Restoring Fluvial Populations of Native Trout

Westslope Cutthroat Trout Source Populations

Over the past three years two populations of genetically pure westslope cutthroat trout have been discovered in Yellowstone National Park. A small tributary of Grayling Creek, now known as "Last Chance Creek," contains the only known remaining genetically pure aboriginal population. The only other known genetically pure population is in the Oxbow/Geode Creek Stream Complex in the Yellowstone River drainage, where westslope cutthroat trout were probably stocked in the 1920s (Figure 16). Both populations have been independently verified as genetically pure by multiple laboratories and found to be free of pathogens, making them extremely valuable to westslope cutthroat restoration within the park and around the region. Both populations were used this year in the High Lake restocking effort (see below), and gametes from the Last Chance Creek population were incorporated into the Upper Missouri River broodstock at the Sun Ranch hatchery in Ennis, Montana.

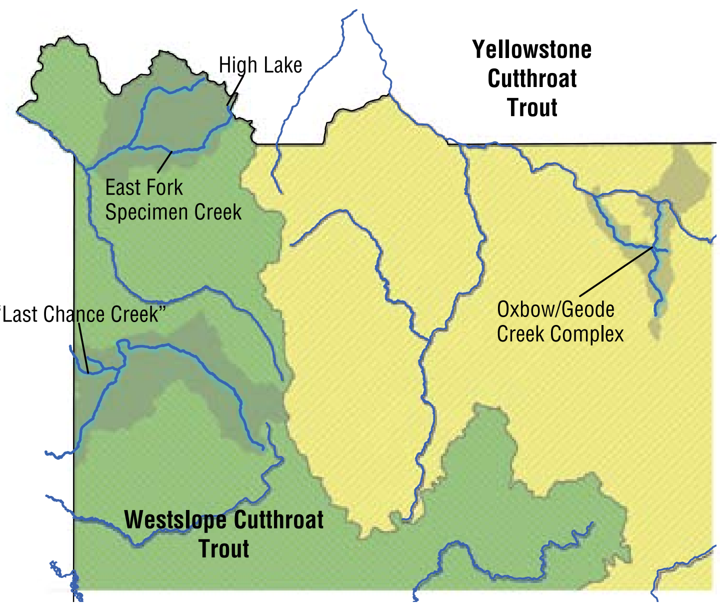


Figure 16. Historical cutthroat trout distribution in the northwestern region of Yellowstone National Park and locations of Oxbow/Geode Creek Complex, Last Chance Creek, and Specimen Creek.

Population estimates made within the past three years have revealed a stark difference between the streams. While Last Chance Creek harbors a viable population of more than 700 westslope cutthroat trout at an estimated density of 35 fish per 100 m of habitat, the Oxbow/Geode Complex population is extraordinarily

NPS/BILL VOIGT

NPS/DEREK RUPERT

Yellowstone cutthroat trout from Trout Lake in the Soda Butte Creek watershed (left). Westslope cutthroat trout from Geode Creek, a tributary of the Yellowstone River (right).


NPS/TODD KOEL


NPS/TODD KOEL


NPS/TODD KOEL


NPS/DEREK RUPERT


NPS/TODD KOEL


NPS/TODD KOEL

Top: Montana Fish, Wildife and Parks westslope cutthroat trout specialist Lee Nelson and MSU fisheries technician Derek Rupert collecting gametes on Last Chance Creek (left); Sun Ranch westslope cutthroat trout hatchery (center); egg incubation trays at the Sun Ranch hatchery (right). Bottom: Gametes after maturation at Sun Ranch (left); High Lake inlet stream with remote site incubator (center); westslope cutthroat trout fry in their new habitat at High Lake (right).

robust, with more than 13,000 individuals at a density 158 fish per 100 m. The reasons for the extremely high fish density in the Oxbow/Geode Complex are unclear and cannot be simply explained by stream size or temperature. The difference in population size warrants different approaches to their utilization as brood sources for restoration efforts (see below). Both populations are being closely monitored to ensure egg and fish collection efforts do not jeopardize their viability.


NPS/TODD KOEL

High Lake and one of its inlet streams at the headwaters of Specimen Creek.

High Lake Westslope Cutthroat Trout Introduction

In 2007 the East Fork Specimen Creek westslope cutthroat trout restoration project again focused on High Lake. To assess the efficacy of the two piscicide treatments done in 2006 (Koel et al. 2007), we checked gillnets that had been left overwinter for evidence of any remaining, introduced adult Yellowstone cutthroat trout and seined the entire littoral zone to look for juvenile fish. These efforts and extensive visual surveys confirmed the absence of fish in High Lake and eliminated the need for an additional piscicide application planned for 2007. It also ensured that stocking westslope cutthroat in the lake could begin during the 2007 field season.

The stocking effort used genetically pure westslope cutthroat trout from the park's two known populations and from the Upper Missouri River broodstock at the Sun Ranch Hatchery. On June 22, 1,200 eyed eggs were flown from the Sun Ranch Hatchery to High

Lake via helicopter and placed in remote site incubators (RSIs). Three weeks later, 177 fertilized eggs collected from 8 female and 12 male wild trout in Last Chance Creek were taken to High Lake on horseback and placed in additional RSIs (Figure 17). On July 25 and 27, trout of various age-classes were flown from the Oxbow/Geode Creek Complex to High Lake via helicopter (Figures 18 and 19).

Subsequent monitoring indicated initial success of all 2007 stocking efforts. Eggs from both sources had a high hatching success rate, indicated by the low number of unhatched eggs left in the incubators and an abundance of fry visible in the inlet streams. Fry were also observed in various locations around the lake margin. Adult fish were seen in the littoral zone feeding on aquatic invertebrates, and several were captured by hook and line. The captured adults appeared robust and healthy and all were released

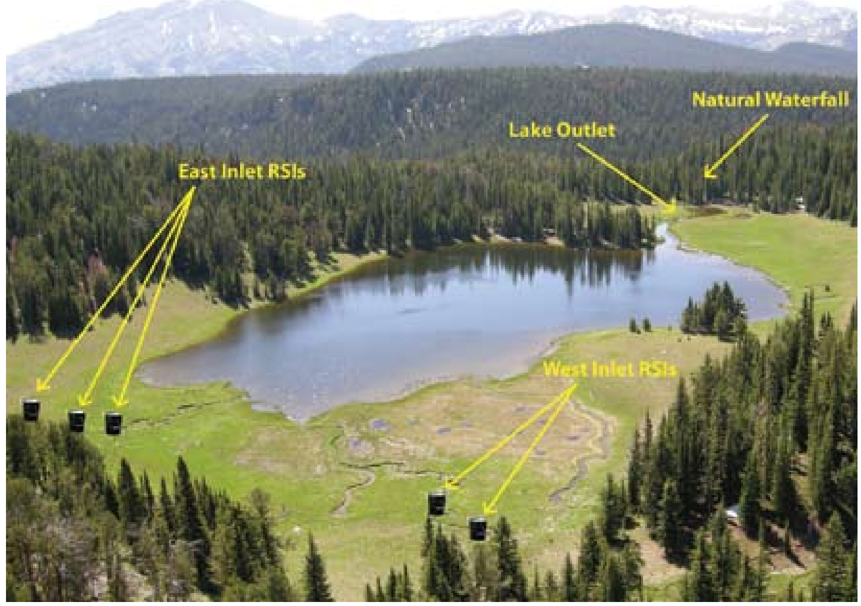


Figure 17. High Lake at the headwaters of East Fork Specimen Creek with locations of remote site incubators (RSIs) during westslope cutthroat trout introduction efforts in 2007.

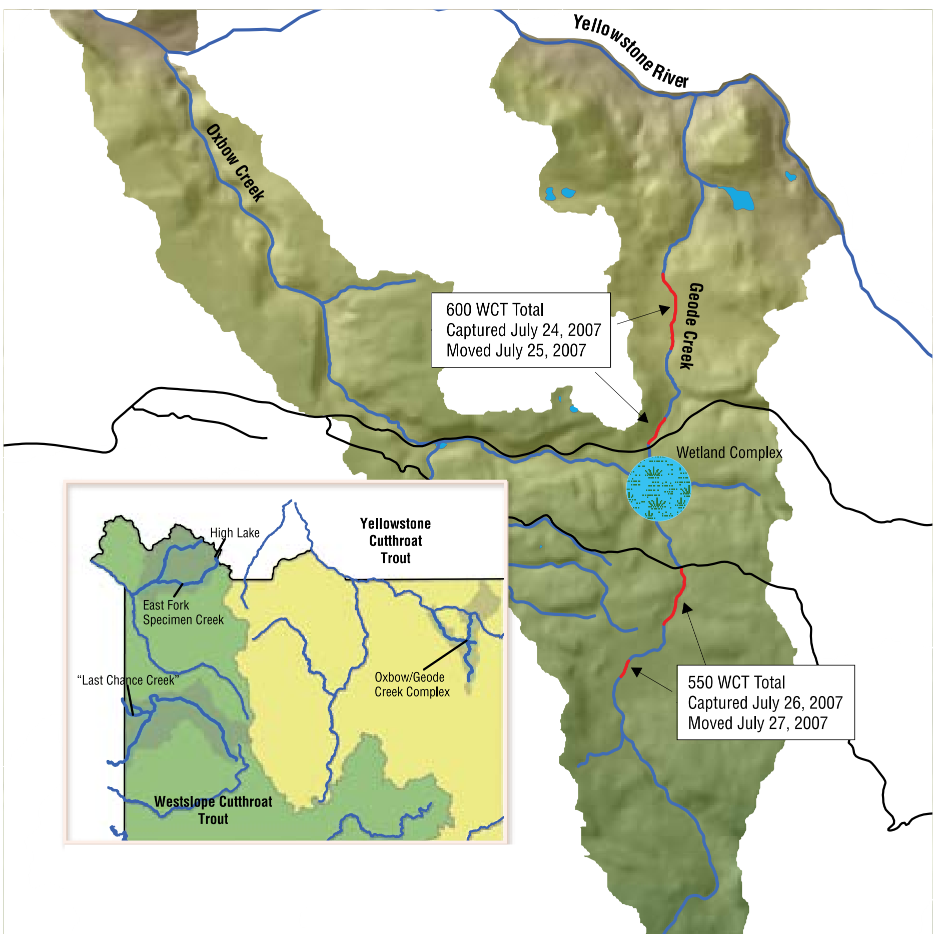


Figure 18. Oxbow/Geode Creek Complex in the northern range of Yellowstone National Park with locations of westslope cutthroat trout collections from Geode Creek in 2007 for purposes of restocking High Lake.

NPS/TODD KOEL NPS/TODD KOEL NPS/TODD KOEL

NPS/TODD KOEL NPS/TODD KOEL NPS/DEREK RUPERT

NPS/TODD KOEL NPS/TODD KOEL NPS/TODD KOEL NPS/TODD KOEL

Top row: Geode Creek watershed downstream from the Grand Loop Road (left); fisheries crew collecting westslope cutthroat trout from Geode Creek (center); westslope cutthroat trout held in the shade prior to transport (right). Center row: Examples of westslope cutthroat trout introduced to High Lake. Bottom row: Crew from Yellowstone Wildland Fire use a helicopter to quickly move westslope cutthroat trout to High Lake.

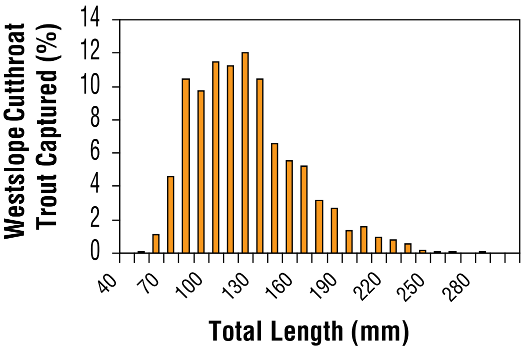


Figure 19. Length-frequency distribution of westslope cutthroat trout collected from Geode Creek and moved to High Lake in 2007.

unharmed. A grebe, a bird species that often eats fish, was also observed on the lake during this time, indicating that other wildlife dependent on fish were beginning to return to the area.

Owl Fire Impacts Specimen Creek Operations

Westslope cutthroat trout restoration efforts in 2007 were limited to High Lake largely because the Owl Fire, a naturally caused 2,810-acre wildfire, burned through a portion of the East Fork Specimen Creek restoration area. One of the most intensely burned areas was the barrier construction site, where construction of a 2-m tall, beaver dam-style barrier to upstream fish movement had begun in 2006. Considerable work, including a 76-m water diversion structure, and approximately 40 mule


NPS PHOTO

The Owl Fire burned the Specimen Creek watershed in 2007.


NPS/DEREK RUPERT


NPS/DEREK RUPERT

The water diversion structure built at the East Fork Specimen Creek fish barrier site before (top) and after (bottom) the Owl Fire.

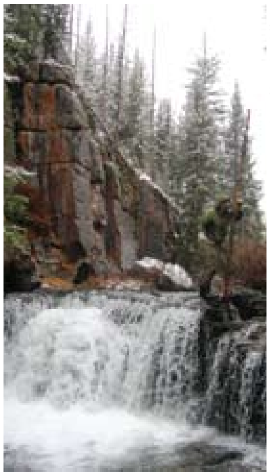
loads of equipment and supplies were completely destroyed by the fire. However, the fire's most significant impact was that we were unable to work at the site due to dangers posed by the fire itself and later by hazard trees left in the wake of the burn. In-stream bioassays planned for the 2007 field season were cancelled and no progress was made toward construction of the barrier. Delays in overall project completion will likely result.

Considerable work, including a 76-m water diversion structure, and approximately 40 mule loads of equipment and supplies were completely destroyed by the fire.

Potential of Returning Arctic Grayling to Grayling Creek

"Among the native (fish) species, the Arctic grayling have suffered the most from man's activities (Dean and Mills 1974)."

Grayling Creek, a tributary of the Madison River (now of Hebgen Reservoir), was historically home to fluvial (stream-dwelling) Arctic grayling (Jordan 1891; Evermann 1893). However, like the fluvial grayling in all other park waters, the grayling of Grayling Creek disappeared by the 1950s due to non-native


NPS/DEREK RUPERT

fish introductions and completion of the Hebgen Dam (Kaya 2000), which submersed the stream's lower reaches where grayling were most abundant. Grayling Creek was investigated in 1970 as the most likely watershed for fluvial grayling restoration (Dean and Mills 1971). Although the lower of the two barriers reported by this survey would have prevented the upstream invasion of non-native fish from Hebgen Lake into the restoration area (Figure 20), a subsequent investigation in 1973 revealed that the lower barrier had been the 12-ft scarp of the 1959 Hebgen Lake earthquake, and that it had since been washed away. Grayling Creek therefore appeared to hold little promise as a grayling refuge and the restoration plans were abandoned (Dean and Mills 1974). However, a 1982 survey of Grayling Creek to assess water quality, fish habitat, and existing barriers (Jones et al. 1983) determined that the upper falls, approximately 2 m in height at that time, would be an effective barrier to upstream movement by fish.


MTFWP/AUSTIN MCCULLOUGH

The upper reaches of Grayling Creek were surveyed in 2007 for trout and habitat suitable for supporting Arctic grayling.

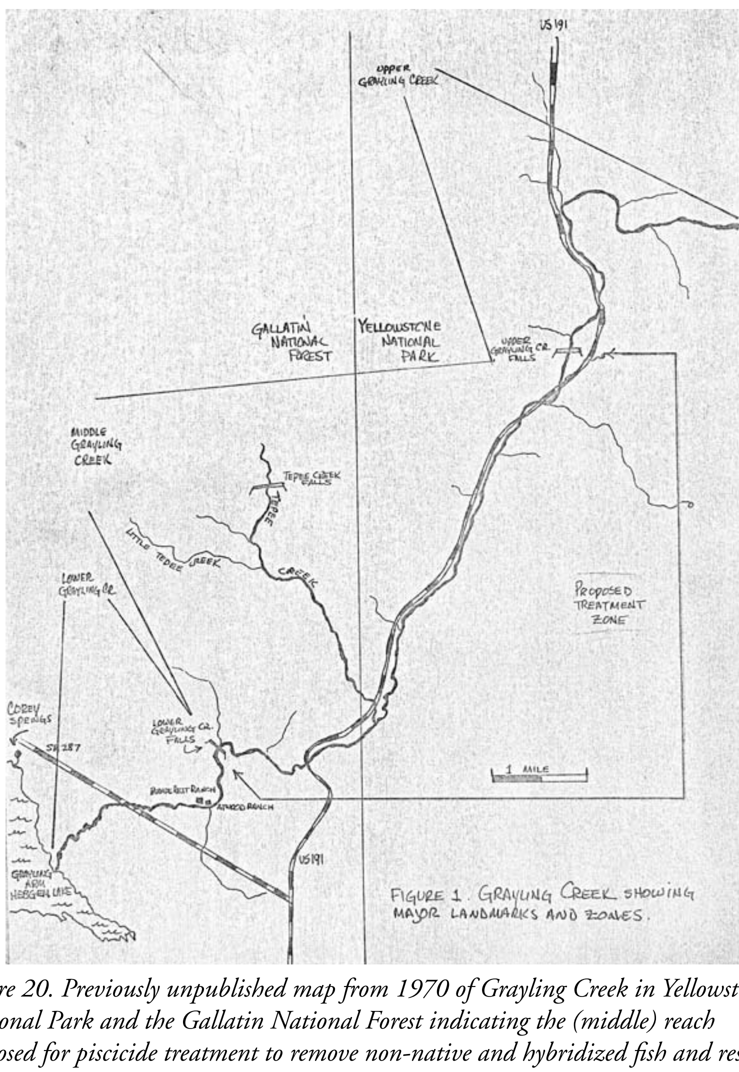


Figure 20. Previously unpublished map from 1970 of Grayling Creek in Yellowstone National Park and the Gallatin National Forest indicating the (middle) reach proposed for piscicide treatment to remove non-native and hybridized fish and restore fluvial Arctic grayling. By 1973, the lower falls, which were a scarp from the 1959 Hebgen Lake earthquake, had been cut through by the creek and judged not to be an effective fish barrier.

We recently determined that the Arctic grayling of the Gibbon River, occasionally caught by anglers, are genetically similar to the introduced, adfluvial populations inhabiting Grebe and Wolf lakes at the system's headwaters (Steed 2007; Koel et al. 2007). As such, they do not represent remnants of the fluvial grayling which were once native to this stream below Gibbon Falls. Because we do not know of any remaining fluvial Arctic grayling in Yellowstone, there is a need to reevaluate all watersheds within the species' native range to locate suitable habitat for fluvial grayling reintroduction efforts. Similar to biologists in the early 1970s and 1980s, we view Grayling Creek as having great potential for a native species restoration project. In September 2007 park fisheries staff teamed with Montana Fish, Wildlife and Parks to survey reaches of Grayling Creek upstream of the natural, bedrock barrier that exists deep in the canyon adjacent to U.S. Highway 191 (upper barrier of Dean and Mills 1971; Figure 20) and assess its suitability for a fluvial Arctic grayling and westslope cutthroat trout restoration project. The stream was walked from its uppermost crossing with the highway to the headwater reaches of the two forks nearly 10 miles upstream. Montana Fish, Wildlife and Parks staff collected habitat data (pool size and depth and spawning tributary suitability) and park staff collected fisheries data (species composition, length, weight, and genetics) via hook and line sampling.

Results of this cooperative effort indicated that Grayling Creek upstream of the upper falls may be suitable for fluvial arctic grayling introduction; however, brown trout persist for several miles upstream and would need to be removed for the project to succeed. Results of the genetic analyses are pending, but visual inspection indicates that genetic purity of westslope cutthroat trout improves in the uppermost reaches of the drainage. Montana Fish, Wildlife and Parks and the Gallatin National Forest have already contributed significantly to the project and indicated that this effort would have important implications for the overall status of fluvial Arctic grayling throughout the region. Further study of the existing fish populations and the Grayling Creek's restoration potential is planned for 2008.

Yellowstone Cutthroat Trout Restoration on the Northern Range

Additional sampling, planning, and preparations were carried out for streams across Yellowstone's northern range in anticipation of future Yellowstone cutthroat trout restoration. Most importantly, extensive barrier testing was conducted on the lower Elk Creek cascades. During four sampling events almost 300 brook trout were captured above the cascades, marked, inspected for previous marks, and moved downstream. No marks were recovered upstream (which would have indicated upstream fish passage) and initial indications are that the cascades are a barrier to upstream fish movement. Additional sampling will be conducted during the summer of 2008 to confirm these findings.

A similar testing method was applied to artificial beaver dams placed by willow researchers on Blacktail and Little Blacktail Deer creeks, none of which were barriers to upstream movement of brook trout. Brook trout distribution was sampled on Carnelian Creek, Glen Creek, and the Joffe Lake system, and the upstream extent of Yellowstone cutthroat

NPS/BRIAN ERTEL

Yellowstone cutthroat trout from Rose Creek in the park's northern range.

and westslope cutthroat was determined for the West Fork of Antelope Creek and Geode Creek, respectively.

Yellowstone cutthroat trout distribution, abundance, and genetic purity were also assessed in Rose, Crystal, Amethyst, and Chalcedony creeks of the Lamar River drainage. A randomly chosen 100-m section in each kilometer of stream (Figure 21) was sampled by completing a single pass with a backpack electrofishing unit. We found Yellowstone cutthroat trout, rainbow trout, and their hybrids (Table 1). Large trout (>400 mm) were present in Amethyst and Rose creeks, many in spawning condition. Although most of the habitat associated with these streams was considered either good or poor for spawning (because of large substrates), rearing habitat was good and evidence suggests that all four of these streams support migratory spawners from the mainstem Lamar River. The field work conducted during the 2007 field season will help us prepare the NEPA documents necessary to move forward with specific restoration projects. Rose Creek as well as the Elk Creek Complex and Reese Creek (both tributaries to the Yellowstone River) continue to be the focus of potential restoration activities. The 2008 Fisheries Program will also look at two of the Lamar River's largest tributaries, where there is strong evidence that the rainbow trout population in Slough Creek and the brook trout population in Soda Butte Creek are expanding.

NPS/DEREK RUPERT

Carnelian Creek, a remote tributary to Tower Creek, was surveyed to determine the uppermost extent of non-native brook trout in the watershed.

Table 1. Tributaries to the Lamar River in Yellowstone National Park that were surveyed in 2007 to determine the status of Yellowstone cutthroat trout (YCT), rainbow trout (RBT), and their hybrids (CTX).

Data includes fish lengths (mean in parentheses), whether or not fish were found in spawning condition, qualitative assessments of spawning and rearing habitats, the presence/absence of any barriers to upstream migration of fish, and the presence/absence of fish that likely migrated into the stream from the mainstem Lamar River.

Stream Name	Mainstem Length (km)	Fish Species	Length Range (mm)	Spawning Condition	Spawning Habitat	Rearing Habitat	Upstream Barrier	Lamar Migrants
Amethyst Creek	8.5	YCT, CTX	66–436 (275)	Yes	Poor	Good	Fairies Falls	Yes
Chalcedony Creek	8.5	YCT, RBT, CTX	62–346 (113)	No	Good	Good	Eden Falls	Possible
Crystal Creek	4.5	YCT, CTX	31–362 (112)	Yes	Poor	Good	Unnamed*	Yes
Rose Creek	10.1	YCT, RBT, CTX	59–442 (242)	Yes	Good	Good	None	Yes

*Several small unnamed seasonal barriers were found on Crystal Creek.

Implications of a Soda Butte Creek Brook Trout Invasion

Non-native brook trout have resided in the headwaters of Soda Butte Creek for decades (Shuler 1995), but were not found in the park until 2003. In 2004 and 2005, biologists from Montana Fish, Wildlife and Parks (FWP) and the U.S. Forest Service chemically removed the source population from a small unnamed tributary upstream of the McClaren Mine tailings. In addition, a multi-agency team led by Jim Olsen, FWP, intensively electrofished Soda Butte Creek for the last four years to remove brook trout. To date, the team has removed nearly 1,800 brook trout of various sizes/ages from seven long river reaches and small tributaries, extending from above Cooke City and downstream to near Ice Box Canyon in the park (Table 2). Although this effort appears to have reduced brook trout abundance (309 were removed in 2004 and only 150 in 2007), of particular concern is an increase in the relative abundance of young-of-year brook trout moving downstream into the park. This trend was also detected via routine electrofishing surveys during 2001–2005 (Koel et al. 2006*b*).

The end result of a brook trout invasion for cutthroat trout has been well-documented

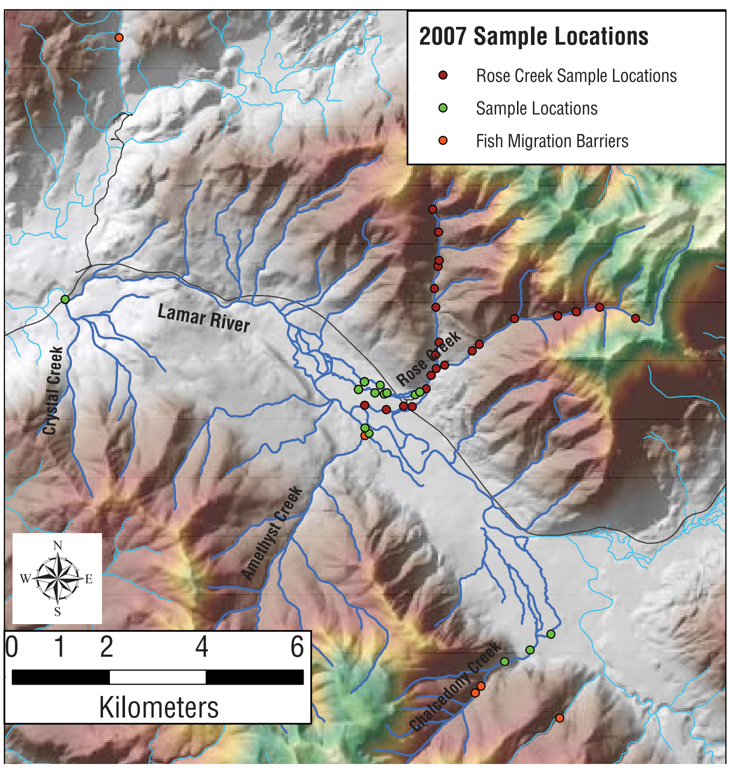


Figure 21. Locations of 2007 electrofishing sample sites and physical barriers to fish movement in the lower Lamar River watershed, Yellowstone National Park.


NPS/TODD KOEL

Slough Creek's third meadow during September 2007.

Table 2. Total (and young-of-year [YOY] only) brook trout removed via electrofishing on upper Soda Butte Creek within the Gallatin National Forest, State of Montana, and Yellowstone National Park, 2004–2007.

Note the downstream shift into the park by YOY brook trout over the four years of this removal effort. Data provided by Jim Olsen, Montana Fish, Wildlife and Parks.

	Removal Reach	2004	2005*	2006	2007
Downstream–Upstream	Hwy 212 to McClaren Mine Tailings	19(1)	3(0)	0(0)	0(0)
	McClaren Mine Tailings to Woody Creek	15(0)	17(0)	3(0)	3(0)
	Woody Creek to Sheep Creek	8(2)	43(0)	16(0)	0(0)
	Sheep Creek to Silver Gate	251(79)	932(51)	142(6)	45(8)
	Silver Gate to Yellowstone Park Boundary	9(3)	80(9)	54(2)	48(19)
	Yellowstone Park Boundary to Warm Creek	7(0)	11(0)	0(0)	50(27)
	Warm Creek to Road Bridge	0(0)	1(0)	0(0)	0(0)
	Tributaries	0(0)	17(0)	15(0)	4(0)
	Totals	309	1,104	230	150

*In 2005 a second removal effort was made post-spawning in October from Sheep Creek to Silver Gate.

elsewhere in the park and across the region. If left unchecked, the brook trout may drive the cutthroat to near extinction. Given the downstream proximity of the Lamar River, including Slough Creek and many other significant tributaries, the threat of the upper Soda Butte brook trout expansion cannot be overstated. To the greatest extent possible, park staff and partner agencies will need to suppress the brook trout in Soda Butte Creek each year into the foreseeable future, if the cutthroat trout of the Lamar River system are to be preserved.

Piscicide Effects on Non-target Species

An important component of our native trout restoration program is to document any long-term effects that piscicides may have on non-target organisms, such as aquatic invertebrates and amphibians. During the summer of 2007, we conducted both aquatic invertebrate and amphibian surveys in areas that are either being restored or have a high potential for restoration in the future. The primary purpose of these surveys is to better understand (1) the natural variation in aquatic invertebrate distribution and community structure; (2) the presence and extent of amphibian breeding populations; and (3) how the piscicides may impact these animals within fluvial trout restoration areas.

Macroinvertebrates in Restoration Areas

Invertebrates are an important element in aquatic food webs and occupy a wide assortment of feeding groups ranging from primary consumers (filter feeders, herbivores, scrappers, and shredders) to predators which feed on other invertebrates, larval amphibians, and young fish. In turn, various life stages of these invertebrates serve as an important food source for fish, birds, and mammals. Of the 29 sites on 16 streams we sampled during 2007 to assess invertebrate populations, 18 were located in current or proposed fish restoration areas (Ruhl and Koel 2007). We also sampled aquatic invertebrates in High Lake and Trout Lake in the northwest and northeast corners of the park, respectively. To date, only samples and data collected from Specimen Creek and High Lake have been processed.

In general, stream invertebrates in the three groups known as EPT taxa—Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)—are less tolerant of environmental stressors than are other aquatic invertebrate groups and are a major component of fish diets. Since EPT taxa are sensitive to changing environmental conditions, higher numbers are indicative of good water quality while lower numbers usually indicate poorer water quality. Conversely, aquatic invertebrates

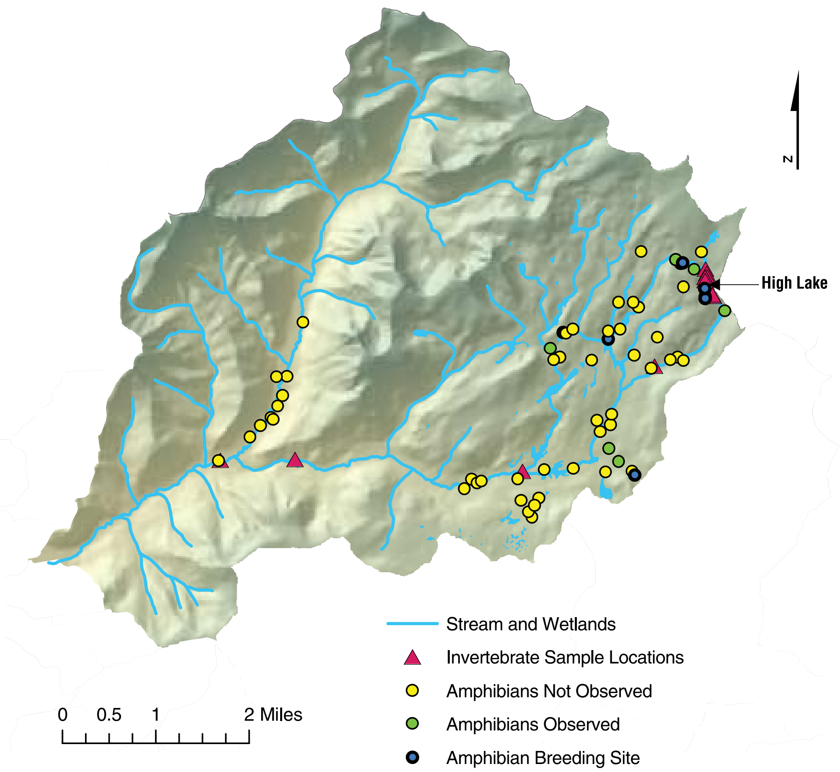


Figure 22. Invertebrate sampling locations and wetlands surveyed for amphibians in the Specimen Creek watershed, Yellowstone National Park, 2006 and 2007.

that belong to the insect order Diptera (true flies) are more tolerant of environmental stressors, with higher densities usually indicating poorer water quality or environmental stress. By assessing these aquatic invertebrate groups, we can predict the overall impacts that potential stressors may have on aquatic systems.

From 2004 to 2007 aquatic invertebrates were collected each August at three locations (sites 1–3) on East Fork Specimen Creek between High Lake and its confluence with the main stem Specimen Creek (Figure 22). In 2006 and 2007 we also sampled three sites (sites 4–6) on East Fork Specimen Creek in the immediate vicinity of High Lake. These samples were collected to assess the impact piscicides have had on aquatic invertebrate communities in the High Lake area, which was treated with rotenone in August 2006.

On East Fork Specimen Creek, the percentage of major invertebrate groups at sites 1–3 has remained relatively constant since 2004. Invertebrate groups at sites 1 and 2, which offer a wider range of habitats with variable substrate size, stream flow, and areas of aquatic plant distribution, demonstrated slightly

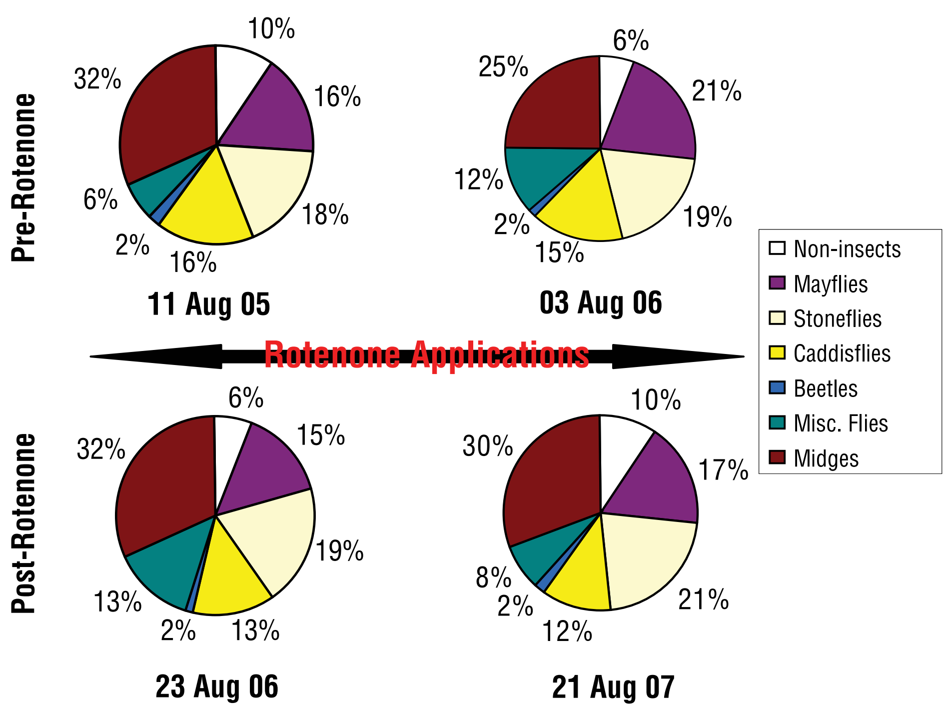


Figure 23. Percentage of major invertebrate taxa from East Fork Specimen Creek (Site 3), located 1 km downstream from High Lake, before and immediately after rotenone treatment in 2006 and one year post-treatment in 2007.

MSU water quality technician Ty Harrison and Student Conservation Association (SCA) intern and international VIP Eeffe Smit collecting flow data on the outlet to Mammoth Crystal Springs.

more annual variability than the invertebrate groups at site 3, located 1 km below High Lake, which demonstrated the most stable invertebrate community between years. Prior to rotenone treatment, the invertebrate samples were comprised of 50% EPT in 2005 and 55% EPT in 2006 (Figure 23). Following rotenone treatment in 2006 and 2007, samples were comprised of 47% and 51% EPT, respectively. This work has provided strong evidence that the piscicide application and other restoration activities at High Lake did not impact invertebrates in reaches downstream in the watershed.

The invertebrate communities in both outlet and inlet stream segments in the immediate vicinity of High Lake (sites 4–6; Figure 24) were the most affected by the piscicide treatment. To evaluate short- and long-term effects, we examined the total number of taxa, the percentage of major invertebrate groups, and the percent invertebrate abundance before and after rotenone treatment. We found a total of 68 invertebrate taxa (identified from 7 samples) in 2006 prior to treatment and 53 taxa after treatment in 2007 (identified from 3 samples). Prior to treatment, 33% and 38% of the invertebrate taxa belonged to EPT groups located within outlet and inlet stream segments, respectively (Figure 24). After treatment, however, EPT taxa declined to 11% and 10% in those segments. We documented a concurrent increase in aquatic fly larvae in these streams. This clearly indicated that in the short term, at least, invertebrate communities were negatively impacted by the rotenone treatment of High Lake.

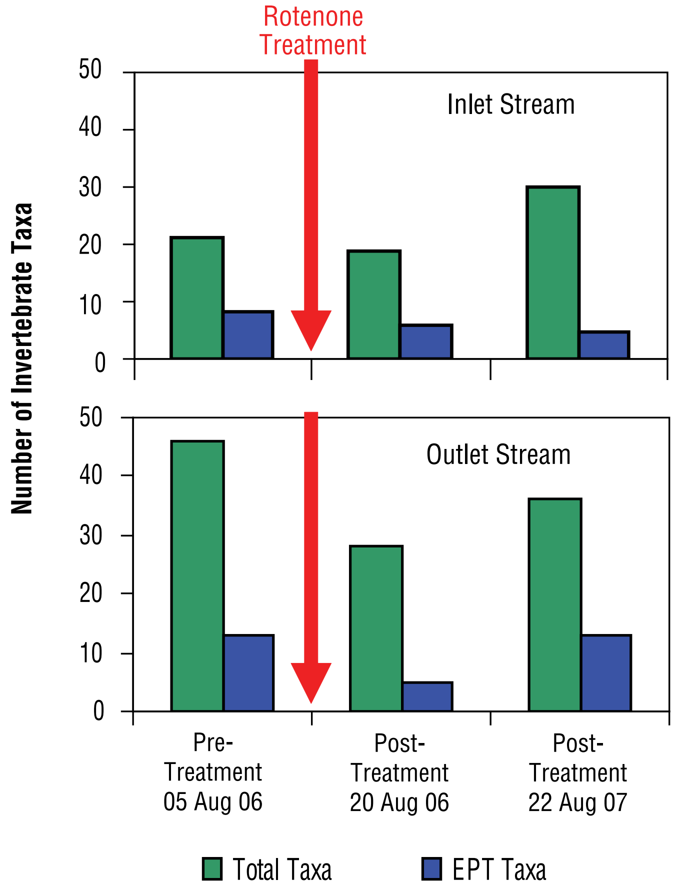


Figure 24. Total number of invertebrate taxa and total EPT taxa from High Lake inlet and outlet streams before and immediately after rotenone treatment in 2006 and one year post-treatment in 2007.

One year after treatment, invertebrate surveys indicated recovery of invertebrate populations within the High Lake outlet stream, while those in the inlet stream remained similar to conditions immediately after treatment. For example, aquatic fly larvae comprised a majority of the invertebrate community during 2006 pre- and post-treatment surveys (Figure 25). During 2007, however, densities of non-insect taxa as well as EPT taxa increased dramatically within the outlet stream. This increase was mainly attributed to four taxa: the fingernail clam (*Pisidium compressum*), two mayfly species (*Diphetor hageni* and *Paraleptophlebia* sp), and one stonefly (*Isoperla* sp). The fingernail clams, in particular, were encountered in low densities prior to treatment, yet reached densities of nearly

...in the short term, at least, invertebrate communities were negatively impacted by the rotenone treatment of High Lake.

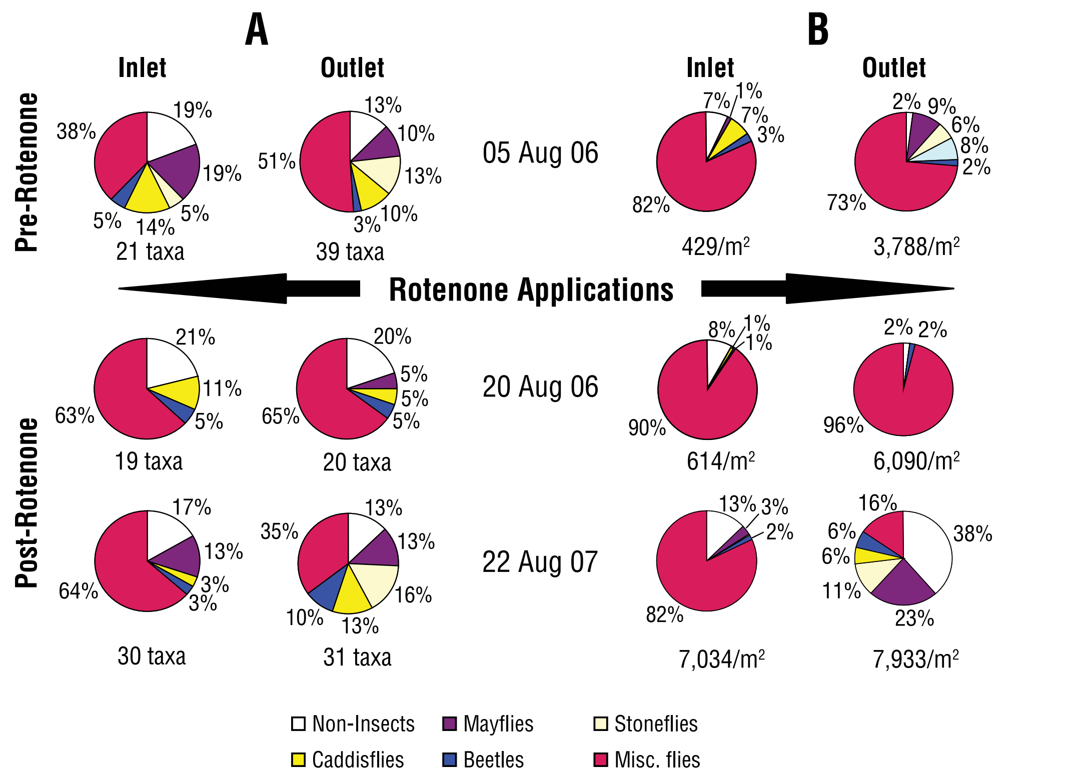


Figure 25. (A) Percentage of major invertebrate taxa and (B) percent invertebrate abundance from High Lake inlet and outlet streams before and immediately after rotenone treatment in 2006 and one year post-treatment in 2007.

3,000/m² in 2007. This increase in densities could be due to natural variation within the population or, possibly, a direct response by the fingernail clams sparked by the removal of trout.

Within High Lake itself the benthic invertebrate communities were not greatly impacted by the rotenone treatment. Prior to rotenone treatment, 25 taxa were identified from 20 samples collected in High Lake bottom sediments (Figure 26), including aquatic fly larvae (16 taxa), caddisflies (2 taxa), and various non-insects (7 taxa). After rotenone treatment, a total of 22 taxa were identified from 29 samples, including aquatic fly larvae (15 taxa) and non-insects (7 taxa). Except for the absence of caddisfly larvae (2 taxa) after treatment, benthic invertebrate groups in the High Lake sediments varied little before and after treatment.

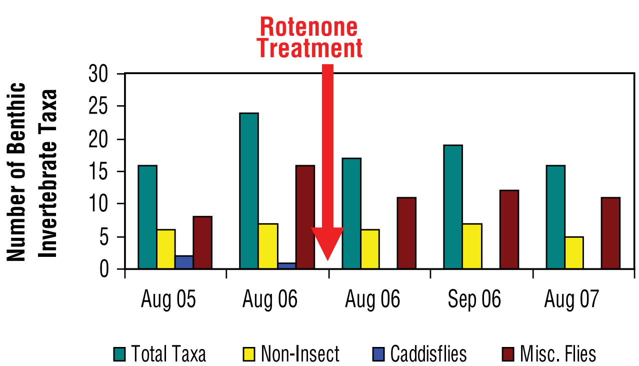


Figure 26. Total number of invertebrate taxa, non-insect taxa, caddisflies, and miscellaneous fly taxa (misc. flies) collected from the benthos of High Lake before rotenone treatment in 2005, before and immediately after rotenone treatment in 2006, and one year post-treatment in 2007.

Amphibians in Restoration Areas

Yellowstone National Park is home to four amphibian species: the Columbia spotted frog (*Rana luteiventris*), the boreal chorus frog (*Pseudacris maculata*), the boreal toad (*Bufo boreas*), and the blotched tiger salamander (*Ambystoma tigrinum*) (Koch and Peterson 1995). In May and July 2007, we investigated 122 wetlands identified by the National Wetlands Inventory (U.S. Fish and Wildlife Service 1998) for the presence of amphibians in areas targeted for native trout restoration. A majority of these wetlands were on the park's northern range (83 sites) and within the

NPS/JEFF ARNOLD

Young-of-year boreal toads using a small puddle on the Firehole Lake Drive resulted in placement of cones to keep traffic from killing them.

Madison River (15 sites) and Specimen Creek (24 sites; Figure 22) drainages in the northwest region of the park. Of the 122 designated wetlands, 46 (38%) had adequate surface waters to warrant a survey; the other 76 (62%) were not surveyed because they were unsuitable for amphibian breeding (e.g., dry, located on slope).

The northern range surveys focused on the Blacktail Deer (Figure 27), Elk, and Rose creek drainages and the small watershed that encompasses Trout Lake. Of the 83 wetland sites, 33 provided habitat that met the amphibian search criteria. The only amphibian species not found by our surveys was the boreal toad. Evidence of breeding (larvae and/or egg masses) was documented at 14 sites, half of which contained at least two species: 10 sites were used by the blotched tiger salamanders for breeding, 7 by boreal chorus frogs, and 5 by Columbia spotted frogs.

The Madison River drainage surveys focused on Duck Creek, which originates on Mount Holmes and flows westward toward the park boundary approximately 13.5 km north of West Yellowstone, Montana. The 14 surveyed sites were located in the extensive floodplain/wetland complex that surrounds the primarily slow moving, deep channeled Duck Creek. Ten of these sites were completely dry, three had adult boreal chorus frogs, Columbia spotted frogs, and juvenile boreal toads, and one had adequate water but we were unable to find any amphibians. No evidence of amphibian breeding was found in this drainage.

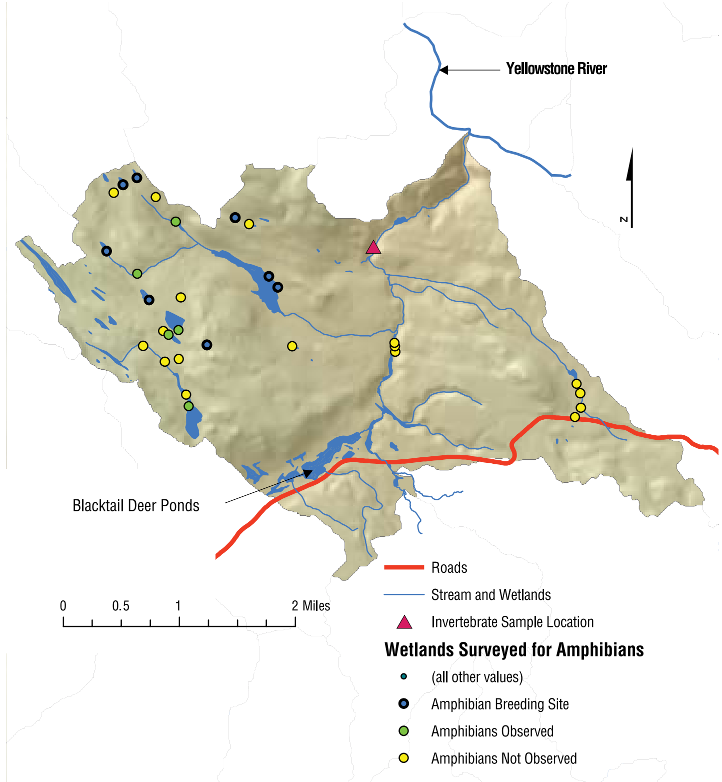


Figure 27. Invertebrate sampling locations and wetlands surveyed for amphibians in the lower portion of the Elk Creek watershed, Yellowstone National Park, 2007.

Of the 24 wetland sites we visited in the Specimen Creek drainage, 7 provided adequate habitat for amphibians (Figure 22), but only Columbia spotted frogs and boreal chorus frogs were found. Evidence of breeding (larvae and/or egg masses) was documented at four sites, all of which had Columbia spotted frogs; two of the sites also had boreal chorus frogs. High Lake, in the upper East Fork Specimen Creek drainage, is characterized by shallow margins dominated by sedge, which appears to be an important substrate for Columbia spotted frog egg laying. Before the rotenone treatment in spring 2006, spotted frog larvae were found only in the lake outlet area (Koel et al. 2007). In spring 2007, however, after the rotenone treatment, we observed adults and tadpoles all around the perimeter of the 7.1-acre lake. Research undertaken with Idaho State University will help us understand rotenone's potential impacts on amphibians and explain increased amphibian use of High Lake littoral areas immediately following removal of introduced fish, which are major predators of amphibians in mountain lakes (Knapp and Matthews 2000; Knapp et al. 2001; Pilliod and Peterson 2001).