mainstem reaches and installing temporary barriers to impede access to spawning habitat. Monitoring the success of the removal program is conducted by examining changes in metrics of brook trout abundance in index reaches in the upper Benewah watershed.

Predator evaluation in Lake Coeur d'Alene

Results from past monitoring efforts indicate that juvenile to adult return rates for adfluvial cutthroat trout in our watersheds are eight to ten times lower than those that have been reported in other lake systems (Gresswell et al. 1994; Huston et al. 1984). Although the processes that are apparently limiting survival are largely unknown, it is imperative to better understand whether

predation is a predominant mechanism regulating survival rates in the lake. A couple small-scale research studies conducted in Lake Coeur d'Alene over the last twenty years suggested that two non-native piscivorous species, northern pike and smallmouth bass, could be significant predators on native cutthroat trout (Rich 1992; Anders et al. 2001). However, the studies were somewhat limited in that they lacked the required temporal resolution to rigorously evaluate predatory impacts on cutthroat trout. Seasonal habitat preferences of both northern pike and smallmouth bass coupled with the migratory behavior of adfluvial cutthroat trout suggest that intensive, focused sampling may be required to effectively evaluate the predatory impact of both species. Northern pike use shallow, vegetated habitats throughout the year and are especially common in those habitats during spring when they are spawning (Casselman and Lewis 1996). Smallmouth bass are also particularly common in shallow-water habitats during the spring (Brown and Bozek 2010). In Lake Coeur d'Alene, shallow-water habitats are almost exclusively located in bays where tributaries enter the lake, and potentially represent areas of high spatial and temporal overlap between northern pike, smallmouth bass, and migratory cutthroat trout. Our program is currently sub-contracting a study to examine the demographics and seasonal dietary preferences of both northern pike and smallmouth bass in select bays of Lake Coeur d'Alene to better describe the potential for these two predators to impact survival rates of cutthroat trout. Field sampling began in the fall of 2011 and continued throughout 2012, with intensive sampling conducted during the spring when cutthroat trout were actively migrating. Results from this study will not be included in this report, but will be presented and discussed in a final report that is due by the end of the year in 2013 and will be included as a supplementary document in a future annual BPA report.

3.2 Methods

3.2.1 Fish Population Status Monitoring (RM&E)

3.2.1.1 Assess the status and trend of natural origin abundance of adult fish populations

Migration traps were installed in both Lake and Benewah creeks to collect abundance and life-history information on adult adfluvial cutthroat trout. A modified floating weir trap, based on the resistant-board weir design (Tobin 1994; Stewart 2002), was used in both watersheds to intercept adult cutthroat migrating upriver (hereafter, referred to as UP traps). The modification entailed installing a rigid support structure underneath the series of floating, interconnected picket panels, and attaching a cabled pulley system to the support structure so that the trap panels could be manually lowered or raised with a winch to maintain their elevation above the water surface. These changes were implemented to improve trap performance by addressing problems associated with periodic high-volume freshets depressing trap panels below the water surface. In 2012, additional modifications were made to the support structure at the Lake Creek trap so that the panels could be lowered all the way down to the streambed. These changes were implemented to permit adults to ascend unobstructed if they were found to be lingering downstream of the trap for extended periods of time as has been observed in previous years (Firehammer et al. 2012). In both systems, UP traps were installed in late winter after ice out but early enough to attempt to capture the majority of the spawning run.

To capture post-spawn descending adults, a modified fence-weir design was used in both watersheds (hereafter, referred to as the DOWN trap). The trap consisted of a series of side-by-side, 8 feet wide by 4 feet high screened panels that completely spanned the width of the channel. A six inch diameter opening was incorporated at the bottom of one of the panels into which a PVC pipe was inserted that transported fish downstream to a livebox. The design included a pop-out panel insert in each screened panel that could be removed during periods of high flow to relieve pressure on the trap. DOWN traps were installed in the spring in both systems as early as possible under amenable discharge levels.

In both watersheds, UP and DOWN migrant traps were positioned downriver of principal spawning tributaries and of most of the recently implemented and projected habitat restoration projects. The UP trap on the Benewah Creek mainstem was installed at river kilometer (rkm) 14.5, with the DOWN trap located immediately upstream (Map 2); the UP trap on the Lake Creek mainstem was installed at rkm 6.0, with the DOWN trap located approximately 0.13 km upriver (Map 3). Traps were checked and cleaned frequently during periods of operation, with checks occurring typically daily during high discharge and associated peak movement periods for cutthroat trout from March through early June to ensure proper trap performance and to assess migration timing and relative abundance.

In 2012, we attempted to install a migrant trap at the mouth of Benewah Creek (rkm 0.1) that would capture both ascending and descending adfluvial adult cutthroat trout (Map 2). Similar to the UP traps installed in our watersheds, this trap was a floating weir design. However, we weren't able to use the winch and pulley assembly that had been used in the other UP traps to support and elevate the floating panels. Instead, sealed 10 in diameter PVC tubes were attached to the underside of the picket panels to buoy the structure and keep the panels elevated above the water surface. The livebox was designed with two separate chambers to hold both ascending and

descending adults; installation of the livebox, however, occurred on May 14 after most of the upriver migrants had likely ascended so that the trap was only considered functional for capturing downriver post-spawn adults. In addition, a fixed low profile picket fence that spanned most of the channel width was installed upstream of the trap to guide descending adults toward the livebox because a couple post-spawn fish were found stranded on the floating trap panels.

Total lengths (TL, mm) and weights (Wt, g) were measured and condition factors (estimated as 10,000*Wt / TL^3) calculated from all adult adfluvial cutthroat trout captured in traps. Adults captured in traps were also scanned for the presence of PIT-tags using a hand-held wand. Adfluvial adults captured in the UP trap that did not scan received a hole punch along the outer margin of the left opercle. In addition, these adults, other than those that had their adipose fin clipped, received a PIT-tag that was inserted into the muscle tissue immediately posterior to the insertion of the pelvic fin; tag insertion into the body cavity was not considered lest they would become expelled on the spawning grounds (Peterson et al. 2004; Bateman et al. 2009). Adults that did scan at the UP trap (i.e., either tagged as juveniles and hence were adipose-clipped, or tagged as adults in previous years) received a hole punch along the outer margin of the right opercle. Tag retention for all groups of tagged adults was assessed during their recapture in the DOWN trap using the opercle punch as a double-mark. Opercle-punches also served as marks that would be used in recapture events at the DOWN trap to generate an estimate of the abundance of adults that migrated upriver of the UP trap. Adult abundance was estimated using Chapman's modification of the Petersen index:

$$N = \frac{(M+1)(C+1)}{(R+1)} - 1, \quad (\textit{Equation 1})$$

where:

- N= the abundance estimate;
- M = number of adults that received a mark;
- C= number of adults captured in the DOWN trap; and
- R= number of adults captured in the DOWN trap that had been marked.

The variance estimate of N was calculated as follows:

$$v(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \quad (\textit{Equation 2})$$

An approximate 95% confidence interval was then calculated as $N \pm 1.96\sqrt{v(N)}$.

3.2.1.2 Assess the status and trend of juvenile abundance and productivity of natural origin fish populations

Outmigrating juvenile cutthroat trout were captured at rkm 14.5 in Benewah Creek and at rkm 6.0 in Lake Creek with the same traps (i.e., DOWN) that were used to capture descending adults. Lengths were collected from all juveniles captured. In addition, at least 25% of the captured juveniles in each system received intra-peritoneal PIT tags following the Pacific States Marine Fish Commission PTAGIS guidelines. Weights were collected from these tagged fish, and the adipose fin was clipped to identify its tagged status for recapture events. Attempts were made to

representatively tag juvenile fish throughout the entire outmigration period, with subsamples of PIT-tagged juveniles used in trap efficiency trials to estimate outmigrant abundance. Trap efficiency trials were attempted every 4-5 days. In addition, subsamples of the PIT-tagged fish used in efficiency trials were held overnight in a PVC-framed net pen upriver of the DOWN trap before their release to permit estimates of post-implantation survival and tag retention rates. Outmigration estimates for each release trial period were derived from recaptured fish enumerated at the trap using a modification of the stratified design (Carlson et al. 1998). Because rates of trap passage have been observed to vary among fish used in trials, all marked fish do not have an equal probability of being caught during a trial's recapture period. Hence, during each trial period, only those tagged fish *available* for recapture were used in calculations rather than all tagged fish released during the trial period. The number of tagged fish considered available for recapture in each trial period was calculated as the sum of those recaptured during that period and those from all release trials interrogated at the FDX array downstream of the trap during that period (this assumes complete detection efficiency at the array for those fish that bypassed the trap). Trial period abundances were thus calculated using the following equation:

$$U_h = \frac{(u_h)(M_h + 1)}{m_h + 1}, \quad (\textit{Equation 3})$$

where:

U_h = outmigrant abundance, excluding recaptured fish, in trial period h;
u_h = number of untagged fish in trial period h;
M_h = number of tagged fish available for recapture in trial period h; and
m_h = number of tagged fish recaptured in trial period h.

The variance estimate of U_h was calculated as follows:

$$v(U_h) = \frac{(M_h + 1)(u_h + m_h + 1)(M_h - m_h)(u_h)}{(m_h + 1)^2 (m_h + 2)}. \quad (\textit{Equation 4})$$

Total outmigration abundance (U) and variance ($v(U)$) were then calculated as the sum of the respective estimates over all trial periods. An approximate 95% confidence interval was then calculated as:

$$U \pm 1.96\sqrt{v(U)}.$$

Full duplex (FDX) PIT-tag arrays have been installed immediately downstream of the UP traps in both the Lake (~ 10 m downstream) and Benewah (~2 m downstream) systems. Interrogations by these arrays permit an evaluation of return rates from prior outmigrating cohorts and also allow an in-season examination of trap performance. The Lake Creek array spans the entire stream channel and consists of three side-by-side 5x5 ft antennas; two side-by-side 10x4 ft antennas constitute the array in Benewah Creek and span the entire wetted width of the channel under most flows. The Lake and Benewah creek PIT-tag arrays were calibrated and started on March 4 and March 10 in 2011 and on February 29 and March 1 in 2012, respectively. Logged interrogation data were downloaded several times a week to monitor fish passage throughout the migratory period. Lake and Benewah creek PIT-tag arrays were respectively shut down on July 11 and June 23 in 2011 and on July 5 and June 15 in 2012 because of lack of fish detections and the absence of fish captured in DOWN traps.

3.2.1.3 Assess the status and trend of spatial distribution of fish populations

Electrofishing surveys were conducted during base flow summer periods from July 20 to August 31 in 2011 and from July 18 to August 22 in 2012 at standardized sites to quantify the distribution and abundance of cutthroat trout and non-native brook trout in each surveyed watershed. Locations of sites are denoted by a river kilometer (rkm) index which represents its longitudinal location within the watershed. For example, site 18.6/1.4/0.3 in the Benewah watershed is positioned in the Windfall Creek sub-basin, which has its confluence with Benewah Creek mainstem 18.6 km from the mouth, and is located 0.3 km up a secondary tributary that enters Windfall Creek 1.4 km from its mouth. Electrofishing was conducted using a Smith-Root Type VII pulsed-DC backpack electrofisher, and followed established guidelines and procedures to standardize capture efficiency (Reynolds 1983). Block nets were placed at the upstream and downstream boundaries of each site to prevent immigration and emigration during sampling. Only a single pass was conducted at each site.

Mainstem and tributary index sites that were sampled in 2011 and 2012 were those that have been repeatedly surveyed over the last 15 years (Maps 2-5). The channel types delineated during early pilot habitat surveys (Lillengreen et al. 1996) served as basic geomorphic units for selecting sample index sites for conducting fish population surveys. In these surveys, stream reaches were stratified into relatively homogeneous types according to broad geomorphologic characteristics of stream morphology, such as channel slope and shape, channel patterns and channel materials, as defined by Rosgen (1994). Stream reaches were further stratified by basin area to ensure that both mainstem and tributary habitats were represented in the stratification scheme. Sample index sites within each reach stratum were randomly selected in proportion to the total reach length. The length of each index site was standardized to 61 meters to encompass at least 20 channel widths for most sites. In 2012, eight new sites, each 100 m in length, were surveyed in each of Windfall, South Fork Benewah (SFB), and West Fork Benewah (WFB) creeks using a stratified-randomized selection procedure (Map 6). Abundances at these sites will serve in forthcoming BACI effectiveness monitoring analyses to evaluate the response of salmonids to prospective tributary restoration actions (e.g., large woody debris additions).

Captured salmonids, including westslope cutthroat trout and brook trout *(Salvelinus fontinalis)* were identified, enumerated, and measured for total length. Based on age-at-length keys derived from previously collected scale samples and on length distributions derived from fish captured in 2011 and 2012, cutthroat and brook trout respectively greater than 70 and 80 mm were considered to be at least one year of age. Abundances at sampled sites were indexed using single pass catch (Jones and Stockwell 1995; Kruse et al. 1998; Bateman et al. 2005; Firehammer et al. 2011) and were calculated for trout considered at least one year of age and for those considered to be young-of-the-year (hereafter referred to as age 1+ and age 0 fish, respectively) separately for each salmonid species, and converted to fish/100 m of stream length to permit comparisons across sites. Other species, such as dace (*Rhinichthys* spp.), redside shiner (*Richardsonius balteatus*), longnose sucker (*Catostomus catostomus*), and sculpin (*Cottus* spp.), were considered incidental catch and were only counted during the electrofishing pass.

3.2.1.4 Assess the status and trend of diversity of natural origin fish populations

Cutthroat trout age 1+ that were captured in electroshocking surveys in 2012 were PIT-tagged in each of Windfall, SFB, and WFB creeks in the upper Benewah watershed (Map 6), and in the

West Fork of Lake Creek (WFL), Bozard sub-drainage, and upper Lake Creek fork in the upper Lake Creek watershed (Map 3). Interrogation data captured from these fish during active and passive recapture events will serve to provide information regarding seasonal movements (e.g., overwintering behavior) and diversity of life-history strategies (e.g., tributaries that support either resident or adfluvial production). Active recapture events will occur at migrant traps and in future electroshocking surveys. Passive interrogation data were collected at fixed half-duplex (HDX) directional PIT-tag arrays that were installed at strategic locations in each watershed. In the upper Benewah watershed, directional arrays were installed at the mouths of SFB, WFB, and Windfall creeks to interrogate fish moving out of or upstream into these tributaries (Map 6). In addition, directional arrays were located downstream of 12-mile bridge and upstream of 9-mile bridge to bookend the mainstem reach that underwent the two phases of stream restoration that occurred from 2005 to 2012 (Map 6). In the upper Lake Creek watershed, directional arrays were installed at the mouths of the upper Lake Creek fork, WFL, and Bozard Creek, the three primary spawning and rearing tributaries. At each of the interrogation stations, solar panels were used to charge the batteries that powered the array. HDX interrogation stations were initialized from July 17 to July 23 in 2012 and checked weekly to download data and ensure their continued operation.

3.2.2 Tributary Habitat RM&E

3.2.2.1 Monitor and evaluate tributary habitat conditions that may be limiting achievement of biological performance objectives

Stream temperatures

Stream temperatures were continuously monitored every 30 minutes at fixed locations along mainstem reaches and in primary tributaries of upper Benewah and Lake creek watersheds using HOBO Temp Pro (Onset Computer Corp.) digital temperature dataloggers (accurate to ±0.2 °C). Air temperatures were also recorded using HOBO H8 Pro Series loggers (Onset Computer Corp.) at a forested and open meadow site in both upper Benewah and Lake creek watersheds. Daily mean water temperatures, and the percent time in which logged temperatures exceeded 17°C were computed for each HOBO logger. The threshold value of 17°C was used because it has been considered to be a 95% upper limit for optimal cutthroat trout growth (Bear et al. 2007). Daily temperature metrics were used to calculate monthly mean values for July and August to permit comparisons within watersheds and across years.

Physical habitat

Riparian and in-channel physical attributes that have been linked to the quality of trout habitat were monitored at sites distributed across SFB, WFB, and Windfall creeks in the upper Benewah watershed (Map 6). These tributaries were chosen to examine reach-scale physical responses to prospective restoration actions (e.g., large wood additions). In 2011, eight sites, 152 m in stream length, were established in each of the SFB and WFB sub-drainages using a stratified-randomized approach. The same eight sites in each sub-drainage were surveyed in 2012, though only a 100 m segment of the original 152 m of site length was sampled. In addition, seven sites, 100 m in length, were established in the Windfall sub-drainage in 2012 using a similar stratified randomized selection process that was used in the other two sub-drainages. Windfall Creek was selected to serve as a control sub-drainage for monitoring the effectiveness of the prospective restoration actions that were targeted for implementation in the WFB and SFB sub-drainages.

Surveys were conducted from June 27 to July 15 in 2011 and from June 21 to July 18 in 2012. The methods used to measure physical attributes, which included pool habitat, substrate composition, canopy cover, and large woody debris are described in detail below.

Pool habitat

Pools were identified according to criteria that comported with other regional habitat monitoring protocols (Peck et al. 2006; AREMP 2007; Heitke et al. 2008). Each pool was measured from tail crest to its upstream end, and depths were recorded at the tail crest and the deepest point for calculating residual pool depth. Percent pool habitat and mean residual pool depth were calculated for each site. In addition, information about the type of pool and the mechanism forming the pool were collected. Pool forming mechanisms included boulder, channel hydraulics, wood, beaver dam, and artificial structure (e.g., culvert). Types of pools included plunge, dammed, scour, and backwater.

Substrate composition

Wolman pebble counts (Wolman 1954) were completed at riffles and pool tailouts along the survey reach. At each of these points a measuring stick or finger was placed on the substrate and the one particle the tip touched was picked up and the size measured. Particle size was determined as the length of the "intermediate axis" of the particle; that is the middle dimension of its length, width and height. A total of 50 particles were counted across bankfull at each location, and a total of five riffle and two pool tailout locations distributed across the reach were sampled. Particles were noted whether they were sampled within or without the wetted channel width. Pebble count data were input into spreadsheets to graph the distribution of particle sizes and calculate pertinent descriptive criteria such as percent fines for each habitat type.

Canopy cover

Vegetative canopy density (or shade) was determined using a conical spherical densiometer, as described by Platts et al. (1987). The densiometer determines relative canopy "closure" or canopy density, which is the amount of the sky that is blocked within the closure by vegetation. Canopy cover over the stream was determined at ten equidistant locations distributed throughout the survey reach. At each location, densiometer readings were taken one foot above the water surface at the following stations: once facing the left bank, once facing upstream at the middle of the channel, once facing downstream at the middle of the channel and once facing the right bank. Percent density was calculated collectively over these four readings for each of the ten locations with an overall mean calculated for the reach.

Large woody debris

Large woody debris (LWD) was surveyed throughout the entire reach. All LWD that was greater than 4 inches in diameter at the small end and 4 ft in length was counted. In addition to these criteria, LWD also had to be either partially located within bankfull or suspended across the channel above the water surface. Living trees and shrubs, however, did not qualify as LWD. For all pieces, the mean diameter and length were estimated and tallied in appropriate size ranges. Size classes were 4-8, 8-12, 12-18, 18-24, and >24 inches for mean diameter. Size classes were 4-10, 10-15, 15-20, 20-25, and >25 feet for length. In addition to the first five pieces of qualifying LWD encountered, the mean diameter and length were measured for every 5th piece of LWD to calibrate the accuracy of the visual length and diameter estimates. Volume of each piece was calculated using the mid-point values of the length and diameter categories to

which the piece was assigned. Total volume and density of LWD was calculated for each site and expressed per meter of stream length. In addition to measuring the volume of LWD, data denoting the function and position of each identified piece were also collected to aid in describing how LWD was providing habitat and influencing channel form within the site. Function categories included: accumulating sediment, forcing a pool to form upstream or downstream, providing in-stream cover, or providing bank stabilization. More than one category could be assigned to individual wood pieces. Categories to describe the position of the identified piece in relation to the stream included: elevated above the bankfull channel, one end within and the other end outside bankfull channel, completely within bankfull channel but exposed, or within bankfull channel but partially buried.

Pool and large woody debris metrics calculated at sites in the SFB and WFB were compared across different surveyed reach lengths and over consecutive years to evaluate their degree of spatial and temporal variability. To evaluate spatial variability, metric values recorded at each site in 2011 were compared between the original 152 m reach length and a 100 m segment that terminated at the downstream end of the original length. To evaluate temporal variability at each site, metrics calculated along the 100 m segment sampled in 2011 were compared to those calculated along the same 100 m length sampled in 2012. For each metric and each site, a standard deviation was calculated using the data collected over consecutive years along the same 100 m. The standard deviations across all sites were used to characterize the average degree of annual variability that may be observed for pool habitat and large woody debris in these two sub-drainages.

3.2.2.2 Monitor and evaluate the effectiveness of tributary habitat actions relative to environmental, physical, or biological performance objectives.

Beaver dams were repeatedly surveyed in 2011 and 2012 along a 3.5 km reach of the upper Benewah mainstem that received treatments as part of Phase 2 restoration implementation. Five surveys were conducted in 2011 from June 28 to October 3, and four surveys were conducted in 2012 from June 25 to November 15. Various attributes that described dam morphology were measured and recorded at each dam location during each survey. Dam morphology attributes included dam type, which indexed the apparent stability, complexity, and derelict state of the dam; the materials used to build the dam; and the dam width and height (Table 1).

Attributes that described the in-stream habitat influenced by dams were measured at each dam location during the final survey in 2012 (November 6-15). The in-stream habitat influenced by a dam was considered to be that channel length that was backwatered by the dam (i.e., the length of channel upstream over which water surface elevation did not change). Attributes evaluated along the backwatered channel length included the inundated surface area, pool surface area, pool volume, and mean residual pool depth. Inundated surface area was calculated by multiplying the backwatered channel length by the average of five wetted channel widths measured at equidistant intervals along the channel length. Pools were identified and measured along the backwatered length using the following criteria. A habitat type was classified as a pool if the maximum depth minus the tail-crest, or control point, depth was greater than one foot of residual pool depth. If a pool was identified, then the upstream and downstream boundaries, demarcated to measure pool length, were those locations at which residual pool depth equaled one foot. For each pool, three stream widths were measured: 1) half-way between maximum

depth and the downstream end of the pool, 2) the point of maximum depth, and 3) half-way between the maximum depth and the upstream end of the pool. Stream widths only included the portion of the channel where the water depth was greater than one foot of residual depth. Finally, at each stream width, three depth measurements were collected equidistant across the measured width. For each dam location, pool lengths and their respective measured widths and depths were used to calculate the collective pool surface area and volume, and the mean residual maximum depth.

Paired data collected at dam locations were used to evaluate seasonal changes in dam height from fall of 2010 to the initial survey of 2011, from the final survey of 2011 to the initial survey of 2012, from the initial to the final survey of 2011, and from the initial to the final survey of 2012. Changes in height over winter and spring periods were analyzed to examine the elimination or reduction of dam structures over periods of high discharge. Changes in height over summer periods were analyzed to examine dam re-building efforts. Paired data that described in-channel habitat was analyzed from the fall 2010 and final 2012 surveys to examine changes in inundated channel length and pool habitat metrics across the Phase 2 restoration reach.

Table 1. List of categories that describe available dam types and dam building materials. Active dams are considered those in which a presence of fresh material (e.g., green stems) has been detected.

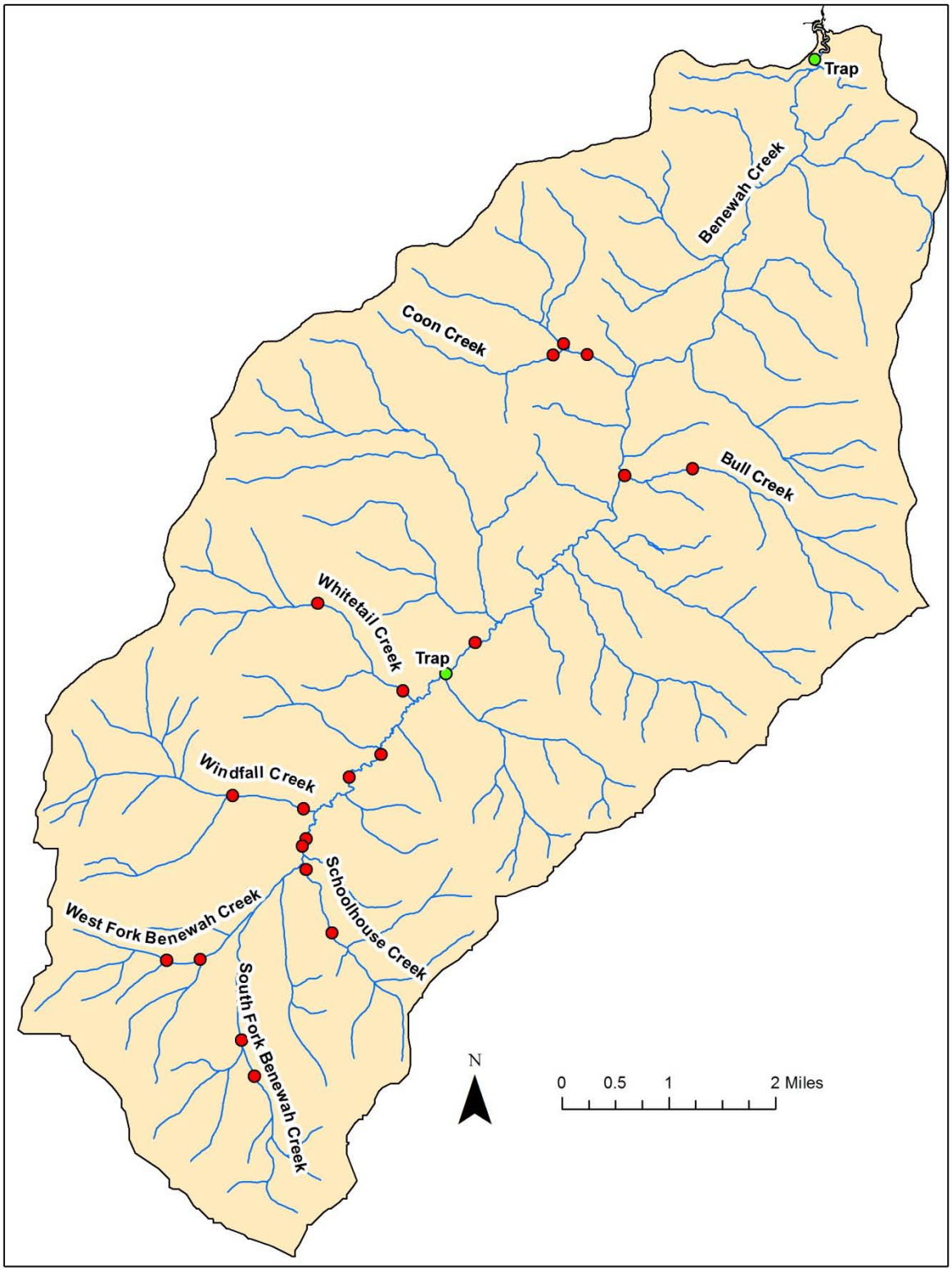
Attribute	Categories
Dam type	Acitve single dam with large wood
	Active dam complex composed of multiple dams utilizing large wood and/or mid-channel islands
	Active single dam without large wood
	Inactive single dam with large wood
	Inactive dam complex composed of multiple dams utilizing large wood and/or mid-channel island
	Inactive single dam without large wood
Dam materials	Key pieces (> 4 inches in diameter; length >= bankfull width)
	Other large wood (> 4 inches in diameter)
	Large wood with root wad
	Small wood (< 4 inches in diameter)
	Herbaceous plant material
	Mud
	Other

3.2.3 Predator/Competitor Control Implementation

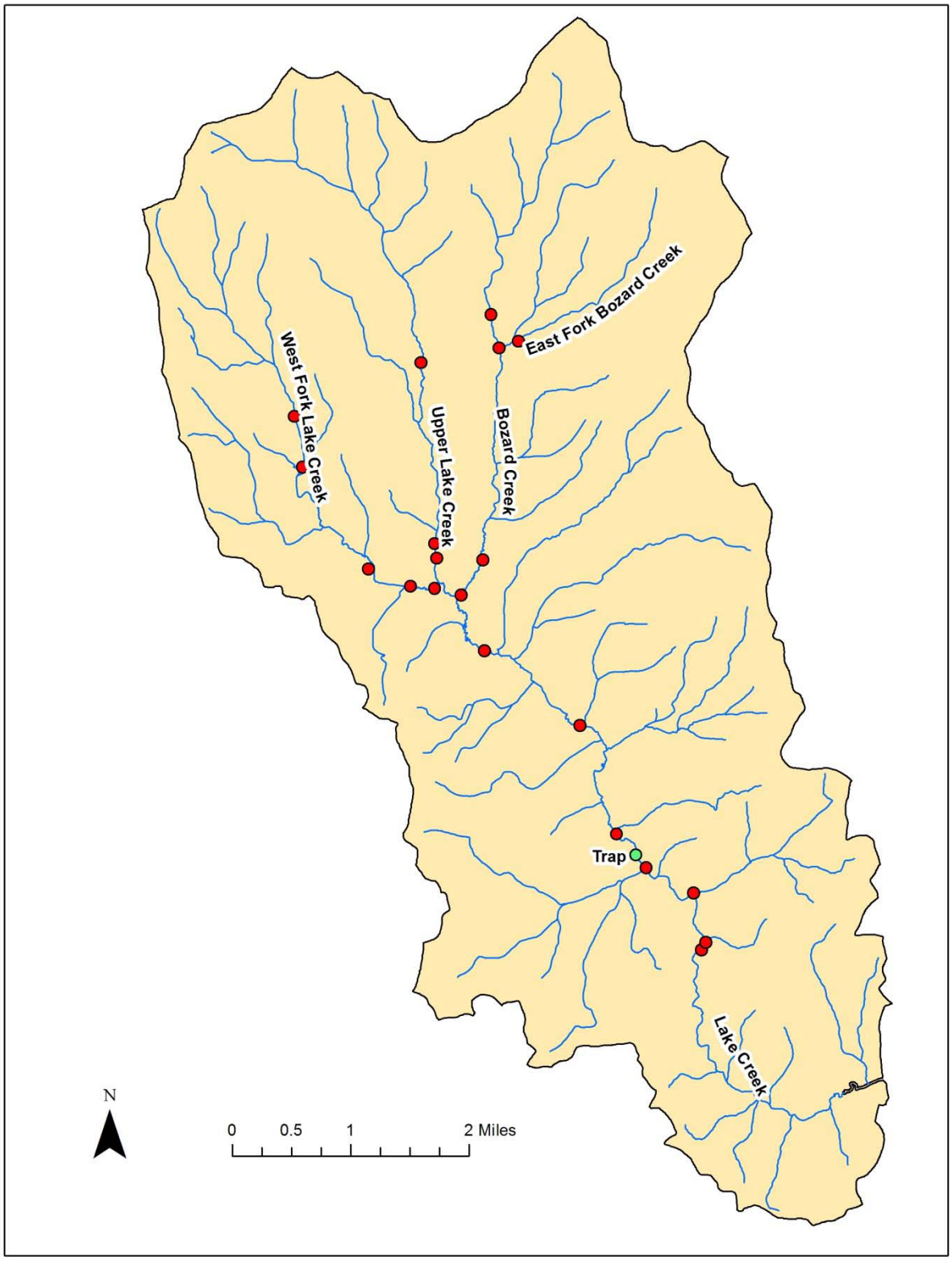
In late summer and early fall, single-pass electrofishing was used to remove non-native brook trout from an index 2 km main-stem reach from the 12-mile bridge upstream to the confluence of the West and South Forks in the upper Benewah watershed (Map 7). High densities of adult brook trout have consistently been found in this reach, and suitable spawning habitat is seemingly much more prevalent in this reach than in mainstem reaches downriver that are of lower gradient and dominated by beaver dam pools. Removal efforts occurred before the spawning period for brook trout but after population surveys were completed in the upper Benewah watershed to prevent the removal activities from biasing index site abundance estimates.

A temporary trap was installed on the Benewah mainstem immediately upriver of 12-mile bridge to intercept ascending brook trout and hence prevent access to habitat upriver. The trap consisted of a downriver fixed weir that spanned most of the channel width but maintained a narrow opening along one bank to allow passage. Another fixed weir spanning the entire channel width and obstructing further upriver movement was installed approximately 25 m upriver. Periodically, the 25 m of enclosed stream length was shocked to remove any brook trout that had entered. In addition, a temporary fixed weir spanning the entire channel width was installed at the mouth of Windfall Creek to prevent access to habitat upriver in this tributary.

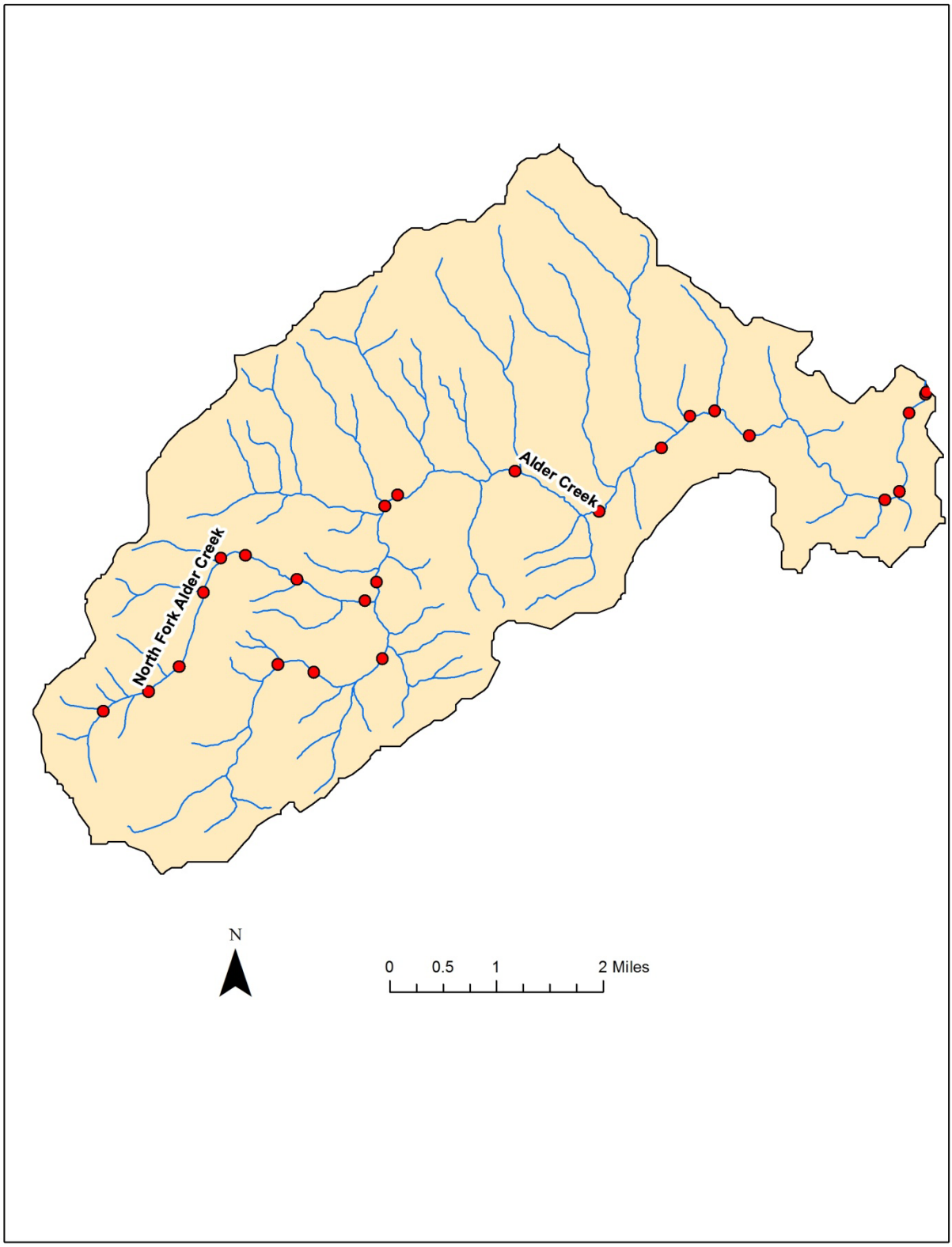
Trends in brook trout abundance were examined using various indices to evaluate the population response to the suppression program. Changes in numbers of brook trout removed from the 2 km index main-stem reach were examined over the period from 2005 to 2012 given that this reach had been consistently sampled in all eight years. Qualitative differences in the length distributions of brook trout removed from the 2 km mainstem index reach were also examined over years to evaluate whether the modified removal tactics that were first employed in 2009 (i.e., only removing fish from the 2 km index main-stem reach and installing barriers) had an impact on reproductive success. Finally, mean density indices of age 1+ brook trout computed across index sites in tributaries of the upper Benewah watershed were examined to evaluate trends from 2004, the initial year of the suppression efforts, to 2012.



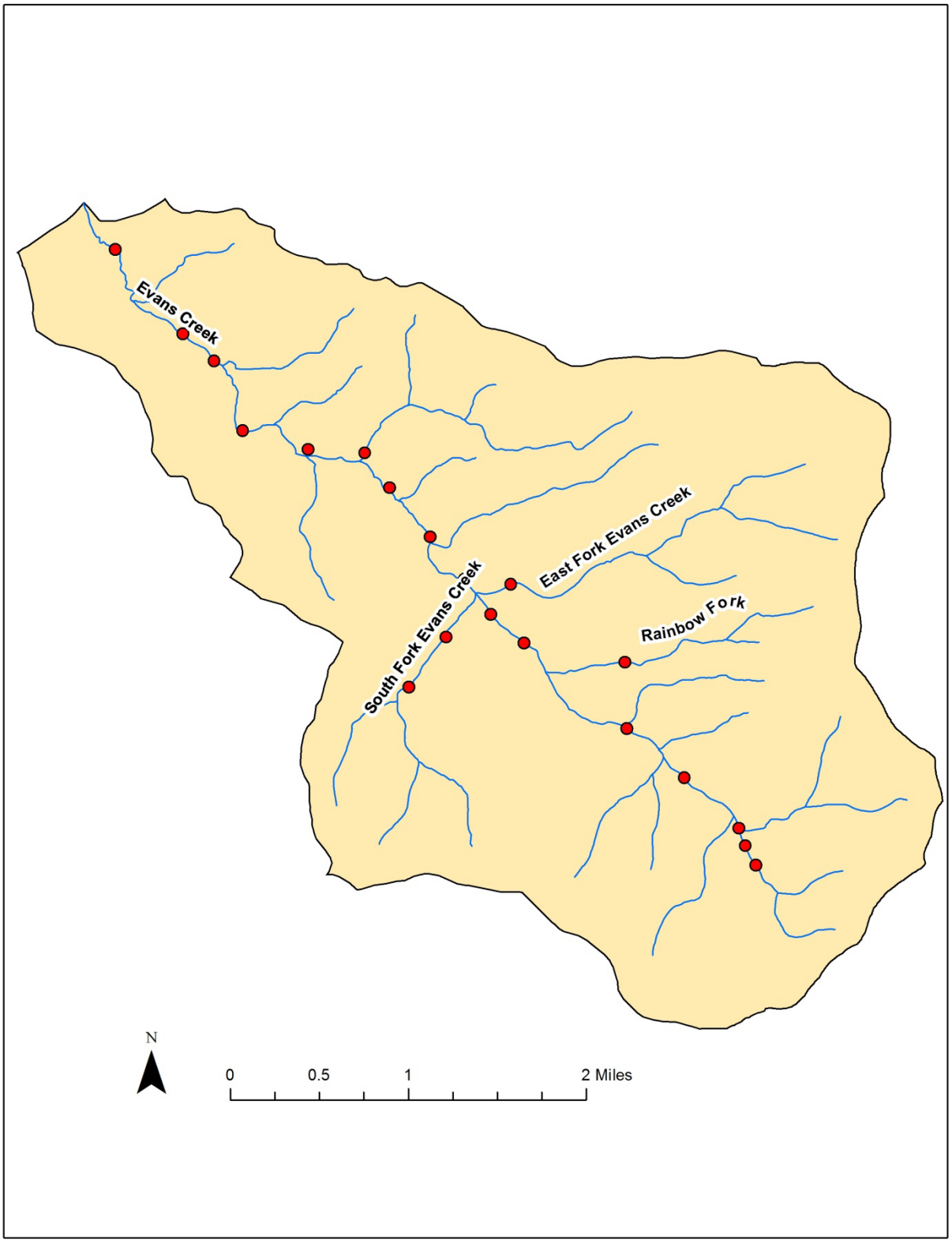
Map 2. Index sites (red filled circles) sampled during salmonid population surveys in Benewah Creek. Locations of migrant traps (green filled circles) are also displayed.



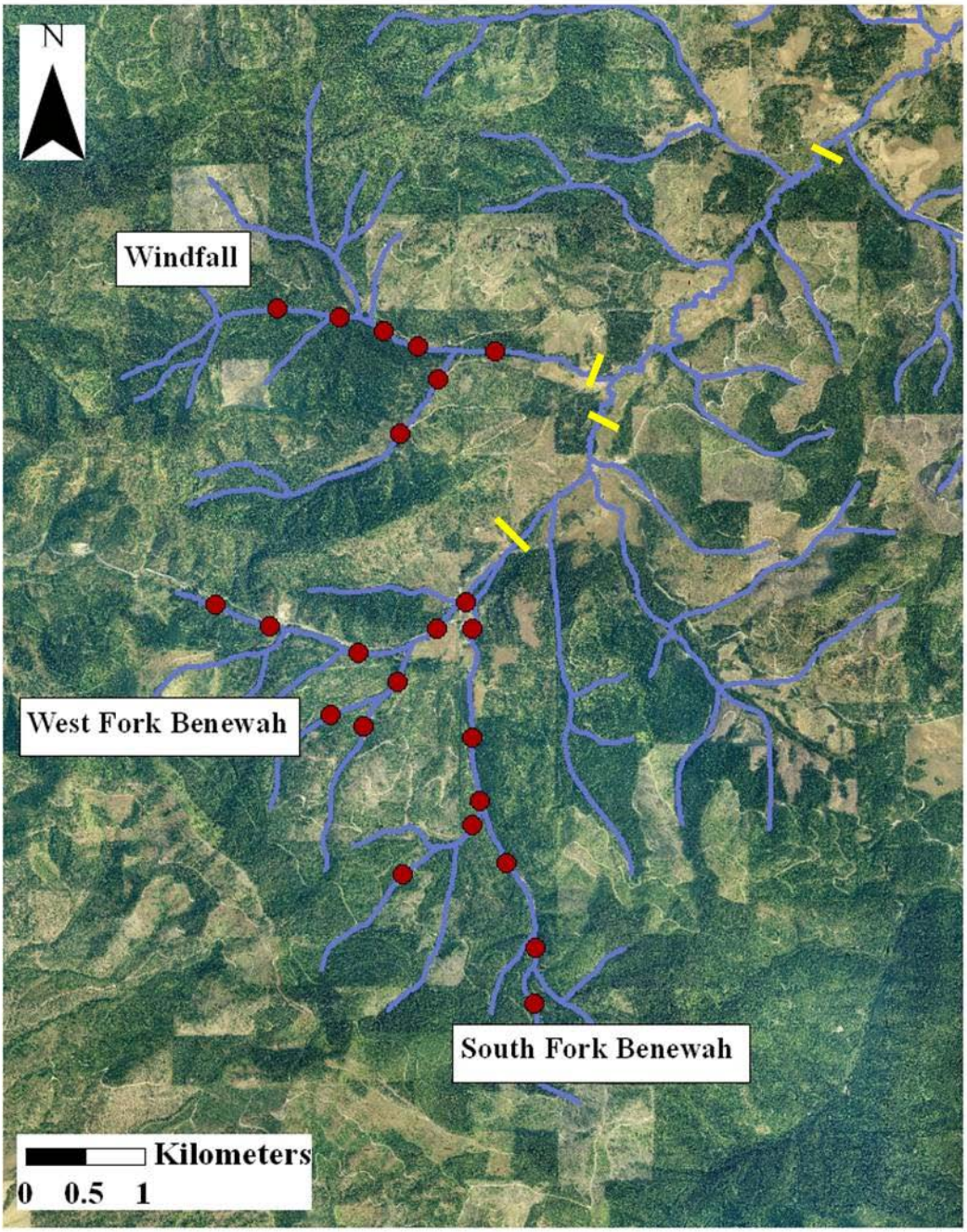
Map 3. Index sites (red filled circles) sampled during salmonid population surveys in Lake Creek. The location of migrant traps (green filled circle) is also displayed.



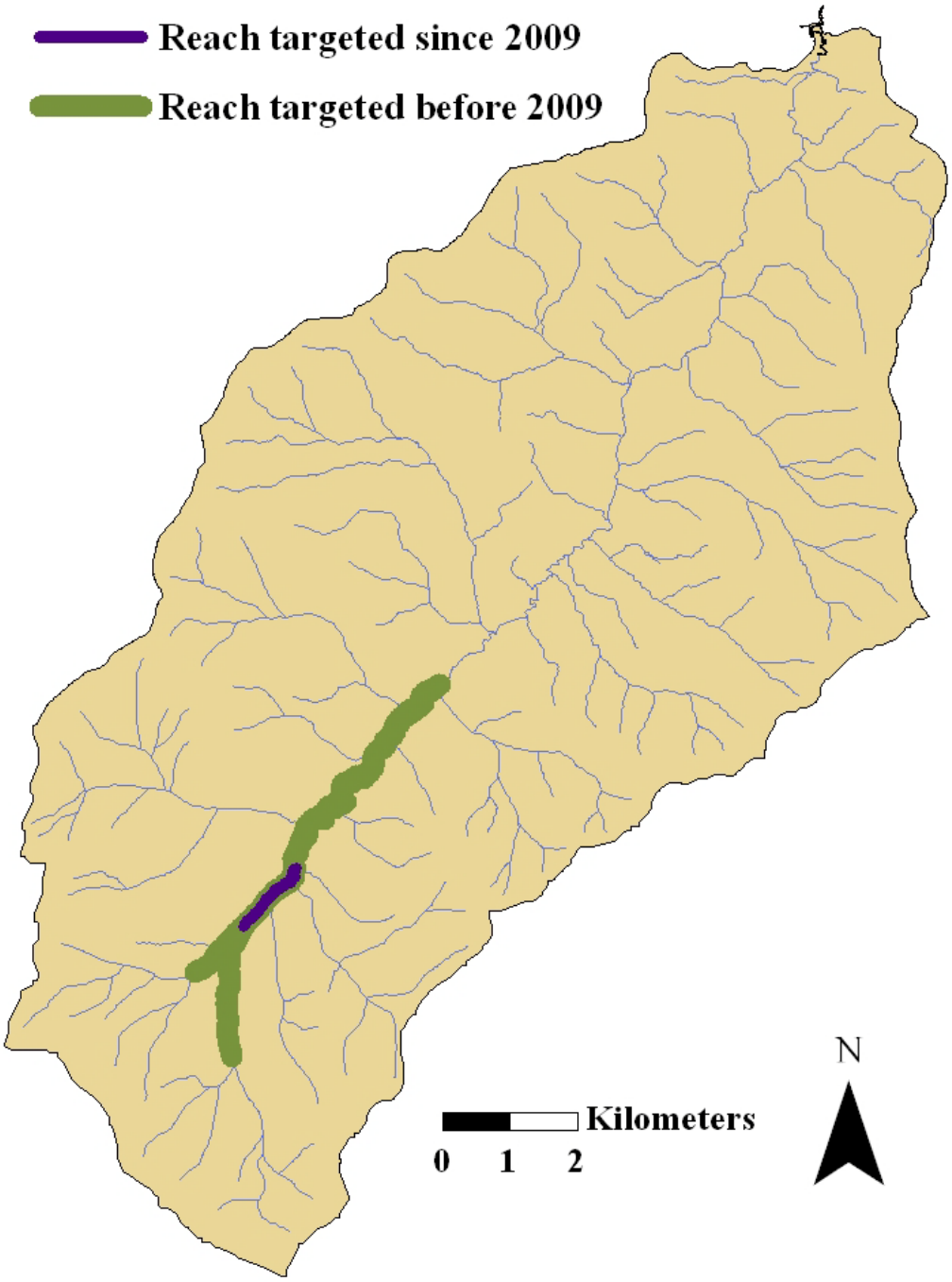
Map 4. Index sites sampled during salmonid population surveys in Alder Creek in 2011.



Map 5. Index sites sampled during salmonid population surveys in Evans Creek in 2012.



Map 6. Location of effectiveness monitoring sites in South and West Forks of Benewah Creek and Windfall Creek (red filled circles) where habitat and fish population surveys were conducted in 2012. Yellow bars depict locations of fixed HDX interrogation stations.



Map 7. Reaches in the upper Benewah watershed where brook trout removal efforts have been implemented since inception of the suppression program in 2004.

3.3 Results

3.3.1 Fish Population Status Monitoring (RM&E)

3.3.1.1 Assess the status and trend of natural origin abundance of adult fish populations

Lake Creek 2011

In 2011, the UP trap in the mainstem of Lake Creek was installed on February 2 and was removed on June 14, yielding a deployment period of 124 d. During this time the trap was checked a total of 90 d (73% of the days) and was considered fishing 59% of the time that it was monitored. The UP trap was compromised during several, extended high flow events from March 10 to April 5 and during brief high flow events on April 26 and May 16, in which water was found flowing over the trap panels (Figure 1). After the May 16 event, panels were lowered to their utmost extent permitting fish to freely pass under all but the lowest flow levels.

The DOWN trap was installed in Lake Creek on May 5 and was removed on July 5, yielding a deployment period of 61 d. During this time, the trap was checked a total of 46 d (75% of the days) and was considered fishing approximately 70% of the time it was monitored (Figure 1). The DOWN trap was compromised during several, extended high flow events from May 7 to May 18 and from May 26 to June 3, in which water was found flowing over the trap panels or induced scouring underneath the panels. In most cases, pop-outs were pulled in anticipation of these rain-induced high flow events to minimize damage to the trap.

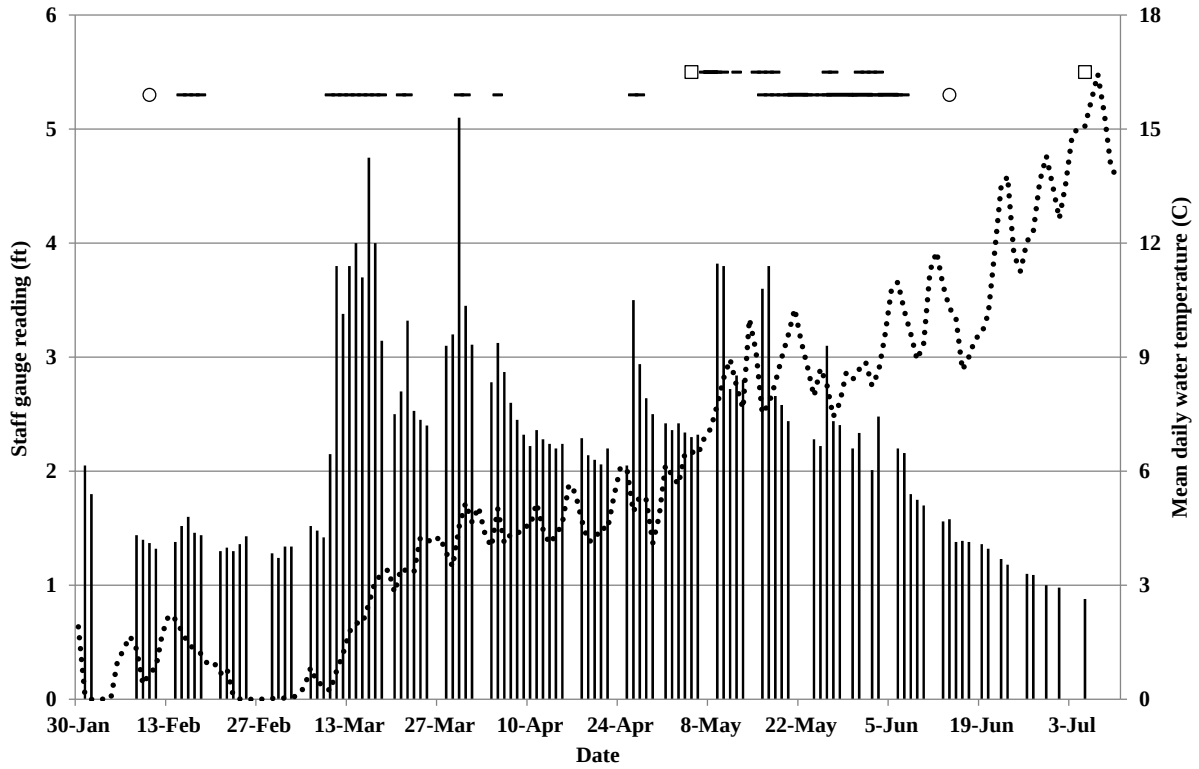


Figure 1. Gauge heights (vertical bars) and mean daily water temperatures (dotted line) collected at the UP trap in Lake Creek from late January to early July, 2011. Open circles and squares at the top represent installation and removal dates for the UP and DOWN traps, respectively. Solid horizontal bars at the top, in line with their respective traps, indicate periods when traps were compromised.

A total of 16 adfluvial adult cutthroat trout was captured ascending upriver in 2011, with 15 of these retrieved from the trap's livebox and one other fish netted immediately downstream of the DOWN trap (Table 2). Of the 15 fish that were processed (one escaped at the livebox), 12 were identified as females (80%) with a mean length and weight of 368 mm and 488 g, respectively. The other three fish were identified as males with a mean length and weight of 390 mm and 539 g, respectively. Fifteen of the 16 fish received an opercle punch, with eight of these receiving a PIT-tag. Most of the fish were captured over a two-day period in late April (Figure 2).

Table 2. Length, weight, and condition factor means and standard deviations (SD) for adult adfluvial cutthroat trout with sex determined that were captured during their upriver and downriver migrations in Lake and Benewah creeks in 2011.

		Total length (mm)			Weight (g)		Condition Factor	
Gender	**N**	**Range**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
			Lake Creek upriver [a]					
Female	12	278 - 515	367.9	71.8	488.2	283.1	0.90	0.05
Male	3	371 - 411	389.7	20.1	539.2	121.9	0.90	0.06
			Lake Creek downriver [b]					
Female	24	259 - 530	346.0	62.9	364.0	268.2	0.80	0.08
Male	29	288 - 514	388.0	48.1	501.7	203.9	0.83	0.07
			Benewah Creek downriver [c]					
Female	14	263 - 510	384.1	78.0	505.8	247.6	0.83	0.09
Male	9	287 - 432	372.1	44.8	463.5	143.6	0.88	0.09

[a] One additional fish of unknown sex escaped processing at the livebox

[b] One additional fish of undetermined sex was 350 mm in total length

[c] One additional fish of undetermined sex was found dead stranded on the floating weir panels

Fifty-two putative adfluvial adults that were PIT-tagged in prior years were interrogated by the FDX fixed antenna array in Lake Creek in 2011 (Table 3). Thirty-five of these fish (67%) were first detected from March 20 to April 5 (Figure 2), during a time of high discharge and of mean daily water temperatures that were increasing and in excess of 3°C. Eleven of the 52 fish were tagged as juveniles, with 2 tagged in 2005 and 3 tagged in each year from 2007 to 2009. Four of the five fish tagged from 2005 to 2007 were also detected in at least one other year, with one fish detected in four other spawning migrations. Forty-one of the 52 detected fish were tagged as adults in prior years, with 33 and 8 tagged in 2009 and 2010, respectively. Eleven of the 33 adults tagged in 2009 were also detected during the 2010 spawning migration. Of those fish that were tagged as adults and captured in 2011, many exhibited growth increments that were less than 20 mm, even for those fish that were at large two years since tagging (Table 3).

The number of elapsed days in which PIT-tagged adults lingered downstream of the trap before either their capture or departure from the UP trap site varied from 1 to 27 d, with 30 of the 52 fish lingering for at least 5 d and 10 of these lingering for at least 10 d (Table 3). For many of the PIT-tagged fish, the number of days of detection closely matched the elapsed period, indicating that fish were repeatedly detected daily while lingering downstream of the trap. Of

the PIT-tagged fish not captured in the UP trap, 24 were last interrogated before their apparent departure during high flow periods from March 21-22, March 29-31, April 4-5, and April 26-27 when water was observed to be flowing over the trap panels.

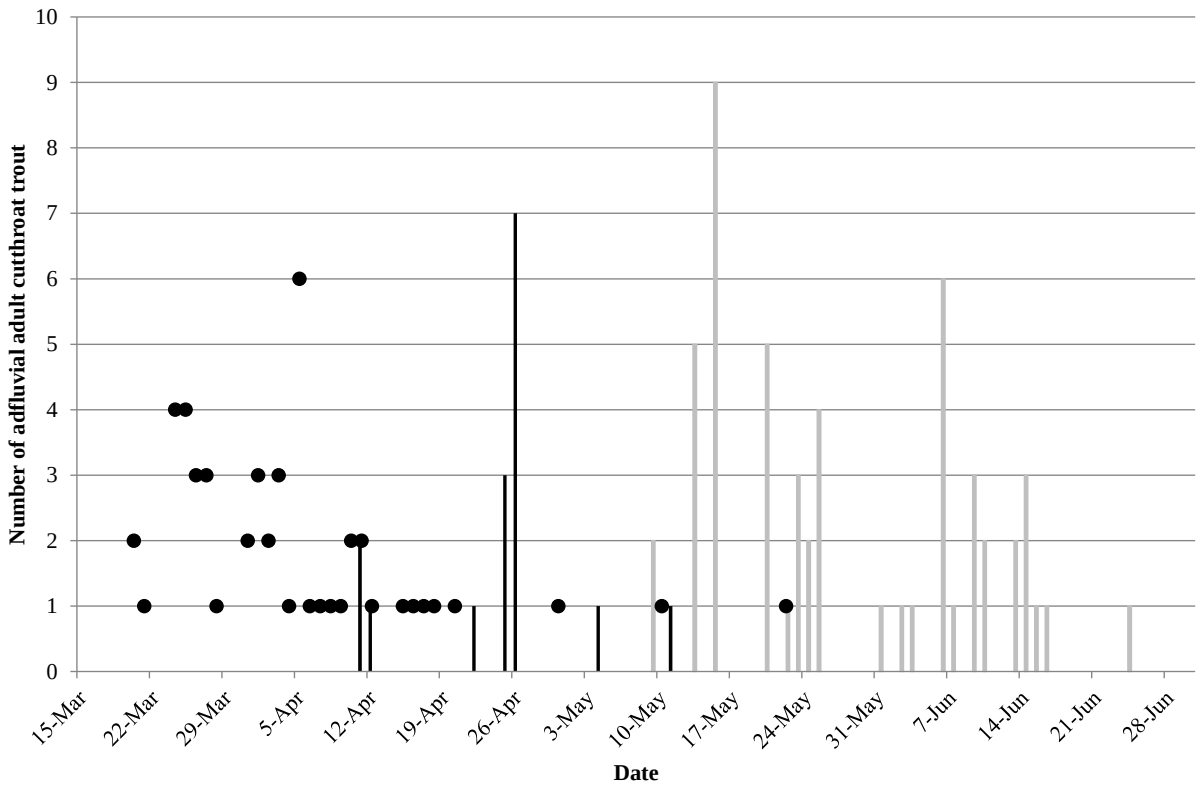


Figure 2. Timing of migratory adult adfluvial cutthroat trout in Lake Creek in 2011. Black and grey bars respectively denote the number of ascending and descending fish captured. Black circles represent the number of PIT-tagged putative adfluvial adults initially interrogated at the FDX array at the UP trap site.

A total of 54 adfluvial adults was captured in the DOWN trap at Lake Creek in 2011 (Table 2). Of the 54 fish, 24 (44%) were identified as females with a mean length of 346 mm and a mean weight of 364 g, and 29 as males with a mean length of 388 mm and a mean weight of 502 g. The mean condition factor was noticeably lower for females captured in the DOWN trap (0.80) than for females caught in the UP trap (0.90), indicating than many of the outmigrating females likely spawned. Fish were captured from May 9, soon after deployment of the DOWN trap, to June 24 (Figure 2).

Six of the 54 adults captured at the DOWN trap had a detectable opercle punch, yielding a spawner abundance estimate of 125 fish (95% confidence interval, 63 – 186). However, given the apparent trap avoidance behavior exhibited by PIT-tagged fish downstream of the UP trap in 2011, the actual number of adults that ascended upriver *to* the UP trap was likely greater than that that ascended *beyond* the UP trap. Using the number of antennae-interrogated fish that were PIT-tagged as adults in prior years as marks and the number of these PIT-tagged fish captured in the DOWN trap as recaptures in a mark-recapture model, an estimate of 230 adults was obtained (95% confidence interval, 122 – 338). In addition to 6 of the 15 opercle-punched PIT-tagged

adults that were recaptured in the DOWN trap, 7 more of the 15 were interrogated by the FDX fixed antennae array moving back downriver, yielding a minimum estimate of spawning ground survival of 87%.

All of the four adult fish captured in the DOWN trap that had been tagged this year at the UP trap scanned indicating that none had shed their tags between capture events. Similarly, both fish that had been tagged as adults in prior years and captured in both traps this year did not shed their tags between capture events. Three of five adipose-clipped adults (tagged as juveniles) that were captured in the DOWN trap did not scan; all three were females.

Table 3. Summary of detection data for juvenile (J) and adult (A) cutthroat trout PIT-tagged in previous years and either recaptured or interrogated by the FDX antenna array during migratory periods in Lake Creek in 2011. Lingering periods downstream of the UP trap were calculated from the time of initial interrogation to either recapture at the UP trap or apparent departure from the site. Departure was considered to be either the last detection day, or in the case where the penultimate (Penult) and last detection days were separated by at least a week, the penultimate detection day.

Tagging information			2011 initial capture data				Fish detected from 2007-2010		Array detections in 2011			Lingering periods	
Year	Life stage	Total length (mm)	Trap	Date	Sex	Total length (mm)	Years	Prior year	First day	Penult day	Last day	Elapsed days	Days detected
2005	J	147	.	.	.	.	3	2010	25-Mar	30-Mar	8-May	6	5
2005	J	146	.	.	.	.	4	2010	11-Apr	15-Apr	16-Apr	6	6
2007	J	173	.	.	.	.	2	2010	3-Apr	4-Apr	5-Apr	3	3
2007	J	178	.	.	.	.	.	.	20-Mar	21-Mar	25-Apr	2	2
2007	J	210	.	.	.	.	1	2009	26-Mar	28-Mar	29-Mar	4	4
2008	J	163	.	.	.	.	.	.	26-Mar	30-Mar	1-May	5	4
2008	J	153	Down	20-May	M	408	.	.	21-Mar	21-Mar	22-Mar	2	2
2008	J	160	.	.	.	.	.	.	10-Apr	10-Apr	11-Apr	2	2
2009	A	445	Down	13-Jun	M	445	.	.	31-Mar	.	31-Mar	1	1
2009	A	405	.	.	.	.	.	.	20-Mar	30-Mar	9-May	11	10
2009	A	392	Up	26-Apr	F	456	.	.	5-Apr	25-Apr	7-May	22	15
2009	A	407	.	.	.	.	.	.	1-Apr	4-Apr	5-Apr	5	4
2009	A	387	.	.	.	.	.	.	11-Apr	16-Apr	17-Apr	7	4
2009	A	340	.	.	.	.	.	.	24-Mar	29-Mar	19-Apr	6	6
2009	A	403	Up	25-Apr	F	406	1	2010	18-Apr	22-Apr	15-May	8	5
2009	A	367	.	.	.	.	1	2010	2-Apr	5-Apr	26-Apr	4	3
2009	A	369	.	.	.	.	1	2010	5-Apr	16-Apr	17-Apr	13	8
2009	A	384	.	.	.	.	1	2010	8-Apr	16-Apr	17-Apr	10	7
2009	A	425	.	.	.	.	.	.	15-Apr	23-Apr	28-Apr	14	10
2009	A	401	Down	16-Jun	F	409	.	.	5-Apr	26-Apr	16-Jun	22	19
2009	A	396	.	.	.	.	.	.	25-Mar	17-Apr	20-Apr	27	14
2009	A	368	.	.	.	.	.	.	24-Mar	30-Mar	29-Apr	7	7
2009	A	506	Up [a]	22-Apr	F	515	1	2010	16-Apr	20-Apr	21-Apr	7	6
2009	A	393	.	.	.	.	.	.	26-Mar	30-Mar	26-Apr	5	5
2009	A	378	Down	13-May	M	398	1	2010	27-Mar	28-Mar	30-Mar	4	3
2009	A	387	.	.	.	.	1	2010	25-Mar	29-Mar	1-May	5	4

[a] Also captured in the DN trap as a post-spawn adult

Table 3 – continued.

Tagging information			2011 initial capture data				Fish detected from 2007-2010		Array detections in 2011			Lingering periods	
Year	Life stage	Total length (mm)	Trap	Date	Sex	Total length (mm)	Years	Prior year	First day	Penult day	Last day	Elapsed days	Days detected
2009	A	404	.	.	.	.	.	.	17-Apr	22-Apr	23-Apr	7	7
2009	A	403	Down	13-May	F	396	1	2010	5-Apr	25-Apr	26-Apr	22	16
2009	A	364	.	.	.	.	.	.	2-Apr	2-Apr	8-May	1	1
2009	A	334	.	.	.	.	.	.	9-Apr	16-Apr	30-Apr	8	6
2009	A	368	.	.	.	.	.	.	3-Apr	5-Apr	28-Apr	3	3
2009	A	392	Up	12-Apr	F	407	.	.	7-Apr	11-Apr	1-May	6	5
2009	A	357	.	.	.	.	1	2010	27-Mar	30-Mar	25-Apr	4	2
2009	A	367	.	.	.	.	.	.	1-Apr	2-Apr	27-Apr	2	2
2009	A	351	Up	26-Apr	F	364	1	2010	20-Apr	25-Apr	6-May	7	6
2009	A	416	Down	24-Jun	M	418	.	.	3-Apr	26-Apr	24-Jun	24	24
2009	A	367	.	.	.	.	.	.	28-Mar	30-Mar	28-Apr	3	3
2009	A	383	Up	11-Apr	F	394	.	.	5-Apr	8-Apr	7-May	7	4
2009	A	344	Up [a]	26-Apr	M	371	.	.	5-Apr	24-Apr	25-Apr	22	21
2009	A	399	.	.	.	.	1	2010	1-Apr	2-Apr	2-May	2	2
2009	A	383	Down	15-May	M	395	.	.	24-Mar	27-Mar	30-Mar	7	5
2009	J	146	.	.	.	.	.	.	24-Mar	24-Mar	28-Apr	1	1
2009	J	172	.	.	.	.	.	.	12-Apr	14-Apr	15-Apr	4	4
2009	J	179	Down	24-May	F	321	.	.	10-Apr	16-Apr	17-Apr	8	6
2010	A	420	Down	9-Jun	M	425	.	.	22-May	.	22-May	1	1
2010	A	354	.	.	.	.	.	.	30-Apr	1-May	2-May	3	3
2010	A	381	.	.	.	.	.	.	31-Mar	2-Apr	9-May	3	3
2010	A	396	.	.	.	.	.	.	4-Apr	.	4-Apr	1	1
2010	A	435	.	.	.	.	.	.	25-Mar	30-Mar	8-May	6	6
2010	A	405	.	.	.	.	.	.	27-Mar	30-Mar	26-Apr	4	3
2010	A	306	.	.	.	.	.	.	10-May	11-May	14-May	5	3
2010	A	327	.	.	.	.	.	.	6-Apr	.	6-Apr	1	1

[a] Also captured in the DN trap as a post-spawn adult

Benewah Creek 2011

In 2011, the UP trap was installed at 9-mile bridge in the upper mainstem of Benewah Creek on January 28 and was no longer monitored after July 5 because of the absence of fish in the trap's live box. During this time the trap was checked a total of 99 d (63% of the deployment period) and was considered fishing 91% of the time that it was monitored. The UP trap was compromised during a brief high flow event on March 10 and during an extended high flow period from March 30 to April 6 (Figure 3) in which water was found flowing over the trap panels.

The DOWN trap was installed at 9-mile bridge on May 24 and was removed on July 5, yielding a deployment period of 42 d. During this time, the trap was checked a total of 23 d (55% of the deployment period) and was considered fishing most of the time. However, immediately after deployment a high flow event damaged some of the panels and the trap was rendered inoperable for a 5 d period while it was being repaired (Figure 3).

Adfluvial adult cutthroat trout were not captured at the Benewah 9-mile UP trap in 2011. However, twenty putative adfluvial adults that had been PIT-tagged in prior years were interrogated by the FDX fixed antenna array immediately downriver of the trap. Of these 20,

over half were first detected during the latter half of March during a period of high discharge and increasing water temperatures (Figure 3 and Figure 4). Two of the 20 were tagged as juveniles in 2008 with both classified as putative hybrids at time of tagging, and the remaining fish had been tagged as adults at the UP trap in 2010, with two of these assigned a hybrid status (Table 4).

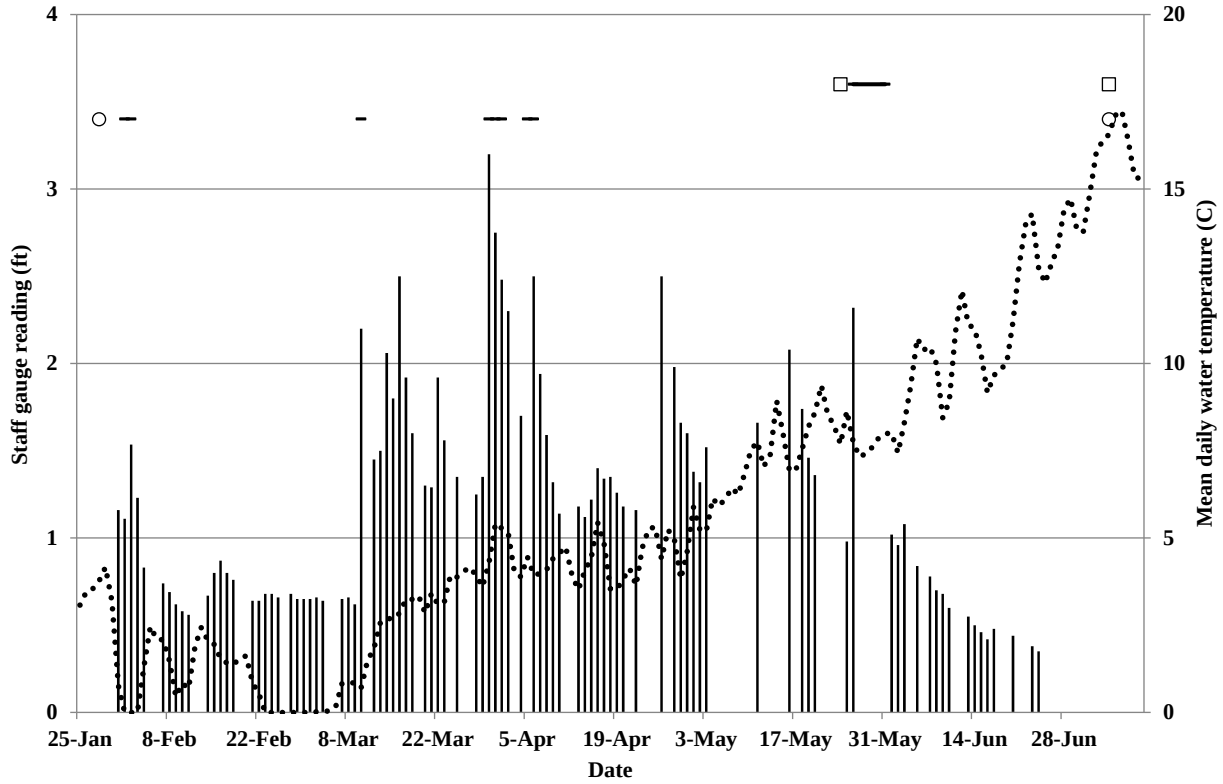


Figure 3. Gauge heights (vertical bars) and mean daily water temperatures (dotted line) collected at the UP trap in Benewah Creek from late January to early July, 2011. Open circles and squares at the top represent installation and removal dates for the UP and DOWN traps, respectively. Solid horizontal bars at the top, in line with their respective traps, indicate periods when traps were compromised.

The number of elapsed days in which PIT-tagged adults lingered downstream of the trap before their apparent departure from the UP trap site varied from 1 to 11 d, with 10 of the 20 fish lingering for more than 5 d (Table 4). For many of the PIT-tagged fish, the number of days of detection closely matched the elapsed period, indicating that fish were repeatedly detected daily while lingering downstream of the trap. Of the 20 detected fish, 15 were last interrogated before their apparent departure during the high flow period from March 30 to April 6 when water was observed to be flowing over the trap panels.

A total of 24 adfluvial adults was captured migrating downstream at the Benewah 9-mile DOWN trap site in 2011 (Table 2). Sixteen of the fish were actually captured by the trap and retrieved from the livebox. Five other fish were captured by electrofishing a short stream reach upstream of the trap, and three fish were found stranded on the panels of the UP trap with one of these found dead. Of the 24 fish, 14 were identified as females with a mean length of 384 mm and a

mean weight of 506 g, and 9 as males with a mean length of 372 mm and a mean weight of 464 g (the dead adult was eviscerated and decomposed beyond sex recognition). Four of the 24 adults were classified as hybrids based on external characteristics. Fish were captured from April 27 to July 5 (Figure 4). Though most fish were captured during June, the distribution of capture events does not likely reflect the distribution of post-spawn adult outmigration times because of the late timing of trap deployment.

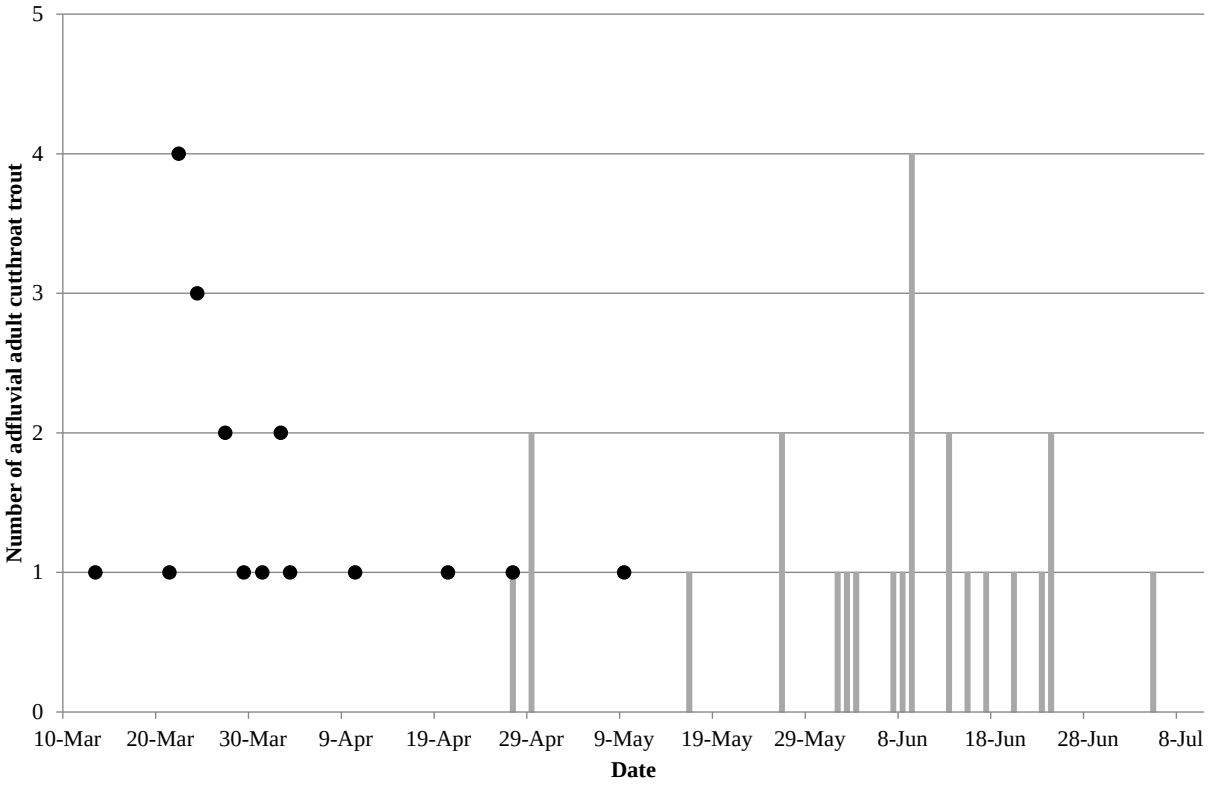


Figure 4. Timing of migratory adult adfluvial cutthroat trout in Benewah Creek in 2011. Vertical grey bars denote the number of descending fish captured. Black circles represent the number of PIT-tagged putative adfluvial adults initially interrogated at the FDX array at the UP trap site.

Given that fish were not available to be marked at the Benewah 9-mile UP trap, a mark-recapture spawner abundance estimate was not derivable for 2011. However, an estimate of the number of adults that ascended upriver and approached the UP trap could be derived, given that PIT tagged fish were available for detection and recapture. Using the number of antennae-interrogated fish that were PIT-tagged as adults in prior years as marks and the number of these PIT-tagged fish captured in the DOWN trap as recaptures in a mark-recapture model, 63 adults were estimated to have approached the UP trap (95% confidence interval, 34 – 93).

Table 4. Summary of detection data for juvenile (J) and adult (A) cutthroat trout PIT-tagged in previous years and either recaptured or interrogated by the FDX antenna array during migratory periods in Benewah Creek in 2011. Lingering periods downstream of the UP trap were calculated from the time of initial interrogation to either recapture at the UP trap or apparent departure from the site. Departure was considered to be either the last detection day, or in the case where the penultimate (Penult) and last detection days were separated by at least a week, the penultimate detection day.

Tagging information			2011 initial capture data				Fish detected from 2007-2010		Array detections in 2011			Lingering periods	
Year	Life stage	Total length (mm)	Trap	Date	Sex	Total length (mm)	Years	Prior year	First day	Penult day	Last day	Elapsed days	Days detected
2008	J	185 [a]	.	.	.	.	1	2010	22-Mar	29-Mar	30-Mar	9	9
2008	J	190 [a]	Down	24-Jun	F	445 [a]	1	2010	27-Mar	29-Mar	30-Mar	4	3
2010	A	374	.	.	.	.	.	.	9-May	9-May	10-May	2	2
2010	A	416	.	.	.	.	.	.	24-Mar	30-Mar	26-Apr	7	7
2010	A	422	Down	9-Jun	F	450 [a]	.	.	22-Mar	30-Mar	9-Jun	9	9
2010	A	403	Other [b]	16-May	U	.	.	.	22-Mar	29-Mar	30-Mar	9	9
2010	A	356	.	.	.	.	.	.	2-Apr	4-Apr	5-Apr	4	4
2010	A	370	Down	3-Jun	M	388	.	.	24-Mar	29-Mar	30-Mar	7	6
2010	A	434	Down	7-Jun	F	452	.	.	22-Mar	29-Mar	30-Mar	9	9
2010	A	411	Down	9-Jun	M	405	.	.	10-Apr	10-Apr	9-Jun	1	1
2010	A	400	.	.	.	.	.	.	29-Mar	30-Mar	16-May	2	2
2010	A	354	.	.	.	.	.	.	24-Mar	30-Mar	26-Apr	7	6
2010	A	396	.	.	.	.	.	.	3-Apr	5-Apr	26-Apr	3	3
2010	A	434	.	.	.	.	.	.	27-Mar	29-Mar	30-Mar	4	4
2010	A	369	.	.	.	.	.	.	13-Mar	18-Mar	23-Mar	11	3
2010	A	410	.	.	.	.	.	.	2-Apr	5-Apr	26-Apr	4	4
2010	A	420 [a]	.	.	.	.	.	.	20-Apr	25-Apr	26-Apr	7	7
2010	A	385 [a]	Other [c]	27-Apr	F	421	.	.	27-Apr	.	27-Apr	.	.
2010	A	365	.	.	.	.	.	.	31-Mar	.	31-Mar	1	1
2010	A	342	Other [c]	9-Jun	M	348	.	.	21-Mar	30-Mar	9-Jun	10	10

[a] Classified as a putative hybrid
[b] Found dead on floating RBW panels
[c] Captured by shocking between the Up and Down traps

Lake Creek 2012

In 2012, the UP trap in the mainstem of Lake Creek was installed on March 20 and was removed on May 12, yielding a deployment period of 53 d. During this time the trap was checked a total of 45 d (85% of the days) and was considered fishing 69% of the time that it was monitored (Figure 5). The UP trap was compromised during an extended, high flow event from March 27 to April 2, in which panels were lowered to the stream bed to prevent damage to the panels and to minimize scouring to the stream bed. On several other occasions on April 13 and April 26, the panels were intentionally lowered to the stream bed to permit ascending adults to freely pass. Trap panels were again lowered on May 8, and remained lowered until their removal date.

The DOWN trap was installed in Lake Creek on May 3 and was removed on June 29, yielding a deployment period of 57 d. During this time, the trap was checked a total of 42 d (74% of the days) and was considered fishing approximately 88% of the time it was monitored (Figure 5). The DOWN trap was compromised during high flow events from June 6 to June 11 and on June

26, a couple days before the trap was removed. In most cases, pop-outs were pulled in anticipation of these rain-induced high flow events to minimize damage to the trap.

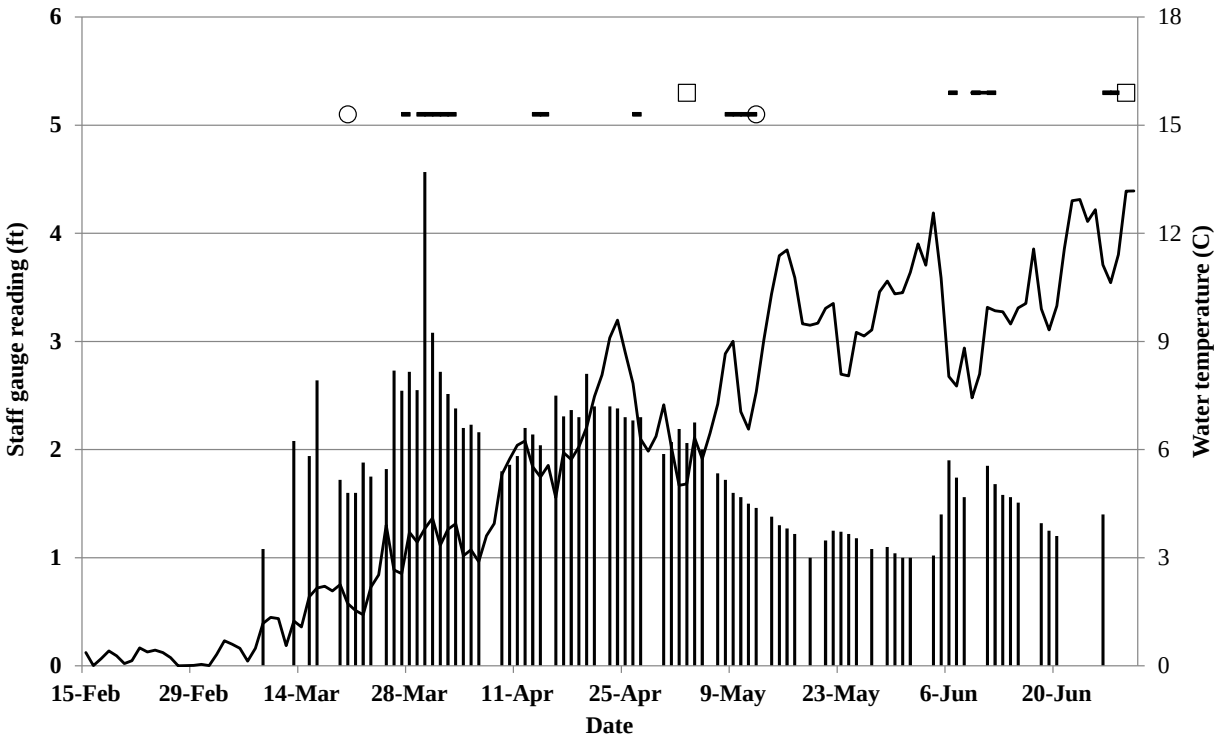


Figure 5. Gauge heights (vertical bars) and mean daily water temperatures (solid line) collected at the UP trap in Lake Creek from mid-February to late June, 2012. Open circles and squares at the top represent installation and removal dates for the UP and DOWN traps, respectively. Solid horizontal bars at the top, in line with their respective traps, indicate periods when traps were compromised.

A total of 121 adfluvial adult cutthroat trout was captured ascending upriver in 2012, with all but one of these retrieved from the UP trap's livebox (Table 5). The other fish was found lodged between the wall of the livebox and the bridge, and released upriver as an ascending spawner. Ninety-seven (80%) of the fish were identified as females with a mean length and weight of 351 mm and 385 g, respectively. The other 24 fish were identified as males with a mean length and weight of 385 mm and 511 g, respectively. All of the 121 fish received an opercle punch, with 96 of these receiving a PIT-tag. Fish were captured from March 27 to May 1, with 73 of the 121 (60%) captured from April 9 to April 13 during a period in which water temperatures were increasing and in excess of 3°C (Figure 6).

Seventy-one putative adfluvial adults that were PIT-tagged in prior years were interrogated by the FDX fixed antenna array in Lake Creek in 2012 (Table 6). Fifty-two of these fish (73%) were first detected from March 24 to April 9 (Figure 6), a timeframe that encompassed a period of high discharge. Thirty-three of the 71 fish were tagged as juveniles, with 1, 4, 6, and 22 respectively tagged from 2007 to 2010. Five of the eleven fish tagged from 2007 to 2009 were also detected in 2011 where they were either captured or presumed to be a migratory adult. Thirty-eight of the 71 detected fish were tagged as adults in prior years, with 20, 15 and 3

respectively tagged from 2009 to 2011. Of those tagged in 2009, all were detected in 2011 with six of these also detected in 2010. Five of the 15 adults that were tagged in 2010 were also detected in 2011. Of the 17 fish that were tagged in prior years as adults and captured in 2012, 12 (71%) exhibited growth increments that did not exceed 30 mm, even including those fish that had been at large for three years since tagging (Table 6).

Table 5. Length, weight, and condition factor means and standard deviations (SD) for adult adfluvial cutthroat trout with sex determined that were captured during their upriver and downriver migrations in Lake and Benewah creeks in 2012.

		Total length (mm)			Weight (g)		Condition factor	
Gender	**N**	**Range**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
				Lake Creek upriver				
Female	97	290 - 442	350.5	28.9	385.1	99.0	0.88	0.06
Male	24	296 - 436	384.8	36.7	511.4	137.6	0.88	0.06
				Lake Creek downriver [a]				
Female	92	250 - 429	347.7	32.6	336.7	103.7	0.78	0.08
Male	45	318 - 525	378.2	36.5	473.7	168.9	0.86	0.17
				Benewah Creek 9-mile downriver				
Female	8	293 - 448	354.5	60.3	416.0	180.9	0.90	0.12
Male	4	335 - 501	424.0	77.8	650.5	330.8	0.79	0.01
				Benewah Creek Hwy 5 downriver				
Female	11	304 - 505	403.3	73.7	618.2	282.6	0.88	0.09
Male	6	375 - 560	449.2	72.7	741.4	285.4	0.84	0.08

[a] One other fish was dropped at the livebox before processing

The number of elapsed days in which PIT-tagged adults lingered downstream of the trap before either their capture or departure from the UP trap site varied from 1 to 12 d, with 29 of the 71 fish (41%) lingering for at least 5 d (Table 6). For many of the PIT-tagged fish, the number of days of detection closely matched the elapsed period, indicating that fish were repeatedly detected daily while lingering downstream of the trap. Of the 50 PIT-tagged adults not captured in the UP trap, 21 and 17 were respectively last interrogated before their apparent departure from the UP trap site during periods from March 28 to April 2 and April 13 to April 14 in which panels were lowered because of high levels of discharge or to permit fish to ascend. Of fish that were captured at the UP trap, five were from the group of fish tagged as juveniles in 2010 (23% of the 22 fish), and 10 were from fish that were tagged as adults in 2009-2011 (26% of the 38 fish). Using the number of PIT-tagged fish that were interrogated by the antennae array as marks and the number of these PIT-tagged fish captured in the UP trap as recaptures in a mark-recapture model, an estimate of 398 was obtained for adults that ascended upriver to the UP trap (95% confidence interval, 275 – 521).

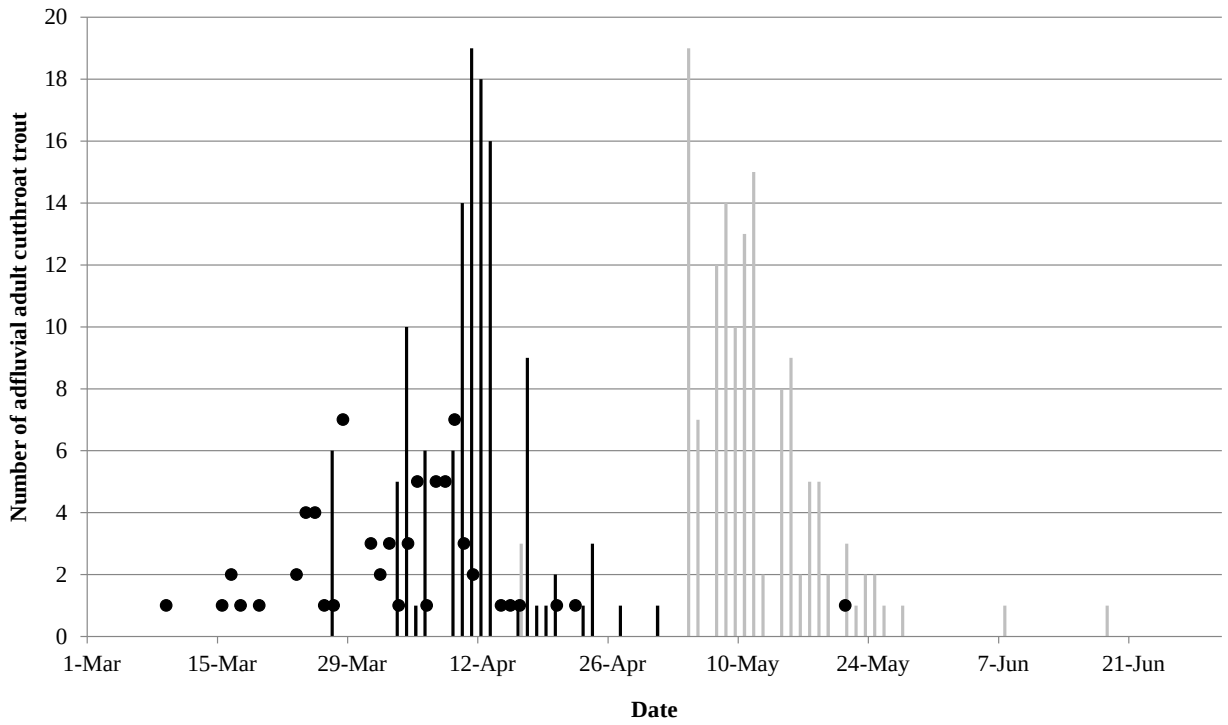


Figure 6. Timing of migratory adult adfluvial cutthroat trout in Lake Creek in 2012. Black and grey bars respectively denote the number of ascending and descending fish captured. Black circles represent the number of PIT-tagged putative adfluvial adults initially interrogated at the FDX array at the UP trap site.

A total of 138 adfluvial adults was captured descending back downriver in Lake Creek in 2012 (Table 5). One hundred and twenty-nine were retrieved from the livebox of the DOWN trap, 7 were captured using dipnets from the reach between the two migrant traps, one was found dead impinged upon a panel of the DOWN trap, and another was found dead lodged between pickets of an UP trap panel. Of the 137 fish that were processed, 92 (67%) were identified as females with a mean length of 348 mm and a mean weight of 337 g, and 45 as males with a mean length of 378 mm and a mean weight of 474 g. The mean condition factor was noticeably lower for females captured in the DOWN trap (0.78) than for females caught in the UP trap (0.88), indicating than many of the outmigrating females likely spawned. Most of the fish (84%) were captured during the first two weeks of trap deployment from May 4 to May 17 (Figure 6). However, given that the largest daily catch of 19 fish occurred the day after the trap was installed, a considerable number of post-spawn adults likely outmigrated prior to trap deployment.

Table 6. Summary of detection data for juvenile (J) and adult (A) cutthroat trout PIT-tagged in previous years and either recaptured or interrogated by the FDX antenna array during migratory periods in Lake Creek in 2012. Lingering periods downstream of the UP trap were calculated from the time of initial interrogation to either recapture at the UP trap or apparent departure from the site. Departure was considered to be either the last detection day, or in the case where the penultimate (Penult) and last detection days were separated by at least a week, the penultimate detection day.

Tagging information			2012 initial capture data				Fish detected from 2008-2011		Array detections in 2012			Lingering periods	
Year	Life stage	Total length (mm)	Trap	Date	Sex	Total length (mm)	Years	Prior year	First day	Penult day	Last day	Elapsed days	Days detected
2007	J	178	UP	Mar-27	F	414	1	2011	Mar-24	Mar-25	Mar-26	4	3
2008	J	127	UP	Apr-12	F	358	.	.	Apr-08	Apr-10	Apr-11	5	4
2008	J	163	.	.	.	.	1	2011	Mar-24	Mar-28	Apr-30	5	5
2008	J	153	UP	Apr-12	M	409	1	2011	Apr-04	Apr-10	Apr-11	9	8
2008	J	152	.	.	.	.	.	.	Apr-07	Apr-11	May-02	5	5
2009	A	392	.	.	.	.	1	2011	May-21	May-21	May-29	1	1
2009	A	506	.	.	.	.	2	2011	Apr-08	Apr-13	May-08	6	6
2009	A	392	UP	Apr-13	F	414	1	2011	Apr-05	Apr-12	Apr-26	9	8
2009	A	393	.	.	.	.	1	2011	Mar-31	Mar-31	May-08	1	1
2009	A	340	.	.	.	.	1	2011	Apr-03	Apr-13	May-02	11	10
2009	A	387	UP	Mar-27	F	411	2	2011	Mar-25	Mar-25	Mar-26	3	2
2009	A	404	DOWN	May-11	F	409	1	2011	Apr-10	Apr-12	Apr-13	4	4
2009	A	357	DOWN	May-08	F	377	2	2011	Mar-24	Mar-26	Mar-29	6	4
2009	A	364	UP	Apr-12	F	391	1	2011	Apr-10	Apr-11	May-10	3	2
2009	A	334	UP	Apr-12	F	365	1	2011	Apr-10	Apr-11	Apr-26	3	2
2009	A	368	.	.	.	.	1	2011	Apr-02	Apr-13	May-08	12	11
2009	A	351	UP	Apr-11	F	371	2	2011	Apr-11	Apr-11	Apr-26	1	1
2009	A	405	.	.	.	.	1	2011	Mar-25	Mar-27	Mar-30	6	4
2009	A	378	UP	Mar-27	M	412	2	2011	Mar-24	Mar-26	May-14	4	3
2009	A	387	.	.	.	.	1	2011	Apr-09	Apr-09	Apr-21	1	1
2009	A	445	UP	Apr-12	M	436	1	2011	Apr-09	Apr-11	May-17	4	3
2009	A	396	.	.	.	.	1	2011	Apr-07	Apr-11	Apr-12	6	5
2009	A	344	DOWN	May-10	M	385	1	2011	Apr-01	.	Apr-01	1	1
2009	A	399	UP	Apr-11	M	422	2	2011	Apr-08	Apr-09	Apr-10	4	3
2009	A	383	.	.	.	.	1	2011	Apr-02	Apr-13	May-10	12	10
2009	J	112	.	.	.	.	.	.	Mar-26	Mar-28	May-02	3	3
2009	J	153	UP	Apr-05	F	354	.	.	Apr-04	Apr-04	May-08	2	1
2009	J	155	UP	Apr-11	F	381	.	.	Apr-08	Apr-09	Apr-10	4	3
2009	J	146	DOWN	May-08	M	332	1	2011	Mar-15	.	Mar-15	1	1
2009	J	154	DOWN	May-04	M	349	.	.	Mar-28	Mar-28	Mar-29	2	2
2009	J	179	UP	Apr-17	F	341	1	2011	Apr-15	Apr-15	Apr-16	3	2
2010	A	332	UP	Apr-24	F	362	.	.	Apr-22	Apr-22	Apr-23	3	2
2010	A	405	DOWN	May-04	F	429	1	2011	Mar-25	Mar-28	Mar-29	5	5
2010	A	341	.	.	.	.	.	.	Mar-31	Mar-31	Apr-24	1	1
2010	A	341	.	.	.	.	.	.	Mar-28	Mar-29	May-08	2	2

[a] Fish found dead impinged on one of the screens of the DOWN trap

[b] Classified as a resident fish

Table 6 – Continued.

Tagging information			2012 initial capture data				Fish detected from 2008-2011		Array detections in 2012			Lingering periods	
Year	Life stage	Total length (mm)	Trap	Date	Sex	Total length (mm)	Years	Prior year	First day	Penult day	Last day	Elapsed days	Days detected
2010	A	344	.	.	.	.	.	.	Mar-17	.	Mar-17	1	1
2010	A	381	.	.	.	.	.	.	Mar-16	Mar-16	Apr-24	1	1
2010	A	334	.	.	.	.	.	.	Apr-04	Apr-13	Apr-26	10	9
2010	A	332	DOWN	May-09	F	368	.	.	Mar-28	Mar-28	Mar-29	2	2
2010	A	420	DOWN	May-04	M	427	1	2011	Mar-27	Mar-27	Mar-28	2	2
2010	A	359	DOWN	May-19	M	400	.	.	Apr-02	Apr-12	Apr-13	12	11
2010	A	381	.	.	.	.	1	2011	Mar-31	Mar-31	May-20	1	1
2010	A	382	.	.	.	.	.	.	Mar-09	.	Mar-09	1	1
2010	A	306	.	.	.	.	1	2011	Apr-20	Apr-24	Apr-25	6	6
2010	A	435	.	.	.	.	1	2011	Mar-28	Mar-28	May-08	1	1
2010	A	339	.	.	.	.	.	.	Apr-01	.	Apr-01	1	1
2010	J	155	.	.	.	.	.	.	Mar-28	Mar-28	Mar-29	2	2
2010	J	223	DOWN	May-24	F	342	.	.	Apr-09	Apr-12	Apr-13	5	5
2010	J	187	UP	Apr-10	F	358	.	.	Apr-07	Apr-09	Apr-26	4	3
2010	J	175	.	.	.	.	.	.	Mar-23	Mar-27	Mar-28	6	6
2010	J	201	OTHER	May-10	F	340 [a]	.	.	Apr-06	Apr-12	Apr-13	8	8
2010	J	203	UP	Apr-17	F	335	.	.	Apr-14	Apr-15	Apr-16	4	3
2010	J	138	.	.	.	.	.	.	Mar-28	Mar-28	Mar-29	2	2
2010	J	156	.	.	.	.	.	.	Mar-16	Mar-16	May-09	1	1
2010	J	161	.	.	.	.	.	.	Apr-07	Apr-10	Apr-26	4	4
2010	J	203	.	.	.	.	.	.	Apr-08	Apr-13	May-02	6	6
2010	J	186	.	.	.	.	.	.	Mar-28	Mar-28	Mar-29	2	2
2010	J	230	.	.	.	.	.	.	Apr-05	Apr-13	Apr-23	9	9
2010	J	192	.	.	.	.	.	.	Mar-25	Mar-31	Apr-26	7	3
2010	J	164	UP	Apr-17	F	327	.	.	Apr-16	.	Apr-16	2	1
2010	J	209	.	.	.	.	.	.	Apr-05	Apr-13	May-02	9	9
2010	J	181	UP	Apr-11	F	371	.	.	Apr-09	Apr-09	Apr-10	3	2
2010	J	198	UP	Apr-10	M	345	.	.	Apr-07	Apr-08	Apr-09	4	3
2010	J	165	.	.	.	.	.	.	Apr-09	Apr-12	Apr-13	5	5
2010	J	134	DOWN	May-18	U	. [b]	1	2011	Mar-23	Mar-23	May-18	1	1
2010	J	160	.	.	.	.	.	.	Mar-19	Mar-27	Mar-28	10	6
2010	J	132	.	.	.	.	1	2011	Apr-09	.	Apr-09	1	1
2010	J	168	.	.	.	.	.	.	Apr-11	Apr-12	Apr-13	3	3
2011	A	315	.	.	.	.	.	.	Apr-09	Apr-13	May-08	5	5
2011	A	345	UP	Apr-13	F	361	.	.	Apr-05	Apr-12	Apr-26	9	7
2011	A	387	.	.	.	.	.	.	Apr-05	Apr-13	May-08	9	7

[a] Fish found dead impinged on one of the screens of the DOWN trap

[b] Classified as a resident fish

Forty of the 137 adults that were captured and processed as they were descending downstream had a detectable opercle punch, yielding a spawner abundance estimate of 410 fish (95% confidence interval, 325 – 495). This estimate was comparable to that derived using interrogated PIT-tagged fish for the number of adults that ascended up to the UP trap site. In addition to the 40 opercle-punched fish, 46 more fish that had been captured at the UP trap and either received

or had PIT-tags were interrogated by the FDX fixed array as they apparently descended back downriver, yielding a minimum estimate of spawning ground survival of 71%. All three of the fish that had been PIT-tagged as adults in prior years, and captured ascending and descending this year, retained their tags. One of the five adipose-clipped fish that were captured ascending and descending this year did not scan, which yielded an estimated 20% tag loss on the spawning grounds for this group of fish tagged as juveniles. Of the 32 re-captured descending adults that had been PIT-tagged this year at the UP trap, 13 did not scan which yielded an estimated percent tag loss of 40.6% for this group of tagged fish. Notably, 12 of the 13 were females. After accounting for the considerable estimate of tag loss of the 96 adult fish PIT-tagged this year, an adjusted spawning ground survival rate estimate of 92% was derived.

Over the years 2010-2012, 40 of the 105 adults that were PIT-tagged in 2009 have been either interrogated or detected in migrant traps (Table 7). Given the tag retention estimate of 88% that was generated for this group of tagged adults (Firehammer et al. 2011), 92 of the 105 fish tagged in 2009 were estimated to be available to be detected in subsequent years. As a result, 43.5% of the 2009 spawners (i.e., 40 of 93) were estimated to have survived to spawn again at least once. Of the 40 adults, 18 were first detected in 2010 with 11 of the 18 (61%) detected again in 2011 and 6 of the 11 (55%) also detected in 2012. The other 22 adults were first detected in 2011 with 14 of these fish (64%) also detected in 2012.

Over the years 2011-2012, 18 of the 83 adults that were PIT-tagged in 2010 have been either interrogated or detected in migrant traps (Table 7). Given the tag retention estimate of 70% that was generated for this group of tagged adults (Firehammer et al. 2012), 58 of the 83 fish tagged in 2010 were estimated to be available to be detected in subsequent years. As a result, 31% of the 2010 spawners were estimated to have survived to spawn again at least once. Of the 18 adults, 8 were detected in 2011 with 5 of these fish (63%) also detected in 2012.

Table 7. Return rates of juvenile and adult adfluvial cutthroat trout PIT-tagged in Lake and Benewah creeks from 2005 to 2010. The number of adults estimated to be available for detection was discounted by the tag retention estimates in their respective year of tagging.

	Juveniles		Adults			
Tagging Year	Tagged	Returned (%)	Tagged	Percent tag retention	Estimated available for detection	Returned (%)
			Lake Creek			
2005	683	14 (2.0)	.	.	.	.
2006	798	10 (1.3)	.	.	.	.
2007	788	15 (1.9)	.	.	.	.
2008	632	8 (1.3)	.	.	.	.
2009	715	7 (1.0)	105	88	92	40 (43.5)
2010	998	26 (2.6)	83	70	58	18 (31.0)
Total	**4614**	**80 (1.7)**	.	.	.	.
			Benewah Creek			
2008	213	6 (2.8)	.	.	.	.
2009	101	2 (2.0)	.	.	.	.
2010	194	3 (1.5)	66	84	55	19 (34.5)
Total	**508**	**11 (2.2)**	.	.	.	.

Benewah Creek 2012

In 2012, the UP trap at 9-mile bridge in the upper mainstem of Benewah Creek was installed on February 17 and was no longer monitored after June 15 because of the absence of fish in the trap's livebox. During this time the trap was checked a total of 47 d (40% of the deployment period) and was considered fishing 62% of the time that it was monitored (Figure 7). The UP trap was compromised during brief rain-induced, high discharge events on March 13-16 and from March 30 to April 2 in which water was observed to be flowing over the trap panels. During other periods from April 18 to April 20 and from April 26 to May 21, the delivery tube that guided ascending adults from the raceway to the livebox was pulled to permit fish to freely pass unobstructed.

The DOWN trap at 9-mile bridge was installed on May 16 and was removed on June 15, yielding a deployment period of 30 d. During this time, the trap was checked a total of 18 d (60% of the deployment period) and was considered fishing only 50% of the time (Figure 7). A brief rain-induced high flow event on May 24-25 scoured out a hole underneath one of the panels that was quickly addressed. However, another heavy rain event on June 5 severely damaged the panels, and flows were not conducive for repairs rendering the trap inoperable the remaining 10 d before removal.

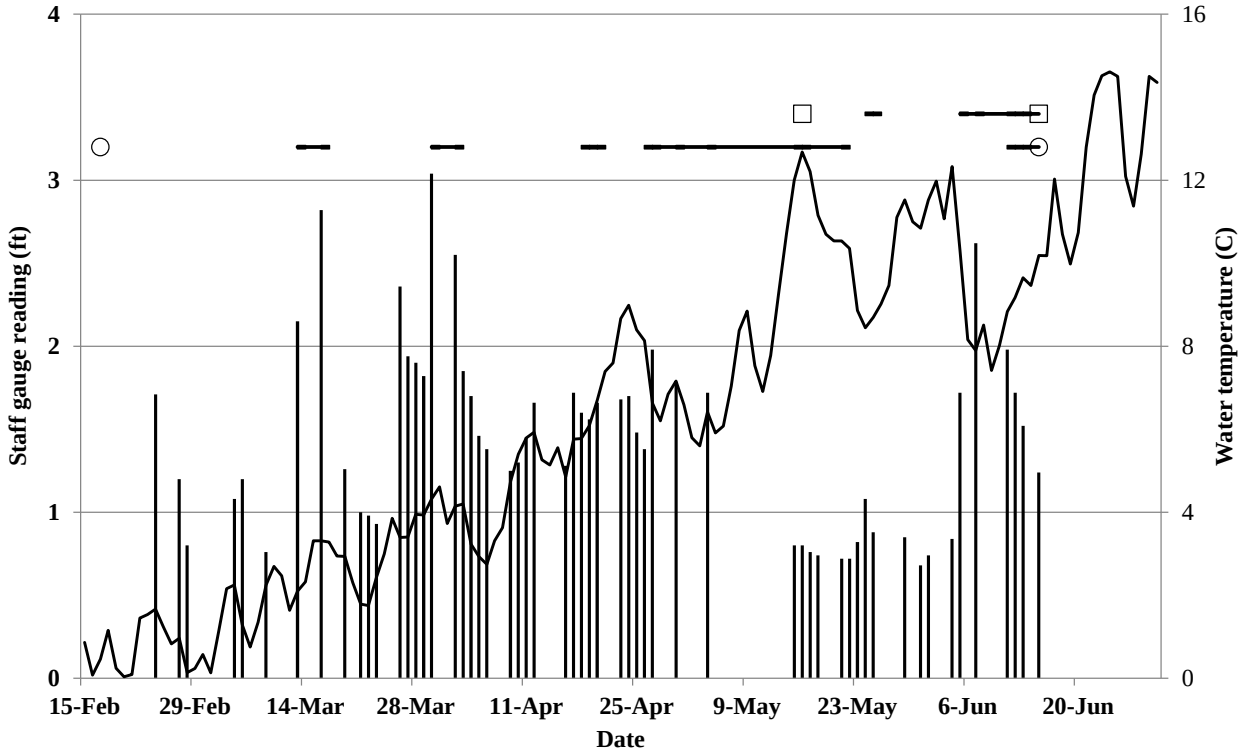


Figure 7. Gauge heights (vertical bars) and mean daily water temperatures (solid line) collected at the UP trap in Benewah Creek from mid-February to late June, 2012. Open circles and squares at the top represent installation and removal dates for the UP and DOWN traps, respectively. Solid horizontal bars at the top, in line with their respective traps, indicate periods when traps were compromised.

The adult migrant trap at the Hwy 5 bridge on the lower Benewah mainstem was operational on May 14 and was removed on June 22, yielding a deployment period of 39 d. A heavy rain event that began on June 5th increased discharge considerably and loaded the guide fence with debris so that water was flowing over the fence rendering it ineffective for diverting fish towards the livebox. High levels of discharge prevented repairs to the guide fence until June 15 when the fence was cleaned and considered operational until its removal on June 22.

Only two adfluvial adult cutthroat trout were captured at the Benewah 9-mile trap site ascending upriver in 2012. One female, 516 mm in length, was captured on March 28, and the other fish, a female 375 mm long, was captured on April 11. Thirteen putative adfluvial adults that had been PIT-tagged in prior years were interrogated by the FDX fixed antenna array immediately downriver of the trap (Figure 8). Of these 13, 9 were first detected from April 8 to April 22, during a period when mean daily water temperatures were increasing from 4 to 8 ^{o}C. Two and three of the 13 were tagged as juveniles in 2009 and 2010, respectively; the other eight fish were tagged as adults in 2010 (Table 8).

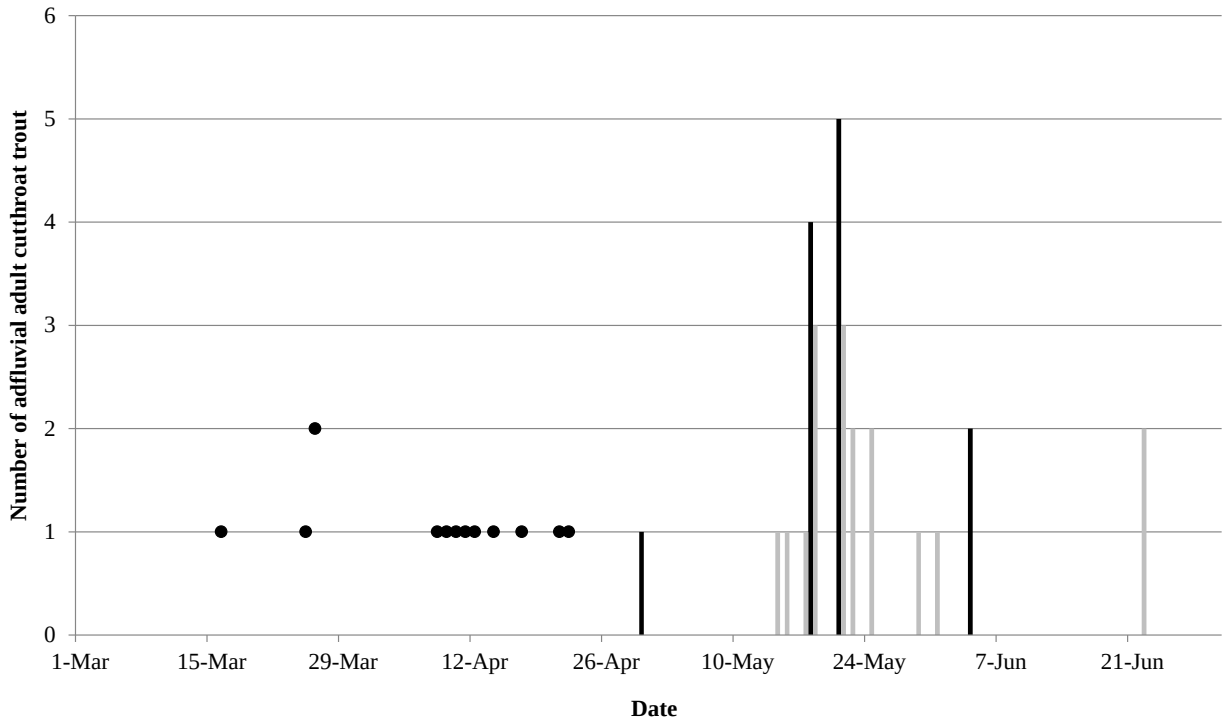


Figure 8. Timing of migratory adult adfluvial cutthroat trout in Benewah Creek in 2012. Black and grey bars respectively denote the number of descending fish captured at the 9-mile and Hwy 5 traps, respectively. Black circles represent the number of PIT-tagged putative adfluvial adults initially interrogated at the FDX array at the 9-mile trap site.

Table 8. Summary of detection data for juvenile (J) and adult (A) cutthroat trout PIT-tagged in previous years and either recaptured or interrogated by the FDX antenna array during migratory periods in Benewah Creek in 2012. Lingering periods downstream of the UP trap were calculated from the time of initial interrogation to either recapture at the UP trap or apparent departure from the site. Departure was considered to be either the last detection day, or in the case where the penultimate (Penult) and last detection days were separated by at least a week, the penultimate detection day.

Tagging information			2012 initial capture data				Fish detected from 2008-2011		Array detections in 2012			Lingering periods	
Year	Life stage	Total length (mm)	Trap	Date	Sex	Total length (mm)	Years	Prior year	First day	Penult day	Last day	Elapsed days	Days detected
2009	J	150	.	.	.	.	1	2010	Apr-09	Apr-18	Apr-19	11	11
2009	J	161	.	.	.	.	.	.	Apr-21	Apr-25	Apr-26	6	6
2010	A	410	.	.	.	.	1	2011	Apr-14	Apr-17	Apr-18	5	5
2010	A	434	.	.	.	.	1	2011	Mar-25	Mar-30	Apr-21	6	6
2010	A	385 [a]	OTHER	Apr-30	F	445 [a,b]	1	2011	Apr-17	Apr-18	Apr-30	2	2
2010	A	396	.	.	.	.	1	2011	Apr-08	Apr-19	Apr-26	12	12
2010	A	354	.	.	.	.	1	2011	Mar-26	Mar-30	Apr-25	5	5
2010	A	416	.	.	.	.	1	2011	Mar-26	Mar-30	Apr-30	5	4
2010	A	367	.	.	.	.	.	.	Apr-10	Apr-18	Apr-26	9	6
2010	A	369	.	.	.	.	1	2011	Mar-16	Apr-22	Apr-23	39	5
2010	J	134	.	.	.	.	1	2011	Apr-11	.	Apr-11	1	1
2010	J	130	.	.	.	.	.	.	Apr-22	Apr-25	Apr-26	5	5
2010	J	136	.	.	.	.	1	2011	Apr-12	Apr-16	Apr-17	6	5

[a] Classified as a putative hybrid

[b] Found in the livebox partition that was open to the stream channel and available to free-swimming fish

The number of elapsed days in which PIT-tagged adults lingered downstream of the trap before their apparent departure from the UP trap site varied from 1 to 39 d, with 12 of the 13 fish lingering for at least 5 d (Table 8). For many of the PIT-tagged fish, the number of days of detection closely matched the elapsed period, indicating that fish were repeatedly detected daily while lingering downstream of the trap. Of the 13 detected fish, 3 were last interrogated before their apparent departure during the high flow period from March 30 to April 2 when water was observed to be flowing over the trap panels. Another seven of the 13 were last interrogated after the livebox delivery tube had been pulled to permit unobstructed upstream passage.

A total of 12 adfluvial adults was captured migrating downstream at the Benewah 9-mile DOWN trap site in 2012 (Table 5). Of the 12 fish, eight were identified as females with a mean length of 355 mm and a mean weight of 416 g, and four as males with a mean length of 424 mm and a mean weight of 651 g. Eight of the 12 fish were classified as hybrids based on external characteristics. Both of the captured PIT-tagged fish that were considered hybrids were also classified as hybrids at the time of tagging in prior years. Most of the descending adults were captured in May (Figure 8), though the distribution of capture events does not likely reflect the distribution of post-spawn adult outmigration times because of the late timing of trap deployment. An adult abundance estimate could not be generated in 2012 because of the lack of marked and recaptured fish.

A total of 17 adfluvial adults was captured migrating downstream at the Benewah Hwy 5 adult trap site in 2012 (Table 5). Fourteen were retrieved from the livebox, and three were found dead stranded on the floating panels of the trap apparently attempting to negotiate the trap as they were descending downstream (the mortalities occurred prior to the installation of the guide fence) . Of the 17 adults, 11 were identified as females with a mean length of 403 mm and a mean weight of 618 g, and 6 as males with a mean length of 449 mm and a mean weight of 741 g. Two of the three adults found dead on the panels were classified as hybrids; these two fish of 505 and 560 mm were the longest fish measured of those captured at the site. Most of the descending adults were captured in May (Figure 8), though the trap was not fully functional for much of the spring migration period so that the distribution of capture events likely does not reflect the distribution of outmigration times for post-spawn adults.

Over the years 2011-2012, 19 of the 66 adults that were PIT-tagged in 2010 have been either interrogated or detected in migrant traps (Table 7). Given the tag retention estimate of 84% that was generated for this group of tagged adults (Firehammer et al. 2012), 55 of the 66 fish tagged in 2010 were estimated to be available to be detected in subsequent years. As a result, 34.5% of the 2010 spawners (i.e., 19 of 55) were estimated to have survived to spawn again at least once. Of the 19 adults, 18 were first detected in 2011 with 7 of these fish (39%) also detected in 2012.

3.3.1.2 Assess the status and trend of juvenile abundance and productivity of natural origin fish populations

Lake Creek 2011

In 2011, a total of 575 juvenile adfluvial cutthroat trout was captured in the DOWN trap in Lake Creek. Juveniles were captured from May 6 to July 5, with approximately 70% of the fish captured in June (Figure 9). Juveniles were captured sporadically in the month of May, though trap efficiency during this time was severely compromised because of intermittent high flow periods. Therefore, the distribution of capture events for juveniles in combination with the late trap installation likely does not reflect the timing distribution of the juvenile outmigrant cohort. The average size of adfluvial juveniles in Lake Creek during 2011 remained relatively similar throughout the period in which they were captured (Figure 10). Seven day moving averages of the total length of juveniles generally ranged between 155 and 160 mm during May and June.

Of the 575 juveniles captured, 219 (38%) received PIT tags. Generally, fish were tagged representatively throughout the period in which they were being captured as supported by the similarity in the cumulative distribution curves for PIT-tagged juveniles and all captured juveniles (Figure 9). In addition, the length distribution of PIT-tagged adfluvial juveniles was similar to that for all juveniles captured in the DOWN trap, with 71-74% of both groups ranging between 141 and 180 mm in total length (Table 9). Nineteen other fish captured in the DOWN trap were classified as likely residents given their external markings. Mean total length of these fish was 210 mm. Seven of the 19 purported resident cutthroat trout received PIT tags.

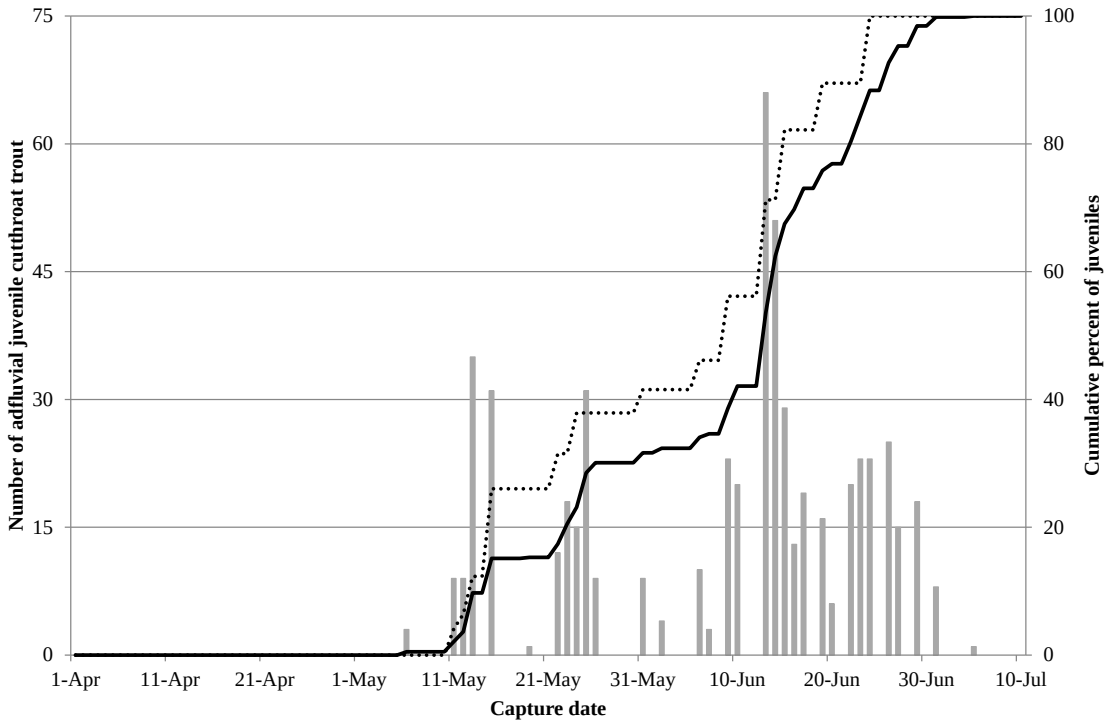


Figure 9. Timing of juvenile adfluvial cutthroat trout captured during the outmigration period in Lake Creek in 2011. Numbers of juveniles (gray bars) along with the cumulative distribution curves for all captured juveniles (solid line) and PIT-tagged juveniles (dotted line) are presented.

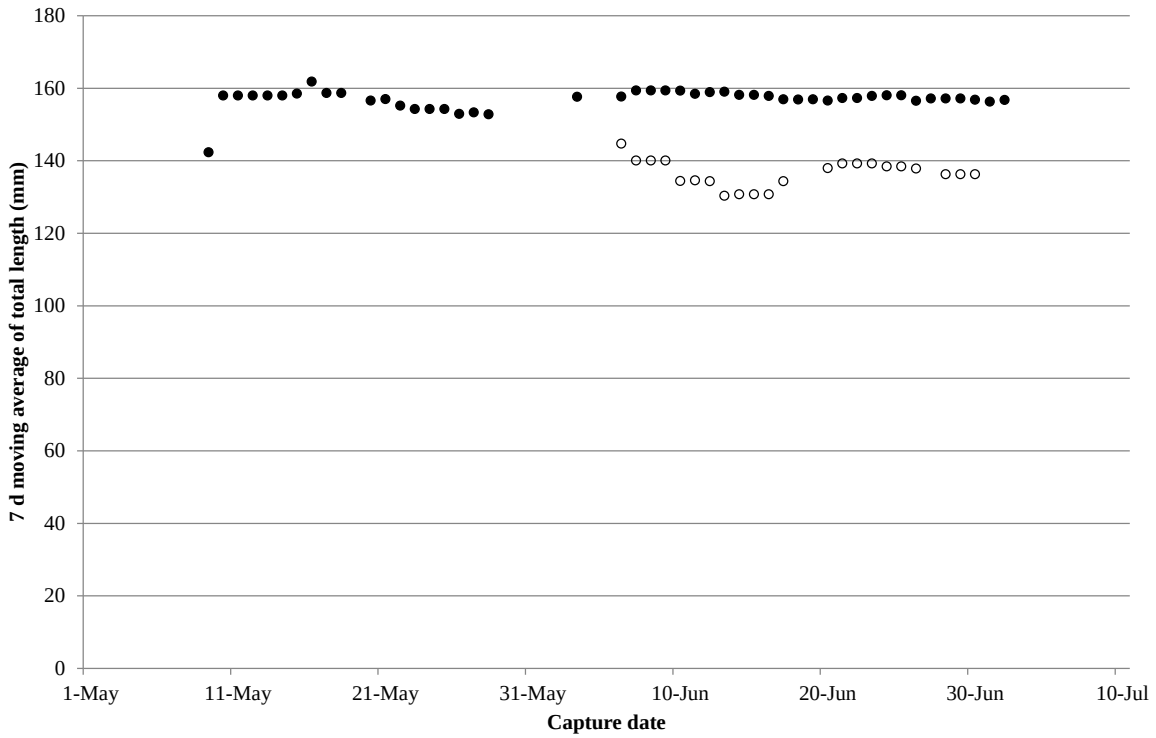


Figure 10. Seven day moving averages of total length (mm) for adfluvial juvenile cutthroat trout captured in the Lake Creek outmigrant trap (filled circles) and the Benewah 9-mile outmigrant trap (open circles) in 2011.

Table 9. Number and percent of adfluvial juvenile cutthroat trout captured and PIT-tagged of various size classes in Lake and Benewah creeks in 2011.

	Lake Creek				Benewah Creek			
	All juveniles		Tagged juveniles		All juveniles		Tagged juveniles	
Length group (mm)	Number	Percent	Number	Percent	Number	Percent	Number	Percent
81 - 100	0	0	0	0	4	3	0	0
101 - 120	8	1	3	1	29	25	9	21
121 - 140	82	14	29	13	37	31	11	26
141 - 160	282	49	105	48	30	25	14	33
161 - 180	142	25	50	23	12	10	6	14
181 - 200	37	6	20	9	4	3	1	2
>200	21	4	12	5	2	2	1	2

A juvenile outmigrant abundance estimate could not be generated for Lake Creek in 2011 because of the inability to capture fish consistently throughout the outmigration period. Although eight release trials were attempted (Table 10), the high flow periods throughout May and during the first week in June that severely compromised trap operations resulted in low numbers of release trial fish (8 to 15 per trial), capture efficiencies less than 0.55, and periods when no fish were captured (e.g., pop-outs pulled to prevent trap damage). During the latter four release trial periods in June, capture efficiencies improved, ranging from 0.75 to 1.0 (Table 10), but an estimate during this time period was not computed given that it likely only captured a small portion of the overall outmigration run and would thus be a spurious estimate for outmigrant production in 2011.

In addition to the inability to consistently capture fish, a considerable percentage of fish from each release trial were neither re-captured nor interrogated by the FDX array (Table 10). The percentage of release trial fish that were not accounted for ranged between 18 and 25% for 4 of the 5 early release trials, and then increased to percentages that ranged between 31 and 70 for the final three release trials. In comparison, only several of the PIT-tagged fish that were released in groups downstream of the DOWN trap were not interrogated by the FDX array. Furthermore, the mean number of days before detection did not exceed 1.2 d for the tagged fish released in groups downstream of the trap, with most of the fish exhibiting similar and rapid downstream movement (e.g., elapsed days typically ≤ 2). Mean number of days before detection for groups of tagged fish released upstream of the trap generally exceeded 2 d, with fish from several of the release trials requiring more than a week before their detection.

Benewah Creek 2011

In 2011, a total of 118 juvenile adfluvial cutthroat trout was captured in the DOWN trap at 9-mile bridge in Benewah Creek, with most of the fish captured during June (Figure 11). The low numbers of fish and the timing of their capture reflect the inability to deploy the trap and maintain its effectiveness under the high spring flows of 2011. Therefore, the distribution of capture events for juveniles likely does not reflect the timing distribution of the juvenile outmigrant cohort in the upper Benewah watershed. Furthermore, five juveniles tagged in 2010 at the migrant trap were each briefly detected by the FDX fixed array over the period March 23 to May 11 in 2011. Presuming that these were 'hold-over' juveniles from 2010 that were actively outmigrating in 2011, the timing of their downstream movement indicates that other juveniles may have also been outmigrating during these early spring periods.

Table 10. Summary of fates of PIT-tagged juvenile adfluvial cutthroat trout used to estimate efficiencies of outmigrant traps in 2011. Trap efficiency trials were conducted in Benewah and Lake creeks, with additional trials conducted downstream of the trap but upstream of the FDX array in Lake Creek.

		Number recaptured		Number detected by array			Unaccounted for fish		Elaspsed days before capture or array detection		
Release date	**Number released**	**Overall**	**Within trial period**	**Overall**	**Within trial period**	**Trap efficiency**	**Number**	**Percent**	**Mean**	**St Dev**	**Max**
Benewah creek tagged fish released upstream of the trap											
3-Jun	8	5	5	2	2	0.74	1	13	2.7	0.76	3
6-Jun	12	5	5	4	4	0.59	3	25	1.8	0.97	3
9-Jun	10	4	4	4	4	0.55	2	20	1.4	1.06	4
13-Jun	9	8	5	1	1	0.85	0	0	3.4	4.48	14
15-Jun	5	3	3	1	1	0.85	1	20	1.3	0.50	2
24-Jun	6	5	5	0	0	1.00	1	17	3.0	0	3
Lake creek tagged fish released upstream of the trap											
22-May	14	6	0	5	1	0.50	3	21	5.2	6.63	25
24-May	15	6	6	6	6	0.54	3	20	1.4	0.51	2
31-May	8	1	0	5	5	0.16	2	25	3.5	6.12	16
6-Jun	10	5	4	5	5	0.49	0	0	1.6	1.90	7
9-Jun	22	18	16	0	0	1.00	4	18	4.1	2.07	10
14-Jun	35	23	22	1	1	0.96	11	31	2.6	2.08	9
20-Jun	16	8	8	3	3	0.77	5	31	2.2	0.40	3
24-Jun	23	5	5	2	2	0.75	16	70	2.6	0.79	4
Lake creek tagged fish released downstream of the trap but upstream of the PIT tag array											
11-May	9	.	.	9	.	.	0	0	1.0	0	1
12-May	5	.	.	5	.	.	0	0	1.0	0	1
13-May	13	.	.	12	.	.	1	8	1.2	0.39	2
15-May	32	.	.	28	.	.	4	13	1.1	0.57	4
15-Jun	24	.	.	23	.	.	1	4	1.0	0.21	2

Of the 118 juveniles captured, 42 (36%) received PIT tags. Generally, fish were tagged representatively throughout the period in which they were being captured as supported by the similarity in the cumulative distribution curves for PIT-tagged juveniles and all captured juveniles (Figure 11). In addition, the length distribution of PIT-tagged adfluvial juveniles was similar to that for all juveniles captured in the DOWN trap, with 81% of both groups ranging between 100 and 160 mm in total length (Table 9).

The total length of adfluvial juveniles in Benewah Creek during 2011 remained relatively similar throughout the period in which they were captured, with seven day moving averages generally ranging between 130 and 140 mm (Figure 10). The size of captured juveniles was noticeably smaller in Benewah than in Lake Creek. For example, 59% of the captured juveniles in Benewah Creek were less than 140 mm in length, compared with 15% of juveniles smaller than this size in Lake Creek (Table 9).

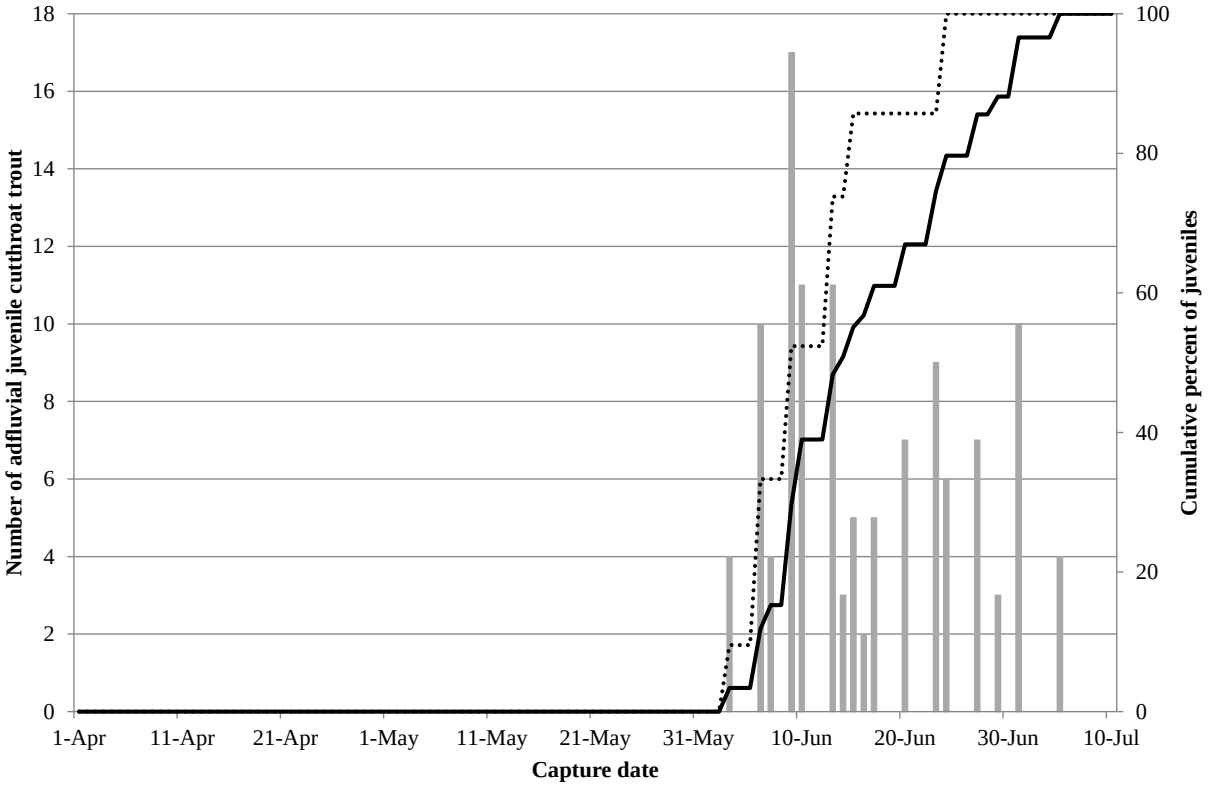


Figure 11. Timing of juvenile adfluvial cutthroat trout captured during the outmigration period in Benewah Creek in 2011. Numbers of juveniles (gray bars) along with the cumulative distribution curves for all captured juveniles (solid line) and PIT-tagged juveniles (dotted line) are presented.

Sixteen other fish captured in the DOWN trap were not classified as adfluvial juveniles given their external markings, with eight of the 16 receiving PIT tags. Mean total length of these 16 fish was 202 mm. Thirteen of the 16 were considered to be resident cutthroat trout and the three other fish were classified as hybrids. One of the hybrids, 248 mm in length, had been tagged at the migrant trap on June 1 in 2010 at 136 mm in length.

A juvenile outmigrant abundance estimate could not be generated for Benewah Creek in 2011 because of the inability to deploy the trap early enough to capture a considerable portion of the outmigrant run. Six release trials were attempted in June when the trap was operating effectively, which yielded estimated trap efficiencies that exceeded 0.55 (Table 10). However, across all release trials several fish were neither re-captured nor interrogated by the FDX array. While this could be the result of imperfect detection efficiency at the fixed FDX array, it was also possible that fish released upstream of the trap may not have migrated back downstream. Lingering behavior upstream of the trap was evident given that the mean number of days before detection for half of the trials exceeded two days; one fish lingered two weeks before detection (Table 10).

Lake Creek 2012

In 2012, a total of 606 juvenile adfluvial cutthroat trout was captured in the DOWN trap in Lake Creek. Juveniles were captured from May 4 to June 27, with approximately 75% of the fish captured throughout May and the first week in June (Figure 12). The distribution of juvenile capture rates likely does not reflect the timing distribution of the juvenile outmigrant cohort in 2012 given that the trap was not installed until May 3. Furthermore, nine juveniles tagged in 2011 at the migrant trap (8 of the 9 tagged in mid to late June) were each detected by the FDX fixed array on only one day over the period March 6 to April 30 in 2012. Presuming that these were 'hold-over' juveniles from 2011 that were actively outmigrating in 2012, the timing of their downstream movement indicates that other juveniles may have also been outmigrating during these early spring periods. The total length of adfluvial juveniles remained relatively similar throughout the period in which they were captured, with seven day moving averages generally ranging between 150 and 160 mm.

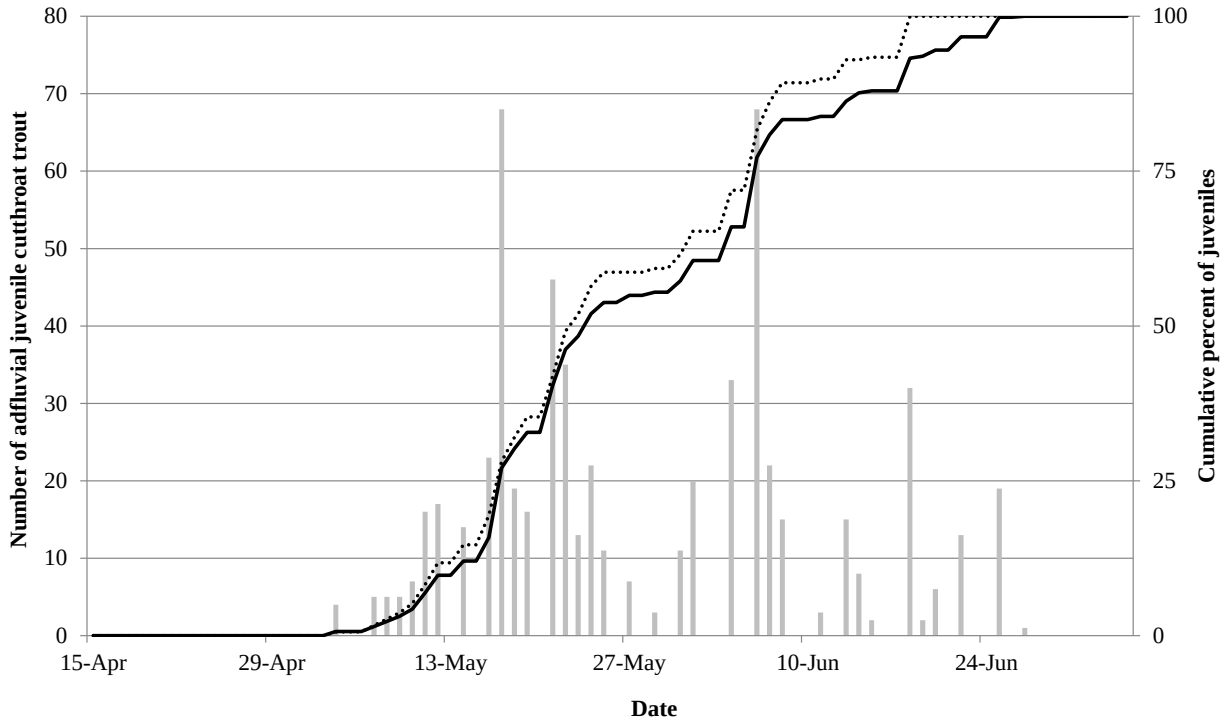


Figure 12. Timing of juvenile adfluvial cutthroat trout captured during the outmigration period in Lake Creek in 2012. Numbers of juveniles (gray bars) along with the cumulative distribution curves for all captured juveniles (solid line) and PIT-tagged juveniles (dotted line) are presented.

Of the 606 juveniles captured, 484 (80%) received PIT tags. Generally, fish were tagged representatively throughout the period in which they were being captured as supported by the similarity in the cumulative distribution curves for PIT-tagged juveniles and all captured juveniles (Figure 12). In addition, the length distribution of PIT-tagged adfluvial juveniles was similar to that for all juveniles captured in the DOWN trap, with 71-72% of both groups ranging between 141 and 180 mm in total length (Table 11). Sixteen other fish captured in the DOWN trap were classified as likely residents given their external markings. Mean total length of these fish was 226 mm. Twelve of the 16 purported resident cutthroat trout received PIT tags.

Table 11. Number and percent of adfluvial juvenile cutthroat trout captured and PIT-tagged of various size classes in Lake Creek in 2012.

Length group (mm)	All juveniles		PIT-tagged juveniles	
	Number	Percent	Number	Percent
81 - 100	0	0	0	0
101 - 120	8	1.3	6	1.2
121 - 140	112	18.5	93	19.2
141 - 160	302	49.9	234	48.3
161 - 180	133	22.0	109	22.5
181 - 200	30	5.0	25	5.2
>200	20	3.3	17	3.5

A juvenile outmigrant abundance estimate of 1141 (±169) fish was generated for the time the trap was deemed fishing in Lake Creek in 2012. This estimate was likely biased low given the late deployment of the trap and the aforementioned evidence that fish were probably outmigrating during periods of high discharge in March and April. Nine trap efficiency release trials were conducted in May and June, with trial periods lasting between 3 and 9 d and groups of 15 to 79 fish (mean, 35 fish) released per trial (Table 12). Trap efficiencies varied from 0.34 to 1.00 across the nine release trials. Small scour holes were often discovered underneath trap panels during those release trial periods where trap efficiencies were estimated to be less than 0.50.

Table 12. Summary of fates of PIT-tagged juvenile adfluvial cutthroat trout used to estimate efficiencies of the Lake Creek outmigrant trap in 2012. Additional trials were conducted downstream of the trap but upstream of the FDX array to examine fish behavior.

Release period	Number released	Number recaptured		Number detected by array		Trap efficiency	Unaccounted for fish		Elaspsed days before capture or array detection		
		Overall	Within trial period	Overall	Within trial period		Number	Percent	Mean	St Dev	Max
Lake Creek tagged fish released upstream of the trap											
May-04 - May-12	15	7	7	6	5	0.61	2	13	5.8	13.0	49
May-12 - May-17	34	12	11	18	17	0.41	4	12	2.9	2.3	10
May-17 - May-20	65	19	15	36	30	0.34	10	15	2.0	1.9	11
May-20 - May-24	16	9	9	6	6	0.55	1	6	1.8	1.0	4
May-24 - Jun-01	35	12	12	20	20	0.38	3	9	1.6	1.3	7
Jun-01 - Jun-06	29	12	11	3	2	0.86	14	48	4.5	1.2	7
Jun-06 - Jun-13	79	27	27	44	44	0.39	8	10	1.5	1.0	5
Jun-13 - Jun-18	15	10	10	1	0	1.00	4	27	3.1	3.4	13
Jun-18 - Jun-27	32	17	17	1	1	0.86	14	44	1.9	1.7	8
Lake creek tagged fish released downstream of the trap but upstream of the PIT tag array											
May-04 - May-12	10	.	.	10	.	.	0	0	1.0	0.0	1
May-12 - May-17	15	.	.	13	.	.	2	13	1.5	1.0	4
May-17 - May-20	20	.	.	17	.	.	3	15	1.0	0.0	1
May-20 - May-24	69	.	.	67	.	.	2	3	1.1	0.3	3
May-24 - Jun-01	14	.	.	14	.	.	0	0	1.0	0.0	1
Jun-01 - Jun-08	30	.	.	29	.	.	1	3	1.4	1.7	10
Jun-08 - Jun-16	20	.	.	20	.	.	0	0	1.2	0.6	3

Throughout trap efficiency trials of 2012, fish from each trial were neither re-captured nor interrogated by the FDX array (Table 12). Though the percentage of fish that were not accounted for was less than 15% during the release trials conducted in May, percentages of unaccounted for fish ranged from 27 to 48% for three of the four trials conducted in June. In comparison, percentages of unaccounted for fish were generally lower for those groups released downstream than upstream of the DOWN trap, with only one fish released downstream of the trap unaccounted for during the month of June (Table 12). Furthermore, the mean number of days before detection did not exceed 1.5 d for the tagged fish released in groups downstream of the trap, with most of the fish exhibiting similar and rapid downstream movement (e.g., elapsed days typically ≤ 4). Mean number of days before detection for groups of tagged fish released upstream of the trap generally exceeded 2 d, with fish from all but two of the nine release trials requiring at least a week before their detection (Table 12).

Over the time period from 2005 to 2010, 4614 juvenile cutthroat trout have been PIT-tagged during spring outmigration periods. Of these fish, only 80 (1.7%) have been detected either by the fixed FDX antenna array or in traps over the years 2006-2012 and deemed to be returning adfluvial adults (Table 7). Though return rate percentages were relatively similar for the six juvenile cohorts, ranging between 1.0 and 2.6, the 2010 tagged cohort has returned at the highest rate. When examining only those cohorts tagged from 2008 to 2010, detected fish generally were larger than those tagged fish that have not been detected (Figure 13). For example, only approximately 35% of juvenile cutthroat trout have exceeded 150 mm in length at time of tagging. However, of those fish that have been detected, 85% were at least 150 mm when tagged. These results were similar to those found for cohorts tagged from 2005 to 2007 (Firehammer et al. 2012).

Benewah Creek 2012

In 2012, only 18 juvenile adfluvial cutthroat trout was captured in the DOWN trap at 9-mile bridge in Benewah Creek from May 18 to June 4. Sixteen of the 18 fish received PIT-tags. The lack of juvenile fish captured was due to the inability to deploy the trap until May 16 and to maintain its operability during deployment (e.g., severe trap damage throughout June because of high flow events). Consequently, a juvenile outmigrant abundance estimate could not be generated for Benewah Creek in 2012. Four other fish captured in the DOWN trap were classified as residents given their external markings, with three of the four receiving PIT tags. Mean total length of these four fish was 212 mm.

Over the time period from 2008 to 2010, 508 juvenile cutthroat trout have been PIT-tagged during spring outmigration periods. Of these fish, only 11 (2.2%) have been detected either by the fixed FDX antenna array or in traps over the years 2009-2012 and deemed to be returning adfluvial adults (Table 7). Return rate percentages were relatively similar for the three juvenile cohorts, ranging between 1.5 and 2.8.

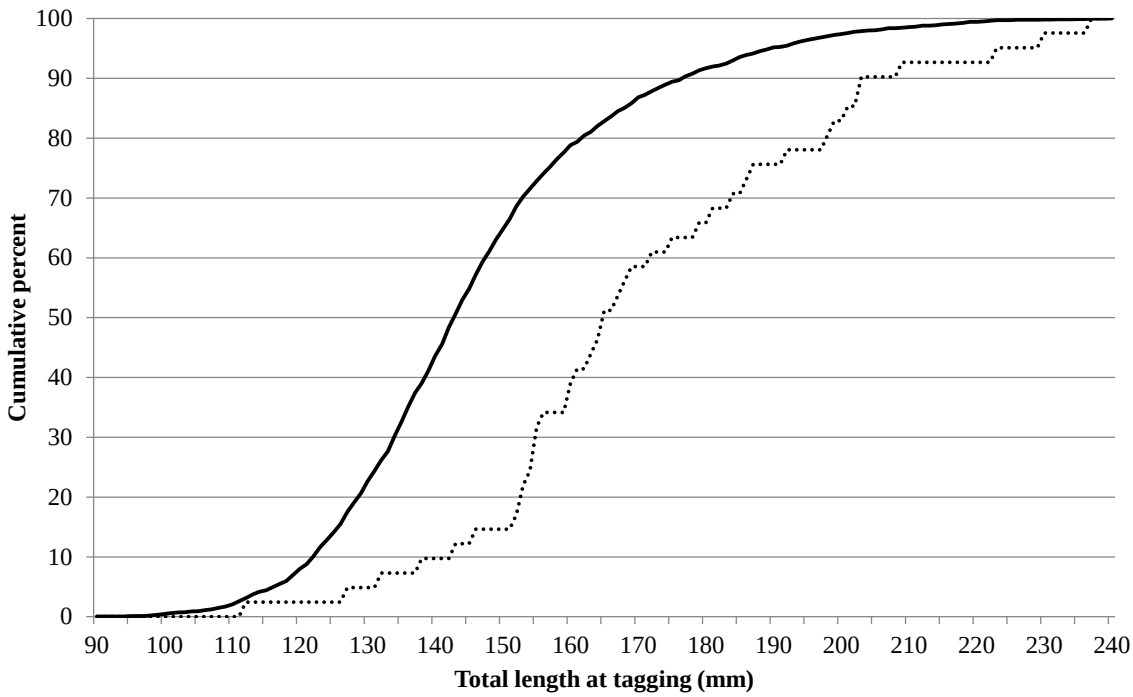


Figure 13. Cumulative distribution curves of length at tagging for all juvenile cutthroat trout tagged from 2008 to 2010 (solid line) and for those fish from these cohorts uniquely detected as returning adults (dotted line) in the upper Lake Creek watershed.

3.3.1.3 Assess the status and trend of spatial distribution of fish populations

2011 Stream Surveys

Twenty-five, twenty-one, and nineteen index sites were sampled in 2011 using single pass electrofishing methodology in Alder, Benewah, and Lake creek watersheds, respectively. The most downstream site in the South Fork of Benewah was omitted from analysis given that many of the captured fish were dropped and not recovered at the end of the site before they were counted and processed. Cutthroat trout were found in all three watersheds, and brook trout were captured only in Alder and Benewah creeks.

In Alder Creek, the distribution of cutthroat trout was generally constrained to lower main-stem reaches with low overall densities throughout the watershed (Table 13), a result consistent with that documented in previous annual surveys. The mean index density of age 1+ cutthroat trout at the five most downstream index sites was 7 fish/100 m (s=9.5), with fish not detected at two of the sites and only one site yielding a density greater than 10 fish/100 m. In the remaining portion of the sampled watershed, age 1+ cutthroat trout were only captured at 5 of the 20 sites, with index densities of less than 2 fish/100 m at these five sites. Age-0 cutthroat were rarely captured at index sites in 2011.

Table 13. Single pass density index (fish/100 m) for cutthroat trout and brook trout of age 1 and older and age 0 sampled by electrofishing at mainstem and tributary sites in the Alder Creek watershed, 2011.

River kilomter index	Cutthroat trout density index (fish/100 m)		Brook trout density index (fish/100 m)	
	Age 1 and older	Age 0	Age 1 and older	Age 0
		Alder Creek mainstem		
0.1	0	0	1.6	0
0.2	0	0	6.6	0
0.6	4.9	0	4.9	0
2	23.0	1.6	9.8	3.3
2.2	6.6	3.3	3.3	0
5.2	1.6	0	3.3	0
5.9	1.6	0	3.3	1.6
6.3	0	0	14.8	8.2
7	0	0	16.4	4.9
8.4	0	1.5	20.9	3.0
10	0	0	22.8	4.6
12	1.6	0	9.8	0
12.3	0	0	44.3	1.6
13.7	1.6	0	47.6	1.6
14.3	1.6	0	36.1	0
15.6	0	0	59.1	21.3
16.2	0	0	65.6	3.3
		North Fork Alder Creek tributary		
14.0/0.1	0	0	64.0	3.3
14.0/1.3	0	0	36.1	3.3
14.0/2.2	0	0	49.2	31.2
14.0/2.6	0	0	134.5	19.7
14.0/3.1	0	0	86.9	11.5
14.0/4.4	0	0	72.2	1.6
14.0/5.0	0	0	31.2	0
14.0/5.7	0	0	21.3	29.5

Brook trout in the Alder Creek watershed displayed distribution patterns that were converse of those exhibited by cutthroat trout, and generally were much more abundant. Though modest numbers of brook trout were captured at the most downstream sites (i.e., sites within the lower six river kilometers), first-pass indices of brook trout abundance were much greater throughout the rest of the sampled watershed (Table 13). The mean index density of age 1+ brook trout at the 18 sites upstream of river kilometer six was 46 fish/100 m (s=31.1), with densities generally increasing from downstream to upstream. Age-0 brook trout were most abundant at the sites in the North Fork Alder tributary where index densities averaged 12.5 fish/100 m (s=12.7).

In the Benewah watershed, results from the 2011 survey were consistent with those reported in previous years, with substantially greater numbers of cutthroat trout found in tributary than in main-stem reaches (Table 14). Moderate mean density indices of 12.3 (s=10.4), 14.8 (s=0), 9.0 (s=5.8), and 15.6 (s=5.8) fish/100 m were computed for age 1+ fish across sites in Whitetail, Windfall, Schoolhouse, and WFB creeks, respectively. Relatively high density indices of age 1+ fish were recorded in Bull Creek, 22.1 (s=5.8) fish/100m, and in SFB Creek, 23.8 (s=8.1)

fish/100 m. Densities within many of the tributaries were greater at upstream than at downstream index sites. The distribution and abundance of age-0 cutthroat trout at index sites in all sampled tributaries varied substantially in 2011, with fish captured at only 8 of the 15 sites. Age-0 density indices were greatest at the two Bull Creek sites (19.7 and 42.7 fish/100 m), the lowermost Coon Creek site (114.8 fish/100 m), and at the uppermost sites in Schoolhouse (14.8 fish/100 m) and WFB (9.8 fish/100 m) creeks. Compared to tributary reaches, density indices of age 1+ cutthroat trout in the sampled main-stem reaches were generally low, averaging only 2.6 fish/100 m (s=1.9). Only two age 1+ cutthroat trout were captured in the two sites located in the Phase 2 restoration mainstem reach (rkm 16.5 and 17.3).

Table 14. Single pass density index (fish/100 m) for cutthroat trout and brook trout of age 1 and older and age 0 sampled by electrofishing at mainstem and tributary sites in the Benewah Creek watershed, 2011.

River kilomter index	Cutthroat trout density index (fish/100 m)		Brook trout density index (fish/100 m)	
	Age 1 and older	Age 0	Age 1 and older	Age 0
Benewah Creek mainstem				
13.5	3.3	0	1.6	8.2
16.5	3.3	0	16.4	1.6
17.3	0	0	9.4	10.5
19.2	1.6	19.7	1.6	3.3
19.3	4.9	3.3	3.3	0
Coon Creek tributary				
7.3/0.8	6.6	114.8	0	0
7.3/1.3	0	0	0	0
7.3/1.1/0.1	0	0	0	0
Bull Creek tributary				
8.9/0	18.0	19.7	0	1.6
8.9/1.1	26.2	42.7	0	0
Whitetail Creek tributary				
15.2/0.2	4.9	4.9	9.8	0
15.2/2.0	19.7	0	0	0
Windfall Creek tributary				
18.6/0.2	14.8	0	11.5	0
18.6/1.4	14.8	3.3	0	0
Schoolhouse Creek tributary				
19.6/0.1	13.1	0	6.6	1.6
19.6/1.2	4.9	14.8	8.2	0
South Fork Benewah Creek tributary				
20.7/2.0	18.0	0	0	0
20.7/2.6	29.5	0	0	0
West Fork Benewah Creek tributary				
20.7/1.1	11.5	1.6	1.6	0
20.7/1.6	19.7	9.8	1.6	0

Brook trout distribution patterns in the Benewah watershed were converse of those displayed by cutthroat trout in 2011 (Table 14). Age 1+ brook trout were relatively lacking and outnumbered by cutthroat trout at sites in Bull Creek, SFB, and WFB, and at upstream sites in Whitetail and Windfall creeks, averaging 0.4 fish/100 m (s=0.8) across sites. In comparison, density indices of age 1+ brook trout were generally greater than or comparable to those generated for cutthroat trout in Schoolhouse Creek and in downstream index sites in Whitetail and Windfall creeks, averaging 9.0 fish/100 m (s=2.1) across sites. Age-0 brook trout were infrequently captured at sites sampled in Benewah tributaries in 2011. In main-stem reaches where cutthroat trout were relatively scarce, numbers of age 1+ brook trout were comparatively modest, with a mean density index calculated at 6.5 fish/100 m (s=6.4). However, computed density indices varied substantially among the main-stem sites. Densities of 9.4 and 16.4 fish/100 m were calculated for the two sites in the Phase 2 restoration reach (i.e., sites 16L and 2010), whereas densities for the remaining sites did not exceed 4 fish/100 m. Age-0 brook trout densities were also modest and variable across sites sampled in main-stem reaches (mean=4.7 fish/100 m; s=4.5), with the highest density of 10.5 fish/100 m calculated for one of the sites in the Phase 2 restoration reach.

Abundance of age 1+ cutthroat trout in Lake Creek was greater in tributary than in main-stem habitats in 2011, but only in the uppermost tributary reaches, a pattern consistent with previous years (Table 15). A mean density index of 28.5 fish/100 m (s=2.7) was calculated for age 1+ fish across the three most upstream sites in Bozard Creek, the two most upstream sites in the West Fork Lake tributary, and the uppermost site in the upper Lake Creek fork. Densities across these six sites were also relatively comparable to one another. In comparison, fish were not captured at sites in the lower reaches of the upper Lake Creek fork and of the West Fork Lake tributary, and averaged 9.0 fish/100 m (s=1.2) at sites in the lowermost river kilometer of Bozard Creek. Age 1+ cutthroat trout were also relatively scarce at sites sampled in main-stem reaches. Densities averaged 1.3 fish/100 m (s=1.8) across the five upstream sites, but increased to 13.1 fish/100 m at the two most downstream sites. Age-0 cutthroat trout were infrequently captured at sites in both tributary and main-stem habitats; the greatest density of 11.5 fish/100 m was computed for one of the lower main-stem sites.

2012 Stream Surveys

In the Evans Creek watershed, age 1+ cutthroat trout were found at moderate to high densities and consistently distributed across most of the sites sampled in 2012 (Table 16). Though densities varied and were relatively low across the five most downstream mainstem sites (mean=3.3 fish/100 m; s=4.8), density indices averaged 25.5 fish/100 m (s=10.4) across the eleven mainstem sites further upstream. Age 1+ cutthroat trout were less numerous in tributary than in main-stem habitats. Densities averaged 8.6 fish/100 m (s=8.2) across the four sampled tributary sites; fish were not captured at the site in the Rainbow Fork. Age-0 cutthroat trout were found at only two of the sites in 2012 and at low densities (< 5 fish/100 m) at each site. One brook trout was captured at a lower main-stem site in 2012.

Table 15. Single pass density index (fish/100 m) for cutthroat trout and brook trout of age 1 and older and age 0 sampled by electrofishing at mainstem and tributary sites in the Lake Creek watershed, 2011.

River kilomter index	Cutthroat trout density index (fish/100 m)		Brook trout density index (fish/100 m)	
	Age 1 and older	Age 0	Age 1 and older	Age 0
		Lake Creek mainstem		
5.2	13.1	4.9	0	0
5.4	13.1	11.5	0	0
6.1	3.3	3.3	0	0
7.1	0	0	0	0
8	3.3	1.6	0	0
10	0	1.6	0	0
12.1	0	0	0	0
		Bozard Creek tributary		
13.4/0.1	8.2	6.6	0	0
13.4/0.8	9.8	0	0	0
13.4/4.1	27.9	0	0	0
13.4/4.5	26.2	0	0	0
13.4/4.0/0.1	26.2	0	0	0
		Upper Lake Creek tributary		
14.1	0	4.9	0	0
14.3	0	0	0	0
17.1	27.9	0	0	0
		West Fork Lake Creek tributary		
13.8/0.6	0	0	0	0
13.8/0.9	0	0	0	0
13.8/2.8	33.4	1.2	0	0
13.8/3.5	29.5	1.6	0	0

In the upper Lake Creek watershed in 2012, the abundance of age 1+ cutthroat trout was greater in upper than in lower reaches of the three tributaries (Table 17), a pattern similar to that observed in the 2011 survey. A mean density index of 45.1 fish/100 m (s=25.8) was calculated for age 1+ fish across the three uppermost sites in Bozard Creek, the two uppermost sites in the West Fork Lake tributary, and the uppermost site in the upper Lake Creek fork. Though densities across the three sites in the Lake and West Fork Lake forks were comparable, densities in the upper Bozard watershed were highly variable ranging from 16.4 fish/100 m to a high of 91.9 fish/100 m at the site in the East Fork of Bozard Creek (rkm index 13.4/4.0/0.1). In comparison to upper tributary reaches, age 1+ cutthroat trout were not sampled in the lower reach of West Fork Lake and were found at a lower mean density of 9.2 fish/100 m (s=6.3) across the four downstream sites of the two other tributaries.

Table 16. Single pass density index (fish/100 m) for cutthroat trout and brook trout of age 1 and older and age 0 sampled by electrofishing at mainstem and tributary sites in the Evans Creek watershed, 2012.

River kilomter index	Cutthroat trout density index (fish/100 m)		Brook trout density index (fish/100 m)	
	Age 1 and older	Age 0	Age 1 and older	Age 0
		Evans mainstem		
0.6	0	0	0	0
1.8	1.6	0	1.6	0
2.1	11.5	0	0	0
2.9	0	0	0	0
3.6	3.3	0	0	0
4.1	21.3	0	0	0
4.5	26.2	0	0	0
5.1	19.7	0	0	0
5.7	23.0	0	0	0
6.1	18.0	4.9	0	0
7.8	26.2	0	0	0
8.5	19.7	0	0	0
9.2	36.1	0	0	0
9.4	52.5	0	0	0
9.6	21.3	0	0	0
9.8	16.4	0	0	0
		East Fork Evans tributary		
5.9/0.3	19.7	3.3	0	0
		South Fork Evans tributary		
5.9/0.5	6.6	0	0	0
5.9/1.0	8.2	0	0	0
		Rainbow Fork tributary		
6.8/0.7	0	0	0	0

In contrast to 2011, age-0 cutthroat trout were frequently captured in 2012 across many of the sites in the three tributaries of the upper Lake Creek watershed (Table 17). Densities of age-0 fish were greatest overall in Bozard Creek, averaging 18.6 fish/100 m (s=1.9) and 8.5 fish/100 m (s=0.5) across the three sites in the upper reaches and the two sites in the lower reaches, respectively. Densities were also moderate at several of the sites in the other two tributaries, even in those reaches that did not support high densities of older fish. For example, densities of 9.8 and 16.4 fish/100 m were respectively calculated for the lowermost site in the upper Lake Creek Fork and for a site in West Fork Lake (rkm index 13.8/0.9) that had recently received restoration treatments.

Table 17. Single pass density index (fish/100 m) for cutthroat trout and brook trout of age 1 and older and age 0 sampled by electrofishing at mainstem and tributary sites in the Lake Creek watershed, 2012.

	Cutthroat trout density index (fish/100 m)		Brook trout density index (fish/100 m)	
River kilomter index	**Age 1 and older**	**Age 0**	**Age 1 and older**	**Age 0**
		Upper Lake Creek tributary		
14.1	3.3	9.8	0	0
14.3	8.2	0	0	0
17.1	44.2	4.3	0	0
		Bozard Creek tributary		
13.4/0.1	7.1	8.9	0	0
13.4/0.8	18.0	8.2	0	0
13.4/4.1	16.4	16.4	0	0
13.4/4.5	50.9	19.7	0	0
13.4/4.0/0.1	91.9	19.7	0	0
		West Fork Lake Creek tributary		
13.8/0.1	0	0	0	0
13.8/0.6	0	0	0	0
13.8/0.9	0	16.4	0	0
13.8/2.8	35.9	1.2	0	0
13.8/3.5	31.2	9.8	0	0

In the Benewah watershed in 2012, cutthroat trout were generally found at comparably moderate densities and consistently distributed across most of the sampled tributary and mainstem habitat (Table 18). In the two tributaries sampled downriver of 9-mile bridge, estimated densities of age 1+ fish were 8.2 and 14.8 (s=4.6) fish/100 m for the lowermost site in Coon Creek (the two upstream sites were virtually de-watered at time of sampling) and the two sites in Bull Creek, respectively. For the sampled habitat upstream of 9-mile bridge, estimated densities of age 1+ fish averaged 12.0 fish/100 m (s=1.5) for the two sites sampled in an upper main-stem reach, 9.0 fish/100 m (s=1.2) for Whitetail Creek, 15.1 fish/100 m (s=8.2) for Windfall Creek, 15.6 fish/100 m (s=1.2) for Schoolhouse Creek, 12.2 fish/100 m (s=6.8) for SFB, and 11.1 fish/100 m (s=8.6) for WFB. Within each of SFB and WFB, densities were generally lower across sites in lower order secondary tributaries than in main tributary reaches (Table 18). In Windfall Creek, the highest densities of age 1+ cutthroat (mean, 26.1 fish/100 m) were found in a secondary tributary to the creek.

The distribution and abundance of age-0 cutthroat trout across sampled sites varied substantially both among and within tributaries in Benewah Creek in 2012 (Table 18). In each of Whitetail, Coon, Bull, and Schoolhouse creeks, age-0 fish were considerably more abundant at sites sampled in the lower than in the upper reaches, with densities in the downstream sites ranging from 27.9 to 34.4 fish/100 m in the latter three tributaries. In both Windfall and WFB creeks, age-0 fish were found to be sporadically distributed with a couple of sites in each creek exhibiting moderate to high densities ranging from 9.0 to 24.0 fish/100 m, and most of the other sites displaying densities less than 3.0 fish/100 m. Age-0 fish were rarely sampled in SFB in 2012.

Table 18. Single pass density index (fish/100 m) for cutthroat trout and brook trout of age 1 and older and age 0 sampled by electrofishing at mainstem and tributary sites in the Benewah Creek watershed, 2012.

River kilomter index	Cutthroat trout density index (fish/100 m)		Brook trout density index (fish/100 m)	
	Age 1 and older	Age 0	Age 1 and older	Age 0
		Benewah mainstem		
19.2	13.1	1.6	4.9	6.6
19.3	10.9	4.1	1.4	5.5
		Coon Creek tributary		
7.3/0.8	8.2	34.4	0	0
7.3/1.3	0	0	0	0
7.3/1.1/0.1	0	0	0	0
		Bull Creek tributary		
8.9/0	18.0	29.5	1.6	29.5
8.9/1.1	11.5	8.2	0	0
		Whitetail Creek tributary		
15.2/0.2	8.2	8.2	0	18.0
15.2/2.0	9.8	1.6	1.6	0
		Windfall Creek tributary		
18.6/0.2	9.8	1.6	9.8	4.9
18.6/1.1	13.3	1.0	1.0	20.5
18.6/1.7	11.3	11.3	2.3	0
18.6/2.0	13.2	1.0	0	0
18.6/2.5	5.0	0	0	0
18.6/3.0	15.8	5.9	0	0
18.6/1.4/0.3	32.2	17.1	0	0
18.6/1.4/0.8	19.9	2.0	0	0
		Schoolhouse Creek tributary		
19.6/0.1	14.8	27.9	9.8	0
19.6/1.2	16.4	1.6	1.6	0
		South Fork Benewah Creek tributary		
20.7/0.6	20.1	1.0	2.0	15.1
20.7/1.6	10.3	3.8	1.9	2.8
20.7/2.1	23.6	0	1.0	0
20.7/2.7	12.5	4.2	0	0
20.7/3.4	10.9	1.0	0	0
20.7/4.0	10.8	0	0	0
20.7/2.1/0.2	6.0	0	0	0
20.7/2.1/0.9	3.0	0	0	0
		West Fork Benewah Creek tributary		
20.7/0.4	6.0	1.0	0	1.0
20.7/0.7	17.0	9.0	1.0	0
20.7/1.5	18.3	2.6	0	0
20.7/2.2	25.0	24.0	0	0
20.7/2.7	0	0	0	0
20.7/1.0/0.3	10.1	1.0	0	0
20.7/1.0/0.8	9.9	5.0	0	0
20.7/1.0/0.5/0.4	2.1	0	0	0

Age 1+ brook trout were relatively scarce at sites sampled across the Benewah watershed in 2012 (Table 18). Estimated densities averaged 1.1 fish/100 m (s=2.4) across all 35 sites, with fish absent at 22 of the sites. At only two sites, the most downstream sites in Windfall and Schoolhouse creeks, were age1+ brook trout found at moderate densities of 9.8 fish/100 m, though at each of these sites were not found to outnumber cutthroat trout. Age-0 brook trout were also typically found at low numbers in the Benewah watershed in 2012 (Table 18). Densities averaged 3.0 fish/100 m (s=7.0) across all sites, with fish not found at 26 of the 35 sites. However, age-0 fish were found to be abundant at four sites in downstream sampled reaches of Bull, Whitetail, Windfall, and SFB creeks, where densities ranged from 15.1 to 29.5 fish/100 m.

3.3.1.4 Assess the status and trend of diversity of natural origin fish populations

A total of 198 cutthroat trout were PIT-tagged during summer surveys at index sites in tributaries of the upper Lake Creek watershed in 2012. Thirty-nine, 111, and 48 fish were tagged in the upper Lake Creek fork, Bozard Creek, and WFL, respectively (Table 19). The variability in numbers of tagged fish among index sites within tributaries reflected the variability in the estimated densities of age 1+ fish that was observed among these sites. Generally, tagged fish were greater in length at the index sites located in downstream than in upstream reaches within all three tributaries (Table 19). Mean total length of tagged fish at the two lowermost sites in each of upper Lake Creek and Bozard Creek ranged from 149 to 231 mm. In comparison, the mean total length of tagged fish at the other six sites located further upstream in the upper watershed ranged from 109 to 131 mm.

Table 19. Number and size of age 1+ cutthroat trout PIT-tagged in tributaries of the upper Lake Creek watershed in 2012.

		Total length of tagged fish (mm)	
River kilomter index	**Number tagged**	**Mean**	**Range**
	Upper Lake Creek		
14.1	3	153.7	76 - 203
14.3	5	231.2	187 - 266
17.1	31	130.8	75 - 221
	Bozard Creek		
13.4/0.1	4	156.0	120 - 217
13.4/0.8	11	149.2	117 - 218
13.4/4.1	10	115.8	84 - 146
13.4/4.5	31	116.8	77 - 211
13.4/4.0/0.1	55	108.7	73 - 215
	West Fork Lake Creek		
13.8/0.1	0	.	.
13.8/0.6	0	.	.
13.8/0.9	0	.	.
13.8/2.8	29	121.8	76 - 201
13.8/3.5	19	125.6	75 - 201

Six of the 198 fish (3%) tagged in the upper Lake Creek watershed were detected exiting their stream of tagging origin over the monitored period (i.e., time of tagging in late July through mid-August of 2012 until the end of February of 2013). Five of the six were tagged at the site located 0.8 rkm up Bozard Creek, with one fish last detected moving up WFL and another moving up the upper Lake Creek fork. The sixth fish was tagged in the upper Lake Creek fork, 0.3 rkm upstream of its confluence with WFL (i.e., rkm index 14.1). This fish was found to move back and forth between the two HDX arrays located at the mouth of Bozard Creek and at the confluence of WFL and the upper Lake Creek fork, and was last detected in Bozard Creek.

A total of 286 age 1+ cutthroat trout were PIT-tagged during summer surveys in the upper Benewah watershed in 2012. Eighty-nine, 93, and 104 fish were tagged in WFB, SFB, and Windfall creeks, respectively (Table 20). The variability in numbers of tagged fish among sites within tributaries, ranging from 5 to 27 in Windfall, 3 to 22 in SFB, and 0 to 25 in WFB, paralleled the variability in the estimated densities of age 1+ fish that was observed among these sites. Though the size of tagged fish was generally comparable among the three tributaries, fish were generally greater in length at sites located in downstream than in upstream reaches within all three tributaries (Table 20). The greatest mean total lengths of 171.3, 160.8, and 153.0 mm, occurred at sites located at rkm 0.2 in Windfall, rkm 1.6 in SFB, and at rkm 0.4 in WFB, respectively.

Seventeen of the 286 (6%) cutthroat trout tagged in the upper Benewah watershed were detected exiting their stream of tagging origin over the monitored period (i.e., time of tagging in late July through mid-August of 2012 until the end of February of 2013). Specifically, six (6%), one (1%), and ten (11%) of the fish that were respectively tagged in Windfall, SFB, and WFB creeks were found to exit (Table 20). Of the eleven fish that exited the two Benewah Forks, one was last detected in the reach between the 12-mile and 9-mile fixed antenna arrays and another was last detected moving downriver of the 9-mile array; the other nine fish were apparently located in the 2 km reach between 12-mile bridge and the confluence of the two forks. Two of the six fish that exited Windfall were detected moving downriver of the 9-mile array; the other four apparently remained in the reach between the 12-mile and 9-mile fixed antenna arrays.

3.3.2 Tributary Habitat RM&E

3.3.2.1 Monitor and evaluate tributary habitat conditions that may be limiting achievement of biological performance objectives

Stream Temperatures

In the upper Lake Creek watershed, ambient stream temperatures were generally cool throughout most of the monitored reaches during the summer of 2011 (Table 21). Mean daily stream temperatures calculated over July and August ranged from 13.8 to 14.5ºC for the three loggers located in reaches proximate to the confluence of the three upper tributaries (data were unavailable for lower West Fork Lake Creek because the temperature logger could not be located and likely had been dislodged during a high flow event). Loggers located further upstream in the Bozard sub-drainage had calculated daily means during these two months that ranged from 11.7 to 12.0ºC (the logger located downstream of the East Fork Bozard confluence also could not be located). The percentage of time recorded temperatures exceeded 17ºC was also generally low

across the upper Lake Creek watershed during the summer of 2011. Percent exceedances during July and August were between 1.9 and 11.0% for the group of three loggers positioned near the confluence of the three tributaries. Recorded stream temperatures never exceeded 17ºC during summer months in the upper Bozard sub-drainage. Stream temperatures in mainstem reaches further downriver were comparatively warmer than those recorded in the upper watershed (Table 21). The mean daily stream temperature near the old H95 bridge (location of the migrant traps) calculated over July and August was 15.8ºC, with recorded values exceeding 17ºC approximately 32% of the time.

Table 20. Number, size, and last interrogation location for age 1+ cutthroat trout PIT-tagged in tributaries of the upper Beneah Creek watershed in 2012.

		Total length of tagged fish (mm)		Locations of last interrogations based on fixed PIT arrays		
River kilomter index	**Number tagged**	**Mean**	**Range**	**Exited tributary**	**Between 9-mile and 12-mile**	**Downstream of 9-mile**
		Windfall Creek				
18.6/0.2	6	171.3	130 - 230	1	.	1
18.6/1.1	13	130.8	108 - 198	2	1	1
18.6/1.7	10	127.0	100 - 145	1	1	.
18.6/2.0	12	125.6	105 - 151	1	1	.
18.6/2.5	5	119.6	98 - 156	1	1	.
18.6/3.0	16	105.9	81 - 166	.	.	.
18.6/1.4/0.3	27	98.6	75 - 187	.	.	.
18.6/1.4/0.8	15	92.7	75 - 158	.	.	.
		South Fork Benewah Creek				
20.7/0.6	20	119.9	94 - 176	.	.	.
20.7/1.6	11	160.8	92 - 217	1	.	.
20.7/2.1	22	122.7	72 - 191	.	.	.
20.7/2.7	12	135.4	95 - 183	.	.	.
20.7/3.4	10	121.2	80 - 171	.	.	.
20.7/4.0	10	108.0	77 - 129	.	.	.
20.7/2.1/0.2	5	119.4	83 - 178	.	.	.
20.7/2.1/0.9	3	115.0	89 - 139	.	.	.
		West Fork Benewah Creek				
20.7/0.4	6	153.0	107 - 211	3	.	.
20.7/0.7	17	137.5	85 - 256	5	1	1
20.7/1.5	20	110.6	81 - 158	2	.	.
20.7/2.2	25	110.4	87 - 156	.	.	.
20.7/2.7	0	.	.	.	.	.
20.7/1.0/0.3	10	128.2	103 - 156	.	.	.
20.7/1.0/0.8	9	105.0	77 - 127	.	.	.
20.7/1.0/0.5/0.4	2	144.5	144 - 145	.	.	.

Stream temperatures in the upper Lake Creek watershed were warmer in 2012 than in 2011 (Table 21). Mean daily stream temperatures calculated over July and August ranged from 15.4 to 16.0ºC for the two retrievable loggers located in reaches proximate to the confluence of the three upper tributaries. Data were unavailable for lower Bozard Creek because the logger could

not be located and likely had been dislodged during a high flow event. Data were also not available for the lower reach of upper Lake Creek because shifting substrate had buried the logger. In the Bozard sub-drainage, mean daily stream temperatures ranged from 13.0 to 13.4ºC. The percentage of time recorded temperatures exceeded 17ºC in reaches proximate to the confluence of the three upper tributaries was also higher in 2012 than in 2011 (Table 21), with percent exceedances during July and August ranging from 26.6 to 36.9%. In the upper Bozard sub-drainage, however, recorded stream temperatures rarely exceeded 17ºC, a result similar to that observed in 2011. Stream temperature data were not available for lower mainstem reaches because the logger could not located and had likely been dislodged by high flows.

Table 21. Comparison of summary statistics among water years from 2007 to 2012 over the months of July and August for water temperatures recorded by data loggers located in reaches of the upper mainstem of Lake Creek and of proximate tributaries. Logger locations are listed in order of relative longitudinal position in the watershed from lowermost to uppermost. 17°C was considered the upper 95% confidence interval limit for westslope cutthroat trout optimal growth (Bear et al. 2007).

Logger location	2007	2008	2009	2010	2011	2012
			Mean water temperature (^{o} C)			
Lake Creek mainstem, near old H95 bridge	17.7	16.1	17.2	16.1	15.8	.
Lake Creek mainstem, downstream of Bozard Creek confluence	15.8	14.4	15.3	14.4	13.8	15.4
Bozard Creek, upstream of Lake Creek confluence	15.6	13.9	14.8	13.8	13.2	.
West Fork Lake Creek, upstream of Lake Creek confluence	14.0	14.6	14.8	14.2	.	16.0
Upper Lake Creek, upstream of West Fork confluence	15.1	14.8	15.1	.	14.5	.
Bozard Creek, downstream of East Fork Bozard confluence	13.7	12.4	13.3	12.3	.	.
East Fork Bozard, upstream of Bozard Creek confluence	13.6	12.2	13.2	12.2	11.7	13.0
Bozard Creek, upstream of East Fork Bozard confluence	13.9	12.6	13.4	12.6	12.0	13.4
			Percent time > 17 ^{o} C			
Lake Creek mainstem, near old H95 bridge	55.0	37.6	52.1	40.6	32.1	.
Lake Creek mainstem, downstream of Bozard Creek confluence	34.2	6.3	15.9	13.6	2.9	26.6
Bozard Creek, upstream of Lake Creek confluence	31.0	5.4	14.4	7.5	1.9	.
West Fork Lake Creek, upstream of Lake Creek confluence	20.6	6.2	13.1	11.5	.	36.9
Upper Lake Creek, upstream of West Fork confluence	24.3	8.2	10.6	.	11.0	.
Bozard Creek, downstream of East Fork Bozard confluence	4.4	0.2	1.2	0.1	.	.
East Fork Bozard, upstream of Bozard Creek confluence	2.9	0.0	0.6	0.0	0.0	0.0
Bozard Creek, upstream of East Fork Bozard confluence	7.4	0.8	2.5	0.0	0.0	1.2

In the Lake Creek watershed, when comparing data over the last six years, stream temperatures during 2011 were comparable to those recorded in 2008 and 2010, moderately cooler than those recorded in 2009, and much cooler than those recorded in 2007 (Table 21). In comparison, stream temperature data in 2012 reflected the temperature signatures that were documented in both 2007 and 2009. In general, the upper Bozard sub-drainage remained relatively cool over the last six years, regardless of the overall summer thermal regime in the upper Lake Creek watershed.

In both 2011 and 2012 in the upper Benewah watershed, ambient mean summer stream temperatures generally increased downstream over the 6.4 km section of the mainstem from the mouth of Schoolhouse Creek to 9-mile bridge, though the longitudinal temperature change was more gradual in upper than in lower reaches (Figure 14). The mean of daily mean temperatures

recorded by data loggers over the months of July and August in 2011 increased 1.7ºC from 12.6 to 14.3ºC downriver across the upper 3.2 km reach. In comparison, stream temperatures increased 2.8 ºC from 14.3 to 17.1ºC along the lower 3.2 km reach. The pattern of increase in 2012 was similar to that observed in 2011, with temperatures increasing from 13.7 to 15.4ºC and 15.4 to 18.2ºC along the upper and lower 3.2 km reaches, respectively. Stream temperatures along this 6.4 km reach averaged 1.0ºC warmer in 2012 than in 2011.

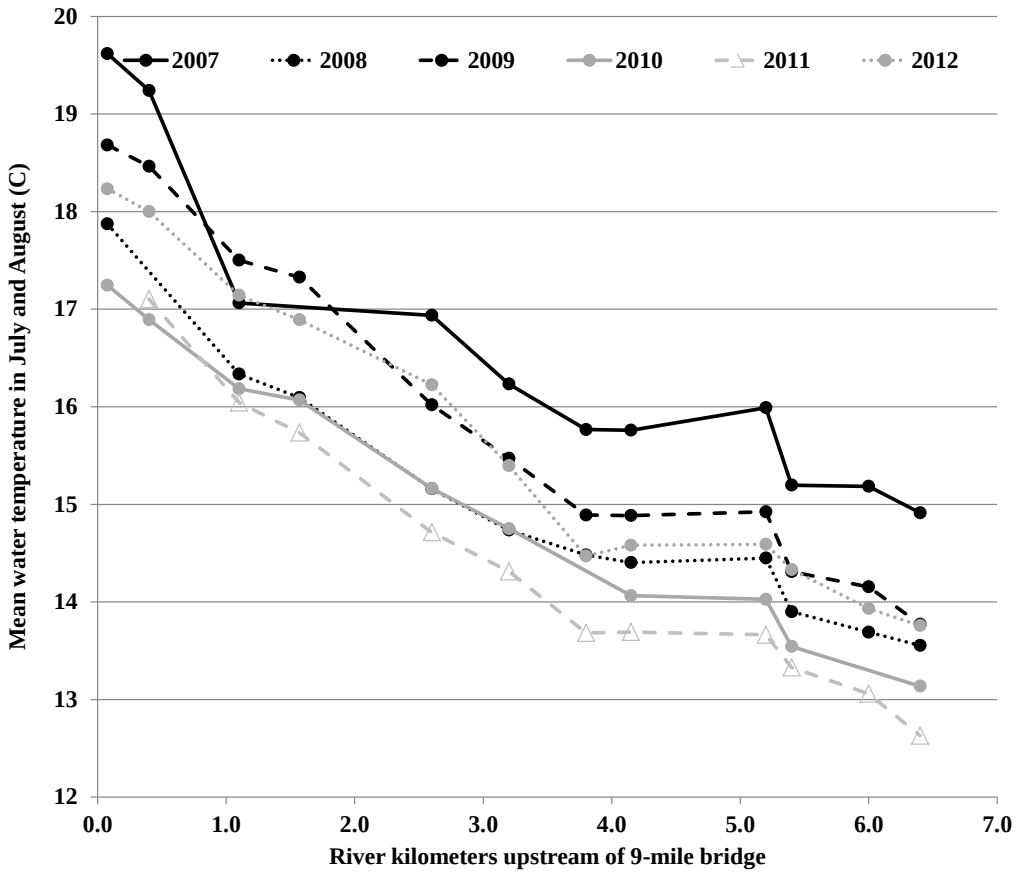


Figure 14. Longitudinal change in the mean stream temperature, computed over July and August, across mainstem reaches upstream of 9-mile bridge in the Benewah watershed, 2007-2012.

Compared with mean stream temperatures, the percentage of time logged water temperatures exceeded 17ºC during July and August in both 2011 and 2012 increased much more dramatically across the lower than the upper portions of the 6.4 km monitored main-stem reach (Figure 15). Along the uppermost 2.6 km reach (i.e., 3.8 to 6.4 km upstream of 9-mile bridge), stream temperatures rarely exceeded 17ºC in 2011 and exceeded this threshold less than 10% of the time in 2012. In comparison, percent exceedances increased downstream from 7 to 52% in 2011 and from 27 to 72% in 2012 over the lowermost 3.2 km. In addition, though percent exceedances across loggers along the uppermost 2.6 km were generally comparable between 2011 and 2012, percent exceedances along the lowermost 3.2 km averaged 21ºC warmer in 2012 than in 2011.

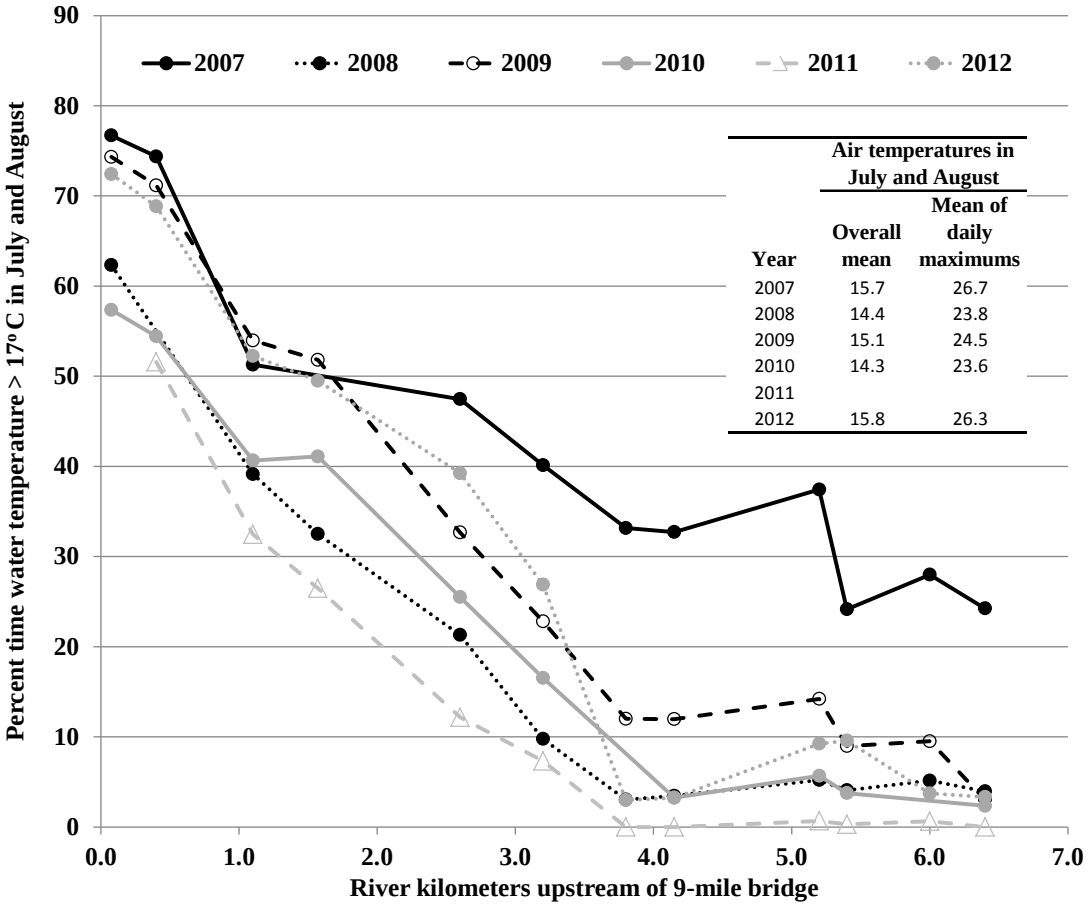


Figure 15. Longitudinal change in the percent time temperatures exceeded 17°C over July and August across mainstem reaches upstream of 9-mile bridge in the Benewah watershed, 2007-2012. Mean of daily mean and maximum air temperatures over Jly and August are displayed in the inset table for years 2007-2010 and 2012.

Consistent with previous years, ambient stream temperatures were cooler in tributaries than in main-stem reaches in the upper Benewah watershed in 2011 and 2012. Mean daily temperatures computed over July and August in lower reaches of monitored tributaries in the upper Benewah watershed ranged between 11.4 and 12.6ºC in 2011 and between 12.5 and 13.6ºC in 2012, values that were respectively lower than those in main-stem reaches. Mean stream temperatures were on average 1.2ºC warmer in 2012 than in 2011 in these tributary reaches. In addition, water temperatures rarely exceeded 17ºC in monitored lower reaches of these tributaries during summers of 2011 and 2012, with the percent time in which loggers recorded values greater than this threshold ranging between 0 and 0.1% in 2011 and between 0 and 3.9% in 2012.

When comparing data over the last six years, ambient summer stream temperatures along the 6.4 km section of the upper Benewah mainstem were generally lower in 2011 than all the previous years (Figure 14 and Figure 15). In comparison, stream temperature metrics computed from the 2012 mainstem data were generally greater than those documented during 2008, 2010, and 2011, and comparable to those calculated during the warm summers of 2007 and 2009 (Figure 14 and Figure 15). However, this pattern was much more prominent in the lower than in the upper

portion of the monitored mainstem reach. For example, when comparing data between 2012 and 2007, two years with similar cumulative degree day profiles for summer air temperatures (Figure 16), the percent time in which stream temperatures exceeded 17ºC during July and August was similar between the two years along the lower 3.2 km but was on average 25% less in 2012 than in 2007 in mainstem reaches further upstream (Figure 15). In fact, percent exceedances recorded along the uppermost 2.6 km in 2012 were comparable to those documented during the cooler summers of 2008, 2010, and 2011.

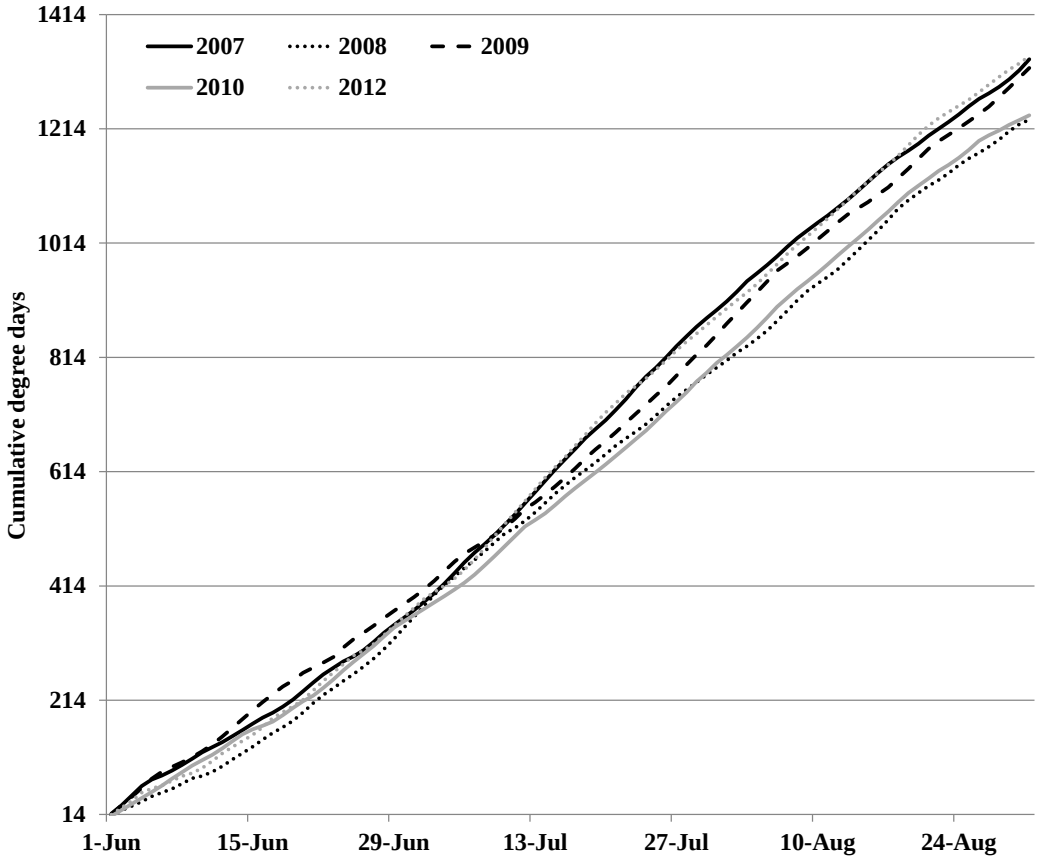


Figure 16. Cumulative degree day profiles for air temperatures recorded from June to August in the upper Benewah watershed over the years 2007-2010 and 2012.

Physical habitat

Percent canopy cover estimates at sites surveyed in tributaries in the upper Benewah watershed were collectively high in 2011 and 2012 (Table 22 and Table 23). In 2011, percentages averaged 87% (range, 70-100) and 90% (range, 62-100) in SFB and WFB, respectively. In 2012, percentages averaged 87% (range, 78-100), 88% (range, 61-100), and 92% (range, 71-96) in SFB, WFB, and Windfall, respectively. In only a few reaches were individual site estimates lower than the percent canopy cover performance standard of 75% that was established for 2nd and 3rd order tributaries by our program. Site estimates at rkm 0.7 in WFB, rkm 2.5 in Windfall, and rkm 2.1/0.2 in a secondary tributary of SFB ranged from 61-71%.

Table 22. Physical habitat attributes measured at 152 m sites in the South and West Forks of Benewah Creek in the upper Benewah watershed in 2011. For each site, mean percent canopy cover was calculated from 10 equidistant channel transects and mean percent fines was calculated from 7 riffle or pool tailout habitat types. Large woody debris and pool habitat were assessed throughout the entire site length.

		Mean percent fines		Large woody debris metrics		Pool habitat metrics	
River km index	**Mean percent canopy cover**	**Bankfull**	**Wetted**	**Count (#/100 m)**	**Volume (m^3/100 m)**	**Percent pool**	**Mean residual pool depth (m)**
			South Fork Benewah				
20.7/0.6	98	30	10	19.7	10.2	18	0.25
20.7/1.6	93	31	8	10.5	0.8	35	0.22
20.7/2.1	85	31	7	23.6	2.0	35	0.21
20.7/2.7	77	44	12	13.8	1.1	31	0.26
20.7/3.4	94	23	4	8.5	1.0	30	0.20
20.7/4.0	100	28	5	36.7	11.1	16	0.26
20.7/2.1/0.2	70	63	21	11.8	1.0	15	0.21
20.7/2.1/0.9	82	39	8	30.8	7.7	11	0.21
Mean	**87**	**36**	**9**	**19.4**	**4.4**	**24**	**0.23**
			West Fork Benewah				
20.7/0.7	62	44	22	7.2	2.7	17	0.23
20.7/1.5	96	34	4	6.6	0.3	31	0.23
20.7/2.2	80	47	2	5.2	1.2	7	0.19
20.7/2.7	100	40	1	8.5	0.7	13	0.17
20.7/1.0/0.3	94	58	27	5.9	0.3	36	0.26
20.7/1.0/0.8	99	79	59	16.4	1.6	26	0.20
20.7/1.0/0.5/0.4	100	80	57	12.5	1.8	30	0.19
Mean	**90**	**54**	**24**	**8.9**	**1.2**	**23**	**0.21**

In the upper Benewah watershed, the percentage of fines in riffle and tailpool habitats varied across and within surveyed tributaries in a consistent manner between 2011 and 2012 (Table 22 and Table 23). For percent fine estimates calculated across wetted areas in 2011, an overall mean value of 9% computed across sites in SFB was lower than the value of 24% computed across sites in WFB. Similarly, though not as pronounced, an overall mean percentage of 14% for SF was lower than the overall mean percentage of 20% for WFB in 2012. In both years, the percent fine estimates that exceeded our 15% performance standard were typically located at sites sampled in downstream reaches and in secondary tributaries (Table 22 and Table 23). For example, percent fine estimates of 18-22% were found at the most downstream sites in both tributaries. High percent fine estimates of 21-29% and 27-63% were located at sites in secondary tributaries of SFB and WFB, respectively. Windfall Creek had the lowest overall mean percent fine estimate of 9% for tributaries sampled in 2012 (Table 23). Percent fine estimates of 18-26% exceeded our performance standard at only two sites in Windfall, one of which was located in the most downstream reach. Compared to the wetted areas, percent fine estimates calculated across bankfull widths in all three tributaries were higher, and reflected similar trends across tributaries (Table 22 and Table 23). Over both years, overall mean bankfull percentages ranged from 36 to 40% and 46 to 54% in SFB and WFB, respectively. In Windfall

Creek, an overall mean bankfull percentage of 31% was calculated in 2012. The high bankfull values reflect the geology of the upper Benewah watershed and the fine-grained, erodible soils that constitute the banks and streambed outside the active channel.

Table 23. Physical habitat attributes measured at 100 m sites in the South and West Forks of Benewah Creek and in Windfall Creek in the upper Benewah watershed in 2012. For each site, mean percent canopy cover was calculated from 10 equidistant channel transects and mean percent fines was calculated from 7 riffle or pool tailout habitat types. Large woody debris and pool habitat were assessed throughout the entire site length.

		Mean percent fines		Large woody debris metrics		Pool habitat metrics	
River km index	**Mean percent canopy cover**	**Bankfull**	**Wetted**	**Count (#/100 m)**	**Volume (m^3/100 m)**	**Percent pool**	**Mean residual pool depth (m)**
			South Fork of Benewah Creek				
20.7/0.6	91	43	21	18.1	9.1	75	0.37
20.7/1.6	87	53	18	5.6	0.5	40	0.21
20.7/2.1	95	28	4	27.7	2.1	26	0.23
20.7/2.7	83	41	8	12.5	2.1	40	0.36
20.7/3.4	81	23	9	10.9	1.8	28	0.21
20.7/4.0	100	44	14	31.4	9.2	26	0.17
20.7/2.1/0.2	84	33	8	6.0	0.8	18	0.21
20.7/2.1/0.9	78	54	29	16.0	4.0	29	0.18
Mean	**87**	**40**	**14**	**16.0**	**3.7**	**35**	**0.24**
			West Fork of Benewah Creek				
20.7/0.4	91	32	8	14.9	3.6	34	0.31
20.7/0.7	61	40	12	4.0	1.5	30	0.29
20.7/1.5	94	39	10	9.9	2.0	44	0.18
20.7/2.2	85	35	12	9.0	0.7	37	0.25
20.7/2.7	93	45	6	7.0	0.8	22	0.15
20.7/1.0/0.3	80	39	14	8.1	0.6	42	0.23
20.7/1.0/0.5/0.4	100	79	63	13.9	8.8	50	0.19
20.7/1.0/0.8	99	55	31	19.9	3.8	55	0.19
Mean	**88**	**46**	**20**	**10.8**	**2.7**	**39**	**0.22**
			Windfall Creek				
18.6/1.1	98	47	26	32.8	5.8	73	0.43
18.6/1.7	95	21	1	27.2	2.9	70	0.33
18.6/2.0	96	28	1	12.2	5.7	57	0.32
18.6/2.5	71	30	18	38.0	5.0	64	0.24
18.6/3.0	92	36	8	15.8	0.7	38	0.25
18.6/1.4/0.3	96	33	3	19.1	5.2	63	0.31
18.6/1.4/0.8	96	24	8	22.9	4.7	44	0.27
Mean	**92**	**31**	**9**	**24.0**	**4.3**	**59**	**0.31**

Large woody debris metrics computed across sites in 2011 and 2012 were consistently the lowest in WFB when compared with those calculated for SFB and the Windfall drainage (Table 22 and Table 23). Over both years, mean counts ranged from 8.9 to 10.8 pieces/100 m and mean volumes ranged from 1.2 to 2.7 m^3/100 m in WFB. In comparison, mean counts and volumes

respectively ranged from 16.0 to 19.4 pieces/100 m and 3.7 to 4.4 m^3/100 m in SFB. Much of the disparity between drainages was due to large loadings that were consistently estimated in SFB at the most downstream site, and at two high gradient sites in the most upstream sampled reach (rkm 4.0) and in a reach of a secondary tributary (rkm 2.1/0.9). Otherwise, LWD volumes at most of the sites in both tributaries were far from meeting our performance standard of 6.0 m^3/100 m. When comparing the three drainages that were sampled in 2012, Windfall had the highest mean LWD count, 24.0 pieces/100 m, and volume, 4.3 m^3/100 m (Table 23). In addition, high LWD loadings were more uniformly distributed across sampled reaches in Windfall than in the other two tributaries.

Pool habitat metrics calculated across sites were comparable between SFB and WFB in both years, though metrics in these two tributaries were lower than those estimated in Windfall (Table 22 and Table 23). In SFB and WFB, percent pool habitat averaged 24 and 23% in 2011 and 35 and 39% in 2012, respectively. In comparison, the mean percent pool habitat value of 59% calculated across sites in Windfall was the highest recorded of all three tributaries in 2012. Similarly, the overall mean residual pool depth value of 0.31 m computed for Windfall was higher than the range of values, 0.21-0.24 m, calculated for the other two tributaries. When excluding those sites located in high gradient reaches (SFB 4.0 and 2.1/0.9, WFB 1.0/0.8 and 1.0/0.5/0.4), percent pool habitat was observed to be linearly related to the volume of LWD present (Figure 17; R^2=0.6).

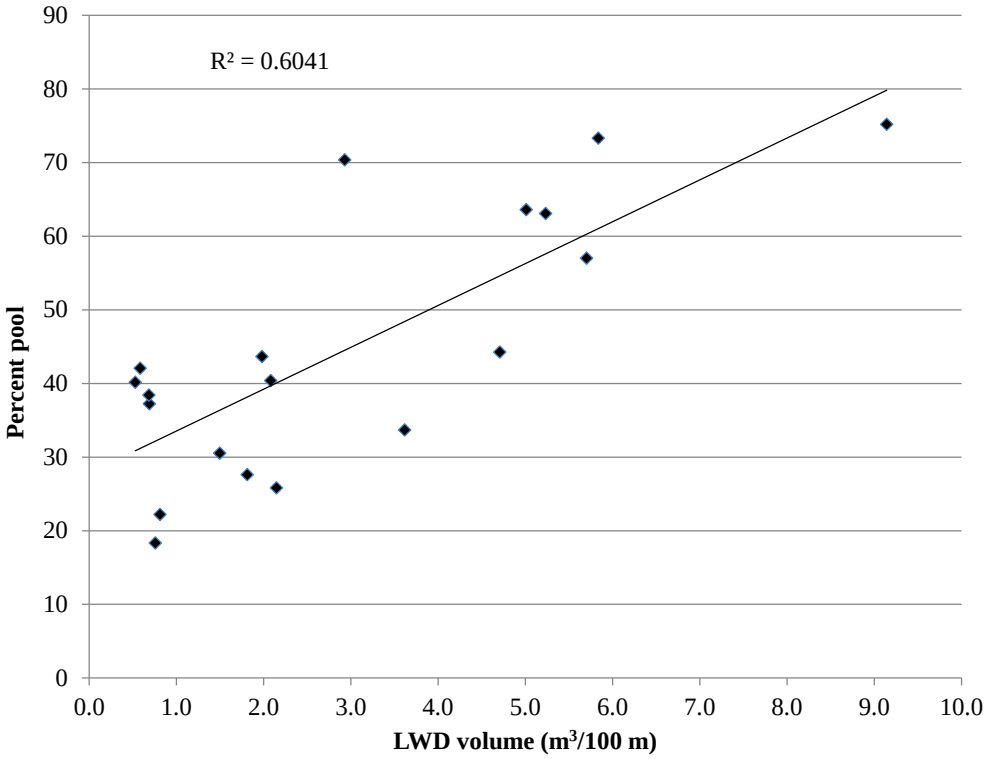


Figure 17. Relationship between percent pool habitat and LWD volume (m^3/100 m) for 100 m sites sampled in South and West Forks of Benewah Creek and Windfall Creek in 2012.

The analyses that were conducted for LWD and pool metrics to evaluate spatial and temporal variability indicated that metric values varied over consecutive survey years but did not depend on the surveyed reach length. For data collected across sites in 2011, the percent difference in mean estimates for percent pool, mean residual pool depth, and LWD volume between the 152 and the 100 m reach lengths were all below 10% for each of SFB and WFB (Table 24). Furthermore, the standard deviation values computed across sites were comparable for each of the two reach lengths surveyed in 2011 for all metrics in both tributaries. These results collectively indicate that the 100 m length represents the habitat conditions captured by the longer reach length for each of the two tributaries.

On the other hand, when comparing the same 100 m reach lengths surveyed in each of 2011 and 2012 across sites in the SFB and WFB, large percent differences in mean estimates between years were observed for percent pool habitat (35-50%) in both sub-drainages and LWD volume (64%) in WFB (Table 24). For each of these metrics the mean values calculated in 2012 were consistently greater than those calculated in 2011. When assessing the annual *site-specific* variability of percent pool habitat, the mean standard deviation value computed across sites ranged from 10.6 in the SFB to 11.3 in the WFB which, in each tributary, represented approximately 35% of the overall mean metric value (Table 24). Similarly, when assessing the annual *site-specific* variability of LWD volume, the mean standard deviation value computed across sites ranged from 0.91 in the SFB to 1.35 in the WFB which represented 23 and 69% of tributary-specific mean metric values, respectively (Table 24).

Table 24. Summary of comparisons of pool habitat and LWD metrics calculated across different sized survey lengths and over consecutive years for the same eight sites surveyed in the South Fork of Benewah Creek and seven sites surveyed in the West Fork of Benewah Creek in 2011 and 2012.

	South Fork of Benewah Creek			**West Fork of Benewah Creek**		
	Percent pool	**Mean resid pool depth (m)**	**LWD volume (m^3/100 m)**	**Percent pool**	**Mean resid pool depth (m)**	**LWD volume (m^3/100 m)**
Estimates from the 152 m reach surveyed in 2011						
Mean	23.9	0.23	4.4	22.9	0.21	1.2
St. Dev.	9.9	0.03	4.5	10.8	0.03	0.9
Estimates from 100 m of the 152 m reach surveyed in 2011						
Mean	24.7	0.23	4.1	24.1	0.22	1.3
St. Dev.	12.0	0.03	4.2	13.2	0.03	1.3
Estimates from the 100 m reach surveyed in 2012						
Mean	35.2	0.24	3.7	40.1	0.21	2.6
St. Dev.	17.8	0.08	3.5	11.3	0.05	3.0
Percent difference between mean estimates from the two different sized survey lengths in 2011	3.3	0.2	6.5	5.1	4.1	8.6
Percent difference between mean estimates from 100 m survey lengths in both years	35.1	6.0	9.4	49.8	3.3	64.4
Standard deviation of metrics at each 100 m reach over 2011 and 2012						
Mean	10.60	0.02	0.91	11.30	0.02	1.35
Percent of overall mean metric value	35.4	10.3	23.4	35.2	10.2	68.9

3.3.2.2 Monitor and evaluate the effectiveness of tributary habitat actions relative to environmental, physical, or biological performance objectives.

The repeated survey of 69 monumented dam locations during 2010 through 2012 indicated a significant declining trend in the number of intact natural beaver dams and beaver influenced habitats in the mainstem of Benewah Creek within the D2 project reach located between river km 14.3 and 17.0 (Table 25; Map 8). The number of intact dams measured in the fall of each year decreased from 38 in 2010, to 21 dams, to only eight dams by 2012; a 79 percent reduction over the survey period. Many of these dams simply were not being maintained by beavers, as the number of dams with signs of recent activity - which we defined as active dams - showed a similar decrease during this period. For example, in 2010 33 dams were active, the following year there were 17, and by 2012 only six dams were considered active.

Consistent with past observations, beavers mainly built upon the dams and gathered building materials during August or later each year. All dam building during 2011 and 2012 occurred in the upstream half of the longer reach that was surveyed with only remnant dams from 2010 found downstream of river km 15.7. Most dams were seemingly abandoned during the fall or winter of 2011 and nearly all remaining dams were subsequently abandoned by the end of August 2012. The height of intact natural dams decreased after 2010 (mean=1.12 ft.), but then increased slightly between 2011 (mean=0.75) and 2012 (mean=0.81 ft.). This trend was likely due to smaller dams being breached while larger dams remained. There was a positive correlation between these remaining intact dams and the presence of stable materials. Mid-channel islands which divided stream flow within the active channel, large root wads, wood that was at least partially buried in the stream bed or banks, other large wood and vertical restoration logs installed to support dams all contributed to dam stability. The dams which used these materials were more structurally sound and created backwater habitats for longer.

All natural dams experienced some loss of height over the winter, attributed to a combination of factors including ice shear and high flows. Between fall of 2010 to spring of 2011, mean dam height decreased 0.99 ft., and from 2011 to 2012 mean height decreased 0.70 ft. Between spring and fall survey periods, the height of active dams increased 0.48 and 0.68 ft. in 2011 and 2012, respectively. This seasonal pattern of dam loss and construction describes changes at progressively fewer dams during the survey period, making inferences largely subjective, but the activity is likely consistent with a decreasing beaver population.

The significant decrease in the number of intact dams is also reflected in metrics describing the backwatered habitat associated with natural beaver dams across years (Table 25). The 4,603 feet of channel inundated by natural dams in 2010 decreased 1,325 feet (28.7%) by 2012. Also the mean inundated channel length decreased from 139 feet to 99 feet over the two years, indicating that more recent dams may have been smaller or with less structural integrity, so that they were not damming as efficiently as before. These natural dams accounted for a total residual pool volume of 29,316 ft^3 in 2010 decreasing to 8,968 ft^3 in 2012; a 69% reduction. The mean residual pool depth for these same dams decreased from 2.6 feet in 2010 to 1.9 feet in 2012. By contrast, the number of restoration structures in the reach increased during the survey period from 5 structures in early 2010 to 21 structures in the mainstem Benewah Creek by late 2012 (Map 8). As natural dams were abandoned, these restoration structures comprised an increasing proportion of the total backwatered habitat within the reach. For a subsample of these structures

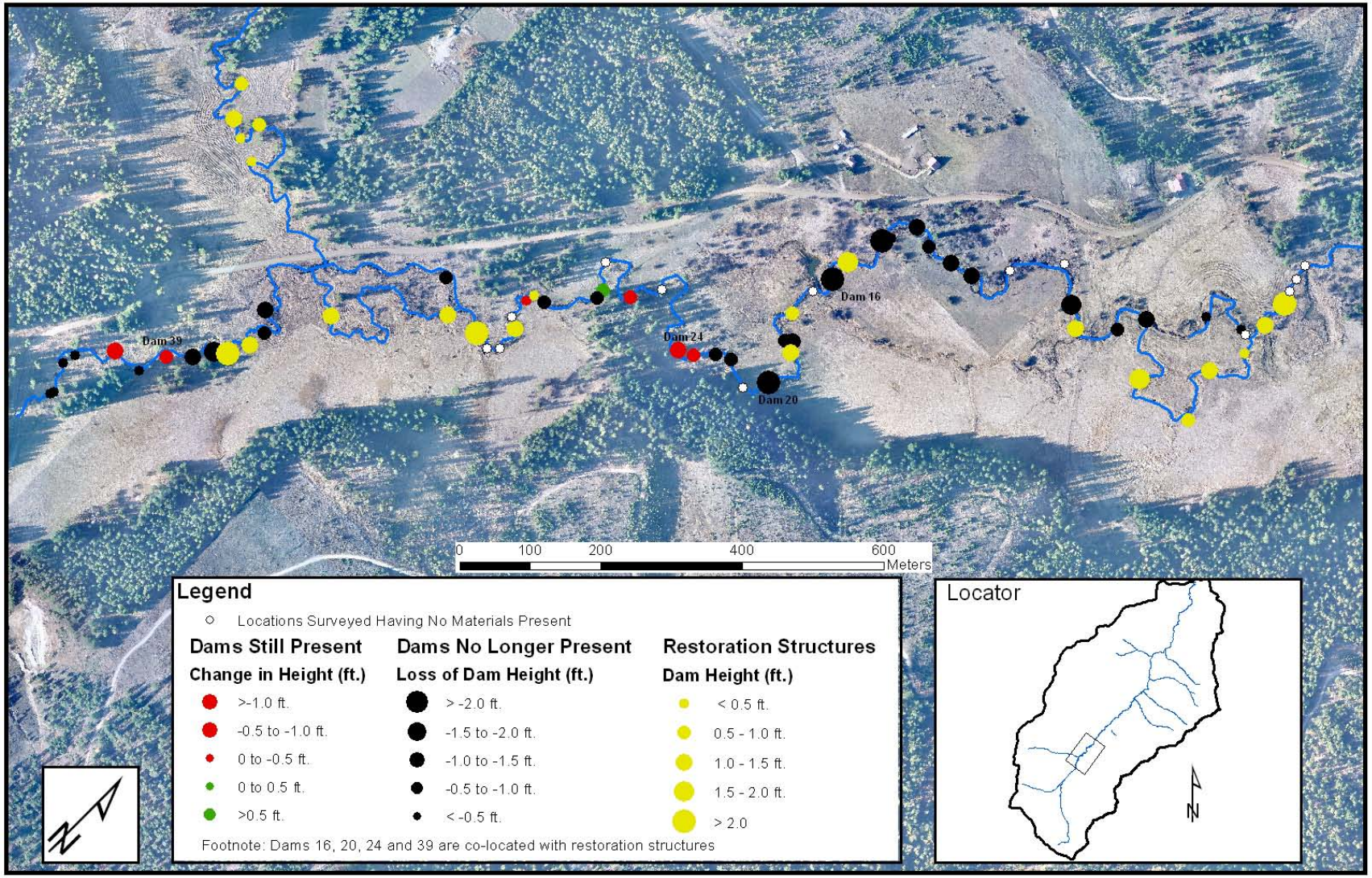
(N=13) that were measured in fall 2012, 2,564 feet of channel was inundated, resulting in a total residual pool volume of 12,925 ft^3 with a mean residual pool depth of 2.6 feet. Restoration structures therefore provided a much greater proportion of the available rearing habitat – 59% by pool volume - compared with natural dams by 2012.

Table 25. Comparisons of dam morphology and backwatered habitat attributes from 2010 to 2012 in the Phase 2 restoration reach of the upper Benewah mainstem.

	2010	2011	2012
Dam morphology			
Number of intact natural dams	38	21	8
Number of active dams	33	17	6
Height of intact dams (ft)			
Mean	1.12	0.75	0.81
Std. Dev.	0.78	0.33	0.51
Change in height of intact dams (ft)			
Previous fall survey to initial survey of current year			
Mean	.	-0.99	-0.70
Std. Dev.	.	0.76	0.30
Over survey periods of current year			
Mean	.	0.48	0.68
Std. Dev.	.	0.44	0.57
Attributes of habitat backwatered at monumented dam locations			
Collectively across all survey locations [a]			
Inundated channel length (ft)			
Total	7565	.	5496
Mean	145	.	119
St. Dev.	115	.	92
Pool volume (ft^3)			
Total	52376	.	20189
Mean	1007	.	439
St. Dev.	1693	.	674
Mean residual pool depth (ft)			
Mean	2.82	.	2.36
St. Dev.	0.84	.	0.68
Change from 2010 to 2012 at individual survey locations [b]			
Inundated channel length (ft)			
Total	.	.	-1325
Mean	.	.	-40
St. Dev.	.	.	73
Pool volume (ft^3)			
Total	.	.	-20349
Mean	.	.	-617
St. Dev.	.	.	1580

[a] Includes restoration structures

[b] Excludes restoration structures



Map 8. Disposition of natural dams and restoration structures surveyed during 2010 through 2012 in the D2 reach of the Eltumish Project in upper Benewah Creek.

3.3.3 Predator/Competitor Control Implementation

In 2011, 91 brook trout were removed from the upper Benewah watershed during suppression efforts. Of these 91, 73 were captured by shocking the 2.0 km reach of contiguous main-stem habitat upstream of the 12-mile bridge to the confluence of the West and South Forks of Benewah Creek. A total of 3 days was expended on these removal efforts within the timeframe of September 1 – 6. Five additional brook trout were removed from the enclosure upstream of 12-mile bridge over the course of brief electrofishing (5-10 minute) sampling occasions that occurred on September 6, September 28, and October 13. In addition, 13 brook trout were removed on October 13 by shocking a 100 m reach immediately upstream of the 12-mile enclosure given that a number of fish were observed to be spawning in that area.

In 2012, 218 brook trout were removed from the upper Benewah watershed during suppression efforts. Of these 218, 201 were captured by shocking the 2.0 km reach of contiguous main-stem habitat upstream of the 12-mile bridge to the confluence of the West and South Forks of Benewah Creek. A total of 4 days was expended on these removal efforts within the timeframe of August 23 – 28. Seventeen additional brook trout were removed from the enclosure upstream of 12-mile bridge over the course of brief electrofishing sampling occasions that occurred on August 28, September 6, September 26, and October 19.

The total number of brook trout removed in the upper Benewah watershed has been considerably declining over the last seven years, with numbers removed in each of 2011 and 2012 less than 50% of that which was removed in each of 2009 and 2010, and less than 25% of that which was removed in each of the years from 2005 to 2008 (Figure 18). In part, these results were due to a reduction in the length of main-stem habitat addressed by our removal efforts in recent years. However, the number of fish removed in each of the last two years from the 2.0 km index main-stem reach upstream of 12-mile bridge, a reach that has been regularly sampled since 2005, were the lowest values recorded over the last eight years, and markedly lower than the numbers removed during the initial suppression years of 2005 and 2006 (Figure 18). In addition, the CPUE of brook trout along the 2.0 km index main-stem reach in 2011 and 2012 was comparable to that in 2010 and substantially less than that in 2007 and in 2009, which was the first year in which the enclosure upstream of 12-mile bridge was implemented as a suppression tactic (Figure 18).

Noticeable differences in the length distributions of brook trout removed from the index reach upstream of 12-mile bridge was observed when comparing data collected from the 2011 and 2012 efforts with those collected in prior years (Figure 19). In 2011, 8% of the captured brook trout were considered to be young-of-the-year (i.e., total lengths <= 80 mm), a percentage that was lower than that documented in 2010 (25%) and markedly lower than those documented in 2005 and 2009 (45-55%). In contrast to that which was observed in 2011, approximately 75% of the brook trout removed in 2012 were deemed to be young-of-the-year.

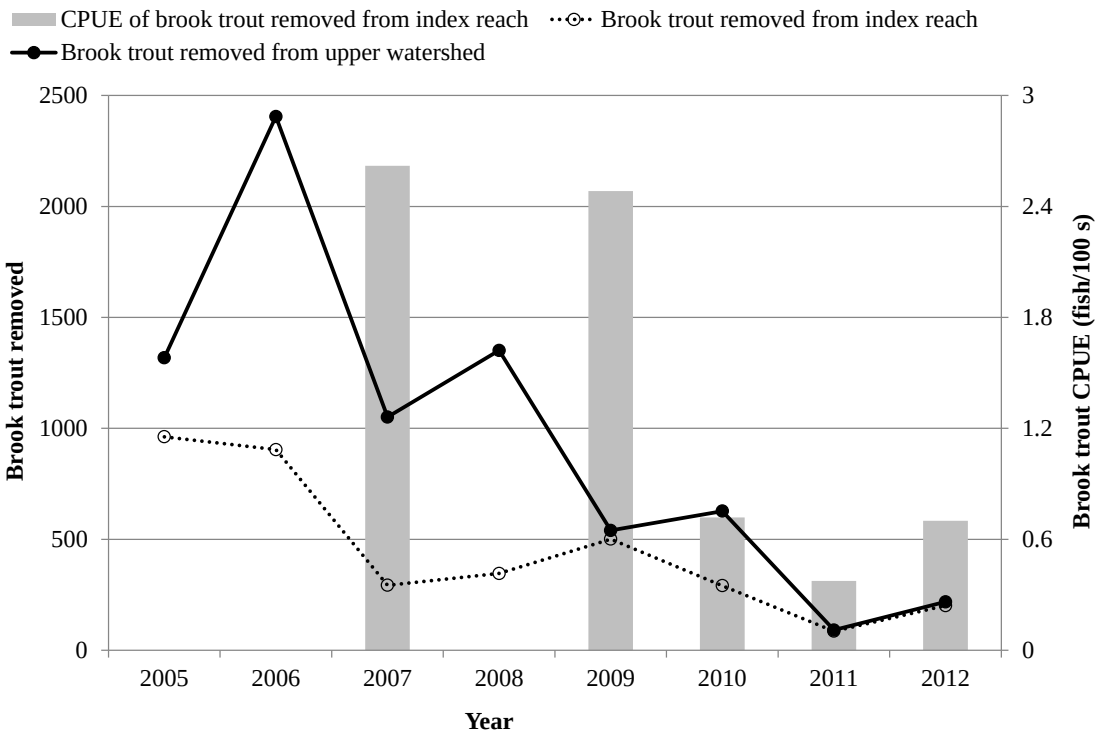


Figure 18. Suppression metrics for brook trout removed from the upper Benewah watershed and from the 2.0 km mainstem index reach upstream of the 12-mile bridge from 2005 to 2012.

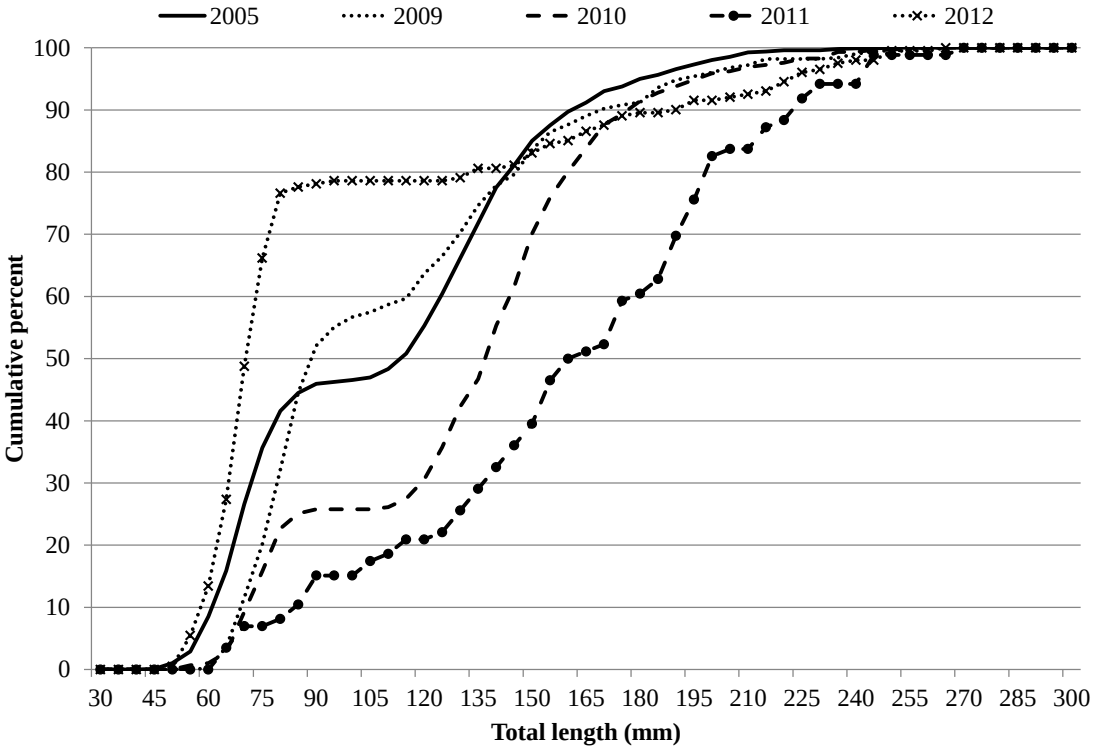


Figure 19. Cumulative length distributions for brook trout removed from the 2.0 km mainstem index reach upstream of 12-mile bridge in the upper Benewah watershed in 2005 and from 2009 to 2012.

A general declining trend in densities of age one and older brook trout has been observed across sampled reaches in tributaries of the upper Benewah watershed over the years of our suppression efforts (Figure 20). Single pass density indices of brook trout averaged 3.9 fish/100 m in 2011 and 2.1 fish/100 m in 2012. These values were the lowest recorded since the commencement of the removal program in 2004, and represent a 40-50% decrease from those estimated during the first four years. A concomitant increase in the percentage of cutthroat trout as overall salmonid catch has also been observed across tributaries in the upper watershed (Figure 20). From 2004 to 2006, the early years of our suppression efforts, cutthroat trout constituted less than 60% of captured salmonids. In comparison, cutthroat trout comprised approximately 80-90% of the salmonids in 2011 and 2012.

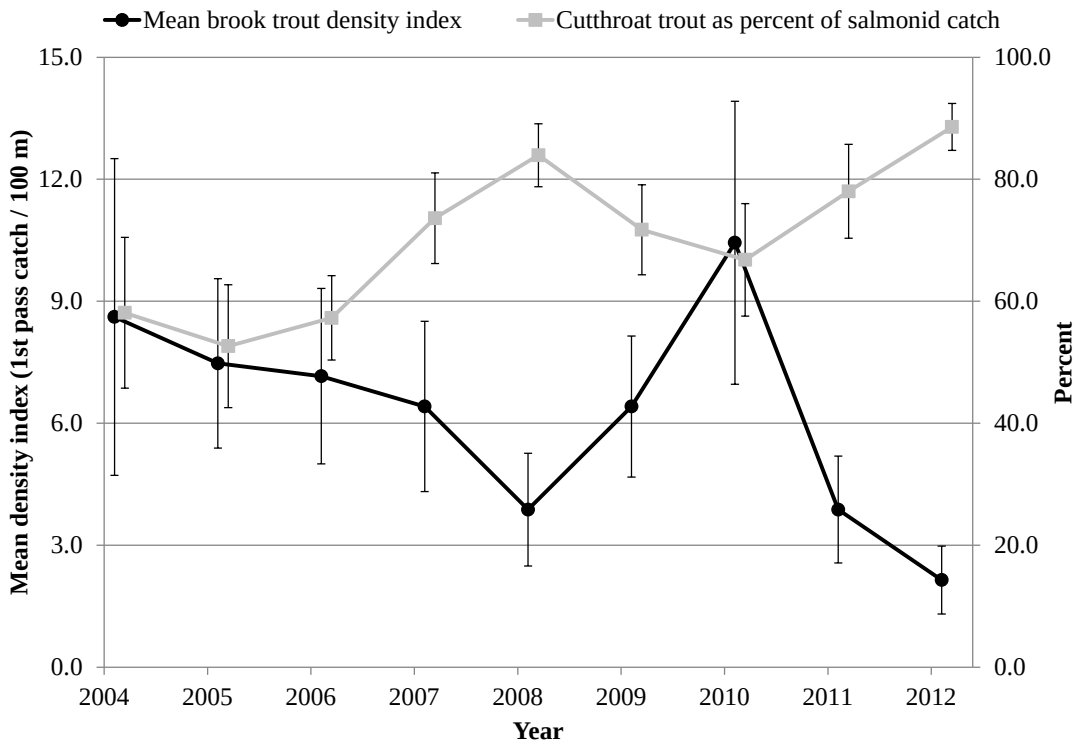


Figure 20. Mean density indices of brook trout age 1+ and older (1st pass catch/100 m) and percent of cutthroat trout as overall salmonid catch (± one standard error) across tributary sites in the upper Benewah watershed that have been regularly sampled over the years 2004-2012.

3.4 Discussion

3.4.1 Fish Population Status Monitoring (RM&E)

3.4.1.1 Assess the status and trend of natural origin abundance of adult fish populations

It is imperative that we reliably track temporal changes in adult spawners given that one of the primary objectives of our recovery efforts is to augment the number of returning adult cutthroat to our watersheds. However, we do not have the ability to consistently capture ascending adults over years in both watersheds to provide a sufficient number of marked fish for accurate annual spawner abundance estimates. Though a rather precise estimate was obtained in Lake Creek in 2012 (±20%), the low number of ascending adults captured in 2011 yielded a lower level of confidence in our estimate (±50%). Furthermore, the lack of ascending spawners captured in Benewah Creek in both years precluded abundance estimation. In some cases, we were able to use PIT-tagged fish that were interrogated at the fixed station downstream of the trap to estimate the number of ascending adults that *approached* the trap, though we do not know how many of those continued to ascend beyond the trap to access upriver spawning grounds. The lingering behavior of PIT-tagged fish that was apparent downstream of the trap in both years and in both systems suggests that fish were either reluctant to ascend into the livebox or had difficulty in navigating the trap to locate the entranceway to the livebox. A number of these lingering adults may have migrated back downriver if they were not able to negotiate the trap even when it was compromised during high flow periods. Indeed, the estimate of the number of adults that *approached* the Lake Creek trap in 2011 was approximately 85% higher than the estimate of spawners that *ascended upriver* of the trap. The lingering and apparent avoidance behavior may be learned from prior experience at the UP trap site. However, the percentage of PIT-tagged first time spawners, which presumably had not yet encountered the trap, that avoided capture in Lake Creek in 2012 was similar to that for fish that had been PIT-tagged as adults in prior migrations.

Given the possibility that our traps were obstructing the upriver movement of spawners, modifications were made to the support structure at the Lake Creek trap in 2012 so that the suspended panels could be lowered all the way down to the stream bed. Several times during the upriver migratory period in 2012 when PIT-tagged fish were observed to linger downstream of the trap, panels were lowered to the stream bed to permit unobstructed upstream passage. Apparently, spawners were not turned away in Lake Creek in 2012 given that the estimate of spawners that ascended past the trap (410) was similar to the estimate of those that approached the trap (398). Similar modifications to the support structure are planned for implementation at the Benewah Creek 9-mile UP trap in 2013. In addition, modifications to the structure of the livebox at the Benewah Creek UP trap are planned for 2013 to facilitate its access by ascending spawners. The PVC tube that adults have been required to ascend to enter the livebox will be removed lest it unduly disrupts migratory behavior. Furthermore, the livebox will be designed with two separate chambers to capture both ascending and descending adults, which will obviate the need for the installation of two different adult migrant traps.

The spawner abundance estimate of 410 fish that was generated for Lake Creek in 2012 was much greater than the estimates of ascending spawners, which ranged from 162 to 230 fish (estimates that were adjusted to account for spawners that *approached* the UP trap), generated for this watershed over the previous three years (Firehammer et al. 2011, 2012). These results may have been due to an increase in the number of new recruits to the spawner population that

resulted from the apparent higher juvenile to adult return rates that were observed for the juvenile cohort that outmigrated in 2010 compared with previous years. Additional years of spawner abundance data will be required to evaluate whether the recent positive trend observed in Lake Creek is genuine or an artifact of our trapping procedures.

3.4.1.2 Assess the status and trend of juvenile abundance and productivity of natural origin fish populations

We also cannot consistently catch nor obtain accurate abundance estimates of juvenile outmigrants with our current trap design. Capture efficiencies were often variable and relatively low during spring periods resulting in rather imprecise estimates. Furthermore, in many years including 2011 and 2012, a considerable portion of the outmigrant run is likely omitted given the inability to deploy the trap during the ascending limb of the hydrograph when juveniles may be first cued to outmigrate. The interrogation of juveniles, which had been PIT-tagged in prior years, in late March through early May in both systems during periods of increasing discharge alludes to the possibility that juveniles were already migrating downriver before trap installation. Aside from problems arising from the timing of trap deployment, periods of trap inoperability during structurally damaging high discharge events that compromised trap performance and suspended trapping operations, like that which occurred in 2011 and 2012, also precludes the ability to capture juveniles and generate unbiased abundance estimates. Consequently, our juvenile outmigrant abundance estimates in both systems are undoubtedly biased low in most years.

There is also a need to address the apparent lack of motivation to outmigrate that was exhibited by juveniles that were PIT-tagged in both watersheds in release trials toward the end of outmigration periods in 2011 and 2012 at the tail end of the spring hydrograph. At this time, it is unclear as to whether juveniles captured late in the season are actively moving out of the system or are just inadvertently intercepted by the trap during localized early-summer foraging movements. On the other hand, the fixed weir traps that have been used to capture adfluvial juveniles may be disrupting the behavior of outmigrants during latter spring periods as discharge declines. At low flows, these traps tend to create a slack water environment upstream, and consequently, may not provide the appropriate velocities that juveniles require to cue continued downriver movement. Similar delayed movements have been noted for juvenile salmonids outmigrating through impounded reaches of larger river systems (Venditti et al. 2000). The apparent dilatory behavior exhibited by tagged juvenile cutthroat trout after their release upstream of the trap may be the result of either trap avoidance behavior or to difficulties in re-negotiating the trap. Whatever the reason, it is imperative that we redress the situation so that we don't adversely disrupt the motivation of adfluvial juveniles to move downstream to the lake. In 2013, we plan to replace the fixed panel weir design that has been used to capture outmigrating juveniles at the Benewah 9-mile site with a rotary screw trap. Unlike the fixed panel traps, screw traps are designed so that they don't impede flow and impound the stream. Furthermore, screw traps can be installed and operated under a much wider range of flows and thus should be capable of sampling a much greater range of the juvenile outmigrant run to provide better unbiased estimates of outmigrant production.

Results from our PIT-tagging efforts that have been implemented since 2005 in Lake Creek and since 2008 in Benewah Creek suggest that approximately 2% of outmigrating juveniles return to

spawn as adults. Although empirical estimates of in-lake survival rates for adfluvial cutthroat trout are scarce, several studies have provided values with which comparisons may be drawn. Annual survival rates of 49% were estimated in Lake Koocanusa for cutthroat trout from reservoir entry as juveniles to first time spawning two years later which equate to approximately a 25% return rate (Huston et al. 1984). Gresswell et al. (1994) estimated a 16-25% return rate for adfluvial juvenile Yellowstone cutthroat trout emigrating from Arnica Creek in the Yellowstone Lake system in the early 1950's. Compared with these studies, our juvenile-to-spawner return estimates are 8 to 10 times lower. These comparisons underscore the importance of understanding the reason for these extremely low return rates given that in-lake juvenile survival has been considered a key vital rate in determining overall population trajectories for adfluvial cutthroat trout (Stapp and Hayward 2002). The additional years of data obtained from juvenile outmigrant cohorts in Lake Creek and those obtained from cohorts outmigrating from Benewah Creek over the last two years have not changed our interpretation of the limiting factors that may be inhibiting adult production in the adfluvial watersheds monitored by our program (Firehammer et al. 2012). Furthermore, the apparent high rate of repeat return of adfluvial spawners in both the Lake (31-64%) and Benewah (35-39%) creek watersheds suggests that the survival bottleneck in the lake is likely occurring at the pre-adult and not the adult stage.

Although the processes that are apparently limiting juvenile to adult survival are largely unknown, it is imperative to better understand whether predation is a predominant mechanism regulating survival rates in Lake Coeur d'Alene and potentially inhibiting recovery of cutthroat trout. As such, the present contracted study that is evaluating the predatory impacts of two non-native piscivores, northern pike and smallmouth bass, on cutthroat trout survival in Lake Coeur d'Alene, should be informative. Cutthroat trout have been found to be a major dietary item for northern pike in earlier studies conducted on Lake Coeur d'Alene (Rich 1992), and smallmouth bass, a documented salmonid predator, have apparently increased in numbers in the last ten years according to lake-wide surveys (Maiolie et al. 2010). Information gained from this study will support the development of alternative actions that may be considered for implementation to manage the fish assemblage in Lake Coeur d'Alene.

3.4.1.3 Assess the status and trend of spatial distribution of fish populations

Population surveys conducted at index sites during the summer and fall of 2011 and 2012 permitted an assessment of cutthroat trout abundance at a much finer spatial scale than that attainable using our migrant trap data. Consistent with surveys conducted in previous years, indices of cutthroat trout density in our adfluvial watersheds were predominantly greater in tributary than in mainstem habitats. Furthermore, in both Lake and Benewah creeks, cutthroat trout were often found at greater numbers in upper than in lower reaches of tributaries. Sub-optimal rearing conditions could be contributing to the low numbers of fish in downstream reaches of these tributaries. Prioritizing these reaches for prospective habitat improvements should increase the productive potential of tributaries, and in the case where tributary mouths are in close proximity to one another, improve connectivity and promote a more robust meta-population structure in upper portions of both watersheds.

The low densities of cutthroat trout documented in mainstem reaches of adfluvial watersheds still imply that mainstem habitats provide less suitable rearing conditions than those found in tributaries. With regards to the mainstem reach in the upper Benewah watershed that has been

addressed by Phase 2 restoration, the lack of cutthroat trout observed at survey sites may be partly due to their avoidance of these areas because of the disturbances imposed by our channel reconstruction activities. In addition, the extent of pool habitat was substantially less in 2011 and 2012 than that documented in prior years in the Phase 2 reach because many of the beaver dams were either compromised or eliminated by high flows in both years and not rebuilt during summer low flow periods. Pool habitat has been shown to be a habitat type favored by cutthroat trout during summer rearing periods in small stream systems (Heggenes et al. 1991; Young 1996; Rosenfeld et al. 2000). However, numerical responses by cutthroat trout to restoration have also not been evident in downstream Phase 1 mainstem reaches (Vitale and Firehammer 2011), where complex pool habitat has been created and sustained over years.

Various explanations have been proferred for the apparent lack of utilization of these restored habitats (Vitale and Firehammer 2011), and we realize that because we are not only amending local deficiencies in habitat complexity but also addressing impaired processes that operate at larger spatial scales, the re-establishment of natural processes will occur gradually, and as such, detection of positive responses by cutthroat trout may require a longer timeframe. However, it is also likely that the sampling techniques that we have been using to survey trout populations in the upper watershed may be inadequate to capture fish in these restored mainstem habitats. Given the thermal refugia that have been observed at the bottom of deep pools in restored reaches (Vitale and Firehammer 2011), cutthroat trout, if present, would most likely be using these micro-habitats. However, restored pools are frequently over four feet deep, and not only is visibility poor but both wading and netting prove challenging at these depths. Furthermore, because of the low conductivities in our watersheds, the electrical fields generated by our backpack electrofishing equipment are exceptionally small and consequently may not elicit electrotaxis in fish positioned along the bottom of deep pools. Fyke nets have also proven to be an ineffective sampling technique in deep, restored pools in upper Benewah mainstem reaches (Firehammer et al. 2012).

We introduced fixed HDX PIT-tag interrogation systems into the upper Benewah watershed in 2012 as an alternative method to examine utilization of restored main-stem reaches by cutthroat trout. Each fixed system consists of an array of antennas that will permit detection of directional movement. These arrays have been installed at the confluences of the West and South Forks of Benewah Creek and of Windfall Creek, and at the upstream and downstream ends of the mainstem reach that has undergone restoration from 2005 to 2012. The network of installed arrays in the upper watershed will allow us to determine if cutthroat trout tagged during summer surveys move downstream from tributary habitats into restored mainstem reaches.

Sampling efforts, including the PIT-tagging of cutthroat trout, were also expanded in 2012 in the South and West Forks of Benewah Creek and in Windfall Creek to begin to describe the abundance and distribution of salmonids at a spatial scale finer than that attainable in population surveys conducted in previous years. Over the past 15 years, summer surveys conducted annually at index sites across the Benewah watershed provided a consistent but very coarse reach-scale description of where cutthroat trout were predominantly found, and consequently our interpretation of distribution patterns have not appreciably changed. With the advent of our summer PIT-tagging program, our monitoring efforts are now focusing on better understanding the spatial and temporal population demographics of cutthroat trout in rearing tributaries,

especially those tributaries that have been targeted for treatment over the next 10 years. As a result, we increased the number of sites in each of the aforementioned three tributaries, and intend to randomly assign these sites annually across reaches within each tributary. Data collected repeatedly across these sites will serve in future analyses to examine response metrics of cutthroat trout (e.g., abundance, survival rates) at the tributary scale to the collective restoration efforts.

In Evans and Alder creek watersheds, which support prevailing resident cutthroat trout populations, spatial distributions were vastly different between systems, but were similar to those documented during previous surveys within each system. Consistent with past years, cutthroat trout in Alder Creek were predominantly found in lower reaches, and at low densities, and have been seemingly displaced from upper reaches of the watershed, where they were virtually absent but brook trout were numerous. In comparison, cutthroat trout in Evans Creek were found to be evenly distributed at moderate densities across main-stem reaches in much of the watershed, a pattern that has been repeatedly observed in our annual population surveys. Because spatial patterns of trout abundance in these two watersheds have not appreciably changed over years, population surveys will be conducted less frequently in the future than in the past.

3.4.1.4 Assess the status and trend of diversity of natural origin fish populations

Few fish that were PIT-tagged in tributary habitats in 2012 in the upper Lake and Benewah creek watersheds moved out of tributaries into mainstem habitats during fall and winter periods. Of the fish found to exit their tagging tributaries in the Lake Creek watershed, all were PIT-tagged within the lower 1.0 km of their respective tributary. These fish may have just been undergoing localized, ranging movements rather than a directed, seasonal migration to overwintering habitat. In the upper Benewah watershed, only a small percentage of fish tagged in Windfall Creek and the West and South Forks of Benewah Creek were detected moving into the restored mainstem reach during fall and winter periods. Deep, low-velocity pools, which have been shown to be preferred winter refuge habitat by cutthroat in small stream systems (Jakober et al. 1998; Brown and Mackay 1995; Harper and Farag 2004; Lindstrom and Hubert 2004), were likely more abundant in reaches of the restored Benewah mainstem reaches than in tributaries. However, seasonal movements may be dependent on the severity of sub-optimal overwintering conditions in tributary habitats, and several years of tagging may be required to examine movement patterns of cutthroat trout under different winter flow regimes. Furthermore, we may find tagged fish to move downstream from tributary habitats the following spring and summer and not move downstream to the lake but rear in restored mainstem reaches for at least another year before outmigrating. Such behavior by juvenile cutthroat trout in the upper watershed could reflect a stepwise migratory pattern during periods of stream residence in which fish gradually move downstream to larger-sized rearing habitats (Zydlewski et al. 2009).

The lack of fish PIT-tagged in the upper Benewah watershed that moved downstream of the 9-mile array (i.e., 3 fish) attests to the absence of a segment of the adfluvial juvenile population that outmigrates downstream to the lake during periods in the fall and winter when rain events increase levels of discharge. Apparently, juveniles in the upper Benewah watershed, notably those rearing in the South and West Forks of Benewah Creek and in Windfall Creek, likely outmigrate to the lake during spring freshets under snowmelt conditions. Interrogation data

collected during the spring of 2013 will help us evaluate whether the percentage of juvenile outmigrants, and thus adfluvial production, differs among the three tributaries.

PIT-tagging ascending adfluvial adult cutthroat trout captured at our migrant traps and interrogating them at the fixed HDX stations at the mouths of tributaries will also permit an examination of where adfluvial production is occurring in the Benewah and Lake Creek watersheds. In 2012, considerably higher densities of age-0 cutthroat trout were documented during population surveys in the Bozard sub-drainage than in the other two Lake Creek tributaries. The differences observed among the three tributaries may have been due to greater numbers of highly fecund adfluvial spawners selecting Bozard Creek over the other two sub-drainages. Adfluvial adult interrogation data, which will initially be available in 2013, will better inform whether indeed there is differential contributions from tributaries to adfluvial production in the upper Lake Creek watershed.

3.4.2 Tributary Habitat RM&E

3.4.2.1 Monitor and evaluate tributary habitat conditions that may be limiting achievement of biological performance objectives

Stream temperatures

The ambient stream temperatures recorded in Lake and Benewah watersheds in 2011 and 2012 still support the suitability of tributaries over mainstem reaches as cutthroat trout rearing habitats during mid-summer periods. Summer water temperatures rarely exceeded 17°C, a value above which is considered sub-optimal for cutthroat trout growth (Bear et al. 2007), in upper reaches of the Bozard Creek sub-drainage in Lake Creek and in tributaries in the upper Benewah Creek watershed during both years. In contrast, temperatures exceeded this threshold more than 30% of the time in mainstem reaches in Lake Creek and more than 50% of the time, most notably in 2012, in upper mainstem reaches of Benewah Creek that were restored as part of Phase 1 treatments from 2005 to 2008. Given the consistently higher densities of cutthroat trout observed in tributary than in upper mainstem habitats, the mid-summer differences in rearing temperatures between tributary and mainstem reaches likely explain in part the distributional patterns of cutthroat trout observed in both watersheds (Dunham et al. 1999; Paul and Post 2001; Sloat et al. 2001; de la Hoz Franco and Budy 2005).

However, in the upper Benewah watershed, the mainstem meadow reach that received Phase 2 restoration treatments over the years 2009-2012 afforded more suitable ambient stream temperatures than restored mainstem habitats downriver. Baseflow water temperatures exceeded the 17°C benchmark less than 10% of the time in much of the Phase 2 reach, even during the warm summer of 2012. In fact, temperature profiles in this reach during 2012 reflected those that were recorded in cooler summers of 2008 and 2010. Observed differences in temperature signatures between the two mainstem reaches may in part be explained by differences in available canopy cover. An enclosed canopy of hawthorne and alder is regularly present along the Phase 2 reach, whereas much of the Phase 1 reach is still relatively exposed partially as a result of the channel re-construction that removed riparian vegetation. Years will be required before the post-construction streamside and riparian plantings will ameliorate the conditions introduced by the channel disturbances.

Alternatively, the observed differences in stream temperatures between the two reaches may also be explained by the greater influence of groundwater inputs in the upper than in the lower reach. Monitored springbrooks in the upper watershed have consistently displayed temperature signatures during summer months that have been much cooler than those recorded in adjacent mainstem habitats (Firehammer et al. 2011). Apparently, the Phase 2 reach of the mainstem may be closer to these off-channel groundwater sources and/or receives substantially more cool groundwater inputs than downstream Phase 1 restored reaches. Well data collected in 2012 corroborates the likely influence of groundwater on stream temperatures along the Phase 2 reach. Groundwater levels in the lower approximately 0.5-0.7 km of this mainstem reach were considerably higher in 2012 than those recorded in both of 2008 and 2009 (Vitale and Firehammer 2013). Over the last four years, nine restoration structures, both engineered log jam analogs and large wood aggregations, have been introduced along this reach as part of Phase 2 treatments. These structures may be functioning to increase the spatial extent and duration of overbank flooding during high flow events and contributing to the elevation of groundwater tables in adjacent floodplain areas, though other factors, such as the amount of spring and summer rainfall that saturates floodplain zones, also likely influences groundwater levels. Both the temperature and groundwater data lend support to the intent of our restoration strategies to increase floodplain connectivity and water retention in upper mainstem reaches of the Benewah watershed.

The similarity of stream temperature profiles in reaches of the upper Benewah mainstem over years with both cool and warm summer air temperatures also indicate that a proper evaluation of whether our habitat enhancement activities are moderating thermal regimes will require accounting for all those drivers that may influence the thermal regime in any given year. Snow pack accumulation and its influence on the flow regime, groundwater inputs, and solar irradiation can all influence stream temperatures during summer rearing periods for cutthroat trout. Consequently, temperature models that examine the influence of channel restoration actions on stream temperature in mainstem reaches of the upper Benewah watershed will thus require the inclusion of covariates other than air temperature, such as percent canopy cover, snow water equivalents, and indices of rainfall accumulation, to clarify linkages.

Physical habitat

Habitat surveys were conducted across reaches in the South and West Forks of Benewah Creek and in Windfall Creek to describe extant conditions for large wood loadings and pool habitat. Among all three tributaries, Windfall Creek had the greatest overall large wood volumes and the highest percentage of pool habitat, and most approached benchmark conditions desired by our program for these two habitat attributes. Consequently, Windfall Creek will serve as a control reference tributary for monitoring the effectiveness of large wood additions that have been proposed for implementation as restoration measures in the South and West Forks of Benewah Creek. The West Fork of Benewah Creek consistently had the lowest large wood loading of all three tributaries and is projected to receive treatments of large wood additions in 2013 to increase the frequency and depth of pool habitat.

Monitoring the effectiveness of large wood additions in creating pool habitat will entail detecting reach scale responses at sites treated in both the South and West Forks of Benewah. However, the power to detect these changes may be affected by the inherent spatial and temporal

variability in channel conditions in these tributaries. With regards to spatial variability, we were interested in whether reducing the surveyed reach length from 152 to 100 m would have any substantial effect on the variability of our metric estimates. The results from the habitat surveys conducted in the two Benewah Forks in 2011 demonstrated small differences in the estimates of percent pool habitat (3-5%) and large wood volume (6-9%) averaged across sites between the two survey lengths. Given that wood additions are expected to increase wood volumes by over 100% in deficient reaches of the two tributaries, and that pool habitat is expected to concomitantly change by over 50%, the differences in the estimates between survey lengths are negligible. For each metric, differences between the standard deviation values calculated for each survey length were also trivial. Collectively, these results indicated that the shorter survey length will still capture similar habitat conditions in these two tributaries as the longer length, and should have an inconsequential effect on the ability to detect reach-scale changes due to our restoration efforts (Cole 2013). Furthermore, decreasing the length of survey sites while maintaining the statistical rigor of the information gained will maximize the efficiency of our monitoring program.

Background temporal variability in channel conditions also influences the ability to detect changes due to treatment affects, and could require increasing the number of temporal replicates to detect these changes. Again, with regards to maximizing the efficiency of our monitoring program, we were interested in evaluating the frequency with which we would have to conduct post-treatment habitat surveys to detect responses in physical habitat due to large wood additions. For each metric, a power analysis was conducted which used the mean of the standard deviations of the two repeated measurements collected over both years at each site to represent annual variability within each tributary (Cole 2013). Though the mean standard deviation values represented a substantial deviation from the mean metric values for percent pool habitat (35%) and large wood volumes (23-69%), the expected effect sizes in pool habitat and large wood loadings that would result from large wood treatments were approximately 2-3 times greater than these estimates of annual variability. Thus, the results from the power analysis indicated that habitat surveys could be conducted less frequently in treated tributaries (e.g., every 3 to 4 years) without sacrificing the ability to detect attendant changes in pool habitat resulting from the additions of large wood (Cole 2013).

3.4.2.2 Monitor and evaluate the effectiveness of tributary habitat actions relative to environmental, physical, or biological performance objectives.

In Benewah Creek, we postulated that a positive feedback cycle may exist where historic beaver trapping and removal of trees and shrubs used by beaver resulted in local extirpation or significant reductions in beaver population size. In this event, neither beaver populations nor beaver-generated fish habitat will recover until riparian vegetation is restored (Pollock et al. 1994). Recovery of beaver-generated floodplain wetlands and their wet meadow, scrub–shrub, and forested plant communities is dependent upon the restoration of lost hydraulic linkages between the channel and its floodplain through annual flood pulses and a locally high water table (Westbrook et al. 2006). However, water availability may not be sufficient in some environments, including arid or semi-arid climates, entrenched and incised channels, and locations where soil characteristics restrict infiltration and water retention for spring plant growth. In such circumstances, beaver were likely the historic mechanism that supplied riparian vegetation with sufficient water to establish and maintain trees and shrubs. Importantly, this

codependent mechanism is not adequately recognized or utilized in the stream restoration toolbox (Pollock et al. 2011).

We looked for alternatives to the more conventional solutions to stream and floodplain restoration that we employed in earlier work in Benewah Creek, where extensive earthwork construction of raised grade controls and riffles in the incised channel and/or relocating the stream to relict channels had been completed between 2005-2008. "Plant-it-and-they-will-come" restoration strategies as a further alternative focus on restoring riparian vegetation with the assumption that beaver populations will reestablish when plant communities are capable of supporting them (Albert and Trimble 2000; Pollock et al. 2011; U.S. Forest Service 2011). However, successful beaver recolonization and riparian vegetation restoration may require long periods of time when the positive feedback mechanism described above has been activated.

We developed and implemented a simple approach that emulates the ecosystem engineering effects of beaver. This approach is less expensive and disruptive than typical large scale engineering efforts and has the potential to restore both fish habitat and floodplain vegetation more rapidly than simply revegetating and waiting for the riparian zone to mature. The approach involves constructing log flow-choke structures that mimic the hydraulic function of a natural beaver dam during flooding (DeVries et al. 2012). By placing these structures throughout the stream reach at locations promoting increased frequency of flood connection with floodplain swales and relict channels, we set the stage to restore the riparian corridor and floodplain more quickly than could be achieved through revegetation alone. We coupled this with several more passive approaches, where 1) vertical posts were used to reinforce active dams, and 2) large wood was placed in the channel and partially buried to provide a stable framework for beaver to build on (MacCracken and Lebovitz 2005). Together we hoped these methods would provide an ecosystem "kick-start" that emulates the mechanisms driving natural floodplain connectivity.

Between 2009 and 2012, treatments have been applied in 30 locations affecting 57 percent of stream habitats within the 3,138 m of the D2 reach of upper Benewah Creek. The recent work was very low impact and cost effective compared with the more disruptive and expensive excavation methods used to construct raised bed riffles and new channels. For example, channel reconstruction was completed at an average cost of US$260/m in downstream reaches. Installation of flow-choke structures cost about US$2,700 per structure, which equated to an estimated US$25/m to US$50/m for an equivalent level of flood flow engagement for a 0.4% stream gradient (time and materials). A key strength of our design is that it is an experimental approach to emulating the effects of beaver dams on channel and floodplain processes. Accordingly, we are monitoring the hydrologic and hydraulic performance of the flow-choke structures, beaver assist structures, and local floodplain wetland response to assess whether we have succeeded in emulating the geomorphic and ecological effects of beaver dams, and to provide us with empirical data to guide future design revisions. For example, we noted after the second year of monitoring that downstream scour protection is more critical for the orifice–weir combination structure than for the simple weir. The flow patterns are more complex for the combination structure, where the weir overflow nappe appears to interact with the orifice jet to create more turbulence near the bed than was anticipated. The simple weir structure has been found to have smaller scour depths downstream that are more consistent with predictions based on hydraulic engineering literature. Importantly, from the riparian floodplain restoration

perspective, we have documented overbank flows across the valley bottom at discharges equal to the approximately 1.5-year return interval flood in the vicinity of our structures. Other reaches without stable beaver dams require much higher discharge for overbank flow. Thus, we are already seeing intended results, where floodplain flow path swales and relict channels are more frequently engaged and those that have been replanted are showing good survival and growth.

The documented loss of beaver dams between 2010 and 2012 in the D2 reach is significant and affects the overall trajectory and scale for recovery of watershed processes. We documented a 79 percent reduction in the direct influence by beaver on aquatic habitats in the reach during this time frame. Nevertheless, in the absence of beaver activity, restoration measures have been effective in a number of regards, including: 1) reconnecting the stream and valley bottom floodplain on a frequent basis to reduce sheer stress and thus erosion potential at streambanks; 2) aggrading stream segments upstream of stable structures; and 3) raising the local water table and reconnecting side-channels and floodplain swales on a more frequent basis to facilitate establishment of native wetland vegetation. In addition, the combination of restoration structures implemented in the reach by 2012 resulted in a total of 781 m of channel inundation, with a total residual pool volume of 366 m^3 and a mean residual pool depth of 0.79 m. These direct effects provide valuable rearing habitats for cutthroat trout in both summer and winter because both juvenile and adult cutthroat trout are known to use deep pools as winter refugia in small stream systems (Brown and Mackay 1995; Jakober et al. 1998;Harper and Farag 2004; Lindstrom and Hubert 2004). These habitats would otherwise be largely absent in the short-term without intervention. While these desirable effects have been occurring at a more finite scale than if beaver had been present and active, they represent a significant improvement in ecosystem process functioning compared with the untreated portions of the mainstem Benewah Creek.

The availability of plant materials, especially woody species, which comprise the preferred food items of beaver in many locations (Masslich et al. 1988; Allen 1983), are still likely in limited supply in the still recovering D2 reach and this may influence the persistence of beaver and natural dams at the site, as well as exert some controls on the overall population through limited resource induced dispersal. Specifically, dispersal seemingly exerts controls on the population sizes of beaver communities due to high mortality rates during dispersal (Payne 1984). Common migration patterns involve movements during spring high flows from higher elevations to downstream areas where beaver structures can flood adjacent lands (Leege 1968). This is consistent with our observations of recent dam building activities in the downstream D1 reach of the ′Ełtumish project. There, no less than eight persistent dams have been built and maintained during the past 2-3 years which induce overbank flows even during the modest flows (~50 cfs; 10% exceedance flow; Hortness and Berenbrock 2001) that occur during the descending limb of the hydrograph. Our observations of the contiguous mainstem restoration activities that now span more than 5.6 km of the upper mainstem Benewah Creek reinforces the need for large scale restoration in influencing physical, biological and ecological processes (Doyle and Shields 2012; Moerke and Lamberti 2003). For instance, Ardon et al. (2010) found that a substantial length and area of stream and wetland restoration was needed in order to attenuate floods sufficiently to allow biogeochemical retention of nutrients: approximately 3 km of stream with immediate connection to over 440 ha of riparian wetlands. Beaver are influential in these processes and this project meets many of the significant thresholds for landscape scale ecological restoration.

Interestingly, these restored stream reaches will likely function synergistically in supporting beaver populations and influencing dispersal to other parts of the watershed into the future.

As a restoration approach, this beaver assisted design seemingly is most appropriate and can be most successful in settings where several of the following criteria can be met: 1) beaver or evidence of beaver activity is present in successive years; 2) stream banks are not readily deformable, as in locations where local soils are comprised of fine textured and cohesive materials (e.g., silt/loam/clay); 3) stream temperatures are not limiting for cold water biota or there is a need to maintain existing favorable groundwater dynamics; and 4) suitable vegetation for dam building and beaver food is available nearby, if not in the treatment reach. In the case of the latter criteria, it may be feasible to sustain a small population of beaver over the short-term by supplying freshly cut cottonwood and aspen branches to use as dam building materials. We have been experimenting with this in the nearby Hangman Creek watershed, and the beaver in Sheep Creek appear to rapidly use the material when provided. Other authors have also demonstrated that beaver will use saplings placed along stream banks for dam construction (Muller-Schwarze and Sun 2003).

3.4.3 Predator/Competitor Control Implementation

A brook trout removal program was initiated in 2004 to suppress the numbers of brook trout found in mainstem and tributary habitats in the upper portion of the Benewah watershed. Our suppression strategy, which annually removes fish before fall spawning periods using a single electrofishing pass, initially focused on contiguous reaches of the upper mainstem from 9-mile to 12-mile bridge and in tributaries where brook trout have been found in relatively high numbers. Since 2009, we have curtailed our mainstem shocking efforts and re-focused tactics toward curbing reproductive success rather than attempting to remove as many fish as possible. An inordinate amount of time was being annually allocated during the initial years to shocking the deep, pool habitats from 9-mile bridge to 12-mile bridge, which have proven to be difficult to effectively shock. Further, these habitats are dominated by low-gradient depositional beaver dam pools, which, though likely serving as suitable rearing habitats (Chisholm et al. 1987; Cunjak 1996; Lindstrom and Hubert 2004; Benjamin et al 2007), may not provide suitable spawning substrates. Currently, we are concentrating our shocking efforts in that reach of the mainstem above 12-mile bridge that seemingly provides more suitable spawning habitat than reaches downriver, and where adult densities have been the greatest over the suppression program (Vitale and Firehammer 2009). We have also erected temporary barriers upstream of the 12-mile bridge and at the mouth of Windfall Creek to inhibit ascending mature brook trout from accessing upstream spawning reaches.

Even though our suppression program has reduced its annual removal efforts, we have been effective at regulating numbers of brook trout at an apparently manageable level. Indices of brook trout abundance in 2011 and 2012 in both index mainstem reaches and across tributary sites in the upper watershed were the lowest recorded since the inception of the program. Furthermore, we have decreased the electrofishing effort expended from approximately three weeks during the initial years of the program to a current investment of 3-4 days. However, brook trout are still occasionally found at moderate levels in some reaches of the upper watershed, particularly in lower reaches of Windfall and Schoolhouse Creeks. Notably, the mouths of both creeks are proximate to that section of the mainstem reach which has consistently

supported the highest adult brook trout densities over the course of the suppression program, and which may be serving as a source of mobile, reproductive individuals for the colonization and establishment of localized sub-populations in lower reaches of these tributaries (Benjamin et al. 2007).

Furthermore, a considerable decline in the number of age 0 brook trout captured in the 2 km mainstem index reach upstream of 12-mile bridge has been observed during the first two years after barriers were installed in the upper watershed, which attests to the effectiveness of our new approach in inhibiting brook trout reproduction. Age 0 brook trout were also rarely captured in 2011 at index sites sampled during summer population surveys in both tributary and mainstem reaches in the upper watershed. In 2012, we did notice an increase in the percentage of brook trout removed from the 2 km mainstem index reach that comprised young-of-the-year, and age 0 fish, though not widely distributed, were present at modest densities in a few select tributary reaches. Evidently, our curbed removal efforts, which began in 2009, has not lead to substantial reproductive output in brook trout in the upper watershed. However, the 2012 data corroborates the compensatory resilience that could occur in brook trout reproduction (Meyer et al. 2006), and cautions against overly relaxing suppression measures.

4.0 TRIBUTARY HABITAT RESTORATION AND PROTECTION

Implementation of restoration and enhancement activities occurred in Benewah and Lake creeks during 2011 and 2012, with most of the projects related to large scale channel restoration efforts in both watersheds. All activities completed during the period June 1, 2011 through December 31, 2012 are summarized in Table 26 followed by a more detailed site characterization and summary of activities for individual treatments. In several locations, multiple treatments have been implemented to meet the objectives for larger sites. These treatments are grouped under the same project ID heading so that the interrelationship of activities is more apparent.

A brief explanation of the project ID that is used in the summary table and in the detailed descriptions is warranted here. The project ID is an alphanumeric code that corresponds to the location of individual treatments in relation to the river-mile of the drainage network for the watersheds of interest. The first digit of the code signifies the watershed that the treatment is located in, using the first letter in the watershed name (e.g., B=Benewah Creek, L=Lake Creek, etc.). The series of numbers that follow correspond to the river-mile location (in miles and 10^{ths}) at the downstream end of treatment sites. River mile is tabulated in an upstream direction from mouth to headwaters and treatments that are located in tributary systems have river mile designations separated by a forward slash (/). For example, the downstream end of project L_8.2/0.7 is located in the Lake Creek watershed 0.7 miles up on a tributary that has its confluence with the mainstem 8.2 miles from the mouth. This nomenclature is intended to indicate the spatial relationship of treatments to the mainstem and tributary aquatic habitats having significance to the target species. Furthermore, it readily conveys information about the relationship of multiple treatments by indicating the distance to common points in the drainage network.

Table 26. Summary of restoration/enhancement activities and associated metrics completed for BPA Project #199004400.

Project Description			Project Chronology			
Project ID	**Activity**	**Treatments (Metrics)**	**2008**	**2009**	**2010**	**2011-2012**
B_9.7 (page 94)	Stream Channel Construction	Channel construction (1,267 m); habitat enhancement (1,796 m)[ab]	Developed restoration design for 2.4 km of mainstem habitats (Reach D-2)	Constructed/enhanced 810 m of stream channel; installed 7 instream wood structures and added LWD to channel (356 m)[a]	Regraded and activated 457 m of side-channel habitats; installed 7 instream wood structures and added LWD to channel (671 m)[b]	Activated 439 m of channel previously constructed in 2009; installed 9 instream structures and added LWD to channel (769 m)
B_9.7 (page 100)	Plant Vegetation	Riparian enhancement (55.35 ha; 6,025 m of streambank)	Planted 2,100 conifers (1.86 ha of floodplain)	Planted 10,058 herbaceous plugs, 4,634 deciduous trees, 3,800 conifers (3.31 ha of floodplain, 742 m of streambank)	Planted 27,957 herbaceous plugs, 6,494 deciduous trees, 50 conifers (2.56 ha of floodplain, 900 m of streambank)	Planted 12,268 herbaceous plugs and 7,977 deciduous trees (1.32 ha of floodplain, 694 m of streambank)
B_12.8/1.5 (page 103)	Fish Passage Improvement	Removed passage barrier (opened 3,390 m of habitat)				Developed project design; removed culvert and road fill; installed grade control
L_8.2/0.7 (page 105)	Stream Channel Construction	Channel construction (1,265 m, 5.76 ha of floodplain wetlands)	Developed restoration design for 1.2 km of tributary habitats in WF Lake Creek.	Signed landowner contract. Constructed 106 m of new channel; created 2 ha of new floodplain; installed 8 instream structures	Constructed 518 m of new channel; created 0.56 ha of new floodplain; installed 33 instream structures	Constructed 336 m of new channel; created 3.2 ha of new floodplain; installed 35 instream structures; repaired 305 m of tributary
L_8.2/0.7 (page 109)	Plant Vegetation	Riparian enhancement (3.6 ha; 2,101 m of streambank)		Planted 800 conifers, 300 herbaceous plugs, 450 deciduous trees (212 m of streambank)	Planted 14,663 herbaceous plugs, 3,670 deciduous trees (0.4 ha floodplain, 1219 m of streambank)	Planted 25,346 herbaceous plugs, 12,261 deciduous trees (3.2 ha floodplain, 670 m of streambank)

Project Description			Project Chronology			
Project ID	**Activity**	**Treatments (Metrics)**	**2008**	**2009**	**2010**	**2011-2012**
L 2.9/0.5 (page 111)	Plant Vegetation	Upland afforestation (97.1 ha)				Planted 81,700 conifers (97.1 ha of uplands)

[ab] Metrics for habitat enhancement related to in channel wood additions were under reported for Project B_9.7 in the 2009 and 2010 annual reports, respectively.

Project B_9.7 – Instream/Channel Construction for the ʼElṭumish Project

Project Location:

Watershed: Benewah	Legal: T45N, R4W, S13 NE ¼ SE ¼
Sub Basin (River Kilometer): 15.6 rkm	Lat: 47.241292N Long: 116.771454W

Site Characteristics:

Slope/Valley gradient: 0.7%	Aspect: N	Elevations: 830 m
Valley/Channel type: B2/C4, E4	Proximity to water: In channel	

Other: Project implements third and final year actions identified in the Reach D2 restoration design, including: activation of 439 m of new channel (element D2-1); construction of nine in-channel structures affecting 197 m of mainstem and 105 m of tributary habitats in Windfall Creek, and addition of in-channel large wood to 237 m of mainstem and 230 m of tributary habitats (element D2-4).

Problem Description: Historically, the Benewah Creek valley was a mosaic of open stands of conifers, wet meadows and stream corridor riparian forest (Mikkelesen and Vitale 2006). Forest composition and structure was maintained by frequent fires. A compositionally diverse, coniferous dominated forest was distributed along complex gradients of elevation, aspect and site water balance. Historically, frequent engagement of flood flows on the valley floor was most likely in response to both (i) blockage effects of large wood pieces falling into the channel and aggregating smaller wood, and (ii) beaver dams, with local gravel and fine sediment accumulations upstream. Whenever the channel did avulse in response to blockages, it likely did so through rapid down-cutting through the easily eroded loess layer, reaching a base gravel layer in the valley relatively quickly and then remaining at the grade defined by that layer. Following a more recent history of intensive logging, forest clearing, beaver trapping, and grazing, the hydraulic influence of local beaver dam/sediment accumulation was reduced or removed. The stream banks were more susceptible to unraveling and channel widening, leading to the state seen at some locations where a new, lower elevation alluvial floodplain appears to have established between the upper bank surfaces defined by the valley floor. Hydraulic analysis of representative channel cross-sections show the overall level of channel incision/entrenchment is approximately equivalent to the capacity of a 5-year return interval peak flow event with some areas exhibiting a capacity that approaches the 10-year peak flow. By comparison, less disturbed channels would typically access their floodplain at the 1.5-2 year return interval flow.

The significantly reduced access of flood flows to the former floodplain and broader valley bottom has affected wetland habitats on a large scale and accelerated streambank erosion. Several avulsion channels and to a lesser extent, remnant historical channels have left portions of the valley bottom with some wetland habitat, however, it appears that shallow groundwater tables have been lowered and recharge of wetlands by overbank flows has been greatly reduced. Many of the remaining wetland areas are only marginal in size and a band of xeric vegetation of variable width is located along the channel margin throughout the project reach. The most recent estimates of stream bank erosion indicate that erosion rates approach 476±208 metric tons/yr/km. When extrapolated to the larger reach located between river kilometer 14.3 and 19.1, total annual sediment yield from streambanks ranges from 1286-3283 metric tons/yr.

This stream reach is located in a portion of the watershed that historically provided important summer and winter rearing habitats for westslope cutthroat trout. Existing conditions currently support low densities of cutthroat trout (<2 fish/100 sq. m). Lack of habitat diversity, localized loss of low gradient channel segments, reduced infiltration of water from adjacent wetlands, and elevated water temperatures are all factors that limit the productivity of these reaches.

Description of Treatment: Several design elements for the D2 reach were implemented during this third and final year of planned construction to address the findings and specific needs identified in the problem assessment:

Element D2-1. Excavation of 439 m of an existing relict channel had occurred in 2009, with the intent of activating this channel following sufficient time to allow establishment of woody vegetation and deep rooted herbaceous plants (e.g., sedges and rushes) to stabilize new stream banks in the reach. Initially, the channel was excavated down to the valley-wide gravel sub-layer with the long profile of the channel generally following the top of the gravel layer, although small pools and riffles were constructed on a directed work basis. The average bankfull channel width conformed to a 6 m design criteria and cross-section side slopes were excavated to approximate a 1.5H:1V ratio. Where the relict channel topography was wider, vegetated benches were constructed at intermediate elevations, with a gentler side-slope between around 30H:1V to 20H:1V. The narrow aspect ratio of the newly excavated channel is comparable to that observed in more heavily vegetated segments where the banks do not appear to have been significantly eroded.

During the summer of 2012, the remaining 25 meters of soil plug which had prevented flows from accessing the new channel was removed, effectively re-routing all stream flow into the relict channel. A log jam was constructed at the upstream end of the bypassed channel segment, then backfilled and graded to function as a high flow swale, passing water during flows that approach bank-full discharge. The downstream end of this channel was left unfilled to function as a connected backwater. Vegetated benches were constructed at the upstream end of the newly activated, relict channel - matching the elevations of naturally formed channel features - to reduce channel scour in the transition area between existing and new channel segments (Photo 1). Completion of this element increased channel length by 197 m and locally reduced stream gradient from 0.45% to 0.24%.

Photo 1. Stream flow was re-routed to 439 m of existing relict channel in 2012, with the by-passed channel re-graded to function as a high flow swale and backwater channel (left). Vegetation is well established from the toe to top of streambanks in the newly active channel (right).

Element D2-4. A total of nine in-channel wood structures were constructed to emulate flow obstruction effects of natural wood jams and beaver dams. Two of these structures were intended to provide improved bank stabilization in lower Windfall Creek and utilized a passive approach by placing 2-4 large logs in the channel, with key pieces anchored in the bed and banks, to provide a key framework that beavers could use in dam construction and which serves as a natural analog that approximates historical, wood recruitment processes. This approach was based on observations that the most persistent, existing dams throughout the Benewah Creek stream corridor are built with mountain alder integrated with remnant in-channel large wood. MacCracken and Lebovitz (2005) found that this technique can work when the channel is unconfined with a wide floodplain, there are no logjams nearby, and when deep pools and banks suitable for beaver dens are nearby. Individual logs are placed across the channel bottom at riffle crest locations, and wedged between small boles driven vertically into the substrate. Fresh black cottonwood and aspen saplings may also be placed along the stream banks above the log structures to encourage beavers to finish the dam construction (Muller-Schwarze and Sun 2003).

The remaining six structures were engineered "flow choke structures" in which the concept was to create increased backwater effects during floods such that the valley floor would become connected annually. The structures affect approximately 197 m of mainstem habitats and an additional 105 m of tributary habitats in lower Windfall Creek by increasing residual pool depth and volume at base flow conditions. Each of the structures consisted of a horizontal log spanning the channel to form a simple weir and several horizontal bank logs to constrict high flows, with sufficient depth to permit passage of floating debris at the bankfull level (Photo 2).

To implement the design concept, construction involved:

1. Placement of a horizontal cross-log that acts as a control weir at flood flows. The bottom elevation of the orifice was designed to emulate general low flow control elevations formed by numerous beaver dams present in the reach, where median depths were 0.36 m at the riffle crest and 0.97 m below the floodplain; these served as natural process-based design criteria for situating the orifice control elevation and the depth of impounded

gravel upstream. An additional horizontal log was buried beneath the weir at a depth that exceeded the estimated scour depth for each site.

2. A series of horizontal cross-logs protruding from each stream bank that project a blocked area in the downstream direction leaving a central orifice area for lower flows to pass through.
3. A pad of rock placed at the downstream end of the structure as a scour countermeasure, to protect the integrity of the structure.
4. A deposit of finer gravel, sized to be comparable to stones occurring naturally in the river banks and bed, placed on the bed of the upstream side of the structure to facilitate smoother streamlines and potentially provided trout spawning habitat.
5. Laid back stream banks within the upstream and downstream footprints of the structure to prevent saturated bank collapse, avulsion, and loss of structure integrity. A maximum graded slope of 1.5H:1V was specified here as an initial approximation to reduce the amount of excavation on either side of the structure while maintaining a saturated slope stability safety factor above 3. The laid back banks were re-vegetated with herbaceous plants.

Photo 2. Engineered "flow choke structures" constructed in Benewah Creek use a combination of weir flow over a horizontal cross-log and lateral constriction by bank logs to provide desired water surface elevation controls. These structures were built in the active mainstem channel of Benewah Creek in locations where natural beaver dams had been previously surveyed.

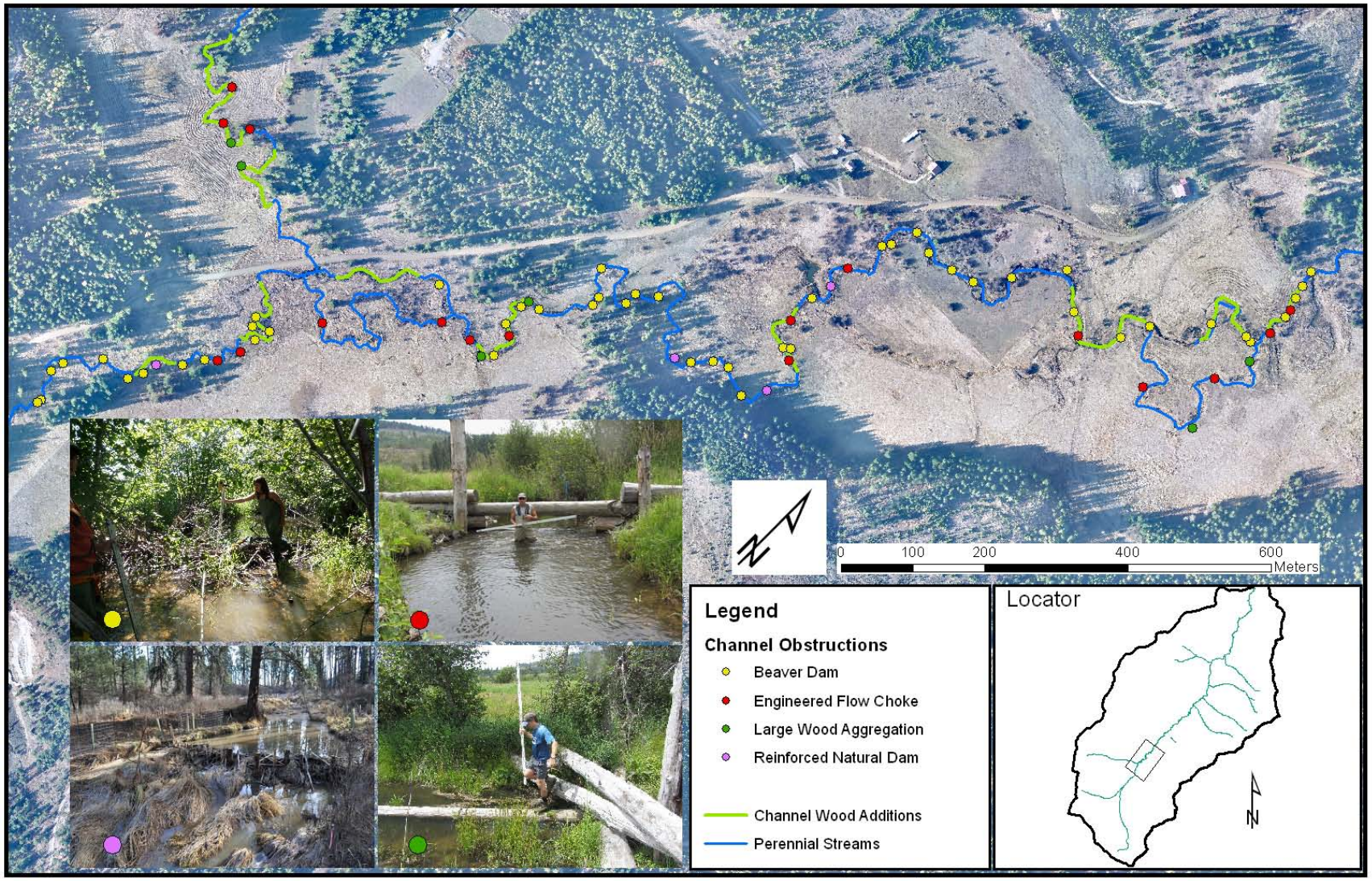
Additionally, as part of this design element approximately 28 cubic meters of wood (45 20-33 ft. long logs) was added to the stream channel and near bank region within a 467 meter reach (237 m in the mainstem and 230 m in lower Windfall Creek) to aid beavers in dam construction and to increase wood loading to approximate a target volume of 6 m^3/100 m for mainstem and tributary habitats in the watershed. Furthermore, three natural beaver dams were reinforced with vertical uprights that were installed through the face of the dam at 2-3 ft. intervals using an excavator and hydraulic hammer. The premise is that these "reinforced" natural dams should be more persistent during high flows and facilitate channel/floodplain connectivity over a longer, contiguous reach.

The three approaches to channel wood additions and beaver dam augmentation that were implemented as part of this design element allows for more frequent and extensive floodplain connection during annual floods and seeks to increase the stability of natural dam complexes. It is a natural analog alternative to the large scale riffle construction employed in the D1 reach of this project that helps maintain connectivity with cooler groundwater during summer months. The cumulative effect of these treatments occurring between 2009 and 2012 have enhanced approximately 1,796 m of mainstem and tributary habitats and improved rearing conditions for native trout by increasing habitat diversity (i.e., instream cover, mean residual depth, pool frequency and volume) and reducing bank erosion typically associated with channel incision/entrenchment (Map 9). Furthermore, the more persistent channel obstructions that have been constructed will facilitate stream bed aggradation over time across the larger reach.

Project Timeline: Coordination with the landowners in the area began in May 2008. A field survey of the site, including wetland delineation, was completed in October 2008. Two design alternatives were developed initially and the preferred site design was finalized in May 2009. The initial restoration work was completed from June through August 2009. Implementation during 2011 and 2012 field seasons completed the last of the design elements that were identified. Ongoing monitoring will continue to evaluate the structural integrity of instream structures and inform the need for repair or maintenance.

Project Goals & Objectives: Goals for this project include 1) create wetland habitats and increase the hydraulic connections with the valley bottom; 2) reduce bank erosion 3) provide a long-term source of large woody debris for natural recruitment; and 4) provide measurable increase in abundance and distribution of westslope cutthroat trout.

Relationship to Scope of Work: This project fulfills the Program commitments for WE F in the 2011 Scope of Work and Budget Request (Contract #52937) and for WE H in the 2012 Scope of Work and Budget Request (Contract #57531) for the contract periods dating June 1, 2011 through May 31, 2013.



Map 9. Location and type of in-channel treatments employed in the D2 reach of the Eltumish Project in upper Benewah Creek. Representative examples are shown for natural beaver dams, engineered flow choke structures, reinforced natural dams and large wood aggregations.

Project B_9.7 – Riparian/Planting

Project Location:

Watershed: Benewah	Legal: T45N, R4W, S13 NE ¼ SE ¼
Sub Basin (River Kilometer): 15.6 rkm	Lat: 47.241292N Long: 116.771454W

Site Characteristics:

Slope/Valley gradient: 0.7%	Aspect: N	Elevations: 830 m
Valley/Channel type: B2/C4 E4	Proximity to water: Floodplain	

Other: Project treats 1.32 hectares of floodplain and 694 m of streambank. Additional planting retreated 1.4 hectares of floodplain previously planted in 2010.

Problem Description: Historically, the Benewah Creek valley was a mosaic of open stands of conifers, wet meadows and stream corridor riparian forest (Mikkelesen and Vitale 2006). Forest composition and structure was maintained by frequent fires. A compositionally diverse, coniferous dominated forest was likely distributed along complex gradients of elevation, aspect and site water balance. Tree species likely included: ponderosa pine, western white pine, western larch, Douglas fir, lodgepole pine, grand fir, western red cedar, Engelmann spruce, aspen and black cottonwood. Historic land use since European contact, including valley-wide forest removal, beaver trapping, in-channel large wood removal, construction of splash dams, timber mill operations, pasture grass management and 70+ years of extensive cattle grazing, has resulted in a radically altered valley ecosystem with eroding stream banks and a plant community dominated by invasive forbs, grasses and woody species unpalatable to cattle.

Description of Treatment: Given the extreme perturbation of stream channel and forest structure and processes, the goal of the ecological restoration of the riparian forest and wetland ecosystem is to steer the system toward recovery using both ecological engineering and restoration forestry. A primary strategy being utilized for the Benewah Creek restoration is the utilization of black cottonwood's unique life history characteristics to rapidly "flip" or change the current degraded riparian ecosystem into a diverse self-sustaining riparian forest. Although black cottonwood's regenerative strategy (seedling establishment on bare alluvial substrates and branch fragment vegetative propagules) likely resulted in it historically playing a non-dominant role in the riparian forest, its life history characteristics make it ideal for rapidly establishing a complex riparian forest. Establishment of a cottonwood forest along the Benewah Creek floodplain and stream banks will provide exceptional hydrologic, biogeochemical and plant and animal habitat functional lift within 5-10 years as well as control the trajectory of ecosystem development over next 100+ years.

Hydrologically, dense plantings of cottonwood will supply local beaver populations with ample dam building materials resulting in local backwater flooding of adjacent wetlands. These hydrologically restored areas will support a diverse emergent, scrub-shrub and forested wetland plant community. Additionally, other hydrologic functions will be enhanced (per Jankovsky-Jones 1999), including dynamic water storage, energy dissipation, and long-term surface water storage. Enhanced biogeochemical functions (also per Jankovsky-Jones 1999) will include the ability of the wetland to contribute to local or regional water quality by the removal of imported

nutrients, contaminants, and other elements or compounds. Given the active use of adjacent private lands for cattle and horse pasture, enhanced beaver dam construction will significantly support wetland sediment and nutrient retention and removal functions.

An established cottonwood forest will rapidly enhance plant community functions through the maintenance of a characteristic native plant community in terms of species composition and physical characteristics of living plant biomass, and of detrital biomass in terms of the production, accumulation and dispersal of dead plant biomass of all sizes (Jankovsky-Jones 1999). The planting restoration design calls for establishing a matrix of floodplain cottonwood interplanted with understory cedar and Engelmann spruce. Cottonwood will establish a closed canopy within about 5-10 years and act as nursery cover for establishing understory conifers. Cottonwood break-up will occur at about 60-90 years, relinquishing understory conifers to a dominant canopy position. This technique has been used successfully with cottonwood and western red cedar in trials in British Columbia (Peterson et al. 1996). The establishment of an interior forest micro-climate following canopy closure will support the development of a native understory riparian plant community. The cottonwood forest will provide significant enhancement of fish and wildlife habitat throughout the Benewah Creek valley as well as the riparian ecosystem. Specifically, the new riparian forest will provide for maintenance of habitat interspersion and connectivity, reflecting the capacity of a wetland to permit aquatic organisms to enter and leave the wetland via permanent or ephemeral surface channels, overbank flow, or unconfined hyporheic grave aquifers, and access of terrestrial or aerial organisms to contiguous areas of food and cover (Jankovsky-Jones 1999). The forest will support enhanced fish habitat through stream shading, allochthonous input of fine, coarse and organic carbon to the aquatic ecosystem, and input of large wood structures in the stream. Vertical and horizontal forest structural elements will maintain bird and mammal habitat throughout the riparian corridor. Cottonwood will also provide dead snags for cavity nesting birds and mammals within about 50 years.

Several existing wetland swales and groundwater fed wetlands covering approximately 1.4 hectares were replanted in 2011 to establish nursery areas for propagation of black cottonwood and willows and to provide forage and dam building materials for beaver. These areas were originally planted in 2010, but poor survival of some woody plants warranted retreatment. In much of these areas, invasive reed canarygrass (*Phalaris arundiacea*) that had become established was mechanically scraped from planting areas prior to treatment. These wetlands have favorable hydrologic conditions for growing and propagation of black cottonwood and willows and these conditions have been further enhanced by more frequent overbank flows attributed to in-channel structures and obstructions that have been installed recently. A total of 2,875 woody plants and 6,134 herbaceous plants were installed. Plant species included eleven species of woody trees and shrubs and ten species of herbaceous sedges (*Carex sp. and Scirpus sp.*) and rushes (*Juncus sp.*).

In the spring of 2012 an additional 3,385 live willow and cottonwood cuttings were planted along 442 meters of stream bank and 1.0 hectares of adjacent floodplain. Then in the fall of 2012, 260 containerized alder, aspen, cottonwood and willow (sp) were planted near the in-channel structures installed on lower Windfall Creek (see Project B_9.7 – Instream/Channel Construction for the ′Ełtumish Project). In addition, 6,134 herbaceous plugs and 1,457 woody

plants were installed on the earthen plug that was constructed on the mainstem Benewah Creek to divert flows into a newly activated relict channel (Element D2-1), treating approximately 252 meters of stream bank and 0.32 hectares of floodplain.

Project Timeline: Two design alternatives were developed initially and the preferred site design and vegetation plan was finalized in May 2009. Annual plantings will be completed in the fall and the spring of each year between 2009-2013. Annual and periodic inspections will be completed to evaluate survival and growth and determine if restocking of planting sites is warranted.

Project Goals & Objectives: Reestablish a patchwork of native vegetation communities on approximately 10 hectares of the valley floor to lay the foundation for a compositionally and structurally diverse forest ecosystem to develop over the next 25-50 years. Achieve minimum stocking densities of 197 trees/hectare and provide for significant increases in canopy density and overhanging vegetation over a 20 year timeframe.

Relationship to Scope of Work: This project fulfills the Program commitments for WE G in the 2011 Scope of Work and Budget Request (Contract #52937) and for WE I in the 2012 Scope of Work and Budget Request (Contract #57531) for the contract periods dating June 1, 2011 through May 31, 2013.

Project B_12.8/1.5 – Instream/Fish Passage

Project Location:

Watershed: Benewah Creek	Legal: S27 T45N R4W SE NE, NE SE
Sub Basin (River Kilometer): 20.7/2.4	Lat: 47.214451 N Long: -116.812811 W

Site Characteristics:

Slope/gradient: 3%	Aspect: E	Elevations: 3040
Valley/Channel type: E3/C4	Proximity to water: In-stream and adjacent floodplain	
Other: Project treats 30 meters of channel and opens 3,390 meters of spawning and rearing habitat in WF Benewah Creek to adfluvial trout.		

Problem Description: WF Benewah Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout. This abandoned stream crossing was identified as a fish barrier in the Forest Road and Fish Passage Assessment completed in 2008. A prioritization process completed by the Fisheries Program ranked replacing this stream crossing as a high priority. A roving fish survey completed in 2009 indicated that fish were not present upstream of the existing stream crossing. Westslope cutthroat trout densities downstream of the crossing averaged 14.42/100 sq. m from 2002 to 2008. This project will restore connectivity with the upper WF Benewah Creek watershed (285 ha) and increase access for native trout to 3,390 m of potential rearing and spawning habitats.

Description of Treatment: This project involved removing an abandoned stream crossing and the surrounding road fill at a site on the WF Benewah Creek (Photo 3). The existing 24" culvert was undersized and perched 0.54 m above the stream channel ($width_{bf}$ = 3.04 m). There was an 8.5% change in channel slope between the upstream and downstream edge of the road fill before the culvert was removed, whereas the natural channel slope was 3% further away from the stream crossing. Five grade control structures, each comprised of 20-25 large boulders, were constructed within 30 m of channel to form a series of step-pools to re-establish natural channel grade downstream of the stream crossing following removal of the culvert (Photo 3). The structures were designed following specifications for cross-vanes (Rosgen 1994). The road fill was removed to create a new floodplain consistent with the floodplain widths upstream and downstream of the crossing. A total of 717 woody plants and 3,142 herbaceous plugs were planted along the stream channel and within the new riparian and upland areas created by removing sections of the abandoned road. Disturbed areas were seeded with native grass seed at a rate of 48 kg/ha.

Photo 3. Passage barrier on WF Benewah Creek.

Project Timeline: NEPA compliance documentation and landowner agreement were completed in 2012. Construction for the project was completed in August 2012 and planting occurred in September of 2012.

Project Goals & Objectives: This project will restore connectivity with the upper West Fork Benewah Creek watershed by removing a barrier to fish passage. Native trout will have access to 3,390 m of prime rearing and spawning habitats upstream of the new culvert. Flood flows will be able to spread out over the adjacent flood plain instead of being blocked and forced over the road.

Relationship to Scope of Work: This project fulfills the Program commitments for WE E in the 2011 Scope of Work and Budget Request (Contract #52937) and for WE G in the 2012 Scope of Work and Budget Request (Contract #57531) for the contract periods dating June 1, 2011 through May 31, 2013.

Photo 4. Boulder cross vanes were constructed to re-establish natural channel grade after the culvert and road fill was removed.

Project L_8.2/0.7 – Instream/Channel Construction for the Hnmulshench Project

Project Location:

Watershed: Lake Creek	Legal: T24N, R45E, S36 E ½ SE ¼
Sub Basin (River Kilometer): 13.1/1.1 rkm	Lat: 47.526627N Long: 117.048639W

Site Characteristics:

Slope/Valley gradient: 0.6%	Aspect: N	Elevations: 792 m
Valley/Channel type: C4/C5	Proximity to water: In-channel and adjacent floodplain	

Other: Project implements final year actions identified in the Hnmulshench restoration design, including: construction of 336 m of new channel to final grade; construction of 35 in-channel wood structures; construction of a grade control structure to connect the new stream with the existing channel; repair of 305 m of incised tributary; and re-grading of a field to create 3.2 ha of new floodplain.

Problem Description: The lower reaches of the WF Lake Creek is an important stream corridor linking the headwaters to the mainstem of Lake Creek. Currently, there is limited production potential for cutthroat trout within the reach due to channel incision, increased fine sediment, slightly elevated stream temperatures, lack of cover, and lack of large woody debris. Fish population data has been collected for the watershed since 1996. This reach had an average westslope cutthroat trout density from 2002-2008 of 1.1 fish/100 sq. meters while fish densities further upstream were greater than 20 fish/100 sq. meters.

This stream rehabilitation project includes 805 m of WF Lake Creek and 305 m of an unnamed tributary. Both streams exhibit many of the classic signs of impairment resulting from channel ditching and straightening; activities typically associated with agricultural development. WF Lake Creek is highly entrenched as a result of incision of the streambed as a series of head-cuts migrated upstream through the reach. Historic head-cuts have already moved upstream through the project reach, and three active head-cuts were identified within the reach. These existing headcuts imply that the incision trend is expected to continue. There is exposed bedrock 91 m upstream of the site preventing further incision above that location. The unnamed seasonal tributary intersects the mainstem at approximately mid way up the project reach. This tributary channel is also deeply incised and two active head-cuts were observed. Bank erosion and bank slope failures have been ongoing in both the mainstem and the tributary since initial incision occurred. Bank erosion rates on the mainstem were estimated to be 8.07 metric tons/year upstream of an existing stream crossing and 28.24 metric tons/year downstream of the crossing. Streambank vegetation is generally reed canary grass and mountain alder. The historic floodplain, where hay is produced, is perched and rarely accessed by flooding. There are 1.1 hectares of wetlands on the property.

Although these erosion processes negatively influence short-term sediment loading, vegetation establishment, and aesthetic, they are the natural processes by which an incised stream can eventually recover over the long term. Through erosion and sediment transport processes (of the streambed initially, and then streambanks and terraces) over several decades the channel will gradually create a new inset floodplain and riparian habitat at the lower level, terraced several

feet below the existing valley bottom. Currently, the channel at the project reach is underway in this recovery process, but at different stages of development through the reach. In some channel segments the new inset floodplain width approaches 12 m while in other segments, width is less than 4.5 m. It is expected to continue to erode downward and laterally until a new floodplain forms that has enough width to allow floods to spread out and when vegetation can become established, to resist the rapid erosion processes that are currently underway.

Description of Treatment: The design developed for this project called for filling 610 m of the existing incised channel and diverting flows into a newly constructed, 922 m long channel that is well connected with the valley bottom to allow dissipation of flood flows over a broad floodplain. Upstream of the newly constructed channel, imported wood would be placed in the existing channel to create habitat. A seasonal stream would be partially filled to repair the degradation that occurred and would be extended to connect with the newly constructed channel. Native plants would be planted in riparian and adjacent upland areas. Large wood would be used throughout the project to increase lateral roughness where needed, create banks and maintain planform until hydric plant communities become established. Construction would increase the stream length by more than 50 percent and 3.64 ha of wetlands would be created through this project (0.33 ha will be filled).

Construction work conducted in 2011 consisted several integrated work elements with the goal of finishing channel construction and activating the new channel. Final floodplain grading was completed in the riparian area along the southwest side of the valley. Excess material was stockpiled temporarily to be used as channel fill in decommissioning the existing incised channel. As in past years, construction of the new channel involved first excavating the new floodplain surface to define a design subgrade with an average dimension of 1.0 m deep by 4.5 m wide. New channel habitat was then constructed over the subgrade by using imported gravels and logs to create streambed and streambanks with diverse micro-habitat features. Bankfull design width for riffles ranged from 3.3 m to 3.6 m moving downstream through the reach. In 2011, a total of 183 m of channel subgrade was excavated and a total of 336 m of mainstem channel was constructed to final grade (Photo 5). A grade control structure, 40 m in length – consisting of large rock designed to be relatively immobile for up to the 50-year flood – was constructed at the downstream end of the project to connect the new channel and the existing alignment. Finally, the seasonal tributary was filled with gravel and large rock to repair local incision (over 305 m of channel was treated), completing major channel work on the site (Photo 6). A new, 3.5 m x 2.2 m culvert was installed to align with an existing road crossing, and the road elevation was raised to accommodate the larger culvert. Floodplain drainage was provided across the road fill via an armored rolling dip. Following completion of the new channel and grade control, the existing WF Lake Creek channel was filled and water was permanently diverted into the new channel by September 2011. Large wood was added to both the existing channel (seven multi-log structures were constructed upstream of the new channel) and to the new floodplain. Floodplain logs were buried at or below grade to provide erosion protection. All disturbed ground was revegetated with native plants (see Project Lake 8.2/0.7 – Riparian/Planting).

Flood events in March 2012 caused some scour on the newly created floodplain. Additional large wood was subsequently placed in these areas to increase floodplain roughness and re-direct flood

flows back into the riparian area. Other maintenance work conducted in 2012 included the construction of three irrigation drains and repair of a channel rill that formed near the grade control.

A summary of key channel response variables reflect a significant improvement in stream and riparian processes that should translate into improved quantity and quantity of in-stream habitats available to native trout (Table 27). Restoration activities have increased channel length by 312 m, resulting in an overall 51% increase in sinuosity from 1.13 to 1.71. Slope decreased by 19% from 0.0047 pre-construction to 0.0038. Restoration efforts have significantly improved stream bank conditions to reduce erosion potential. Bank height ratio was reduced by 75% from 4.37 to 1. The extent of wetland habitats has been increased by 302%. Changes in temperature attributes were monitored using two hobo water temperature loggers, one placed in the backwatered reach just upstream of the new channel and the second logger placed approximately 610 m downstream in a pool tail-out within the newly constructed channel. The mean of daily means for the lower temperature site was 17.3 ˚C and 18.6 ˚C during the months of July and August 2012, respectively. The upper temperature location had a mean of daily means value of 15.5 ˚C and 15.3 ˚C for the same period. By August, the mean of daily minimum for both locations was 13.5 ˚C. However, the mean of daily maximum values differed between the two sites by as much as 7.9 ˚C. These observed differences in temperature signatures are likely explained by differences in available canopy cover. An enclosed canopy of alder is regularly present upstream of the new stream channel in the backwatered area, whereas most of the new channel is very exposed due to the site having been a farm field with no riparian vegetation present until the construction of the new channel occurred. Years may be required before this site has a mature riparian canopy. The difference between temperatures in the two sites should decrease as vegetation communities continue to mature.

Table 27. Summary of change for selected response variables for the Hnmulshench Project on WF Lake Creek.

Response variable	**Before**	**After**	**% Change**	**Objective**
Sinuosity	1.13	1.71	+51	>1.50
Slope	0.0047	0.0038	-19	<0.004
Entrenchment ratio	5.14	14.45	+181	>12
Belt width (m)	10.1	26.82	+166	>20
Floodprone area width (m)	7.62	50.59	+563	>42
Bank height ratio	4.37	1.00	-75	1.0
Acres of wetland	2.8	10.79	+302	>9

Photo 5. A section of new stream channel following construction (left). Construction was completed in summer and the channel activated in September 2011. The same area is shown in August 2012 (right).

Photo 6. Degraded seasonal cheek before (left) and after restoration in June 2012 (right).

Project Timeline: The site design was finalized in May 2009. All NEPA work was completed by August 2009. Construction occurred between August-October 2009; July-August 2010; and July-September 2011.

Project Goals & Objectives: Goals for this project include 1) create wetland habitats and hydraulic connections with the valley bottom; 2) reduce bank erosion 3) provide a long-term source of large woody debris for natural recruitment; and 4) provide measurable increase in abundance and distribution of westslope cutthroat trout.

Relationship to Scope of Work: This project fulfills the Program commitments for WE H in the 2011 Scope of Work and Budget Request (Contract #52937) and for WE E in the 2012 Scope of Work and Budget Request (Contract #57531) for the contract periods dating June 1, 2011 through May 31, 2013.

Project L_8.2/0.7 – Riparian/Planting

Project Location:

Watershed: Lake Creek	Legal: T24N, R45E, S36 E ½ SE ¼
Sub Basin (River Kilometer): 13.2/1.1 rkm	Lat: 47.526627N Long: 117.048639W

Site Characteristics:

Slope/gradient: 0.6	Aspect: N	Elevations: 2600
Valley/Channel type: C4/C5	Proximity to water: Channel and adjacent floodplain	

Other: Project treats 3.2 ha of floodplain and 670 m of streambank construction in 2011. Additional planting in 2012 treated areas scoured by spring floods.

Problem Description: Current wetland function is degraded along the WF Lake Creek channel as a direct result of processes related to channel incision and entrenchment occurring since prior to the 1930's. Based on local site conditions and conditions in reference wetlands in other nearby watersheds, it is evident that both groundwater and periodic overbank flooding once provided much of the hydrology that maintained characteristic wetland plant communities in the project area. A band of xeric vegetation of variable width is located along the channel margin throughout the incised reach and most native vegetation has been replaced following a long history of farming which has encroached on the channel. A number of natural groundwater-fed springs that historically connected to the channel are now diverted directly to an irrigation pond, further isolating the stream and floodplain from natural hydrologic processes.

Restoration of the WF Lake Creek is underway to restore stable channel pattern and geometry and reconnect the stream and historic floodplain by creating 944 m of new stream channel in valley. In 2011, 3.2 ha that comprises new floodplain was disturbed through construction activities. This area will require rapid establishment of woody and herbaceous species to support the short- and long-term stability of the site.

Description of Treatment: A vegetation plan was developed for the site based on inventories of native wetland plant species conducted during wetland delineations and functional assessments on the project site and at a control site in the watershed. Planting activities are more fully described in the WF Lake Creek Restoration Planting Plan and in the Stormwater Pollution Prevention Plan (SWPPP) for construction activities. The plan identifies a mix of 27 native species to be planted on the site, delineates planting areas based on key environmental gradients, and provides material specifications and planting densities. Plant species include seven species of woody trees and shrubs, 10 species of herbaceous sedges (*Carex sp. and Scirpus sp.*) and rushes (*Juncus sp.*), and 10 species of herbaceous grasses.

A total of 20,199 herbaceous plugs and 11,291 woody plants were planted in the fall of 2011 along 670 m of newly constructed stream bank and 3.2 ha of new floodplain (Photo 7). In addition, newly graded floodplain surfaces and stockpile areas were hand seeded and mulched with herbaceous grasses applied at a rate of 48 kg/ha. Additional plantings were completed in April and September 2012 in areas that had experienced floodplain scour the previous spring.

This planting consisted of 970 woody plants and 5,147 herbaceous plugs. Additional grass seed was also applied in areas that were scoured.

Project Timeline: The site design was finalized in May 2009. All NEPA work was completed by August 2009. Construction for 2010 occurred between July and August. Woody plants and herbaceous plugs were planted in September 2010 and 2011. Permanent seeding and mulching occurred in October-November 2011. All major restoration work was completed in October 2011.

Project Goals & Objectives: Goals for this project include 1) create wetland habitats and hydraulic connections with the valley bottom; 2) reduce bank erosion 3) provide a long-term source of large woody debris for natural recruitment; and 4) provide measurable increase in abundance and distribution of Westslope Cutthroat Trout. Success criteria include: establish at least 80% herbaceous cover by native species at the end of 2 years following site disturbance.

Relationship to Scope of Work: This project fulfills the Program commitments for WE I in the 2011 Scope of Work and Budget Request (Contract #52937) for the contract periods dating June 1, 2011 through May 31, 2012.

Photo 7. Vegetation response in floodplain wetlands adjacent to the WF lake Creek project site following initial planting in November 2011 (left) and in October 2012 (right).

Project L_2.9/0.5 – Upland/Planting

Project Location:

Watershed: Lake Creek	Legal: T47N, R5W, S4; T48N, R5W, S34,S21
Sub Basin (River Kilometer): 4.6/0.8	Lat: 47.4745N Long: 116.9703W (approximate)

Site Characteristics:

Slope/gradient: 3-25%	Aspect: Various	Elevations: 792-822 m
Valley/Channel type: NA	Proximity to water: Upland	
Other: Project treats 97.1 ha of previously farmed uplands with highly erodible soils		

Problem Description: The project site consists of 97.1 hectares of uplands that variously drain to the mainstem of Lake Creek at river mile 0.8, 1.85, 2.55 and 2.95. The forest was cleared from this area in the late 1920's through 1950's and has had a history of cropping up until the early 2000's. Thirty-seven percent of the area is classified as highly erodible, with sheet and rill erosion generating an estimated 67 tons/year of sediment with a delivery rate of 10% and gully erosion generating an additional estimated 6 tons/year with a delivery rate of 45%. The single pass density index for all ages of cutthroat trout tends to be higher in this reach of Lake Creek (23.0 – 44.3 fish/100 m in 2010) than in upriver mainstem reaches. Sediment abatement is an important limiting factor to address in maintaining productivity within this reach.

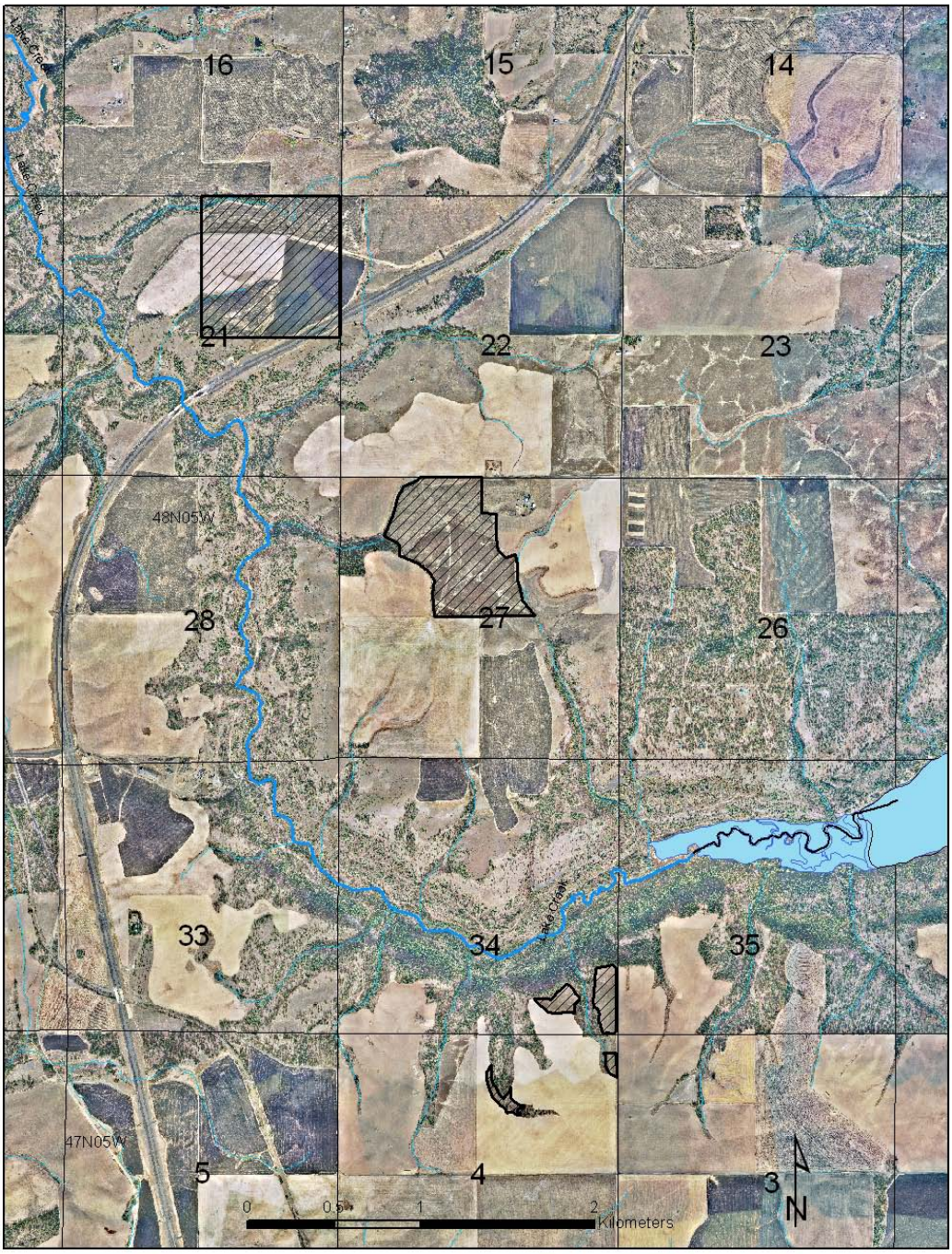
Description of Treatment: All acreage and numbers of trees planted are approximate (Map 10). 1) Bitter Road Tract (47N-5W, S4 & 48N-5W, S34): In November, 2011, 7,500 conifers were planted on 8.7 hectares (862 trees per hectare or 350/acre). The seedlings had been dipped in Plantskydd to repel herbivores, but it apparently wore off before spring. Due to low survival (19 to 33 percent) in the spring, a planned spot spray of herbicide was delayed. The area was interplanted in November 2012 to replace mortality with 5,400 additional trees. Rigid, mesh tree tubes were applied for protection from browse. Herbicide was also applied as a dormant spot spray of Atrazine 4L on the same day trees were planted to control competition the following spring. 2) Allotment 619 (48N-5W, S21): In May, 2012, 38,800 conifers were planted on 51.3 hectares (780/hectare or 315/acre), with Velpar L applied to spots around the trees. Survival rates in October were between 30 and 46 percent, so interplanting is planned for April 2013 to add 26,000 seedlings in spots already treated with herbicide. 3) Ness Road Tract (48N-5W, S27): In May, 2012, 30,000 seedlings were planted on 40.4 hectares (743/hectare or 300/acre). Spot herbicide treatment used Velpar L on 36.8 hectares and glyphosate/Atrazine on 3.6 hectares. Survival in September was 86% and 68%, respectively and re-planting is not currently needed.

Project Timeline: Initial treatments occurred in November 2011 and May 2012, respectively. Additional trees were planted to replace mortality in November 2012 at one site and interplanting is planned for a second site for April 2013.

Project Goals & Objectives: Restore prior converted forest habitat back to a native forest community. Reduce sheet and rill erosion and increase water retention. Achieve a minimum acceptable stocking rate after 5 years: 200 trees/acre on at least 70% of the planted areas.

Survival surveys will monitor stocking in first, second and fifth years after planting. Further replanting would be scheduled where survival surveys indicate that the minimum acceptable stocking rate is not achieved.

Relationship to Scope of Work: This project fulfills the Program commitments for WE D in the 2011 Scope of Work and Budget Request (Contract #52937) for the contract periods dating June 1, 2011 through May 31, 2012.



Map 10. Location of lands targeted for afforestation in the Lake Creek watershed, 2012.

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