Management Plan for Conservation of Yellowstone Cutthroat Trout in Idaho

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EXECUTIVE SUMMARY

The goals of the Management Plan for the Conservation of Yellowstone Cutthroat Trout in Idaho (Plan) are to ensure the long-term persistence of the subspecies within its current range and to do so at levels capable of providing angling opportunities. The Idaho Department of Fish and Game (IDFG) will strengthen and expand populations within the historical range of the subspecies. This Plan summarizes historical and current information through 2006 on Yellowstone cutthroat trout (YCT) throughout its range in Idaho. The Plan describes the known status of YCT populations in Idaho within 13 Geographic Management Units (GMUs) with respect to abundance, trends, genetics, and an evaluation of existing threats. Finally, the Plan presents IDFG management strategies and conservation actions based on habitat conditions, genetics, and population status.

An assessment of YCT distribution and abundance is provided for streams in the Upper Snake River Basin based on stream surveys at nearly 1,000 sample sites, the majority of which (84%) were selected randomly. YCT were the most widely distributed species of trout at these sample sites followed by brook trout, rainbow trout, YCT x rainbow trout hybrids, and brown trout. Of the sites that contained YCT, more than half did not contain other species of trout. Where nonnative trout were sympatric with YCT, brook trout were the most common species.

In the 11 GMUs where sample size permitted abundance estimates, there were about 2.2 million trout ≥ 100 mm (± 1.2 million), and of these, about 1.0 million (± 0.4 million) were YCT. Similarly, we estimated that about 2.0 million trout < 100 mm (± 1.4 million) were present, of which about 1.2 million (± 0.7 million) were YCT. Both estimates are almost certainly biased low, especially the estimate for trout < 100 mm. Based on the distribution of fish found in this study, and on expertise of local biologists, YCT are segregated into approximately 70 sub-populations, but estimates could be made for only 55 sub-populations. Of these, 44 sub-populations contained more than 1,000 YCT and 28 contained more than 2,500 YCT.

The IDFG assessed long-term changes in YCT abundance and size structure across southeastern Idaho by electrofishing 77 stream segments in the 1980s and again in 1999-2000 to test whether populations of YCT had changed. At these 77 locations, density of YCT ≥ 100 mm long did not change, averaging 41 fish/100 m of stream during the 1980s and 41 fish/100 m during 1999-2000. The proportion of the total catch of trout comprised of YCT also did not change measurably, averaging 82% in the 1980s and 78% in 1999-2000. At the 48 sites where size structure could be estimated for both time periods, there was a slight shift toward larger fish (≥ 100 mm), but the change was due entirely to the shift in size structure at sites in the Teton River. The number of sites that contained rainbow trout and hybrids increased from 23 to 37, but the average proportion of the catch composed of rainbow trout and hybrids did not increase (7% in 1980s versus 7% in 1999-2000).

Genetic hybridization in YCT populations was determined at 70 locations using genetic analyses of nuclear DNA, and phenotypic assessments of hybridization were compared to genetic analyses from 55 of these locations. Results indicated that: 1) genetic analyses corroborated visual determination that hybridization was absent at 37 of 55 sites; 2) at the 7 sites where biologists visually failed to discern genetically-detected hybridization, the percentage of rainbow trout alleles in the population was low (< 1 %) at all but two locations; and 3) where hybridization was detected both visually and genetically (11 sites), levels of introgression were strongly positively correlated between methods. Based on this strong agreement, YCT are classified phenotypically as "pure" and "≥ 90% pure" at 81% and 90%, respectively, of the study sites within these GMUs.

Based on investigations of genetic diversity and genetic population structure using mitochondrial and microsatellite DNA analyses, it appears that YCT are naturally structured at the drainage level, but also that habitat fragmentation has significantly altered this structuring and has led to reduced gene flow among sub-populations. Management and conservation regarding genetic diversity should focus at larger scales in areas of connected habitat and at the stream level in areas of degraded habitat to ensure the maintenance of genetic variation. Over the long-term, connectivity should be restored when possible to minimize losses in genetic diversity; preserve historical processes of gene flow, life-history variation, and metapopulation dynamics. However, due to the strong likelihood of rainbow trout invasion and subsequent introgression in some drainages, use of periodic translocations from genetically pure, local streams is a more preferable option.

Stocking of hatchery-produced fish has been an integral part of the IDFG's fisheries management for many years. In GMUs with small numbers of reservoirs, stocking rates have generally declined in the last 40 years. However, the reverse is generally true where there are numerous reservoirs. Rainbow trout have dominated the species composition of stocked fish. In the 1980s and 1990s, more than 44 million rainbow trout were stocked in YCT waters, many of which were potentially viable. However, the majority of these rainbow trout were fall spawning domesticated stocks that exhibit poor survival in riverine environments. Cutthroat trout, largely YCT from the Henrys Lake Hatchery, were historically stocked at rates of about 100,000 annually into waters outside of Henrys Lake. Henrys Lake generally receives between 1.0 million and 1.3 million YCT annually from the hatchery program. Brook trout stocking has ceased in YCT waters with the exception of Henrys Lake. In 2000, the IDFG implemented the stocking of only triploid rainbow trout in YCT waters.

Legacy and ongoing impacts to YCT include hybridization/introgression with non-native trout, water impoundments and dams/diversions, hydroelectric projects, road culverts, angler exploitation, non-native fish interactions, disease, grazing, and private ponds. Loss of water, non-native fish invasions, and degraded habitat are the most significant factors limiting expansion of YCT populations.

In this Plan, the IDFG provides a scheme for assessing long-term potential risk to populations based on genetic, population and connectivity factors. Management actions are described for various types of populations in the various risk categories. Of high concern for future management action are core (genetically pure) YCT populations. Recommended actions for depressed core populations include protective fishing rules, no stocking of non-native species, and habitat expansion. Of mid-level concern are conservation populations (from 1-10% introgression). Carefully controlled stocking of genetically pure YCT into depressed populations (less than 500 adults) will be considered if there are no habitat constraints and further invasion of rainbow trout can be prevented. Sport fishery (>10% introgression) populations may receive triploid rainbow trout or triploid YCT stocking where warranted to maintain the sport fishery and where stocking will not further degrade the level of introgression. Where genetic status is unknown but can be inferred, populations should be managed as though they were either core or conservation populations, depending on whether introgression is unlikely or likely, respectively. The IDFG will lead efforts in Idaho to protect, preserve, and perpetuate YCT populations and will do so in cooperation and collaboration with other interested parties.

GOALS

The goals of the Management Plan for Conservation of Yellowstone Cutthroat Trout in Idaho are:

1) Ensure the long-term persistence of the subspecies within its current range in Idaho;
2) Manage YCT populations at levels capable of providing angling opportunities; and
3) Restore YCT to those parts of its historical range in Idaho where practical.

The Idaho Department of Fish and Game is a participant in two interstate and/or interagency agreements relative to Yellowstone cutthroat trout. One is a Memorandum of Agreement (MOA) for Conservation and Management of Yellowstone Cutthroat Trout signed by the states of Montana, Idaho, Wyoming, Nevada and Utah, U.S. Forest Service, Yellowstone National Park, and Grand Teton National Park (State of Montana et al. 2000). This MOA defines shared goals and objectives for YCT across its historical range, and outlines a process of cooperation, coordination, and data sharing among the signatories. The IDFG also is a participant in a position paper entitled, Genetic Considerations Associated with Cutthroat Trout Management (Utah Division of Wildlife Resources 2000). The goals of the parties to the MOA are to "ensure the persistence of the YCT subspecies within its historic range," to "manage YCT to preserve genetic integrity," and to "provide adequate numbers and populations" for preservation of both intrinsic and recreational values of YCT. This IDFG Plan will guide staff to fulfill the objectives of that MOA. Those objectives include identifying existing populations, maintaining or improving genetic diversity and purity of core and conservation populations, restoring populations where needed, and a public outreach effort which will garner support for these activities. This Plan presents information current through calendar year 2006. The IDFG will update this Plan on a regular basis.

OBJECTIVES

1. To describe what is known about the subspecies in Idaho in one document that is regularly updated.

2. To identify and describe watersheds within the Idaho range for the subspecies.

3. To identify management concepts that will ensure long-term viability and persistence of current populations.

4. To identify management concepts that will enable restoration of YCT populations in those areas where restoration is feasible.

5. To provide guidelines for long-term monitoring of YCT populations to enable continuing evaluation of populations and their genetic status.

6. To promote general public outreach efforts directed at anglers concerning YCT.

SYSTEMATICS AND PREVIOUS STATUS ASSESSMENTS

Behnke (1992) described the taxonomy of native western trout including the YCT. The YCT (*Oncorhynchus clarkii bouvieri*) is one of ten subspecies of *O. clarkii*. The other recognized subspecies in Idaho are the westslope cutthroat trout (*O. clarkii lewisi)* and the Bear River (Bonneville) cutthroat trout (*O. clarkii utah)*. The westslope cutthroat trout inhabits the Salmon River drainage and northern Idaho drainages and the Bonneville cutthroat trout is found in the Bear River system in southeastern Idaho. The YCT evolved apart from rainbow (*O. mykiss*) and redband trout (*O. mykiss gairdneri*), and YCT lack isolating mechanisms that would allow them to coexist with *O. mykiss* and other non-native trout species (Behnke 1992).

Although YCT are generally visually distinguishable from westslope cutthroat trout based on spot size (Behnke 1992), to simplify matters, YCT are defined here as those cutthroat trout found in the Snake River drainage above Shoshone Falls, and in the Yellowstone River drainage. Now-extinct populations include Waha Lake, Idaho, and Crab Creek, Washington, where they likely persisted since the last ice age. Behnke (1992) stated, “There is no doubt that Yellowstone cutthroat and westslope cutthroat trout represent highly differentiated subspecies.”

Some taxonomists including Robert Behnke recognize the “fine-spotted” cutthroat trout of the upper Snake River as a separate subspecies (*O. clarkii behnkei*) of cutthroat trout (Behnke 1992). The distribution of the fine-spotted morphotype overlaps that of the large-spotted form of YCT, which is an unusual occurrence since all other cutthroat trout subspecies are geographically isolated from each other. Because of the overlap in taxonomic characters and the occasional specimen with intermediate spotting, Behnke (1992) suggests that hybridization and limited gene flow do occur. The known distribution of fine-spotted cutthroat trout extends in the Snake River drainage from below Jackson Lake (Wyoming) downstream to Palisades Reservoir, encompassing all tributaries from the Gros Ventre River to the Salt River (Behnke 1992). Below Jackson Lake, the first three tributaries (Pacific Creek, Buffalo Fork, and Spread Creek) contain YCT as the native trout. Populations of fine-spotted and large-spotted YCT occur in the Gros Ventre, the YCT in headwater tributaries, and the fine-spotted in the rest of the drainage. Before Jackson Dam was constructed to raise the level of Jackson Lake, cutthroat trout could move freely between the lake and Snake River below. A large number of hatchery-reared fine-spotted cutthroat trout have been stocked into Jackson Lake and the upper Snake River over the years, confounding the original distribution patterns of these two forms. The downstream distribution of the fine-spotted form is unknown because of Palisades Reservoir and Dam. Below Palisades Dam downstream to Shoshone Falls, the large-spotted YCT is the native trout. Geneticists have not been able to differentiate between large-spotted YCT and the fine-spotted forms (Loudenslager and Kitchin 1979; Leary et al. 1987; Allendorf and Leary 1988; Mitton et al. 2006 in review; Novak et al. 2005). In 2006, the Idaho Chapter of the American Fisheries Society sponsored a symposium entitled, Exploring Differences between Fine-spotted and Large-spotted Yellowstone Cutthroat Trout, in Idaho Falls, Idaho (Van Kirk et al. 2006). The IDFG does not consider the fine-spotted form of YCT a distinct subspecies; however, until and if the question of subspeciation is answered, for the purposes of this Plan, the IDFG considers the fine-spotted form a unique morphotype of YCT and will manage it accordingly.

Thurow et al. (1997) indicated that YCT occurred (or were predicted to occur) in 662 subwatersheds, or about 66% of their potential range. In addition, YCT were introduced in 140 subwatersheds outside its potential range by stocking primarily in high mountain lakes. Thurow et al. (1997) also indicated, however, that there were strong populations in 32% of subwatersheds within the potential range, and in 48% of the current range. However, if only

Idaho YCT are considered, the proportion of subwatersheds with strong populations would probably be less than for their entire range because the entire range considered by Thurow et al. (1997) included western Wyoming, where a large proportion of strong populations were found or predicted to be found. Thurow et al. (1997) did not define "strong," but let fishery professionals classify the population as strong, depressed, absent or transient based on their best professional judgment. May (1996), in summarizing results from questionnaires completed by biologists with personal knowledge of localized systems, suggested that viable YCT populations remained in only 43% of the historical range in Idaho. However, in a more recent rangewide assessment, May et al. (2003) estimated that YCT currently occupy about 43% of historical habitats range-wide (61% in Idaho). Throughout much of the Idaho range, YCT currently exist in sympatry with rainbow trout, brook trout (*Salvelinus fontinalis)*, and/or brown trout (*Salmo trutta)*.

GEOGRAPHIC MANAGEMENT UNITS

The Snake River flows through southern Idaho from east to west and is almost 1,700 km long from its headwaters in Yellowstone National Park to its confluence with the Columbia River. The Upper Snake River Basin is that part of the Snake River drainage from Shoshone Falls upstream to the headwaters of all tributaries, except the South Fork Snake River drainage above its confluence with the Salt River at the Idaho—Wyoming border. Shoshone Falls is a 65-m high natural waterfall in south-central Idaho that isolated YCT from other native trout in the Columbia River basin (Meyer et al. 2006). Elevations in the Upper Snake River Basin range from over 4,000 m in mountainous terrain to under 1,000 m at Shoshone Falls. The historical range of YCT in Idaho included the entire Upper Snake River Basin excluding the Big and Little Lost rivers (Behnke 1992).

To facilitate summary of the available information and to provide geographic focus for conservation efforts, we subdivided the Upper Snake River Basin into 14 geographic management units (GMUs; Lentsch et al. 2000) based largely on major river drainages, which generally also characterized the presumed historical distribution, present population status, and suspected or known movement patterns of YCT, as well as other management considerations (Figure 1). The 14 GMUs were defined as Beaver/Camas/Medicine Lodge, Blackfoot River, Goose/Big Cottonwood/Dry creeks, Henrys Fork of the Snake River, Henrys Lake, Palisades and Salt Rivers, Portneuf River, Raft River, Rock/Bannock creeks, Fort Hall Indian Reservation, Snake River Proper, South Fork Snake River, Teton River, and Willow Creek. The Fort Hall Indian Reservation is not considered in this Plan because it falls within the jurisdiction of the Shoshone Bannock Tribes. The following 13 GMU descriptions are largely taken or modified from IDFG (2001).

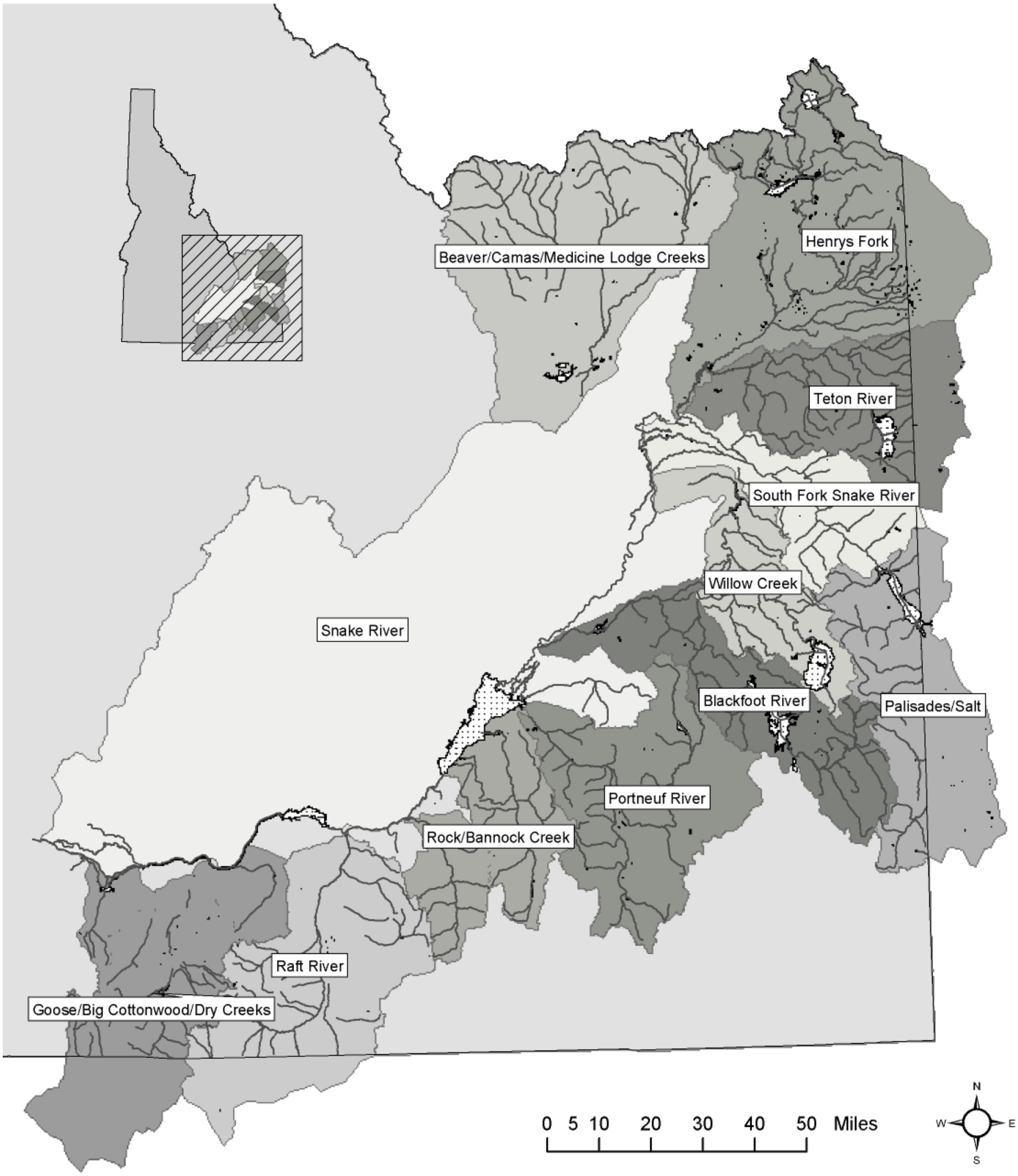

Figure 1. Location of YCT Geographic Management Units (GMUs) in Idaho.

Beaver/Camas/Medicine Lodge creeks

The Camas, Beaver, and Medicine Lodge creek drainages are all part of the "Sinks" drainage (Figure 2). This GMU is approximately 5,088 km^2 in size. All of the streams in the Sinks area disappear or flow subsurface into the Snake River Plain Aquifer. Streams become marginal where they flow into the Snake River Plain due to diversion and freeze out. Where groundwater inflow is lacking, wintertime air temperatures often cause streams to become icebound and leave their channels. Productivity of these streams is generally high due to large amounts of groundwater input; however, habitat degradation has occurred to most streams primarily due to past and/or present grazing practices on private and public rangeland, channelization, and irrigation diversions often dewater the lower segment of most drainages. Stream quality and fish populations vary from excellent to poor where streams alternately intersect and perch above the groundwater table or enter irrigation ditches.

Based on assessments of nongame fish assemblages, historical records, and geological shifts in drainage patterns, YCT are thought to be the only native salmonid in the Beaver/Camas/Medicine Lodge drainages. YCT are only recently considered native to the Beaver/Camas/Medicine Lodge GMU based on information presented at a symposium held at the 2002 meeting of the Idaho Chapter of the American Fisheries Society, in Pocatello, Idaho (see Van Kirk et al. 2003). At this symposium, Bart Gamett, U.S. Forest Service (personal communication) related evidence that indicates it is likely that the YCT found in these drainages originally came from the Henrys Fork drainage across a low divide which appears to have drained into both the Snake and Lost River systems at various times. Although YCT are found in many streams throughout the various drainages, rainbow trout of generally small size are the predominant fish except for some headwaters and a few minor tributaries where brook trout are dominant.

The Camas Creek drainage includes Mud Lake, Beaver, and Camas creeks. Healthy populations of wild rainbow trout and brook trout exist in most headwater streams. Several YCT populations are isolated from rainbow and brook trout (Middle Dry, Moose creeks) and other YCT populations exist sympatrically with rainbow trout or brook trout or both. Brown trout fingerling releases have provided a limited fishery for larger trout in Camas Creek. Water conditions limit trout populations in the lower ends of these streams. Mud Lake originally contained large numbers of cutthroat trout, but high summer temperatures, fluctuating water levels, and low winter dissolved oxygen have greatly decreased the suitability for trout. Mud Lake has lacked a coldwater fishery since water management changes in the early 1960s impacted Camas Creek and Mud Lake water quality. Experimental introductions of Lahontan cutthroat trout (*O. c. henshawi*) began in 1990 to evaluate this subspecies potential under existing high alkalinity and temperature conditions. Since introduction, Lahontan cutthroat trout have provided a limited fishery, primarily during the winter ice season. The IDFG will continue to evaluate the benefits of this program.

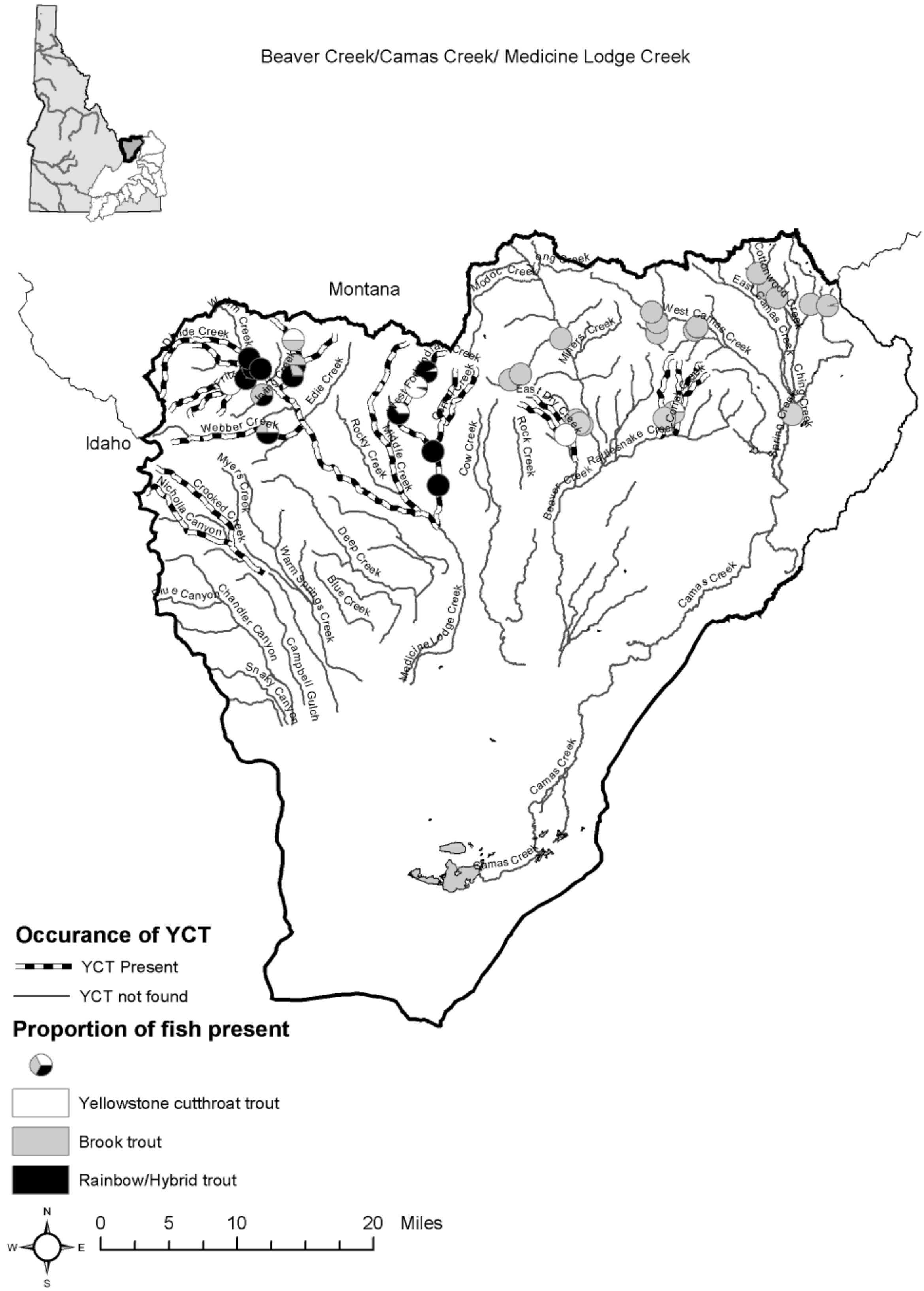

Figure 2. Beaver/Camas/Medicine Lodge creeks GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

Electrofishing surveys of the Medicine Lodge drainage documented good populations of YCT and brook trout present in several tributaries although naturalized rainbow trout are the dominant species. YCT tend to be distributed in the headwater reaches of small streams and tributaries, whereas rainbow trout dominate the mainstem and the lower tributary reaches. *Myxobolus cerebralis* (causative agent of whirling disease) was found in rainbow trout collected from the Medicine Lodge drainage in 2001. To date no population level impacts are known, though assessments have been minimal. The Medicine Lodge drainage has not been stocked since 1983 and has been managed under the wild trout regulation (two trout possession limit) since 1996.

There are no recent creel surveys on Beaver, Camas, or Medicine Lodge creeks. In 1987, estimated angler effort for Medicine Lodge Creek was 3,700 hours with a catch rate of 1.1 fish/hour. In 1982, estimated effort for the Medicine Lodge drainage was 5,300 hours with a catch rate of 1.1 trout/hour. Effort and catch rates were lower than those observed during 1963 (11,000 hours fished with 1.4 fish/hour). Rainbow trout comprised 94% of the fish harvest during 1982. What information is available on this GMU is found in Corning (1961), Corsi (1989), Elle and Gamblin (1993), Meyer and Lamansky (2005), and De Rito and Emery-Miller (2006).

Blackfoot River

The Blackfoot River GMU (Figure 3) is described in detail in LaBolle and Schill (1988) and in Thurow (1980a, 1980b) and is approximately 2,794 km^2 in size. The Blackfoot River and tributaries total 554 km. Blackfoot Reservoir covers 7,692 hectares and contains nearly 432 million cubic feet (350,000 acre-feet) of water at full pool. The Blackfoot River is the major tributary to Blackfoot Reservoir and has a mean annual inflow of 4.7 cubic meters per second (168.cubic feet/second). The river upstream from the reservoir extends 56 km to its origin at the confluence of Lane and Diamond creeks.

Habitat conditions generally are fair in the upper river basin and tributaries with a few exceptions due to livestock grazing and irrigation diversions. One of the largest phosphate ore reserves in the United States is located in this drainage. Environmental problems associated with phosphate mining were first documented in the 1990s with die offs of domestic horses and sheep that grazed in watersheds below Blackfoot drainage phosphate mines. Investigation of potential effects of selenium generated from phosphate mines on the fish and wildlife in the upper Blackfoot River drainage is ongoing.

Large (>457 mm long) YCT that are occasionally caught downstream from Blackfoot Reservoir probably escape from the reservoir. Good rearing conditions in tributaries and reduced bag limits for YCT have allowed numbers of fish to increase in the lower river especially above Wolverine Creek. Mountain whitefish (*Prosopium williamsoni)* are the dominant game fish species in the river downstream from Wolverine Creek.

The Blackfoot River, its tributaries, and Blackfoot Reservoir play integral roles in the life history and ecology of YCT. Mature YCT from the reservoir ascend the river mainly in May and enter upper tributaries or the main river channel to spawn in late May and June. Most of the progeny of both fluvial and adfluvial YCT rear in Blackfoot River tributaries for varying periods of up to two years. Many juvenile YCT then migrate to Blackfoot Reservoir until they are ready to return to the river to spawn. Other juveniles migrate from tributaries to the river where they rear to adulthood

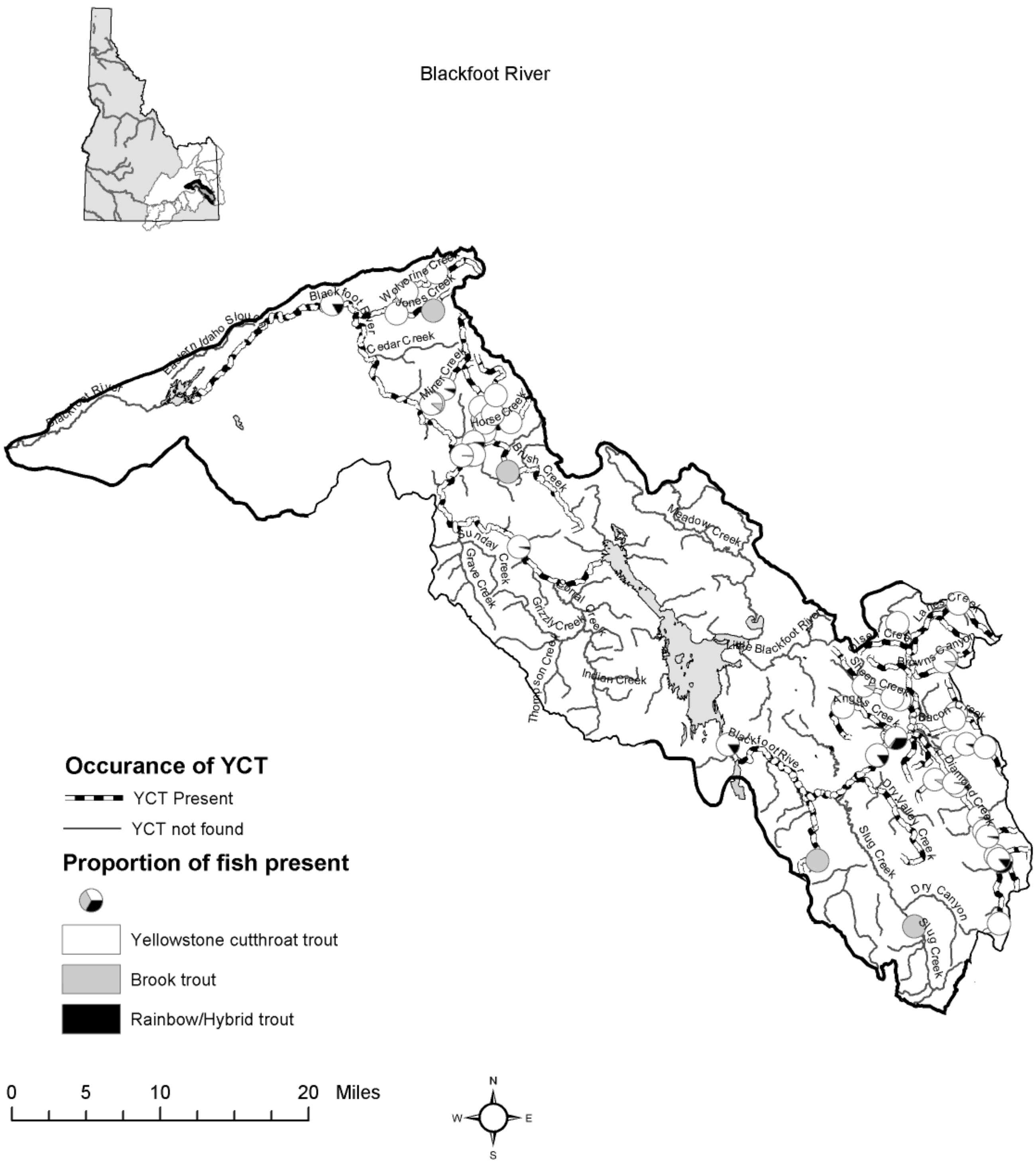

Figure 3. Blackfoot River GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

Trout harvested from Blackfoot Reservoir are almost entirely hatchery rainbow trout. All YCT must be released by anglers and hatchery cutthroat trout have not been stocked since 1995. YCT made up about 90% of the catch from the river and tributaries upstream from Slug Creek.

In the late 1990s, precipitation was abundant which led to high flows and a full reservoir. This coincided with the stocking of a large number of rainbow trout fingerlings in the reservoir and subsequent upriver movement of some of these fish. In 2000, IDFG geneticist Matt Campbell analyzed a sample of *Oncorhynchus* from the upper Blackfoot River system and found that 10.6% of the YCT were introgressed with rainbow trout genes. He also documented that 2.5% of the pre-spawn adfluvial YCT were introgressed with rainbow trout genes.

Since 2000, only sterile rainbow trout have been stocked in Blackfoot Reservoir and more recently, these trout have been sex-reversed females, which not only are sterile, but do not exhibit spawning migration or spawning behavior. Additionally, beginning in 2001, all rainbow and hybrid trout sampled from the upper Blackfoot system have been removed and anglers have been encouraged to harvest these fish.

Studies completed in the Blackfoot River GMU in the 1970s and 1980s indicated that the native YCT population was being overexploited. Size and number of YCT caught had decreased significantly prior to 1985. Special regulations were implemented in 1985 to offset this decline but the regulations proved ineffective. An evaluation of the YCT population made in 1988 showed that the river fishery had completely collapsed.

In 1983, IDFG began stocking Bonneville cutthroat trout from Bear Lake in Blackfoot Reservoir. These fish were reared for one year in the Grace Hatchery prior to release as five-inch fingerlings. Bear Lake cutthroat trout were treated with morpholine at the hatchery prior to release and were planted in the Little Blackfoot River at its mouth. The stream also was treated with morpholine to attract fish at the time of spawning. This planting location and morpholine treatment was an attempt to maintain the separate strains of cutthroat trout. Egg survival from Bear Lake cutthroat trout spawners captured in the Little Blackfoot River was poor. Beginning in 1990, the Bear Lake cutthroat trout were released in the Blackfoot River. Beginning in 1991, IDFG attempted to trap all trout ascending the upper Blackfoot River from Blackfoot Reservoir. All trout except native YCT were removed from the river at a fish trap to prevent them from spawning and possibly interbreeding with native YCT. This program failed since the trap was not effective except during low flows.

In 2000, anglers and IDFG biologists observed numerous rainbow trout in the upper reach of the Blackfoot River. About 80,000 hatchery rainbow trout were generally stocked in spring and summer per year, but the emphasis during the early 1990s was on fingerling stocking. The target release was 2,000,000 rainbow trout annually. However, in 1991 an evaluation demonstrated very poor survival of these fish with almost no benefit to anglers. With increased precipitation from 1995 through 1999, IDFG again planted large numbers of fingerlings as well as catchable size rainbow trout. The IDFG has stocked only sterile rainbow trout since 2000.

Since 1990, all native YCT caught in the reservoir had to be released by anglers. From 1990 through 1997, only two YCT over 457 mm long could be harvested per day on the Blackfoot River. Since 1998, all YCT had to be released on the upper Blackfoot River and tributaries and no bait fishing is allowed.

Computer modeling done by IDFG in the late 1980s to simulate the native YCT population indicated 12 to 15 years would be necessary under these regulations before the fishery could be restored to 1959-1960 levels. Anglers harvested 15,000 native YCT in 1959 from the upper Blackfoot River and 20% (3,000) of these were 508 mm or longer. The mean length of adfluvial YCT spawners sampled at the Blackfoot River trap in 2001 was 490 mm. A rough approximation of what the adfluvial spawning run out of Blackfoot River would have to be to attain a catch that included 3,000 cutthroat at least 508 mm long: for 6,000 adfluvial spawners caught, half of which were over 508 mm and assuming a maximum catch of 50% of the run, the adfluvial run would have to be near 12,000 fish. IDFG began monitoring the adfluvial population in 1991 with an adult trap on the Blackfoot River located one mile upstream of the reservoir. The 1987-1992 drought impeded progress on this program. As of the year 2000, restoration appeared to moving in a positive trend with large numbers of YCT spawners observed on spawning grounds and upper-river anglers reporting good catches of large YCT. The spawning run lasts about one month and occurs during the peak of the annual hydrograph. The “floating-weir” used only functioned when flows were low to moderate and was over topped when the flow was high. Because of this, IDFG was only able to trap the annual spawning run in 1991, 1992, 1995 and 2001. Beginning in 2002, IDFG installed an electric weir that functions at any flow and we have spawning run numbers annually from 2002 through 2006.

Blackfoot Reservoir was built for irrigation storage and has a maximum capacity of 473 million cubic meters (350,000 ac-ft). Annual irrigation demand is about 123 million cubic meters (100,000 ac-ft) and average annual precipitation provides about 123 million cubic meters (100,000 ac-ft) of refill. During a series of drought years, storage progressively ratchets downward and during abnormally high precipitation years, the opposite occurs. During the 15 years prior to the bench mark year of 1959, precipitation was uniformly good, and there was always near or above 370 million cubic meters (300,000 ac-ft or 86% of capacity) of water in Blackfoot Reservoir at the beginning of the annual irrigation season and near or above 247 million cubic meters (200,000 ac-ft or 57% of capacity) in the fall at the end of the irrigation season. These reservoir volume regimes were excellent for trout growth and survival and conditions were optimal to provide excellent fishing for adfluvial cutthroat trout in 1959.

Annual minimum volumes in Blackfoot Reservoir from 1988 through 1993 ranged from a high of 38% in 1989 to a low of 6% in 1992 with proportionately low annual maximum volumes. Cutthroat trout growth and survival probably suffered because of these low water volumes in terms of seasonally low oxygen and high water temperature and possibly because of high densities of other species such as suckers, chubs, and carp, which are more tolerant of wider ranges of dissolved oxygen and temperature than cutthroat trout. Precipitation and water storage were abundant from 1993 through 2000 and then precipitously fell between 2001 and 2005, reaching a low in 2003 and 2004 of near 16 million cubic meters (13,000 ac-ft or 4% of capacity). The trend in annual counts of adfluvial YCT spawners can at least partially be explained by the trend in water storage (Table 1).

A second important factor to consider relative to the trend in the number of adfluvial YCT spawners is avian predators, especially American white pelicans. Pelicans are native to Idaho, nesting only at Blackfoot Reservoir and Minidoka National Wildlife Refuge. Their numbers throughout the country were depressed from the effects of DDT until its persistence declined in the environment well after its ban in the early 1970s. Additionally, in the 1950s and 1960s, pelicans were often killed indiscriminately by anglers or possibly under local authority of depredation permits to reduce impacts on fisheries. Like YCT, pelicans are a Species of Greatest Conservation Concern in the State of Idaho Comprehensive Wildlife Conservation Strategy.

Pelicans attempted to nest on Blackfoot Reservoir islands in the 1950s and 1960s but anglers destroyed their nests. This was at a time when YCT flourished in the Blackfoot Reservoir system. Pelican numbers were low and reservoir volumes were high. The relative importance of each of these factors to the abundance of YCT in the Blackfoot River GMU is unknown. No pelican nests were recorded in the 1970s. In the 1980s, Idaho State University ornithologist Chuck Trost observed pelicans at Blackfoot Reservoir but no nesting. Early in the 1990s, pelicans began nesting on Gull Island in Blackfoot Reservoir. In 2002, IDFG began monitoring pelicans and their nests due to concern about their impact on newly stocked hatchery trout. Annual monitoring documented rapid population growth of pelicans from 676 nests in 2002 to near 1,400 in 2005 and 2006. Bird scars observed on migrating YCT spawners became a concern in 2003. In 2004, all bird scars on migrating cutthroat at the Blackfoot River fish trap were recorded by IDFG. Seventy percent of the 125 cutthroat trout that arrived at the trap had bird scars. From 2004-2006 in the Blackfoot River near its confluence with the reservoir, IDFG used a number of hazing techniques including Zon guns, air boats, shotgun cracker shells, and bird lines at 100-foot intervals. IDFG was permitted by the U.S. Fish and Wildlife Service (FWS) to shoot up to 50 pelicans in an attempt to prevent pelican predation during the spring YCT spawning migration. To date these efforts have been ineffective. A total of 13 birds were taken in 2006 with little or no effect.

The rapid increase in numbers of American white pelicans at Blackfoot Reservoir may be a significant factor in the rapid decline of adfluvial YCT. On a statewide basis, there are only two colonies of breeding pelicans, one at Blackfoot Reservoir and another located 80 miles away on Lake Walcott. Total number of breeding pelicans for these two colonies is probably between 5,000 and 6,000 birds. From a wildlife management perspective, this may be an acceptable number on a statewide basis; however, relative to fishery management goals for Blackfoot River adfluvial YCT, it is presenting a conflict. The IDFG management goal is to have a spawning run of 10,000 to 15,000 adfluvial YCT to provide the public with a highly prized fishery as occurred in the 1950s. IDFG fishery managers do not believe it is possible to attain this goal without a concurrent effort to manage numbers of American white pelicans.

Table 1. Blackfoot Reservoir annual maximum and minimum storage volumes, available data on adult Yellowstone cutthroat trout spawners migrating upstream in the Blackfoot River above Blackfoot Reservoir, and available information on American white pelicans at Blackfoot Reservoir from the 1950s to 2006. (n/a designated information not available).

Year	Maximum volume	Minimum volume	Adult YCT Spawners	Pelicans
1950	346,050	262,790	n/a	
1951	349,800	266,465	n/a	
1952	336,250	257,614	n/a	
1953	339,780	208,223	n/a	
1954	296,155	219,686	n/a	
1955	306,654	185,630	n/a	
1956	337,132	276,224	n/a	
1957	344,790	272,283	n/a	
1958	343,360	190,170	n/a	
1959	286,208	203,510	Large catch of large trout (3,000 over 20 inches long). Run size probably 10,000 to 15,000	Pelicans attempt to nest. Anglers destroyed nests.
1988	283,166	118,150	n/a	
1989	219,655	132,490	n/a	
1990	190,790	64,040	n/a	A few pelicans begin
1991	160,878	77,780	575	nesting on Gull Island
1992	129,240	22,060	521	
1993	187,897	36,820	n/a	
1994	227,406	87,900	n/a	
1995	242,585	101,155	1,663	
1996	329,190	212,354	n/a	
1997	337,662	206,321	n/a	
1998	342,823	238,940	n/a	
1999	341,570	253,115	n/a	
2000	309,612	177,188	n/a	
2001	239,270	88,360	4,747	
2002	142,775	40,805	902	676 pelican nests No bird scars on 125 random cutthroat photos
2003	97,780	13,975	427	837 pelican nests Some bird scars on YCT. Set Zon guns to haze pelicans
2004	64,460	13,120	125	874 pelican nests 70% of migrating YCT with bird scars. Used various hazing methods without success
2005	130,150	28,760	20	1,400 pelican nests. Set bird lines over 2 miles of lower river
2006	218,387	143,300	20	1,274 pelican nests. Bird lines not set due to rising water. 13 pelicans destroyed under permit

The number of fluvial YCT residing in the upper Blackfoot River and tributaries appears to be stable on the 6-mile river reach within the IDFG Blackfoot Wildlife Management Area where estimates of 4,092 and 3,564 YCT at least one year old have been made in 2005 and 2006, respectively. There has been no livestock grazing on this reach since 1994 and riparian and river substrate habitat conditions have improved for YCT. YCT exhibiting the fluvial life history can sustain the YCT population through low water years and low carryover storage in Blackfoot Reservoir. IDFG has little influence over water management. However, IDFG and the FWS should cooperate on the development of a management plan to address avian predation on the Blackfoot system adfluvial YCT population.

Further information on YCT in the Blackfoot River GMU is found in Corning 1961; Casey 1966; Heimer 1972, 1979, 1980, 1986, 1987; Thurow 1980a, 1980b; Thurow et al. 1981; Neve and Moore 1983; Heimer et al. 1987; Schill and Heimer 1988; Schill and LaBolle 1990; Schill et al. 1990; Mende et al. 1993; Scully et al. 1993; and Meyer and Lamansky 2002a.

Goose/Big Cottonwood/Dry creeks

Goose Creek originates in the Albion Mountains of south-central Idaho, flows southward into Nevada, and then flows northward back into Idaho until it empties into Goose Creek (Oakley) Reservoir (Figure 4). This reservoir stores water for irrigation and flood control. It supports a fishery of stocked rainbow trout, some cutthroat trout, and walleye (*Stizostedion vitreum)*. A few small tributaries in the GMU were historically stocked with rainbow trout and cutthroat trout but do not appear to harbor remnant YCT populations. Land and water use in this GMU is primarily agriculture-related.

The Goose/Big Cottonwood/Dry Creeks GMU is approximately 4,029 km^2 in size. Historic information on fish populations in this GMU is found in Irving 1955, Bell 1981, Grunder et al. 1987, Grunder et al. 1989, Partridge and Corsi 1989, and Partridge and Corsi 1991. Big Cottonwood and Dry creeks are tributaries to the Snake River isolated by Murtaugh Reservoir. Fishery surveys done by IDFG on Dry Creek in 1988 (Partridge and Corsi 1990) and 1999 (Partridge et al. 2002) indicate the presence of a hybridized YCT x rainbow population. However, BLM extensively surveyed Dry Creek again in 2005 but did not find hybridized YCT. Dry Creek YCT densities (fish>100mm) averaged 0.21 fish/m. Fishery surveys were also completed by IDFG in Trout and Piney creeks where average YCT densities were found to be 0.12 and 0.00 fish/m, respectively. In 2006 the Idaho Department of Environmental Quality (IDEQ) surveyed the fish population in upper Goose, Little Goose, Little Piney, and Thoroughbred creeks in 2006 and reported average salmonid densities of 0.23, 0.00, 0.33, 0.21 fish/m, respectively.

Genetic samples have been secured from several streams within this GMU. Tissues were collected and preserved from Trout, Big Cottonwood and Dry Creeks in 2005. In 2006, IDEQ and IDFG collected tissue samples from fish in upper Goose, Little Goose, Little Piney, and Thoroughbred creeks. Only Trout Creek samples have been processed to date and results showed the presence of hybridization at significant levels (IDFG, unpublished data).

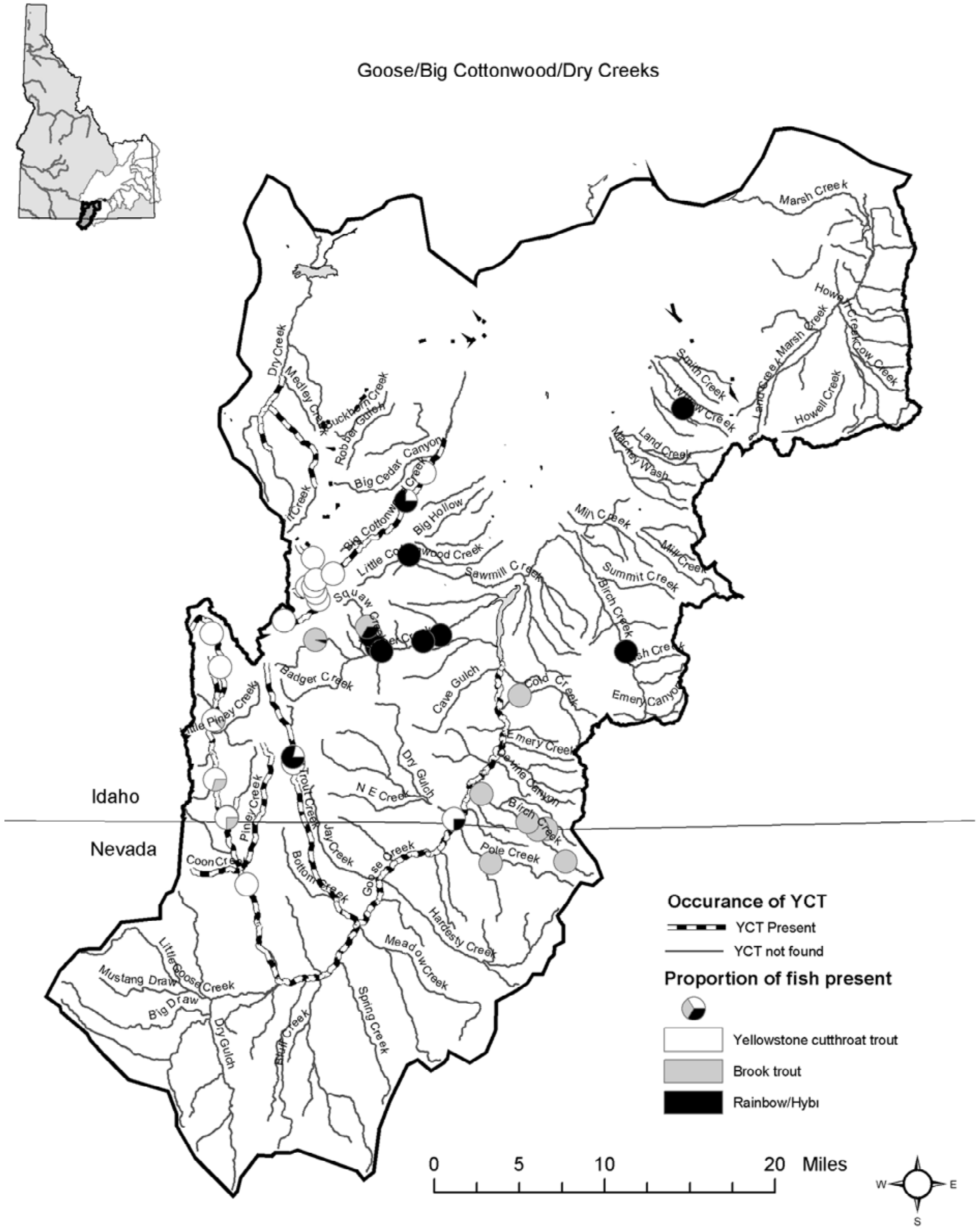

Figure 4. Goose/Big Cottonwood/Dry creeks GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout captured were not included in these plots.

Henrys Fork Snake River

The Henrys Fork Snake River GMU (Figure 5) includes the Fall and Warm rivers as well as the Henrys Fork from its origin to the confluence with the South Fork Snake River, but excludes the Teton and the Henrys Lake drainages. This portion of the Henrys Fork Snake River GMU is approximately 5,295 km^2. About half of the GMU lies on federal land (mainly the Targhee-Caribou National Forest). The Henrys Fork Snake River originates in the Island Park Caldera, with over half of the total discharge above Ashton coming from a series of springs on the east side of the caldera (Benjamin 2000). The largest of these, Big Springs, has a discharge of over 5.0 meters per second (177 cubic feet/second) and is the headwaters of the Henrys Fork. The Henrys Fork Snake River GMU is extremely important to the regional economy primarily for irrigated agriculture and the recreational value of its world famous fishery.

The Henrys Fork Snake River GMU supports only a small fraction of the YCT it did prior to the 1900s. The YCT population was prolific enough to support numerous commercial fishing operations in the late 1800s (including Henrys Lake). The exploitation of these fish may have contributed to their decline; however, it is more likely that concurrent aggressive stocking programs utilizing rainbow trout and brook trout had more to do with the loss of YCT throughout the drainage (Van Kirk and Gamblin 2000). In 1958 and again in 1966, piscicides were used to treat the Henrys Fork above the Island Park Dam to remove nongame fish. In 1958, the river was chemically treated upriver to Mesa Falls while in 1966 it was treated to Ashton. The YCT populations were largely eliminated by these treatments downstream to Mesa Falls. Following the chemical treatments, rainbow trout were restocked in the drainage. In addition to the effects of exploitation, exotic fish stocking, and chemical treatments, habitat degradation and fragmentation likely played a role in the loss of cutthroat trout populations.

Currently, there are few isolated populations of YCT located in small streams in the drainage (e.g., Tygee Creek). In addition, there are limited cutthroat populations living in sympatry with rainbow trout in (e.g., Fall River, Robinson, Conant, and Squirrel creeks) in the drainage that are likely introgressed. Jaeger et al. (2000) estimated that YCT are found at least seasonally in about 17% of and exclusively occupy only about 3% of their historic range in the Henrys Fork drainage. In an update of that assessment conducted by the Henrys Fork Foundation in cooperation with the U.S. Forest Service and IDFG, De Rito and Emery-Miller (2006) reported that 86% of the total stream length of the Henrys Fork drainage (1,743 km) has now been surveyed. They found that of the 1,501 stream km surveyed, YCT occupied 25% of their historical range in the drainage at least seasonally, and the estimated stream length occupied exclusively by YCT was 50.4 km, or 5% of historical.

Efforts to reestablish YCT in portions of the drainage began in 1999 when Golden Lake and its tributaries (East, Middle, and West Thurman creeks) were treated with piscicide to remove rainbow and brook trout from the drainage. Because of an incomplete kill or reinvasions, the effort was repeated in 2000. In 2001, genetically tested cutthroat from Henrys Lake were stocked in Golden Lake. Unfortunately, rainbow trout were still present in the system following the two treatments. A passage barrier was modified to ensure that immigration from below the Golden Lake Dam was not occurring and the number of YCT stocked in the lake was increased in an attempt to swamp the remaining rainbows. It is IDFG's objective to develop a conservation population of YCT in Golden Lake within Harriman State Park. The IDFG will evaluate genetic and population information in the future to determine if objectives are being met.

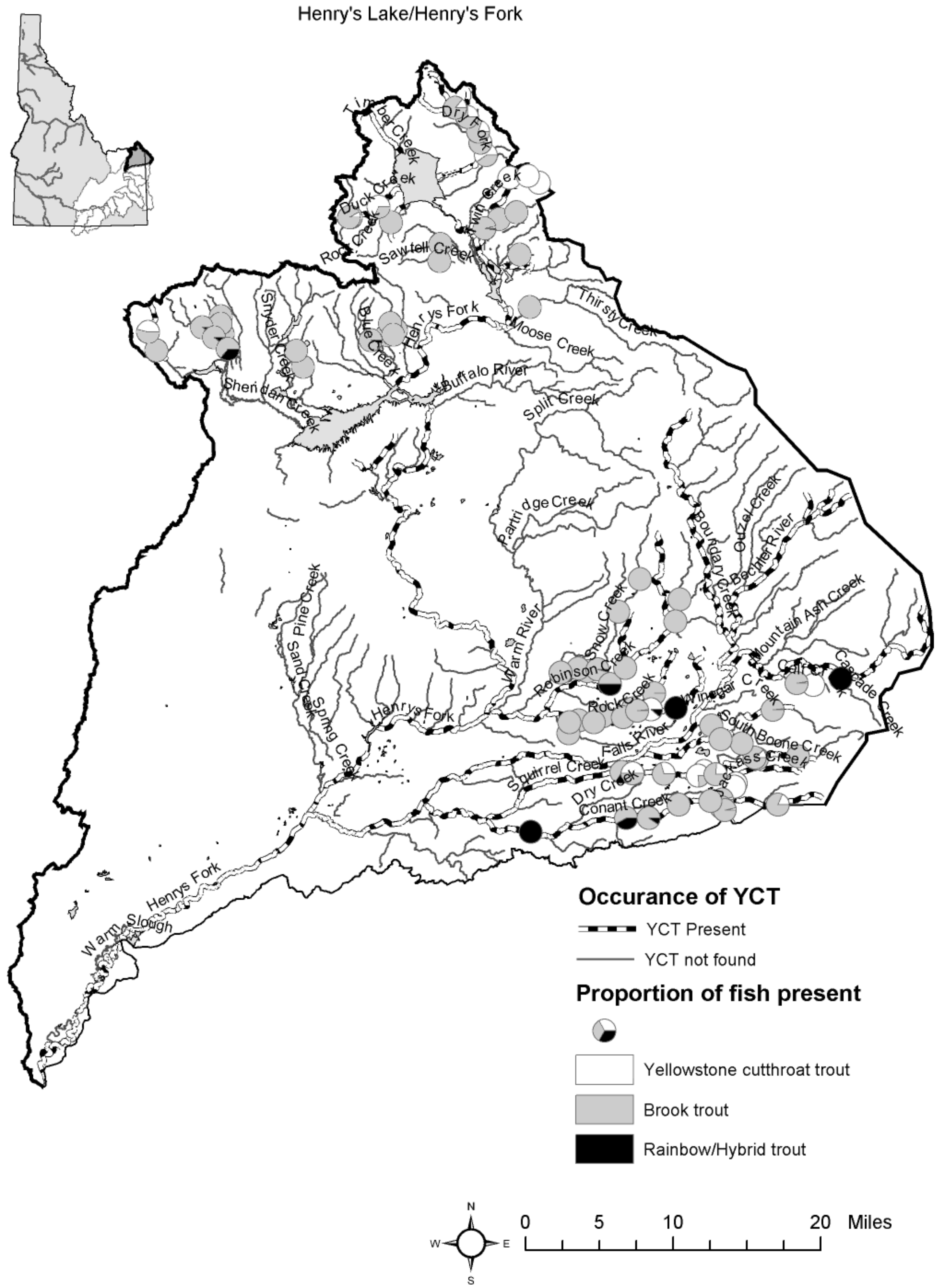

Figure 5. Henrys Fork Snake River and Henrys Lake GMUs. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout captured were not included in these plots.

Beginning in 2002, fingerling YCT were also stocked in the Henrys Fork above Island Park Reservoir. Though this program will not result in reestablishment of a viable wild population of fluvial YCT, the IDFG hopes it will benefit the fishery by creating an early summer run of spawning fish from Island Park Reservoir or the Henrys Fork Snake River below Macks Inn.

Henrys Lake

The Henrys Lake GMU (Figure 5) comprises approximately 222.2 km^2. Major tributaries are Targhee, Howard, Duck, and Timber creeks. In 1923, a dam was completed on the outlet to increase the storage capacity of Henrys Lake, increasing the lake level by about 5 meters. Today, the lake is approximately 2,632 surface hectares with a storage capacity of around 111 million cubic feet (90,000 acre-feet).

Henrys Lake has long supported a fishery for large, native YCT. A commercial trout fishery existed as early as 1877, and the first organized sport fishing club was established in 1888 (Van Kirk and Gamblin 2000). Since 1924, hatchery operations at Henrys Lake have taken cutthroat trout eggs for use in maintaining fisheries in many areas of Idaho, including Henrys Lake. Although YCT provide the majority of the angler catch, Henrys Lake is noted for large cutthroat x rainbow hybrids. Henrys Lake is managed with wild trout regulations for YCT, hybrids, and brook trout. In the late 1970s, declines in YCT stocks due to low water flows in the tributaries caused drastic declines in the spawning runs. Because sufficient cutthroat trout escapement and egg take at the hatchery is necessary to produce rainbow x cutthroat hybrids, the poor returns restricted the hybrid program at that time. A two-fish limit was instituted in 1980 to protect reduced populations of cutthroat, and an attempt to improve natural production was initiated. Since 1981, cooperative agreements between IDFG, the Henrys Lake Foundation, and area ranchers have improved riparian and in-stream spawning and rearing habitat through protective fencing of spawning tributaries of Henrys Lake. Fish losses to irrigation ditches were reduced by cooperative diversion screening projects. These activities will continue on Duck Creek, Howard Creek, Targhee Creek, and Kelly Springs. Evaluations of enhanced trout recruitment from these spawning tributaries to Henrys Lake have been ongoing since 1997.

The IDFG manages the Henrys Lake fishery primarily for YCT, and secondarily for rainbow trout x cutthroat trout hybrids and brook trout. Catch rate goals are 0.45, 0.15, and 0.10 fish/hour, respectively. Annual stocking consists of 1.0 to 1.3 million Henrys Lake cutthroat fingerlings, 200,000 hybrids, and 100,000 brook trout. Cutthroat and hybrid fingerlings are reared from eggs taken from Henrys Lake stock, while brook trout fingerlings stocked in 2005 and 2006 are reared from eggs provided by Kootenay Hatchery in British Columbia, Canada.

Past proposals by IDFG to terminate the popular rainbow-cutthroat hybrid program for the protection of YCT in Henrys Lake have met with overwhelming public opposition. Because the hybrid program was a potential threat to the genetic integrity of the cutthroat population, IDFG developed techniques to produce sexually sterile rainbow-cutthroat hybrids to replace sexually viable hybrids. Since 1998, all hybrids stocked are sterilized through heat or pressure induced triploidy. Gill net and angler catches are demonstrating that the sterile fish are performing well in the fishery.

Brook trout are also a very popular component of the Henrys Lake fishery. The state record brook trout (2.6 kg) was caught in Henrys Lake in the early 1970s. Brook trout stocking was terminated after 1998 primarily due to budgetary constraints. It was believed that natural brook trout production could maintain the established catch rate goal of 0.1 fish/hour. Angler and gill net catch in 2001 and 2002 reflected minimal natural recruitment. Based on strong public demand for a trophy brook trout fishery and decades of evidence that a strong cutthroat population has existed in the lake with the brook trout program, IDFG made the decision to re-implement the brook trout stocking program. As with the hybrid program, the brook trout eggs are sterilized to ensure the stocking program poses no threat to natural production of YCT in Henrys Lake tributaries.

There is a host of published reports on Henrys Lake. Kemmerer et al. (1924) probably first described Henrys Lake. Irving (1954) described the limnology of the lake in his paper on YCT ecology. Additional literature includes Irving 1955, Coziah and Platts 1964, Wallace et al. 1978, Rohrer and Coon 1979, Rohrer 1983, Rohrer and Thorgaard 1986, Grunder 1986, Greider 1986, George 1988, Brostrom and Watson 1988, and Van Kirk and Gamblin 2000. Other Henrys Lake information is found in annual reports from IDFG.

Palisades/Salt River

The Palisades/Salt River GMU (Figure 6) consists of both Palisades Reservoir and the many streams within Idaho upstream of the reservoir. This GMU is approximately 3,267 km^2 in size. Palisades Reservoir, completed in 1956, inundated 32 km of historically productive YCT habitat. In addition, Palisades Dam blocked migration of fluvial YCT from the lower South Fork Snake River into the many tributaries above the dam. The reservoir straddles the Idaho-Wyoming border and the states cooperatively manage the fishery.

Palisades Reservoir supports populations of YCT, mountain whitefish, brown trout, lake trout (*Salvelinus namaycush)*, and a small population of kokanee salmon (*O. nerka)*. The recreational fishery is supplemented annually with Snake River fine-spotted cutthroat trout produced at the Jackson National Fish Hatchery. The reservoir is managed under general fishing regulations. The fishery in Palisades Reservoir has declined since the 1960s along with the productivity of the reservoir. Fishing effort was an estimated 22,500 angler hours during 1993 with catch rates of around 0.35 fish/hour and a harvest of approximately 7,000 fish. This reflects a significant loss of angler participation when contrasted with a 1980 creel survey when total effort was nearly 200,000 hours. In 1965, effort was nearly 31,000 angler days (approximately 150,000 hours), harvest was approximately 58,000 fish, and catch rates were 0.46 fish/hour. Large fluctuations in water level (up to 24.4 m) limit the production of benthic and littoral macroinvertebrates and ultimately limit the productivity of the reservoir. Lake trout and kokanee were introduced but only small natural populations have developed.

Three of the upstream tributaries, Big Elk, McCoy, and Bear creeks, are impacted by the same factors described above for Palisades Reservoir. All three streams are managed under special restrictive angling regulations (2 YCT, none <406 mm). Although none of these tributaries are directly supplemented with Jackson National Fish Hatchery cutthroat trout, spawning runs of reservoir cutthroat trout that include hatchery fish heavily influences them. These spawning runs have recently increased in strength and duration and have become very popular seasonal fishing events. McCoy Creek has a July 1 opener which prevents fishing for adfluvial spawners in this stream since most of these fish have returned to Palisades Reservoir by July 1. This rule was implemented in the late 1990s to eliminate hooking mortality and handling stress on pre-spawn YCT. Most of the spawners are less than 406 mm long so only a small percentage of pre-spawning fish are available for harvest. The biological and social implications of this special rule on McCoy Creek should be further evaluated.

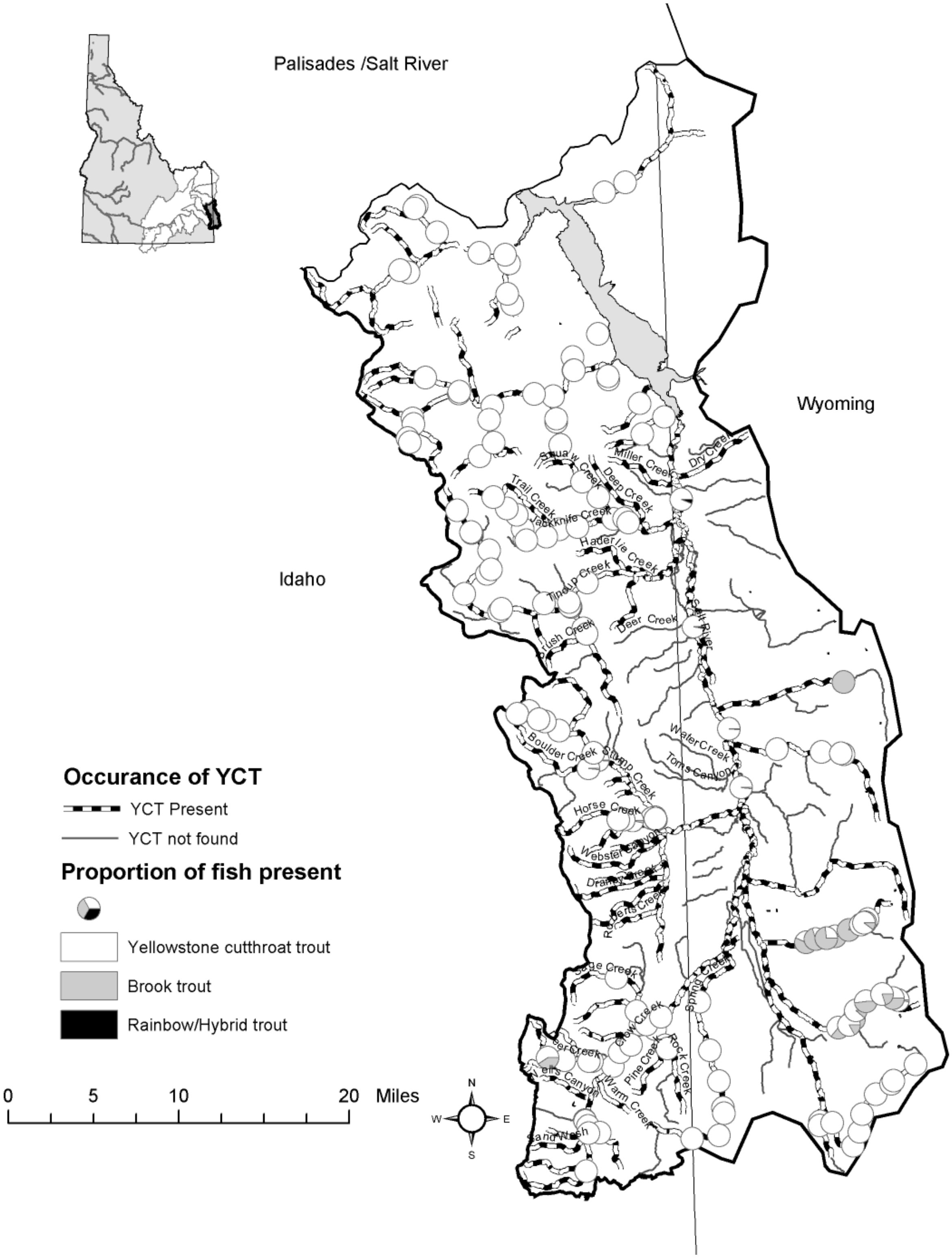

Figure 6. Palisades/Salt River GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

Although the Salt River lies in Wyoming, many of the tributaries originate in Idaho including Jackknife, Tincup, Stump, and Crow creeks. The trout limit in these tributaries is six with no more than two being YCT. Fisheries interaction between the Salt River and its tributaries and Palisades Reservoir is not clearly understood. Idaho is cooperating with Wyoming to define fish movements to assist management efforts. Isaak and Hubert (2001) reported that water diversion structures exist on virtually all mountain streams near their entry to the Salt River valley. Most first and second order mountain streams that flow into the main valley before contributing to a larger mountain tributary have had their flows permanently diverted into irrigation canals. Large mountain tributaries also have portions of their flow diverted. Some streams are completely dewatered and some have only part of the water diverted, but diversion structures probably hinder fish passage to some degree on most streams

Additional information on the Palisades/Salt River GMU can be found in: Corning 1961, Jeppson et al. 1965, Wiley 1969, Jeppson 1976, Heimer 1979, Ball and Jeppson 1980, Moore 1980, Moore et al 1981,Corsi and Elle 1986, Heimer et al. 1987, Schill and Heimer 1988, Elle et al. 1993, Elle and Corsi 1994, Teuscher 2001, and BioAnalysts, Inc (2006).

Portneuf River

The Portneuf River (Figure 7) and tributaries total 478 km of stream and drain nearly 3,487 km^2. In addition, there are four irrigation storage reservoirs in the drainage covering 690 hectares.

The Portneuf River flows in a U-shape, beginning and ending on the Fort Hall Indian Reservation. The upper end of Chesterfield Reservoir is also on the Fort Hall Indian Reservation. From the Portneuf River confluence with American Falls Reservoir upriver to Siphon Road, the Portneuf River is on the Fort Hall Indian Reservation. The Shoshone-Bannock Tribes manage the reaches of the river and reservoir that are on the Fort Hall Indian Reservation, which is approximately 91 km^2 in size. From American Falls Reservoir upstream to Pocatello, the river receives considerable spring water additions and has desirable water temperature for trout.

The Portneuf River within the city of Pocatello was channelized in the early 1960s and replaced with 2.4 km of a flat-bottom, vertical-sided concrete flume that is a barrier at most flows to upstream fish movement and another 7.6 km of riprap lined channel which borders both ends of the concrete channel. The concrete channel is 12-m wide with 3-m high walls. During mid summer when most of the upriver flow is diverted, river depth in the channel is extremely shallow.

The reach from Pocatello upstream to Marsh Creek has low flows during the irrigation season due to water withdrawals. This reach contains very few YCT and moderate numbers of brown trout and receives very little fishing pressure. This reach is adversely affected by sediment, irrigation withdrawals eroding stream banks, and elevated water temperatures.

From the confluence of Marsh Creek upstream to the Portneuf/Marsh Valley Canal diversion, sediment impacts are less, but low flows caused by irrigation withdrawal adversely affect the populations of brown trout, the main game species in this reach. Much of the sediment in the lower Portneuf River comes from Marsh Creek.

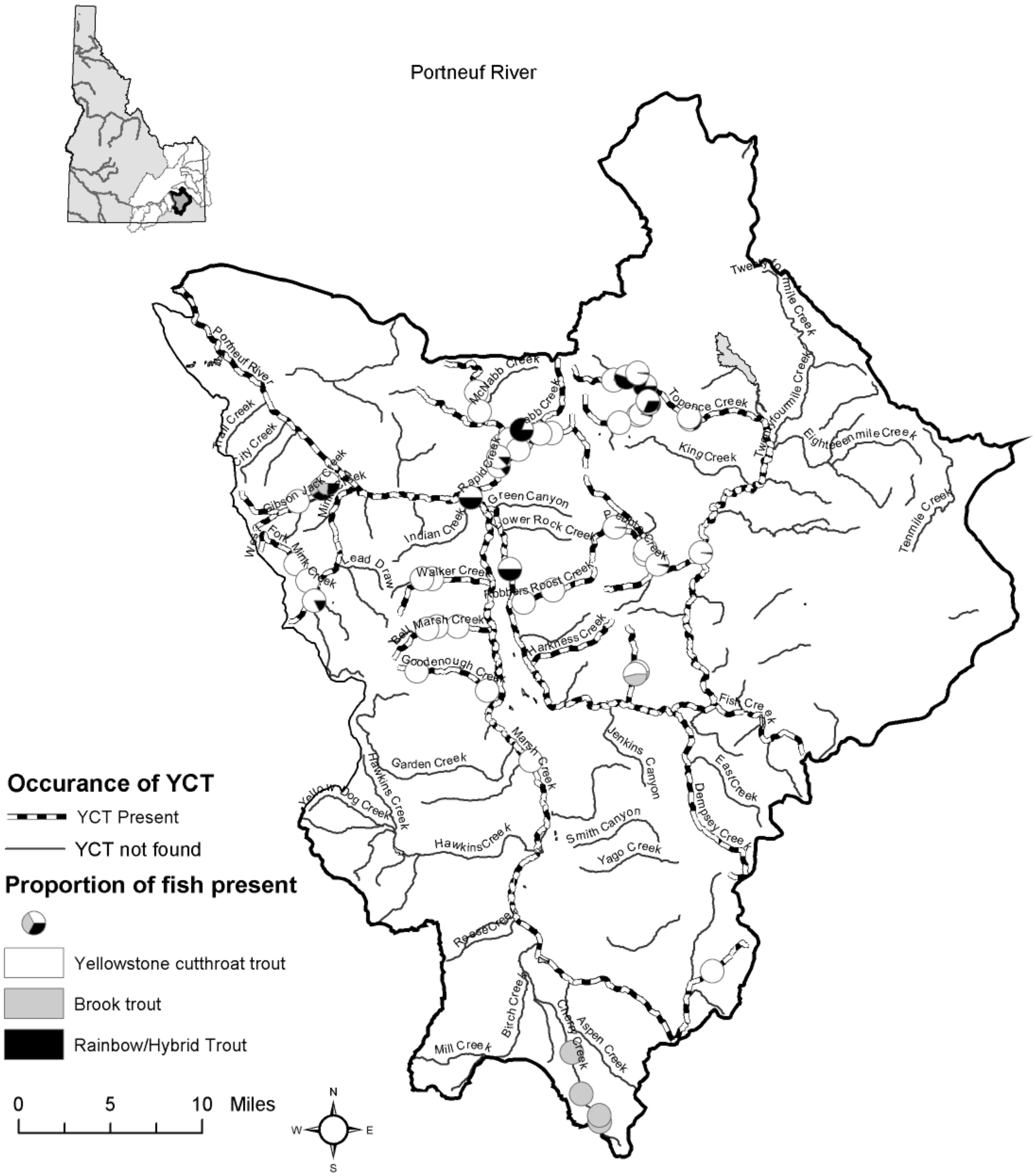

Figure 7. Portneuf River GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Fort Hall is not shown. Any brown trout that were captured were not included in these plots.

Conditions improve upriver from the Portneuf/Marsh Valley diversion since very little water is diverted upriver from this location. During summer, water is added to this reach from Chesterfield Reservoir for diversion approximately 32 km downriver at the Portneuf/Marsh Valley Canal. From the Portneuf/Marsh Valley Canal upstream to Lava Hot Springs, a distance of approximately 6.4 km, the main problem for fish is severe bank erosion caused by improper livestock grazing, removal of willows, and exacerbated by bank full flows during the summer growing season. This area contains a mixture of hatchery and natural rainbow trout, brown trout, and YCT. The 26 km from Lava Hot Springs upstream to Kelly-Toponce Road Bridge once supported an excellent wild rainbow trout population and was a very popular fishery. In 1979, an estimated 7,000 anglers fished 17,300 hours and caught 3,000 wild rainbow trout, 4,200 hatchery rainbow trout, and 900 YCT in this area. Fish population sampling in this reach indicated the trout population was comprised of 69% wild-natural rainbow trout, 19% hatchery rainbow trout, and 12% YCT.

Historically, the Portneuf River above Lava Hot Springs was a "blue ribbon" trout stream (Mende 1989). Harvest of native YCT on the river declined in the late 1980s to a few hundred fish annually and was so low that restrictive regulations would not have been effective. For the past 20 years, IDFG and the Friends of the Portneuf, Southeast Idaho Fly Fishers, and Trout Unlimited have worked cooperatively with landowners to restore riparian habitat by constructing and maintaining riparian corridor fences. IDFG, angler groups, the Natural Resource Conservation Service, and landowners began a cooperative effort to correct sediment problems in the Portneuf-Marsh Valley Canal Company's "outlet canal," the channelized reach of the Portneuf River below Chesterfield Reservoir. This reach was identified as the primary source of sediment to the river below.

This 16-km reach of the Portneuf River upstream from the Kelly-Toponce Road Bridge to Chesterfield Reservoir was extensively damaged by stream channel alterations and is seasonally dewatered during low flow years while Chesterfield Reservoir is refilling. As a result, this reach presently contains few trout. From Chesterfield Reservoir upstream, the river has a base flow near 0.06 cubic meters/sec and has many large beaver ponds. This reach is managed by the Shoshone Bannock Tribes.

In the 1996-2000 period, reduction in sediment occurred because of the following projects:

1. Improvement of existing riparian corridor fences.

2. Construction of additional corridor fences.

3. Development of a DEQ/Soil and Water Conservation District project to exclude livestock from and revegetate the outlet canal.

4. Development of a Portneuf-Marsh Valley Canal Company, Idaho of Water Resources, IDFG project to construct grade control structures in the outlet canal.

Major tributaries to the Portneuf River include Mink, Marsh, Rapid, Dempsey, Pebble, and Toponce creeks. They may serve as spawning areas for fluvial trout from the Portneuf River and nursery areas for juvenile trout. However, trout movement and the importance of these tributaries to the river have not been studied.

Four irrigation reservoirs are located in this drainage: Hawkins, Wiregrass, Chesterfield, and Twenty-four Mile. The lack of suitable spawning areas and annual irrigation drawdown precludes the development of wild trout fisheries in these waters. The return of Utah chub to Chesterfield Reservoir after chemical renovations or reservoir draining, limit management options to stocking of catchable-size trout in most years. Trout grow rapidly and many are caught the first season. Carryover occurs when water levels are favorable and fish are caught at much larger size (0.90 to 1.81 kg) the following year. Chesterfield Reservoir was renovated with piscicide in 1992 and 2001 after being drained for irrigation.

Much of the river is now adversely impacted by human-related activities. Sedimentation, unstable stream banks, and irrigation are the predominant problems. The Portneuf River GMU, however, still boasts a few productive tributaries that support salmonids, especially Mink Creek, Pebble Creek, and Toponce Creek, and there is a fair YCT population in the main river above Pebble Creek. Scully et al. (1993) reported declining cutthroat trout densities in the upper river. Rainbow trout dominated the samples. In drought years, when flows are warmer and slower, carp (*Cyprinus carpio)* are able to successfully spawn.

Since 2004, the 5-mile reach between the Kelly-Toponce Road Bridge and the Pebble Area Bridge has been managed as catch-and-release for YCT. Also, rainbow trout are no longer stocked in that river reach. An evaluation of benefits to the YCT population will occur in 2007.

Further information on the Portneuf River GMU is found in IDFG management reports, including Casey et al. 1969, Mallet 1975, Heimer 1979, 1980, 1986, 1987, Heimer et al. 1987, Mende 1987, Mende 1989, Heimer and Ratzlaff 1987, Schill and Heimer 1988, Scully et al. 1993, and Meyer and Lamansky 2002b.

Raft River

The Raft River originates in Utah; flows northward near the City of Rocks area in south-central Idaho, and then flow out onto the Raft River plain (Figure 8). As it flows northward through the high desert, it is dewatered for irrigation. The Raft River GMU is approximately 1,280 km^2 in size. It is estimated that about 504 km of perennial streams exist in this GMU. Various irrigation practices and diversions have changed parts of the mainstem Raft River so significantly that much of the lower sections no longer flow as perennial. There are approximately 2,790 km of intermittent streams in this GMU with many of the streams being ephemeral and normally dry and carry water only during storm events.

The fish species found in this GMU include YCT, rainbow trout, brown trout, brook trout, cutthroat x rainbow hybrids, kokanee, sculpin (*Cottus* spp.), redside shiner (*Richardsonius balteatus*), longnose and speckled dace (*Rhinichthys cataractae* and *R. osculus*), and sucker species (*Catostomus spp*).

Sublett Reservoir is the only named reservoir in the Raft River GMU and is located on lands administered by the Forest Service. Its primary use is for irrigation storage. The reservoir is approximately 32 hectares in area and drains about 117 km^2. Rainbow trout and YCT are present in Sublett Creek, Lake Fork Creek, the North and South forks of Sublett Creek, and Sublett Reservoir. Brown trout and kokanee have been introduced to Sublett Reservoir.

There are YCT in headwater reaches of the Raft River GMU. Although there is sparse information on the Raft River GMU in the literature, Bell (1979) includes some data on Raft River tributaries. Sublett Reservoir has salmonid reproduction in tributary streams. Below the reservoir, the river dissipates via withdrawals until it is completely dewatered. Eightmile Creek,

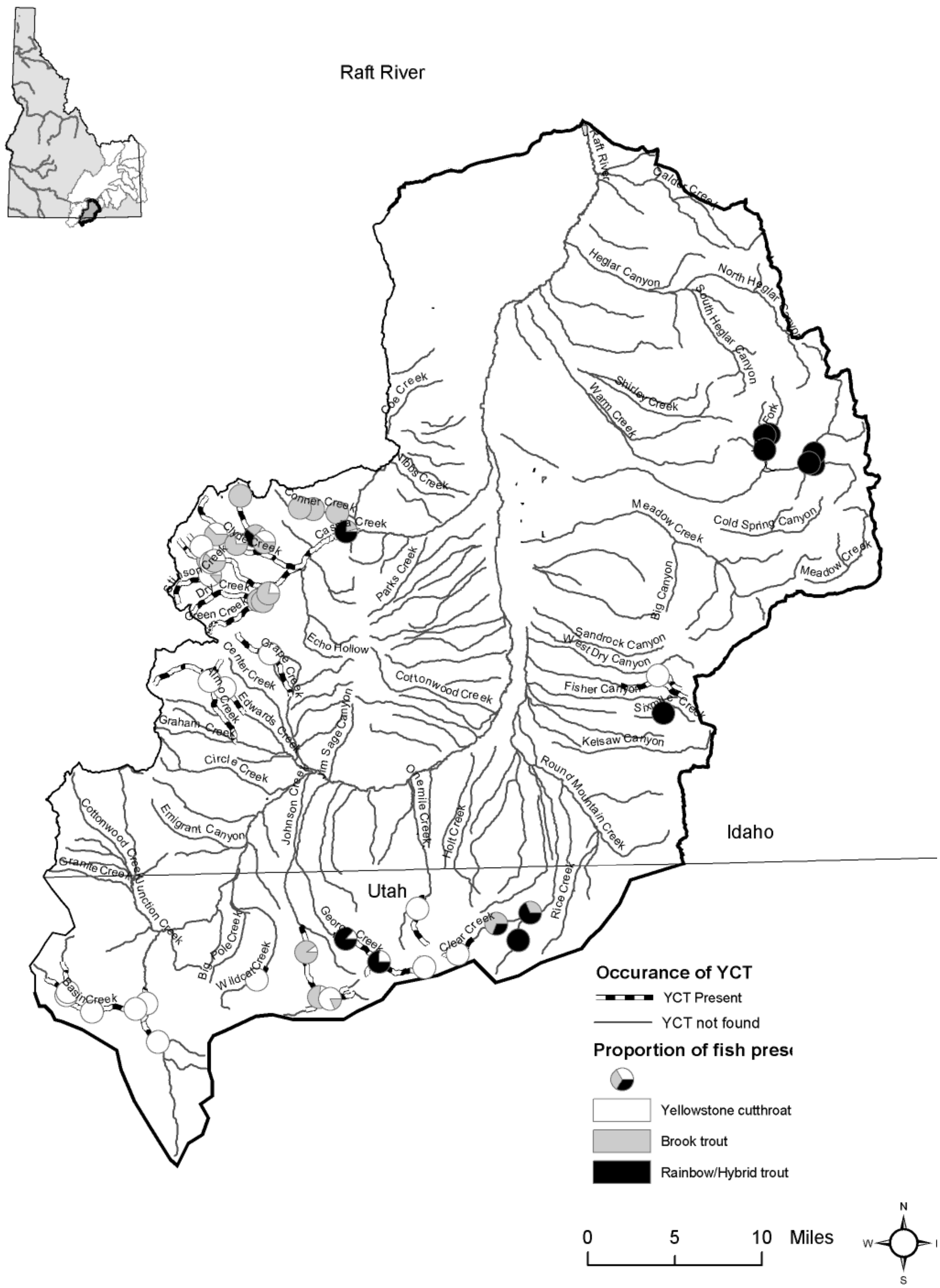

Figure 8. Raft River GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

an isolated tributary to the Raft River originating on the west flank of Black Pine Mountain, supports a population of YCT (Grunder et al. 1987) that are genetically pure, and Sixmile Creek, an adjacent drainage to Eightmile Creek supports a hybridized population of YCT (Partridge et al. 2002). Many of the remaining populations of YCT in the Raft River GMU are in Utah.

Recent sampling efforts were conducted to expand on data collected by the Native Species Assessment Project by IDFG. Surveys were done to further evaluate potential core populations and to sample areas the project bypassed due to the random sampling protocol. The Forest Service and Idaho Department of Environmental Quality sampled Almo, Eightmile, Edwards, and Grape creeks in 2005 and reported YCT (>100mm) densities of 0.21, 0.18, 0.00, 0.21 fish/m^2, respectively. Only one site was sampled on Edwards Creek. Genetic samples were collected but not processed to date. In 2006 the Forest Service sampled in the headwaters of Cassia Creek including Stinson, Cold Spring, Flat Canyon, and New Canyon creeks documenting sympatric YCT and brook trout populations.

Other than Sublett Reservoir, this GMU does not receive much angling use and IDFG has sparse recreational fishing information except for an occasional spot creel check.

Rock/Bannock creeks

Bannock Creek (Figure 9) lies principally on the Fort Hall Indian Reservation of the Shoshone Bannock Tribes. Some of the headwater tributaries are outside of the reservation and contain populations of YCT. Trout in these tributaries are generally small and there is very little angling. Connectivity with other YCT populations is not currently possible on Bannock Creek, at least from downstream because of a barrier a short distance upstream from the mouth that is associated with State Highway 86. Both Bannock and Rock creeks are significantly impacted by agricultural practices that have resulted in fine sediment deposition in the lower reaches and poor water quality. The only fishery at this time is on the East Fork Rock Creek for hatchery rainbow trout that are stocked annually.

Additional information on this GMU is found in Irving 1955, Cochnauer 1980, and Gamblin 1980.

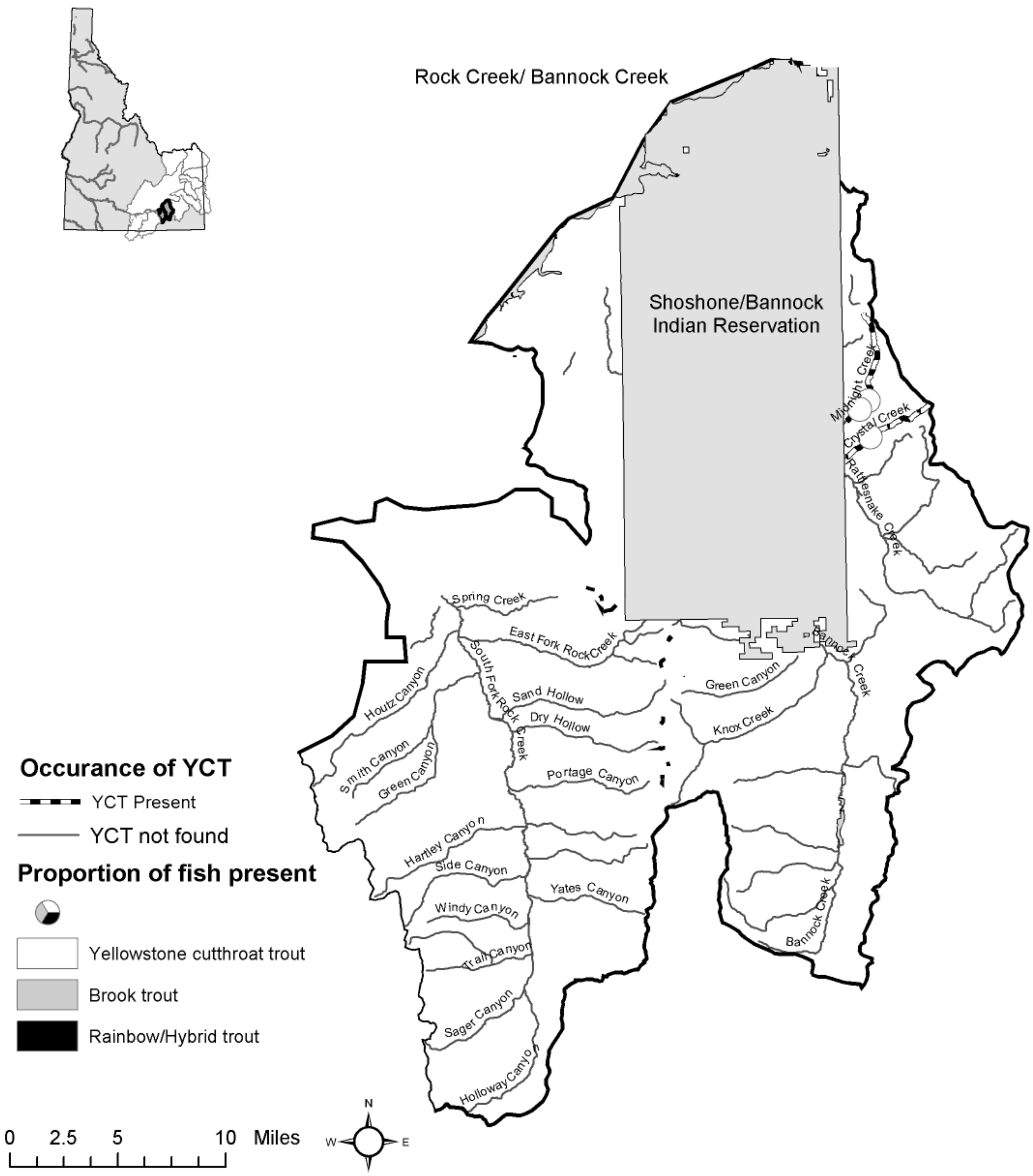

Figure 9. Rock/Bannock creeks GMU. Streams that are thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

Snake River Proper

The Snake River from Shoshone Falls upstream to Massacre Rocks is highly regulated with variable flows controlled by releases from Milner Dam, American Falls Dam, and Minidoka Dam (Figure 10). The only known self-sustaining YCT population within this reach is in Vinyard Creek, a short spring-fed tributary that flows into the Snake River from the north side less than one kilometer upstream of Twin Falls Dam. This population of YCT is small in size and extensively hybridized with rainbow trout (Warren and Partridge 1994).

The Snake River from Massacre Rocks upstream to the confluence of the Henrys and South forks encompasses a variety of habitat types. This section extends about 201 km of which approximately 32 km is flooded by American Falls Reservoir.

The 10 km of river from Eagle Rock upstream to American Falls Dam is considered an excellent trout stream. In 1998, fishing effort was an estimated 63,555 hours with and estimated catch of 34,066 fish, of which 26,912 were trout. Almost all the trout were hatchery produced, with an estimated catch of only 238 native/natural YCT. This section is noted for trophy size trout; numerous trout taken were between 508 mm and 610 mm long. To reduce harvest of large trout, a fishing rule of six trout, of which only two may be over 406 mm long, was implemented in 1998. Only two of the daily bag limit of trout may be YCT. Individual fish size and fish population size are influenced by the amount of water retained in American Falls Reservoir and the amount of minimum winter flow provided by the U.S. Bureau of Reclamation. Many of the large trout in the river reach are reared in the reservoir before passing through the dam.

Some of the trout stocked in American Falls Reservoir annually migrate downstream in mid- to late- summer as the reservoir warms and dissolved oxygen becomes low in the hypolimnion. Reservoir releases in mid summer sometimes result in high temperatures and low oxygen in the tailrace. Winter storage of water in the reservoir for irrigation supplies reduces river flows, placing additional stress on trout. During winter following heavy demand on stored water, the Bureau of Reclamation generally releases flows into the Snake River below American Falls Dam that are less than 5% of mean annual flow. Immediately after the 2005 and 2006 irrigation seasons, the Bureau of Reclamation reduced flows to near 10 m^3/sec (4% of mean annual flow) for several weeks and then increased flows in mid-winter to over 56 m^3/sec once the Bureau of Reclamation was certain that American Falls Reservoir would fill prior to the following irrigation season. Severely reducing flow for several weeks or months in the fall reduces the wetted river channel, which concentrates fish in shallow water with reduced current. This makes them vulnerable to fish-eating migratory birds (pelicans, cormorants). The low flow also decreases the amount of river bottom available for crayfish, insects, and snails that are important food sources for fish. Many of the invertebrates die as the declining flow recedes away from their rocky substrate cover. Flows less than 10% of mean annual flow appear to cause degraded water quality conditions that are adverse to fishery resources.

American Falls Reservoir covers 23,513 hectares and has a usable storage of over 2.0 billion cubic meters (1,671,300 acre-feet). It supports a popular recreational fishery with an estimated 26,000 rainbow trout harvested and 125,000 angler hours expended during good water years when carryover water storage is adequate. During 1993, immediately following a six-year drought, fishing effort declined to 69,000 hours and catches decreased to 8,000 trout. American Falls Reservoir is typically stocked with catchable size rainbow trout in early May. Trout grow from 228 mm to 406 mm or more during the year following stocking. Most trout caught range in size from 0.6 to 1.1 kg and most are of hatchery origin. The IDFG evaluated the

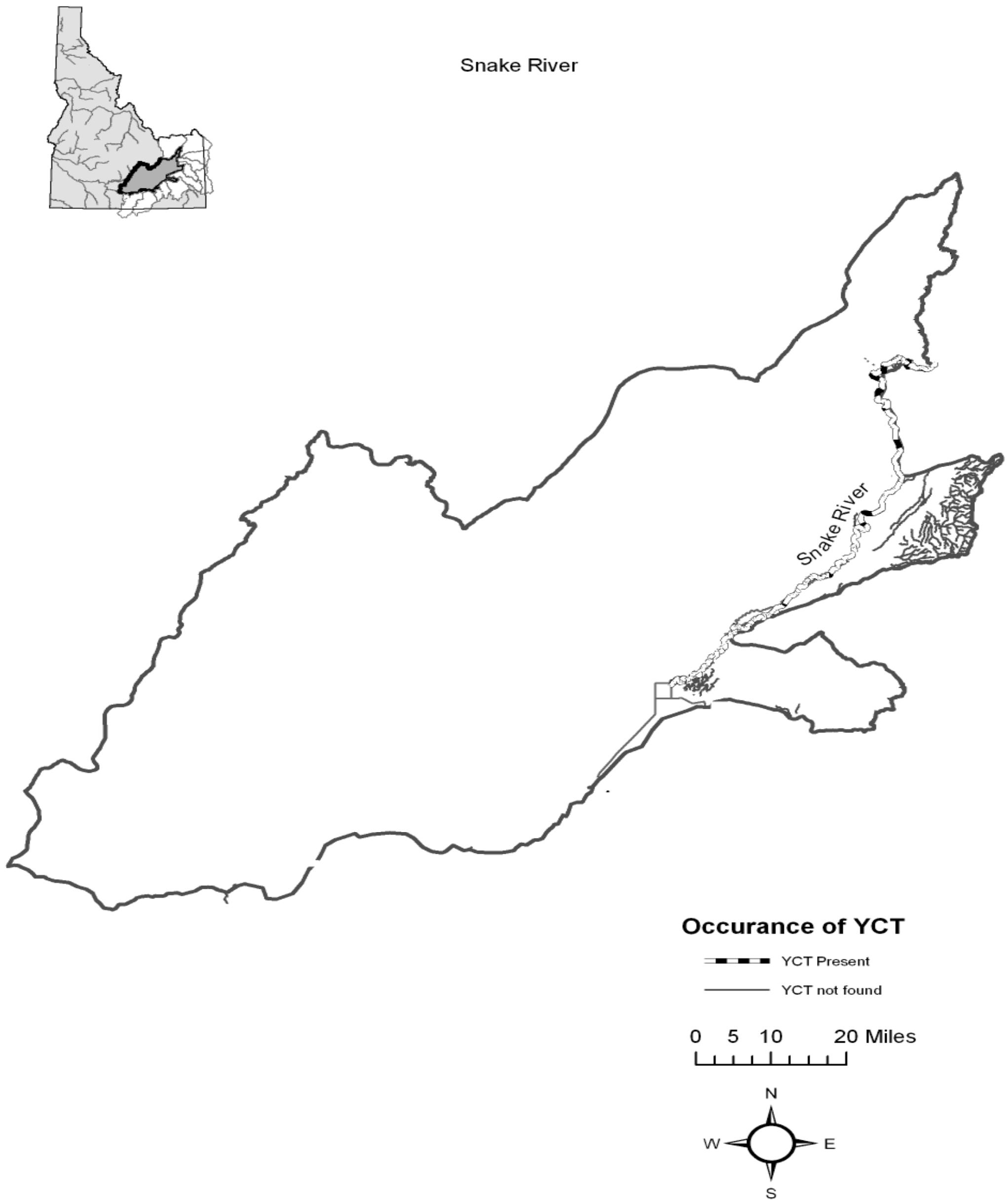

Figure 10. Snake River GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

use of fingerlings stocked in the reservoir and river above and found them to be successful for developing a fishery. There is also a fishery for smallmouth bass (*Micropterus dolomieui)* and yellow perch (*Perca flavescens)*.

The Snake River from the backwaters of American Falls Reservoir upstream to Tilden Bridge, a distance of approximately 32.2 km, supports an exceptional trout fishery. Most of the trout are hatchery rainbow trout, with lesser numbers of brown trout and YCT. The river in this area has limited public access because of private land on the west and the Fort Hall Indian Reservation on the east. Numerous natural springs begin on the reservation in the area known as the Fort Hall Bottoms located near the upper end of American Falls Reservoir between the Portneuf River on the south and the Snake River on the north. The springs produce approximately 2.2 billion cubic meters (1,800,000 acre-feet) of water annually, more than enough to fill American Falls Reservoir. The two largest of the reservation springs are Clear Creek (11.2 km long) and Spring Creek (18 km long). These high quality trout spawning and rearing streams are managed by the Shoshone-Bannock Tribes.

The Snake River flows 60 km from Gem State Power Dam to Tilden Bridge and runs through a mixed cottonwood riparian community. Large volumes of water are diverted from the river at numerous points in this reach for irrigation purposes. During the April through October irrigation season, river flows vary depending on amount released from upriver storage and on amount diverted at each canal. Occasionally, more water is diverted than released from upriver dams and the river flow becomes very low or ceases temporarily. Between 1987 and 1988, the IDFG documented catch rates of 0.08 to 0.25 trout/hour between American Falls Reservoir and the Gem State Dam. Hatchery rainbow trout comprised the majority of the catch. However, large wild rainbow trout, brown trout, and YCT are also caught in this reach. Large numbers of rainbow trout and brown trout have been stocked in this reach since 1991, and the fisheries in the Snake River and American Falls Reservoir below have improved. Brown trout stocking was discontinued in 1999.

The fishery in the Snake River from the Gem State project to the outflow of the upper Idaho Falls Power Plant is primarily a put-and-take hatchery rainbow trout fishery. The IDFG and the City of Idaho Falls stock this reach with catchable-size rainbow trout. Hatchery rainbow trout provide the majority of the catch in this reach but YCT, rainbow trout, and brown trout are also important components of the fishery. The hydropower impoundments in this section block upstream migration of spawning trout and provide less productive trout habitat than run-of -river reaches.

The remainder of the upper Snake River from the Idaho Falls Upper Power Plant to the confluence of the Henrys Fork and South Fork (62.8 km) produces occasional catches of large rainbow trout and YCT. Brown trout are also caught in this reach. No hatchery stocking occurs above the upper power plant pool. The fishery in this area has declined since the Teton Dam failure due to silt deposition and loss of habitat. Little improvement has occurred. Because of hatchery space limitations and very poor return to the creel, this river reach will not receive catchable trout.

South Fork Snake River

The South Fork Snake River GMU comprises 2,590 km^2 in eastern Idaho between the Idaho-Wyoming state line and confluence with the Henrys Fork Snake River. The Snake River upstream of Palisades Dam drains an area of 13,488 km^2 primarily in Wyoming. South Fork

Snake River flows are regulated by releases at Jackson Lake (Wyoming) and Palisades Reservoir in Idaho. During the summer irrigation period, releases from these reservoirs are made to meet irrigation demand, flood control requirements, and to balance stored water between the reservoirs. Winter releases from Palisades Dam are directed by storage carried over the end of the irrigation season. In the driest years, releases in the late fall and winter have been less than 28.3 m^3/sec. The BOR operates a hydropower facility on Palisades Dam. Palisades Reservoir is 6,518 hectares in size at full pool.

The South Fork Snake River supports an ecologically and economically important population of native YCT (Figure 11). This population is one of the few remaining healthy fluvial populations within their historical range in Idaho (Thurow et al. 1988; Van Kirk and Benjamin 2001; Meyer et al. (2006). Despite the overall health of cutthroat trout in the South Fork Snake River, a variety of anthropogenic factors affects the long-term survival of YCT throughout the South Fork. These include non-native species, quality and quantity of tributary spawning/rearing habitat and alteration of the natural hydrograph for the purposes of flood control and irrigation water storage.

Fish populations have been monitored by IDFG with electrofishing since 1986. Although stocking of rainbow trout in the mainstem and tributaries stopped in the early 1980s, rainbow trout have increased in abundance from about 1% of the total catch in 1982 to 35% of the catch in 2004 (Table 5). The non-native rainbow trout population poses a serious threat to YCT, primarily through genetic introgression. In response to the expanding rainbow trout population, IDFG has led a collaborative effort to conserve native YCT in the South Fork by: 1) encouraging anglers to harvest rainbow and hybrid trout while reducing harvest of cutthroat trout, 2) manipulating flows in the main river to the detriment of rainbow and hybrid trout but to the benefit of cutthroat trout, and 3) controlling hybridization in critical cutthroat trout spawning tributaries with the use of fish weirs.

Regulations in the South Fork have evolved over the years, gradually increasing protection of YCT and removing harvest restrictions on rainbow trout. In 2004, this culminated in rule changes that prohibited all harvest of cutthroat trout in the South Fork and the main tributaries. In addition, the limit on rainbow and hybrid trout was removed, and the section of river from the Heise cable to Palisades Dam, which had been closed from November 30 through Memorial weekend, was opened to year-round fishing. This change was intended to increase rainbow trout harvest by allowing anglers an opportunity to fish for rainbow trout throughout the winter and during the spawning season. The rule changes were coupled with an aggressive outreach campaign to raise angler awareness of the threat posed by rainbow trout, offer guidance on identifying rainbow and hybrid trout, and encourage their harvest.

A research project utilizing radio telemetry to describe where and when rainbow trout, cutthroat trout, and rainbow x cutthroat hybrids are spawning, indicated rainbow and hybrid trout primarily use mainstem side channel habitat while YCT use both mainstem side channel and tributary habitat (Henderson 1999; Henderson et al. 2000). Following these results, an intensive tributary management program was implemented to preserve the genetic integrity of YCT spawning in Burns Creek, Pine Creek, Rainey Creek, and Palisades Creek. Permanent tributary weir and trapping facilities now allow IDFG personnel to block escapement of rainbow and hybrid spawners and allow passage of nearly genetically pure YCT spawners. Genetic tissue samples taken and analyzed in 2000-2002 showed that with training, fisheries personnel could minimize the genetic contribution of rainbow trout to less than 1% of the upstream migrants (Host 2003).

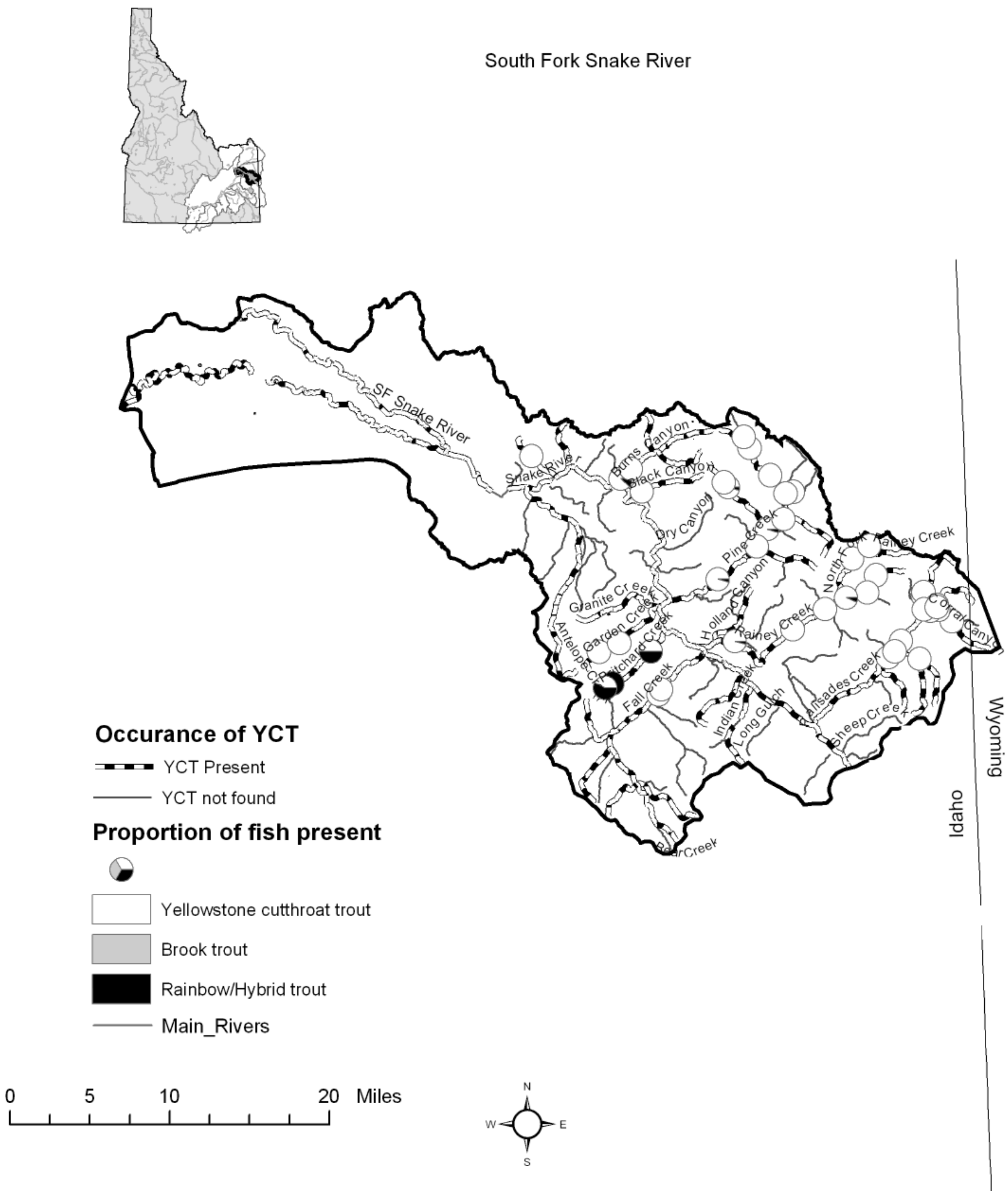

Figure 11. South Fork Snake River GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

Flows in the South Fork influence everything from insect and fish production to cottonwood regeneration. Because the hydrologic regime is the primary driver of ecological processes in large gravel-bed rivers such as the South Fork Snake River, and because the South Fork Snake River is flow-regulated, the ecological effects of hydrologic regime and alteration on this river have received increased attention in recent years. Recent research with Idaho State University (ISU) has shown flows strongly influence reproductive success of both rainbow and cutthroat trout. Though the mechanisms are largely speculative, Moller and Van Kirk's (2003) analysis indicated that in years with a high peak runoff, relative to a low winter flow, the ratio of cutthroat to rainbow trout recruits approached 10:1. Alternatively, in years with a minimal spring runoff peak following high winter flows, the cutthroat to rainbow recruitment ratio was around 1:1. They concluded that to favor cutthroat trout and discourage rainbow trout, the peak flow in the spring should be 15 or more times higher than the base flow in the previous winter. High and sharp runoff peaks, similar to a free flowing river are also needed (Moller and Van Kirk 2003). In response to this research, the Bureau of Reclamation (who operates Palisades Dam) has incorporated simulated high flow runoff events in recent years.

From a fishery management perspective, relatively low densities of YCT in the lower reach of the South Fork Snake River are also a concern. It is possible that these low densities result from adverse environmental conditions such as unfavorable flow regimes, loss of fish to irrigation canals, or a decline in habitat quality. All three of these conditions are primarily a result of management of reservoirs and diversions in the Snake River system for storage and delivery of irrigation water. Van Kirk and Benjamin (2001) found that the lower South Fork Snake River experiences a much greater degree of hydrologic alteration than does the upper river. A beneficial outcome of the high degree of alteration, however, seems to be the inability of the rainbow trout population to expand throughout the lower river.

Teton River

The Teton River originates on the west slope of the Teton Mountains and drains around 2,929-km^2 total in Idaho and Wyoming combined (Figure 12). The mainstem Teton River is about 102 km long from its headwaters to the confluence with the Henrys Fork near Rexburg, Idaho. Upstream from the confluence approximately 26 km, the Teton River splits into two forks (North Fork and South Fork). The flow into these two forks is regulated for irrigation purposes.

The Teton River supports one of the most important remaining fluvial YCT populations in the Upper Snake Basin. In addition to YCT, mountain whitefish, rainbow trout, rainbow x cutthroat hybrids, and brook trout are abundant. The IDFG has performed quantitative population assessments of trout (all species) in the valley section of the Teton River since 1987. A population survey in 2003 indicated YCT in the Teton River had declined by 96% in the survey reach. By 2005, the population had increased slightly, and rainbow trout had increased significantly. Average YCT density increased from 2 to 7 fish/ha and was accompanied by improved recruitment. Strong age-1 and possibly age-2 year classes were observed in 2005, and mean lengths and quality stock densities had returned to average. It is likely that improved flows in spawning and rearing tributaries have improved the YCT population. However, cutthroat trout density remains well below the long-term average of 33 fish/hectare observed prior to 2003.

Major tributaries to the lower Teton River and the Teton Canyon reach are Moody, Canyon, Bitch, and Badger creeks. In the upper valley, the major tributaries are on the eastern side, originating in the Teton Mountains in Wyoming. These include North and South Leigh,

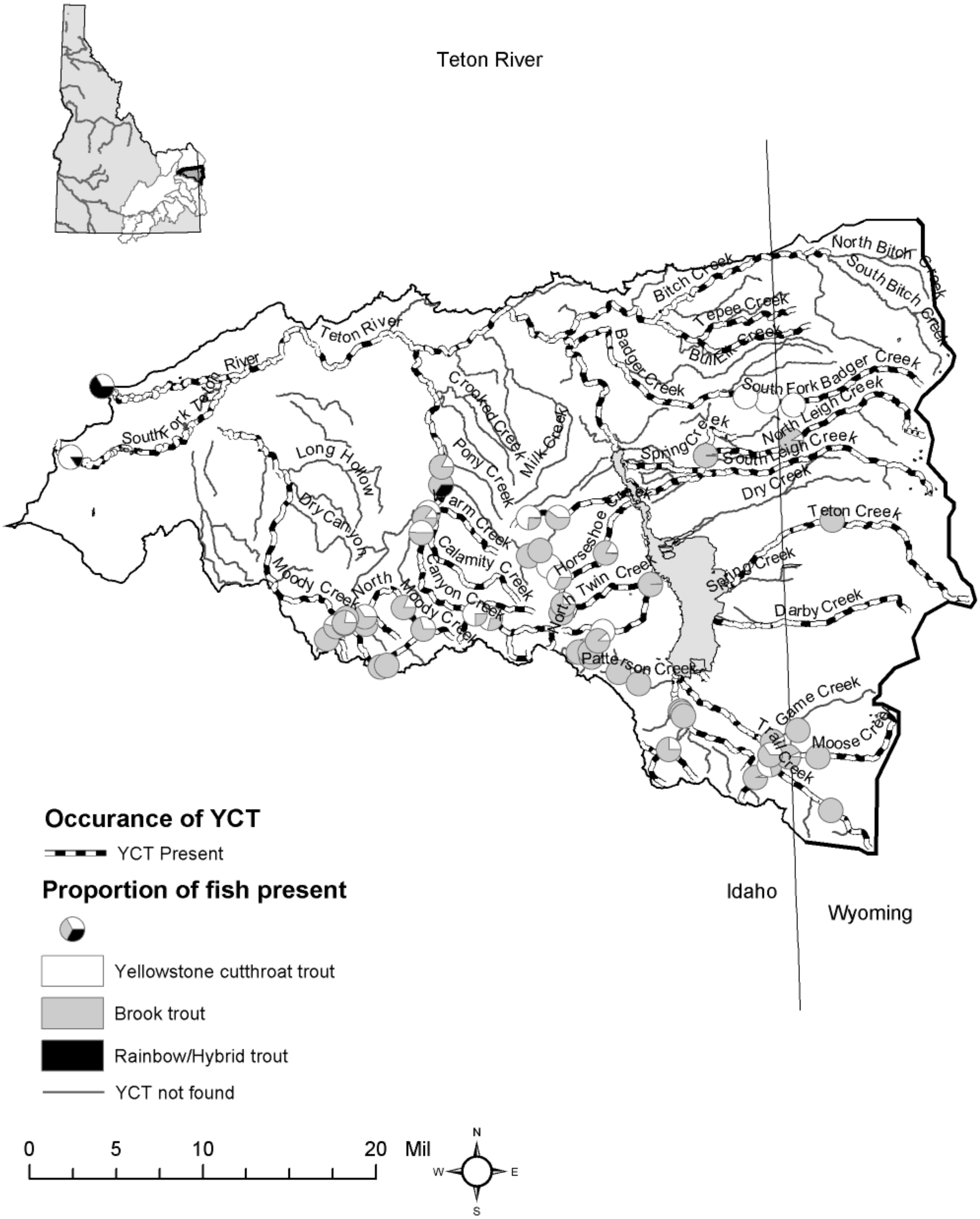

Figure 12. Teton River GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

Teton, Darby, Fox, and Trail creeks, in addition to several smaller streams. Tributaries to the upper Teton River are generally characterized by an intermittent reach where the stream is seasonally dewatered. Downstream of dewatered reaches, most of the streams resurface as spring fed creeks and contain sympatric populations of YCT along with brook trout and rainbow trout. The upper reaches of the most disconnected of these streams (Darby, South Leigh, and Badger creeks) support allopatric populations of YCT, whereas the other tributaries contain primarily brook trout. Bitch Creek, the largest of the Teton River tributaries, is entirely connected and is dominated by YCT. The most recent fishery survey information for the upper reaches of the tributaries above and including Bitch Creek can be found in Colyer (2006). A description of YCT distribution and spawning ecology in the lower reaches of the tributaries can be found in Koenig (2006).

Though the causes of decline of YCT in the Teton Valley are unclear, a number of factors are suspected to have an impact. These include water diversion and irrigation, non-native fish populations, stream channelization, extensive rip-rapping, the prevalence of *Myxobolus cerebralis* (the causative agent of whirling disease), loss of tributary and mainstem habitat to grazing and development, and drought.

Diversion of water from tributaries for irrigation in the upper portion of the basin has resulted in profound changes to the ecosystem through alteration of the hydrology and loss of in-stream flows. In a comprehensive assessment of the hydrology of the upper Teton River Basin and the implication to cutthroat trout, Van Kirk and Jenkins (2004) describe a hydrologically altered system where water is withdrawn from tributary streams for irrigation before it returns to the Teton River as groundwater. Prior to irrigation, the river was a snowmelt-dominated system, exhibiting a pronounced peak associated with spring runoff. With the implementation of flood irrigation using surface flows from tributaries, the hydrology shifted to a groundwater dominated system, characterized by the absence of a pronounced peak. The authors estimated a decrease in annual peak springtime flows of about 35% and an increase in winter flows of around 20%. In recent years, a conversion from flood irrigation to sprinkler irrigation has restored some of the natural shape to the hydrograph, however, the system is still groundwater dominated. The hydrologic shift has likely played a significant role in the fish population characteristics. Concurrent research by Idaho State University (Moller and Van Kirk 2003) demonstrates that in general, native YCT dominate fluvial systems characterized by their natural snowmelt dominated hydrology, whereas rainbow trout are found in greater abundance in systems with a dominant groundwater influence. Long-term persistence of the fluvial YCT population likely depends on successful restoration of the natural hydrology, including a naturally shaped hydrograph and increased magnitude and duration of tributary flows.

Downstream of the Teton Valley, the river was irreparably damaged by construction and collapse of the Teton Dam in 1976. When the dam collapsed in June 1976, the evacuation of the almost full reservoir resulted in a discharge of nearly 48,138 m^3/sec below the dam site. These flows not only altered the river below the dam site, but the evacuation of water resulted in a series of massive landslides that transformed the Teton River Canyon from a riffle-pool environment into a series of deep, slow pools with short, high gradient rapids. In addition to the habitat alteration caused by the Teton Dam failure, water table declines, loss of in-stream flows to irrigation diversions, cattle grazing, channelization, rip-rapping, and development have restricted the quantity and quality of Teton River fish habitat.

The Teton River Fishery Enhancement Program began in 1988 to improve fishing by restoring habitat lost by the flood and by gradual, cumulative changes from land use practices. Cooperative fencing, pasture management, and livestock non-use agreements with landowners are used to protect and improve riparian habitat in tributaries and mainstem river sections. In addition, revegetation and tree revetments are used to speed recovery and reduce sediment, and fish passage problems at culverts and canal diversions are being resolved.

Harvest has likely had little effect on the YCT population in recent years. Restrictive cutthroat trout harvest rules were implemented in 1990 in response to declining abundance and size structure. YCT continued to be managed under special restrictive angling regulations (2 YCT, none < 406 mm) until 2006, when harvest was prohibited on all cutthroat trout in the Teton River and its tributaries. Harvest of non-native rainbow and hybrid, is allowed under the general six fish limit. Brook trout are managed under the 25 fish daily limit.

In excess of 1,000,000 cutthroat fingerlings were stocked annually in the mid 1980s. This was reduced to 150,000 in the late 1980s, and fingerling plants were discontinued after 1991 due to poor return rates and increasing numbers of wild fish. In addition, the Teton River fishery was annually supplemented with hatchery rainbow trout until 1994, after which the IDFG discontinued stocking hatchery rainbow trout to minimize the threat of introgression. Currently, wild rainbow and hybrid trout continue to pose a threat to the genetic integrity and long-term viability of native YCT populations. A genetic analysis of the Teton River YCT population conducted by the University of Idaho Hagerman Laboratory found an estimated population introgression level of 21%. The analysis failed to detect rainbow trout alleles in 75% of the 65 trout examined.

Whirling disease was detected in the Teton Valley in 1995. Research initiated in 1997 to assess the potential impacts to wild salmonid populations showed high infection rates for both hatchery and wild rainbow trout and YCT. A follow up research project (Koenig 2006) evaluated juvenile trout recruitment in the Teton Valley and also indicated a high rate of infection with *M. cerebralis*. However, the lack of high quality spawning and rearing habitat in tributaries, and the abundance of brook trout in the available habitat were additional factors believed to limit YCT recruitment.

Willow Creek

The Willow Creek GMU includes over 153 km of streams above Ririe Reservoir (Figure 13). This GMU is approximately 1,929 km^2 in size. Most of the streams are situated in narrow canyons and contain wild YCT populations. Major tributaries to Willow Creek are Grays Lake Outlet and Crane, Meadow, Sellars, and Tex creeks. Water flows vary from extremes of several thousand cubic feet per second during spring runoff to a few cubic feet per second in late summer through winter in Willow Creek. Since 1924, up to 24.6 million cubic feet (20,000 acre-feet) of water a year has been diverted from the Willow Creek drainage to Blackfoot Reservoir through Clark's Cut Canal. Intensive agricultural practices have contributed to poor riparian habitat conditions in the upper parts of this GMU. Water quantity and quality is degraded as a result. The Natural Resource Conservation Service (NRCS) has identified the Willow Creek drainage as one of the ten worst soil erosion areas in the United States.

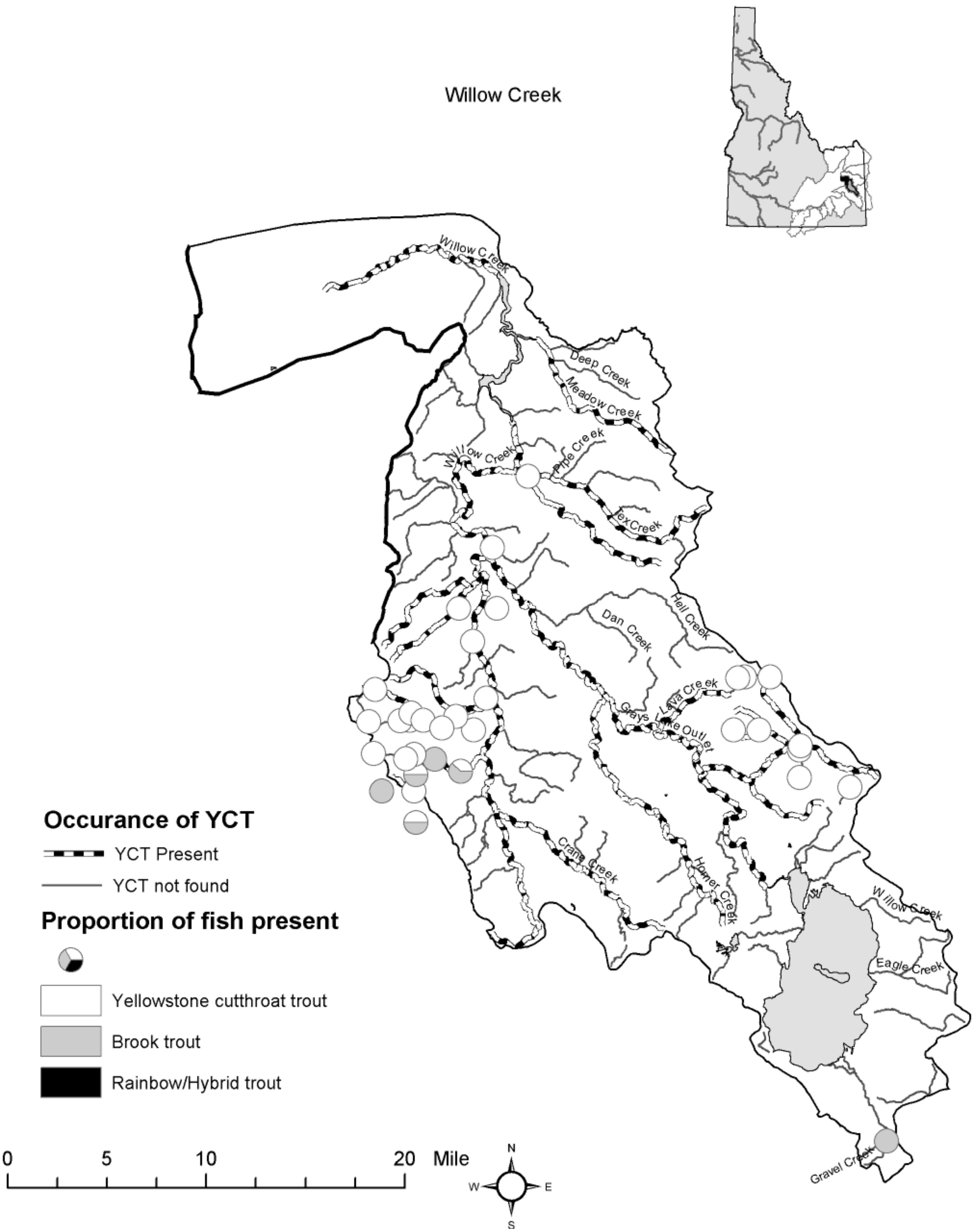

Figure 13. Willow Creek GMU. Streams that are currently thought to contain or lack YCT are labeled. Dots indicate survey sites from the Native Salmonid Assessment project and depict what species were present at the site in proportion to their abundance. Any brown trout that were captured were not included in these plots.

A water quality program was initiated to reduce loss of top soils and improve the water quality of Willow Creek above Ririe Dam. Riparian habitat improvement through improved grazing management is a high priority on federal, state, and private lands. The IDFG has worked with the NRCS, BLM, the Eastern Idaho Grazing Association, and other local groups to facilitate improvements in resource management practices.

Cutthroat trout in the mainstem Willow Creek and Grays Lake Outlet are dependent on downstream movement from tributary spawning and nursery areas. Most tributaries of Willow Creek contain populations of YCT and/or brook trout. YCT presently dominate the catch in tributaries. Hatchery catchable rainbow and brown trout fingerlings are no longer stocked in the Willow Creek drainage above Ririe Reservoir. No wild rainbow trout have been found recently in the Willow Creek drainage and genetic surveys in 1999 and 2000 have documented that Willow Creek YCT are free of rainbow trout introgression. Native YCT populations are presently depressed in the drainage but remain viable. Overharvest of YCT contributed to their decline. Beginning in 1990, restrictive angling regulations were enacted for cutthroat trout. The harvest limit is two cutthroat; all fish less than 406 mm must be released.

The construction of Ririe Dam on Willow Creek was completed by the Corps of Engineers in 1976. Ririe Reservoir has a total storage capacity of 99 million cubic meters (80,540 acre-feet) and a surface area of 595 hectares. Management priorities are flood control and irrigation water storage. The reservoir is drawn down to at least 43 million cubic meters (35,000 acre-feet) annually by November 1 to provide winter flow storage (flood control). Only 32.2 km from Idaho Falls, Ririe Reservoir has developed into a popular fishery. This fishery is supported primarily through catchable size hatchery trout and kokanee salmon. Kokanee have been stocked since 1990. In 2001, return rates of catchable triploid rainbow trout were comparable with catchable YCT. Therefore, beginning in 2003, the IDFG started stocking only YCT. Steep banks and limited access restrict bank anglers to 35% of the effort.

Smallmouth bass were introduced into Ririe Reservoir from 1984 to 1986. A self-reproducing smallmouth population has developed from the original introductions.

The 32.2 km of Willow Creek below Ririe Dam is controlled by reservoir operations for irrigation and flood control. This segment of Willow Creek is annually dewatered to keep ice buildup from causing floods near Idaho Falls. Maintaining a wild fishery in this area is only feasible with a minimum streamflow below Ririe Reservoir, although numerous trout from irrigation ditches that flow into Willow Creek via the South Fork Snake River provide a seasonal fishery. The IDFG no longer stocks rainbow trout in this reach. Prior to the construction of Ririe Dam and annual dewatering of lower Willow Creek, the average annual catch rate was 0.44 trout/hour with 10,500 hours (5,600 angler days) of effort expended annually.

Additional information on the Willow Creek GMU is found in Corsi 1986, Corsi 1984, Corsi and Elle 1994, Corsi and Elle 1989, Jeppson and Ball 1979, and Meyer and Lamansky 2002a.

POPULATION STATUS

The IDFG has gathered much information in the last two decades regarding the status of YCT in Idaho. Long-term data are available from many populations, most notably in the South Fork Snake River, Henrys Lake, Blackfoot River, and Teton River. From 1999 to 2003, IDFG conducted a landscape level inventory of YCT in the Upper Snake River Basin in an effort to characterize the status of YCT focusing primarily on tributaries where there was little information. In conjunction with this work, a tremendous volume of genetic information work was gathered for YCT populations. Subsequently, this section is divided into three subsections: YCT abundance, YCT trends, and YCT genetics.

YCT Abundance in Idaho

In a broad study covering several years, IDFG surveyed fish abundance at nearly 1,000 randomly distributed stream locations and obtained additional quantitative fish abundance data from other agencies and entities in an effort to determine status and abundance of YCT in the Upper Snake River Basin (Figure 14). For full methodological details, please refer to Meyer and Lamansky (2005) and Meyer et al. (2006). At each stream survey location, abundance estimates for all trout were derived from depletion or mark-recapture electrofishing techniques. Using the formulas in Scheaffer et al. (1996), estimates of total population abundance within individual populations were made based on mean abundance estimates within a population and the number of kilometers occupied by a population. Estimates were made for each GMU, and where possible, for smaller subpopulations within GMUs. In Meyer et al. (2006), the Upper Snake River Basin was divided into similar but not exactly the same GMUs as in this Plan.

YCT were found at 457 sites and were the most widely distributed trout species captured (Table 2), followed by brook trout, rainbow trout, hybrids, and brown trout. Of the sites that contained YCT, more than half did not contain any other species of trout. Where nonnative trout were sympatric with YCT, brook trout were most commonly present.

In the 11 GMUs where sample size permitted abundance estimates, there were an estimated 2.2 million trout ≥100 mm in total length (± 1.2 million), and of these, about 1.0 million (± 0.4 million) were YCT (Table 3). Similarly, we estimated that about 2.0 million trout <100 mm (± 1.4 million) were present, of which about 1.2 million (± 0.7 million) were YCT (Table 3). The latter estimate is biased low because of IDFG inability to estimate abundance of trout <100 mm in larger-order rivers (where we used mark-recapture methods).

Based on known distribution and on results from a recently completed genetics study (see below in the section “YCT Genetics in Idaho”), YCT were divided into approximately 70 subpopulations, but abundance estimates could be made for only 55 subpopulations. Of these, 44 subpopulations (80%) contained more than 1,000 YCT, but the species was allopatric relative to other trout in only 20 (45%) of those 44 subpopulations (Table 4).

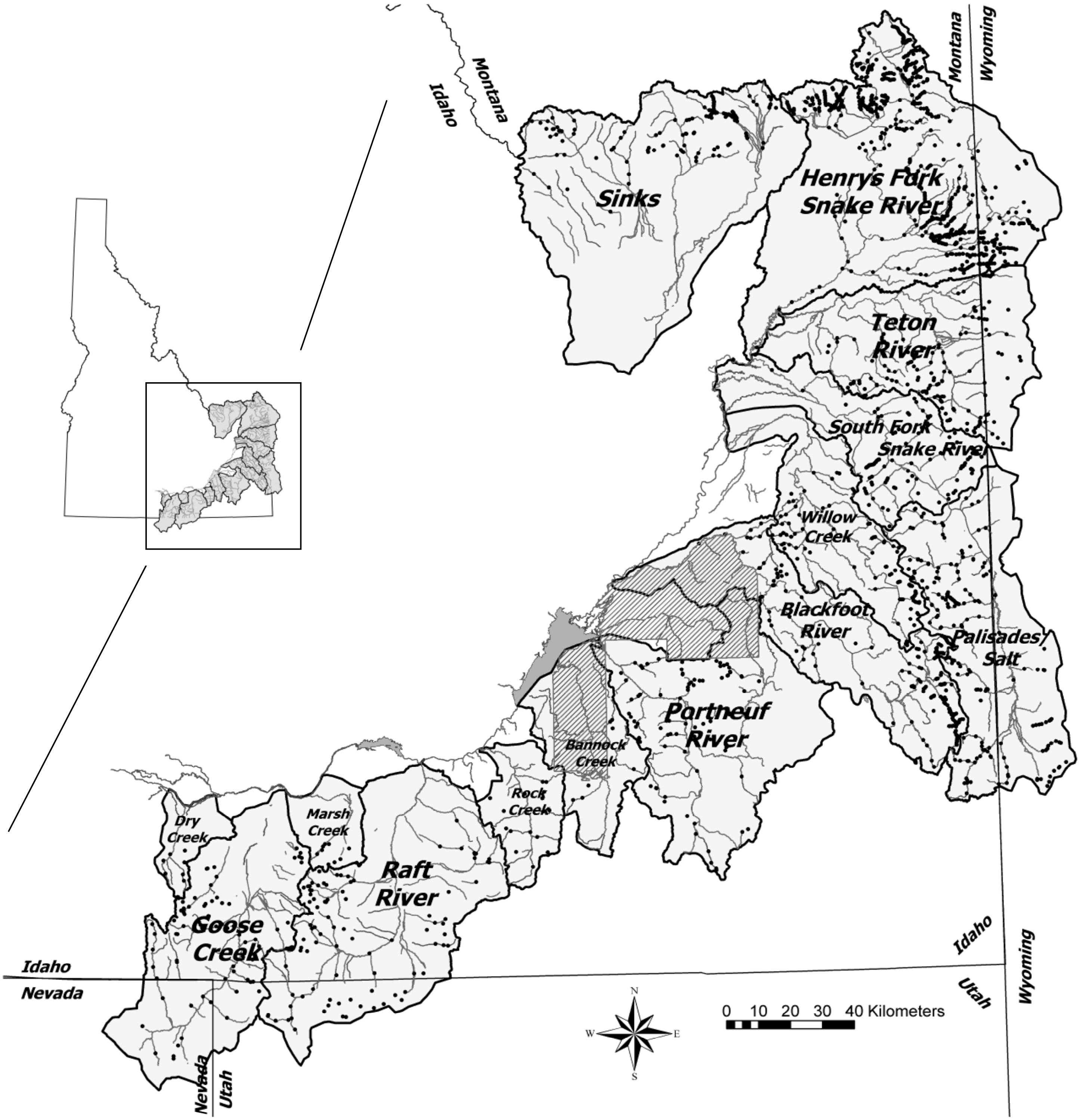

Figure 14. Distribution of stream survey study sites (dots) that were used to estimate trout abundance in the Upper Snake River Basin in Idaho. The shaded area is the unsampled Shoshone-Bannock Indian Reservation.

Table 2. Stream network and distributional extent of trout in the Upper Snake River Basin (USRB) by Geographic Management Unit. HFSR is Henrys Fork Snake River; SFSR is South Fork Snake River; YCT is Yellowstone cutthroat trout; RT/HY is rainbow trout and hybrids; BKT is brook trout; and BNT is brown trout.

Stream network and study sites	Sinks	HFSR[a]	Teton	Palisades/Salt	SFSR	Willow	Blackfoot	Portneuf	Bannock[a]	Rock[a]	Raft	Goose	Dry	Marsh	Total
Total kilometers in USRB	2,604	3,546	2,383	2,938	1,822	1,699	2,178	2,225	641	650	3,769	2,446	135	437	27,229
Kilometers included in trout estimates[b]	1,437	2,184	1,278	1,531	897	865	1,155	1,094	257	315	1,826	1,273	75	194	14,379
Total number of sites sampled	69	119	95	163	78	58	82	83	7	15	95	80	7	10	961
Sites containing trout	35	87	59	150	47	23	49	51	3	0	53	37	3	8	605
Sites containing YCT	10	34	45	148	46	21	45	47	3	0	35	20	3	0	457
Sites containing RT/HY	13	20	12	7	13	0	19	21	0	0	17	14	0	0	136
Sites containing BKT	25	72	53	22	0	4	13	8	0	0	24	13	0	8	242
Sites containing BNT	2	7	3	37	6	2	0	7	0	0	6	0	0	0	70
YCT sites containing other trout	8	27	40	56	14	4	25	25	0	0	18	7	0	0	224
YCT sites containing RT/HY	5	6	8	7	12	0	19	21	0	0	6	4	0	0	88
YCT sites containing BKT	4	24	38	21	0	2	9	4	0	0	17	3	0	0	122
YCT sites containing BNT	0	2	3	36	6	2	0	7	0	0	0	0	0	0	56
Dry or nearly dry sites	19	32	24	6	27	23	14	10	2	14	32	30	4	2	239

[a] GMUs where Yellowstone cutthroat trout distribution was restricted and sites were not selected at random.

[b] Excludes the "first-order only"streams not included in our analysis (see methods)

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Table 3. Estimates of total trout abundance (N_{census}) and 95% confidence intervals (CIs) for trout in Geographic Management Units (GMUs) in the Upper Snake River Basin, Idaho. NA indicates where inadequate data were available from which to make estimates.

	Yellowstone cutthroat trout				Rainbow trout and hybrids				Brook trout				Brown trout			
	≥ 100 mm TL		< 100 mm TL		≥ 100 mm TL		< 100 mm TL		≥ 100 mm TL		< 100 mm TL		≥ 100 mm TL		< 100 mm TL	
GMU	N_{census}	± 95% CI	N_{census}	± 95% CI	N_{census}	± 95% CI	N_{census}	± 95% CI	N_{census}	± 95% CI	N_{census}	± 95% CI	N_{census}	± 95% CI	N_{census}	± 95% CI
Sinks drainages	15,943	14,773	7,868	8,668	43,219	35,782	16,996	23,470	99,537	45,758	52,834	30,716	377	522	0	
Henrys Fork Snake River[a]	----------------------NA----------------------				----------------------NA----------------------				----------------------NA----------------------				----------------------NA----------------------			
Teton River	85,272	26,473	120,120	80,683	22,902	24,134	1,518	908	193,186	56,881	304,146	107,861	1,135	1,399	502	979
Palisades/Salt	282,141	76,979	212,503	139,461	802	539	0		11,906	11,161	898	1,026	70,155	27,790	11,778	16,528
South Fork Snake River	205,917	79,774	136,783	53,601	58,925	104,410	1,622	2,722	0		0		160,719	176,169	6,737	9,802
Willow Creek	53,509	18,632	27,526	24,820	0		0		9,162	14,937	27,223	50,540	2,398	NA	640	NA
Blackfoot River	117,021	36,406	427,034	264,446	11,748	5,980	423	652	4,614	4,824	4,545	5,397	0		0	
Portneuf River	97,961	39,312	62,460	35,420	13,577	11,773	1,639	1,402	60,816	67,368	53,424	55,107	29,476	39,028	2,969	4,166
Bannock Creek[a]	----------------------NA----------------------				----------------------NA----------------------				----------------------NA----------------------				----------------------NA----------------------			
Rock Creek[a]	0[b]		0[b]		----------------------NA----------------------				0[b]		0[b]		0[b]		0[b]	
Raft River	101,222	35,812	100,201	55,258	91,858	55,565	163,808	177,273	117,293	64,829	99,864	66,212	9,811	10,661	446	870
Goose Creek	50,209	30,201	86,554	57,981	47,053	37,493	4,723	5,646	57,440	53,556	75,352	86,342	0		0	
Dry Creek	8,770	2,390	3,425	NA	0		0		0		0		0		0	
Marsh Creek	0		0		0		0		30,412	24,581	31,284	35,880	0		0	
Total	1,017,965	360,752	1,184,473	720,339	290,085	275,676	190,729	212,074	584,366	343,894	649,568	439,080	274,071	255,569	23,071	32,345

[a] GMUs where Yellowstone cutthroat trout distribution was restricted and sites were not selected at random.

[b] Although no trout abundance estimates were possible, this species was absent from the GMU.

Table 4. Estimates of stream kilometers, total abundance of trout (N_{census}) by species, and effective population size (N_e) of Yellowstone cutthroat trout (YCT) within individual YCT subpopulations in the Upper Snake River Basin. RT/HY is rainbow trout and hybrids; BKT is brook trout; BNT is brown trout. NA indicates where inadequate data were available from which to make estimates. GMUs where no estimates were possible are not listed.

	Total stream	Estimates of total abundance (N_{census}) within each YCT sub-population				N_e of YCT approximated from:	
Sub-Population	km	YCT	RT/HY	BKT	BNT	Number of spawners	N_{census} * 0.1
Sinks drainages							
1 Crooked Creek	23.8	-NA-					
2 Fritz Creek	24.6	70	165	0	0	7	0
3 Webber Creek	17.2	79	158	79	0	8	0
4 Irving Creek	17.7	158	487	1,002	0	16	79
5 Middle Creek	NA	-NA-					
6 Indian Creek	45.9	5,012	11,240	0	0	501	472
7 WF Rattlesnake Creek	10.8	-NA-					
8 EF Rattlesnake Creek	15.6	1,237	0	2,960	0	124	148
9 Moose Creek	2.6	56	0	1,311	0	6	0
10 Dry Creek	17.8	3,035	0	0	0	303	615
11 Corral Creek	8.9	-NA-					
Henrys Fork Snake River							
1 Henry's Lake tributaries	21.6	-NA-					
2 Tygee Creek	9.8	2,388	0	0	0	239	27
3 Conant Creek	26.1	1,483	69	3,183	0	148	77
4 Squirrel Creek	13.8	1,925	27	2,152	0	192	19
5 Boone Creek	15.5	814	0	12,982	0	81	23
6 Calf Creek	7.2	2,347	0	0	0	235	0
7 Wyoming Creek	13.6	421	269	0	0	42	158
8 Robinson Creek	14.0	-NA-					
9 Bechler River	NA	-NA-					
10 Twin Creek	8.7	185	123	740	0	18	0
Teton River							
1 Moody Creek	34.3	3,184	0	22,041	112	318	128
2 Packsaddle Creek	13.0	8,273	60	8,092	0	827	30
3 Horseshoe Creek	19.6	4,991	37	4,806	0	499	70
4 Mahogany Creek	13.3	2,931	0	6,250	0	293	94
5 Badger Creek	21.5	11,128	0	0	0	1,113	407
6 Teton Creek	31.3	-NA-					
7 North Leigh Creek	33.0	2,265	47	19,281	0	227	118
8 South Leigh Creek	NA	-NA-					
9 Darby Creek	NA	-NA-					
10 Twin Creek	10.2	-NA-					
11 Trail Creek and tribs.	77.0	7,048	840	19,253	0	705	59
12 Teton River and tribs.	256.2	54,577	16,745	63,479	1,038	5,458	5,988
Palisades/Salt River							
1 Entire GMU	1531.0	494,644	802	12,804	81,933	49,464	41,289

Table 4. Continued.

Sub-Population	Total stream km	Estimates of total abundance (N_{census}) within each YCT sub-population: YCT	RT/HY	BKT	BNT	N_e of YCT approximated from: Number of spawners	N_{census} * 0.1
South Fork Snake River							
1 Garden Creek	11.3	1,715	0	0	0	172	159
2 Fall Creek	51.7	15,202	0	0	0	1,520	594
3 Upper Palisades Creek	30.8	23,089	19	0	0	2,309	1,937
4 SF Snake River and tribs.	396.7	205,608	54,080	0	150,946	20,561	25,897
Bannock Creek							
1 Entire GMU	17.5	- - - - - - - - - - - - - - - - - - - -NA- - - - - - - - - - - - - - - - - - - -					
Willow Creek							
1 Entire GMU	865.0	81,035	0	36,385	3,038	8,104	8,906
Blackfoot River							
1 Lower Blackfoot R. and tribs.	214.9	132,314	2,007	1,177	0	13,231	2,371
2 Upper Blackfoot R. and tribs.	262.7	134,195	6,802	2,874	0	13,420	2,145
Portneuf River							
1 Rapid Creek	51.3	14,765	1,364	0	532	1,477	1,960
2 Walker Creek	10.4	232	0	0	0	23	63
3 Bell Marsh Creek	10.3	1,652	0	0	0	165	146
4 Goodenough Creek	10.9	2,241	0	0	0	224	518
5 Robbers Roost Creek	8.9	1,061	0	0	0	106	272
6 Harkness Creek	9.2	- - - - - - - - - - - - - - - - - - - -NA- - - - - - - - - - - - - - - - - - - -					
7 Mink Creek	16.5	2,113	221	0	38	211	468
8 Gibson Jack Creek	14.1	1,270	339	269	0	127	241
9 East Bob Smith Creek	8.1	1,592	0	1,065	0	159	655
10 Dempsey Creek	20.4	- - - - - - - - - - - - - - - - - - - -NA- - - - - - - - - - - - - - - - - - - -					
11 Fish Creek	11.5	- - - - - - - - - - - - - - - - - - - -NA- - - - - - - - - - - - - - - - - - - -					
12 Pebble Creek	29.8	12,749	334	0	0	1,275	1,178
13 Toponce Creek	31.2	6,130	1,553	0	6,858	613	564
14 Right Hand Fk Marsh Creek	6.6	104	0	0	0	10	26
Raft River							
1 South Junction Creek	21.3	3,923	0	0	0	392	171
2 Wildcat Creek	1.8	42	0	0	0	4	5
3 Johnson Creek	13.4	3,003	0	4,890	0	300	97
4 George Creek	12.6	4,971	6,093	0	0	497	506
5 Onemile Creek	5.3	2,874	0	0	0	287	213
6 Clear Creek	3.3	1,762	0	0	0	176	184
7 Eightmile Creek	9.3	5,265	0	0	0	526	366
8 Grape Creek	8.7	1,163	0	0	0	116	159
9 Cassia Creek	67.8	11,182	1,432	13,051	0	1,118	751
10 Edwards Creek	6.1	801	0	0	0	80	67
11 Almo Creek	12.8	2,038	0	0	0	204	0
Goose Creek							
1 Goose Creek	62.3	33,763	2,628	3,353	0	3,376	228
2 Big Cottonwood Creek	35.5	20,043	263	0	0	2,004	454
Dry Creek							
1 Entire GMU	75.0	12,195	0	0	0	1,220	6,477

While estimation of population size for major river drainages or subpopulations has obvious utility in evaluating risk to population persistence, assessment of genetic risks stemming from small population size is also desirable. Genetic risks to small populations are related to declines in heterozygosity, which is a function of the overall population size. However, it is not the absolute number of individuals in a population that is relevant to the amount of genetic variation in the population, but rather the effective population size (N_e; Wright 1931).

IDFG attempted to approximate N_e in two ways. First, Frankham (1995) reviewed 192 estimates of the ratio of N_e to the total population size from a wide variety of wildlife species and found that the ratio was about 0.10. Thus, we multiplied our total estimates of abundance of YCT by 0.1 for our first approximation of N_e.

Rieman and Allendorf (2001) approximated N_e by using a generalized age-structure simulation model to relate N_e to adult spawning numbers under a variety of bull trout life history characteristics (some of which closely match YCT), and suggested the most realistic estimates of N_e were between 0.5-1.5 times the mean number of adults spawning annually. We chose the midpoint of this range as a starting point for our approximations. Previously we developed a method of estimating the number of spawners in a population by developing models that predict the size at which YCT mature at any given location (Meyer et al. 2003a). For our second approximation of N_e, the number of spawners within individual GMUs and subpopulations was estimated, and N_e was approximated by multiplying these estimates by 1.0.

Results were compared against the "50/500" rule developed by Frankham (1980) and Soule (1980) and widely accepted in conservation biology. The 50/500 rule states that an N_e of at least 50 is needed to avoid inbreeding depression in the short term, while at least 500 is needed to avoid serious genetic drift and maintain genetic variation in the long term. Our estimates of N_e exceeded 50 and 500 for one or the other approximation in 49 (89%) and 26 (47%) of the subpopulations, respectively. Furthermore, there was a strong positive 1:1 agreement between N_e estimation methods (r = 0.84; n = 55), lending support that neither method was drastically inaccurate and that our approximations were probably reasonable.

Results from this study indicate that, despite certain declines from historic levels, YCT remain relatively widespread and are more abundant than any other salmonid in the Upper Snake River Basin. Most populations do not appear to be so small that inbreeding depression is likely in the short-term. However, the small size of many populations does suggest that periodic monitoring of genetic diversity and abundance in the smallest populations will be necessary, and translocations in the near future may be needed to maintain acceptable levels of genetic diversity in these streams. Estimates are needed for sub-populations where data is currently lacking.

YCT Trends in Idaho

Although YCT have undergone a considerable decline in abundance and distribution since European settlement of the western United States, the extent of this decline and of more recent changes (i.e., the last 20 years) remains unclear because most broad-scale assessments of YCT status to date have been largely qualitative (Thurow et al. 1988; Varley and Gresswell 1988; May 1996; Thurow et al. 1997). For example, May (1996), summarizing results from questionnaires completed by biologists with personal knowledge of localized systems, suggested that viable populations remained in only 43% of the historical range in Idaho. Thurow et al. (1997), using a similar method, estimated that YCT populations were strong in 32% of their entire potential range, nearly all of which occurred in Wyoming. Quantitative assessments have also focused on the proportion of historical range now occupied. For instance, Kruse et al. (2000) found that 26% of the 104 trout-bearing streams in the Greybull and Shoshone river drainages in Wyoming outside of Yellowstone National Park contained genetically pure YCT.

An alternative method of assessing declines in abundance and distribution is long-term monitoring of specific populations over a broad geographic area. Trend data for YCT was available from several sources. First, IDFG has collected long-term trend data from the Teton River and South Fork Snake River through annual electrofishing surveys and from the Blackfoot River through YCT spawner counts over the Blackfoot River weir.

In addition, in 1999 and 2000, IDFG personnel revisited numerous locations throughout the Upper Snake River basin that were previously sampled between 1980 and 1989 (Meyer et al. 2003b). The objective of this study was to assess changes in YCT populations between the 1980s and 1999-2000 by comparing estimates of abundance, distribution, and size structure from these locations. Hereafter this study is termed the 'pre-post study.'

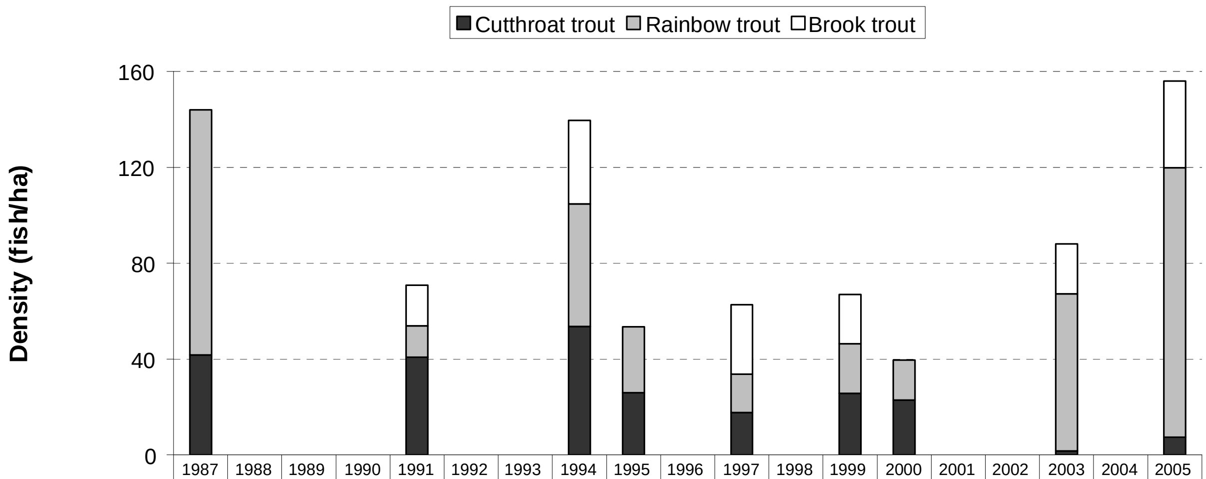
Teton River Trends

Long-term trend data are available from several sections on the Teton River (Table 5). Average YCT densities in the upper Teton River were about 40 fish/ha in the late 1980s and early 1990s (Figure 15). Following special harvest regulations implemented in 1990, they increased to around 60 fish/ha by 1994 but then declined to 20 fish/ha by the late 1990s and 2000. Less than 2 fish/ha were estimated in 2003 though that had increased to 7 fish/ha in 2005. From 3 to 78% of the electrofishing catch over the various sections and years was YCT (Table 5). The upper Teton River (from Highway 33 at Harrop's Bridge upstream to the confluence with Trail Creek) is roughly 40 km long, averages 33.3 m wide, for a total surface area of about 133 ha. This translates to about 250 YCT total during 2003 and 900 in 2005. If only a portion of these is adults, then the population was near the minimum equilibrium size generally considered at risk of extinction. Special regulations were recognized as warranted to protect YCT from any harvest in the upper Teton River and catch and release rules were implemented throughout the Teton River drainage for YCT in 2006.

The 2005 density estimate for all trout combined was the highest recorded (Figure 15). The increase since the late 1990s is due to increasing numbers of rainbow trout and hybrids but not YCT or brook trout. Rainbow trout declined from about 100 fish/ha in the late 1980s to about 20 fish/ha in the 1990s and 2000, except 1994 when there were 50 fish/ha. They rebounded to 65 fish/ha by 2003 and a record 112 fish/ha by 2005. From 5 to 90% of the electrofishing catch over the various sections and years was rainbow trout (Table 5). There were about 8,650 rainbow trout total in the upper Teton River during 2003 and 14,900 during 2005. Brook trout have ranged from 5 to 60% of the catch and their densities, when unbiased estimates were possible, have hovered around 20 to 35 fish/ha (Figure 15). There were about 2,800 brook trout total in the upper Teton River during 2003 and 4,800 during 2005. Like brown trout in the upper South Fork Snake River, brook trout in the upper Teton River have been relatively stable. In general, YCT and brook trout were more common and abundant, whereas rainbow trout were less common and abundant, moving upstream (Table 5). Only two brown trout have been caught since 1987, and they may have been introduced illegally from the lower Henrys Fork Snake River or South Fork Snake River.

Table 5. Estimated density (fish/ha) of age 1 and older Yellowstone cutthroat trout (YCT ≥100 mm), rainbow and hybrid trout (RBT ≥100 mm), and brook trout (BKT ≥150 mm) in five electrofishing sections of the upper Teton River, 1987-2005 (Garren et al. 2006). All sections are in the Teton Valley and are listed going upstream.

Year	Estimated Number per Hectare			Percent Composition		
	YCT	RBT	BKT	%YCT	%RBT	%BKT
Breckenridge Section						
1987	19	167	--	15	70	15
1994	17	80	--	18	76	5
1995	18	27	--	40	43	17
1997	16	16	47	30	25	45
1999	25	38	--	44	37	18
2003	1	110	3	3	90	6
Rainier Section						
1987	22	77	--	26	52	22
1991	--	--	--	30	46	24
2000	16	26	--	56	31	13
Buxton Section						
1987	49	64	--	45	35	21
1991	15	--	5	38	39	24
2000	30	7	--	59	27	14
Nickerson Section						
1987	76	--	--	52	7	41
1991	67	13	29	47	21	32
1994	90	22	35	56	19	25
1995	33	--	--	78	6	16
1997	20	--	10	64	8	28
1999	26	3	20	56	11	33
2003	2	21	39	6	34	60
2005	11	38	36	13	37	50
White Bridge Section						
1994	149	6	116	60	5	35



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Brook trout					17			35			29		20				21		36
Rainbow trout	102				13			51	27		16		21	17			65		112
Cutthroat trout	42				41			54	26		18		26	23			2		7

Figure 15. Age-1 and older cutthroat, rainbow, and brook trout density (fish/ha) averaged over all electrofishing sections except White Bridge, upper Teton River, Idaho, 1987-2005 (Garren et al. 2006). Asterisks denote years that were not sampled.

YCT and rainbow trout average lengths and quality stock densities have increased dramatically in all sections. Recent YCT quality stock densities of 40-50% reflect not only larger and older fish from reduced harvest but also fewer juvenile fish (Figure 16). Brook trout have also increased in size but to a lesser degree. Because recent creel surveys have shown that harvest is minimal, the declining population is likely due to depressed recruitment and year class failures. Current research is focusing on the causes. Whirling disease was documented in 1995 and may be a major factor, but other possible causes include low and altered flow regimes from drought and irrigation, riparian habitat degradation, and water quality problems from agriculture and housing development. A slight improvement in recruitment was observed in 2005. Fingerling cutthroat trout stocking was discontinued after 1991, and catchable rainbow trout stocking was discontinued after 1994.

These long-term YCT population trend data come from the upper Teton River (Valley), but other data exists for the middle (Canyon) and lower river. Most other information was collected from 1998-1999.

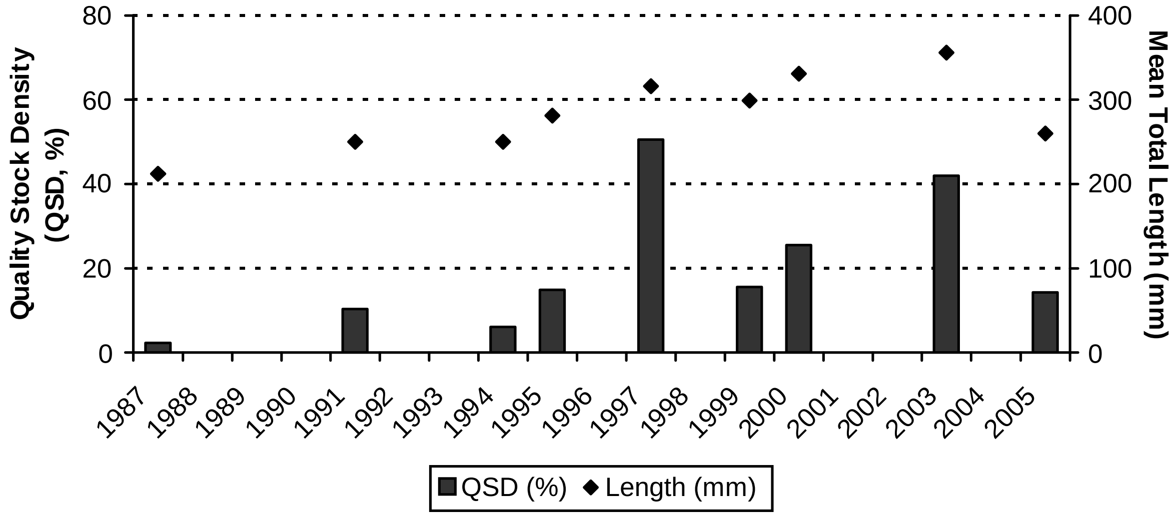
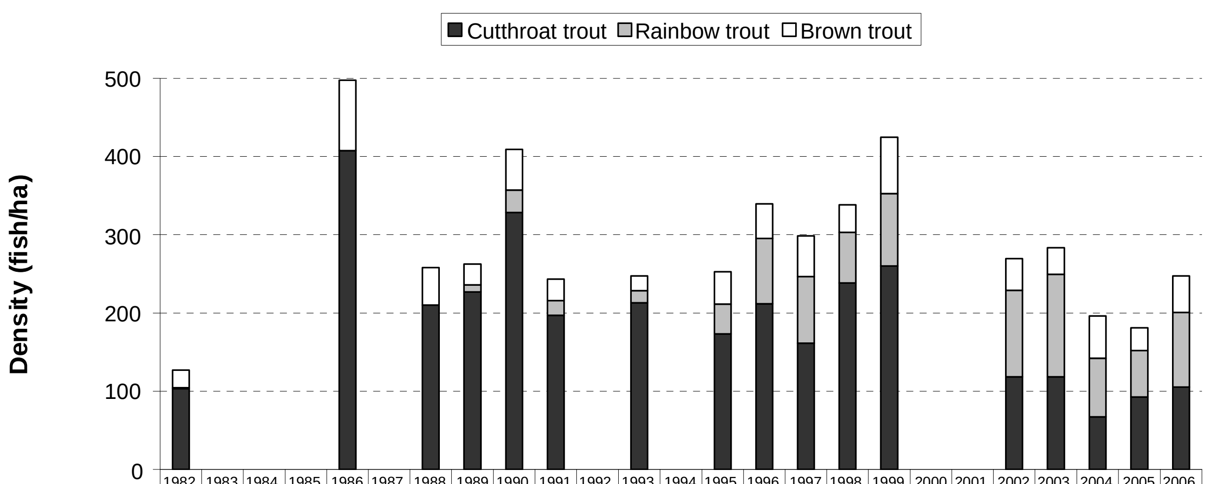


Figure 16. Yellowstone cutthroat trout quality stock density (QSD) and mean total length over all Teton Valley electrofishing sections combined, Teton River, Idaho, 1987-2005 (Garren et al. 2006). Asterisks denote years that were not sampled.

South Fork Snake River Trends

Long-term trend data in the upper South Fork Snake River indicates that YCT densities were about 100 fish/ha in the early 1980s (Figure 17; Table 6). Following special harvest regulations implemented in 1984, they increased to over 400 fish/ha by 1986 but have since gradually declined to about 100 fish/ha. The proportion of YCT in the electrofishing catch has also declined from around 80-90% in the late 1980s and early 1990s to 41% in 2006. In 2003-2004, YCT ceased being the predominant taxa in the upper river and were surpassed by rainbow and hybrid trout. YCT have been increasing since then, possibly because of more favorable flow conditions and the implementation of catch-and-release rules in 2004. Rainbow and hybrid trout densities have gradually increased from one fish/ha in the early 1980s to about 130 fish/ha in 2003. Following removal of harvest limits in 2004 and extending the season to allow fishing for spawners in the spring, they declined to 60 fish/ha by 2005. Rainbow and hybrid trout increased again to 95 fish/ha in 2006. The proportion of rainbow and hybrid trout in the electrofishing catch has increased from around 1-5% in the 1980s to a record 35% by 2004, though the proportion declined to 32% by 2006. Brown trout in the upper South Fork Snake River have been relatively stable, ranging from about 20 to 90 fish/ha and 7 to 27% of the catch through 2006.



	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Brown trout	22				90		48	27	52	27		19		41	44	52	35	72			41	34	54	29	46
Rainbow trout	1							9	29	19		15		38	84	85	65	92			111	131	75	59	95
Cutthroat trout	103				407		210	227	328	197		213		173	212	161	238	260			118	118	67	93	105

Figure 17. Age-1 and older cutthroat, rainbow, and brown trout density (fish/ha) at the upper (Conant) electrofishing section, South Fork Snake River, Idaho, 1982-2006 (Moore and Schill 1984; Schrader and Fredericks in press).

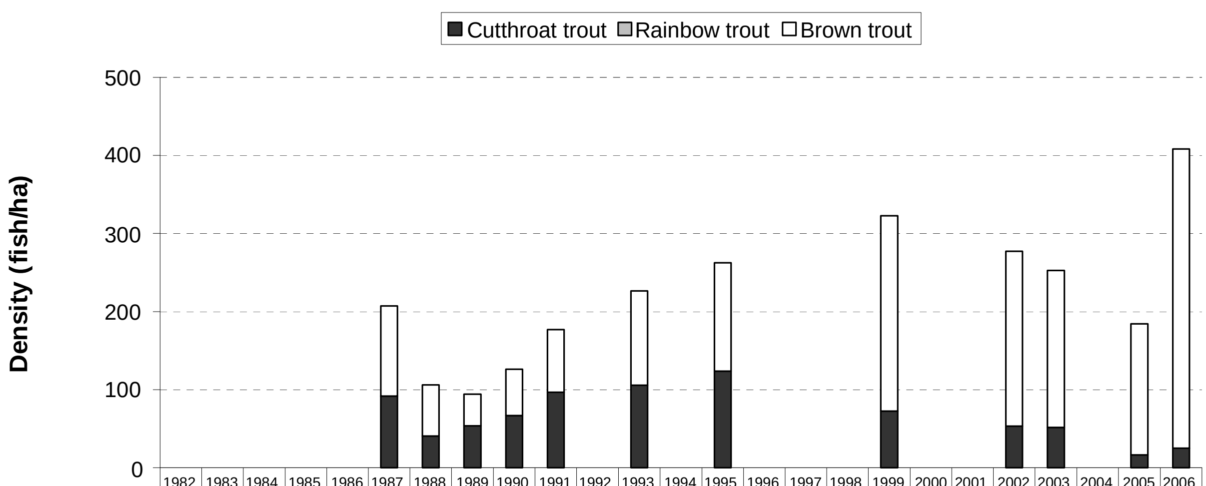
Table 6. Estimated density (fish/ha) of age 1 and older cutthroat trout (YCT ≥102 mm), rainbow and hybrid trout (RBT ≥152 mm), and brown trout (BRN ≥178 mm) in the upper and lower electrofishing sections of the South Fork Snake River, 1982-2006 (Moore and Schill 1984; Schrader and Fredericks in press).

Year	Estimated Number per Hectare			Percent Composition		
	YCT	RBT	BRN	%YCT	%RBT	%BRN
Conant (upper) Section						
1982	103	1	22	80	1	18
1986	407	--	90	83	2	14
1987	--	--	--	86	2	12
1988	210	--	48	88	3	9
1989	227	9	27	89	4	7
1990	328	29	52	84	6	9
1991	197	19	27	80	7	13
1992	--	--	--	83	5	12
1993	213	15	19	85	6	9
1994	--	--	--	79	9	12
1995	173	38	41	69	16	16
1996	212	84	44	66	15	18
1997	161	85	52	54	27	18
1998	238	65	35	59	20	21
1999	260	92	72	63	19	18
2000	--	--	--	66	22	11
2001	--	--	--	58	25	16
2002	118	111	41	53	34	14
2003	118	131	34	47	33	20
2004	67	75	54	41	35	23
2005	93	59	29	48	27	25
2006	105	95	46	41	32	27
Lorenzo (lower) Section						
1987	92	--	115	38	<1	61
1988	41	--	65	36	1	63
1989	54	--	40	34	1	65
1990	67	--	59	38	<1	62
1991	97	--	80	37	1	63
1993	106	--	121	37	2	62
1995	124	--	139	32	1	67
1999	73	--	250	23	<1	76
2002	53	--	224	18	<1	81
2003	51	--	201	13	<1	86
2005	16	--	168	7	1	92
2006	25	--	383	8	1	91

From 1987-1995, YCT densities in the lower river ranged from about 40 to 125 fish/ha, but they gradually declined to 25 fish/ha by 2006 (Figure 18; Table 6). Brown trout densities ranged from 40 to 140 fish/ha from 1987-1995, but they increased to 380 fish/ha by 2006. YCT have ranged from 7 to 38% and brown trout have ranged from 61 to 92% of the electrofishing catch over the years. Compared to the upper river, there are relatively fewer YCT, more brown trout, and fewer trout overall in the lower river. Rainbow and hybrid trout are virtually absent in the lower river. In general, cutthroat and rainbow trout are more common and have higher densities moving upstream from the confluence to Palisades Dam, whereas brown trout are less common and have lower densities.

YCT quality stock densities in the upper river have ranged from 2 to 21% since 1986 (Figure 19). Increasing quality stock densities during the 1987-1994 drought years, and again during the 2000-2005 droughts, probably reflects depressed recruitment and successive year class failures. However, larger and older fish from reduced harvest may also have been a factor. Quality stock densities declined as recruitment increased during the good water years of the late 1990's.

Additional YCT data exists for two other sections in the upper river (Palisades and Dry Canyon) and one other section in the lower river (Twin Bridges). The Palisades section was sampled in 1987, 1989, 1991, 1995, and 1997 but the YCT data are not reliable as hatchery fished flushed from the reservoir cannot be accurately distinguished from fluvial fish residing in the river. Dry Canyon was sampled in 1988, and Twin Bridges was sampled in 1989, 1991, and 2000.



	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Brown trout						115	65	40	59	80		121		139				250			224	201		168	383
Rainbow trout																									
Cutthroat trout						92	41	54	67	97		106		124				73			53	51		16	25

Figure 18. Age-1 and older cutthroat, rainbow, and brown trout density (fish/ha) at the lower (Lorenzo) electrofishing section, South Fork Snake River, Idaho, 1987-2006 (Schrader and Fredericks in press).

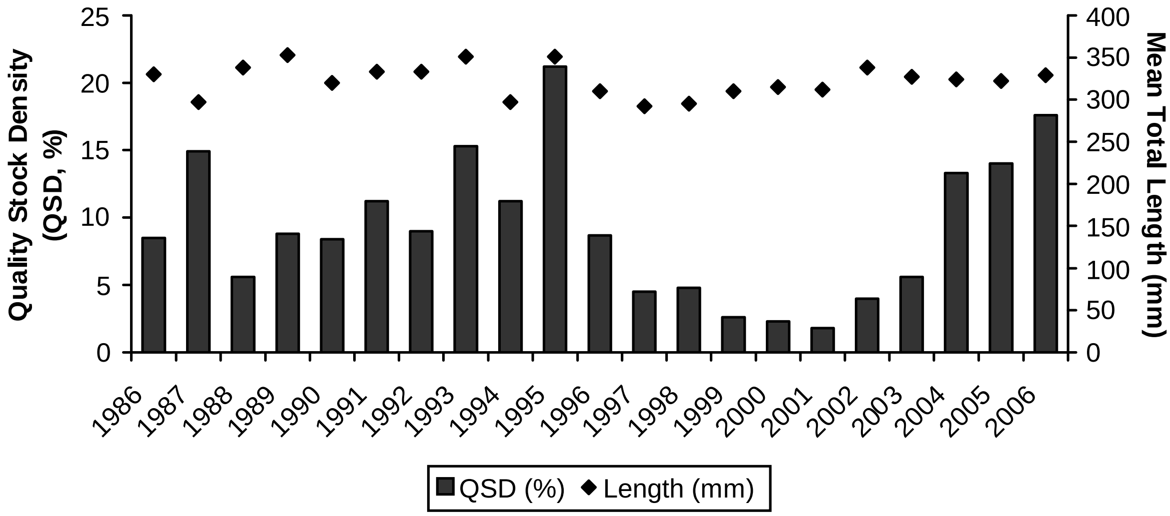


Figure 19. Cutthroat trout quality stock density (QSD) and mean total length in the upper (Conant) electrofishing section, South Fork Snake River, Idaho, 1986 to 2006 (Schrader and Fredericks in press).

Pre-Post Study Trends

For detailed information on the design and results from this study, see Meyer et al. (2003b). In short, stream survey sites that were sampled with electrofishing gear in the 1980s were relocated in 1999-2000 using maps, photographs, and/or by finding original site-boundary stakes, so that the exact same reach of stream was sampled during both periods. This eliminated any spatial bias to the data. Seasonal bias was eliminated by replicating the later sample date as close to the original calendar date as possible. Thus, 65% of the sites were resampled within two weeks of the original calendar date, 88% within four weeks, and all within six weeks. Electrofishing surveys were performed in the same manner as above. Seventy-seven sites were relocated and resampled to compare YCT abundance, distribution, and size structure between the two time periods.

Abundance of YCT ≥100 mm did not change, averaging 41 fish/100 m of stream during the 1980s and 41 fish/100 m of stream during 1999-2000 (Table 7). Abundance was lower at 33 locations and higher at 44 locations. At five locations, no YCT ≥100 mm were captured in 1999-2000 where they had been captured in the 1980s, but one of these sites did contain YCT <100 mm. Total trout abundance (including rainbow trout and hybrids, brook trout, and brown trout) also remained relatively unchanged between time periods, averaging 51 fish/100 m of stream in the 1980s compared to 54 fish/100 m of stream in 1999-2000 (Table 7).

The proportion of the total catch of trout comprised of YCT also did not change, averaging 82% in the 1980s and 78% in 1999-2000. At the 48 sites where size structure could be estimated for both periods, there was a slight decline in the proportion of YCT 100-200 mm (74% vs. 66%), but the change was due entirely to the shift in size structure at the Teton River sites (Table 8).

Table 7. Comparison of trout abundance estimates (fish/100 m of stream for fish ≥100 mm) derived from removal (D) or mark-recapture (MR) methods at 77 study sites across southeastern Idaho between the 1980s and 1999-2000. Study site length and mean width in meters. Ninety-five percent confidence intervals (CI) are blank where estimates were not possible. NA refers to not available. YCT is Yellowstone cutthroat trout; RT/HY is rainbow trout and hybrids; BNT is brown trout; BKT is brook trout.

		Study site			Total trout abundance						Trout abundance							
					1980s			1999-2000			YCT		RT/HY		BNT		BKT	
Site	Stream	Length (m)	Width (m)	Esti-mate	Est.	95% CI	Year	Est.	95% CI	Year	1980s	1999-2000	1980s	1999-2000	1980s	1999-2000	1980s	1999-2000
								Raft River and Goose Creek drainages										
1	Birch Creek	80	1.9	D	3		1987	31	31-31	2000	1	0					1	31
2	Cold Creek	60	1.5	D	5	5-10	1987	6	6-9	2000	5	0					0	6
3	Eightmile Creek	82	1.3	D	6	6-8	1986	23	23-25	2000	6	23						
4	Trout Creek	110	3.2	D	55		1987	8	8-9	2000	4	7	51	1				
								Portneuf River drainage										
5	Pebble Creek	207	2.3	D	59	57-62	1986	15		2000	44	14	14	1			1	0
6	Pebble Creek	98	4.6	D	39	38-43	1986	52	52-54	1999	33	45	6	7				
7	Pebble Creek	104	3.6	D	80	77-85	1986	58	58-59	1999	76	44	4	14				
8	Pebble Creek NF	133	1.8	D	35	35-36	1986	15		1999	35	15						
9	Big Springs Creek	105	NA	D	29	29-30	1986	28	28-30	1999	24	26	5	2				
10	King Creek	70	11.3	D	7	7-9	1986	0		2000	7	0						
11	Toponce Creek	180	1.7	D	1		1986	0		2000	1	0						
12	Toponce Creek	89	6.6	D	112	101-127	1986	35	35-37	2000	8	5	105	1	0	29		
13	Toponce Creek, MF	80	NA	D	79	79-81	1986	96	96-97	2000	3	17	76	78				
14	Toponce Creek, SF	99	2.7	D	134		1987	47	45-53	2000	116	46	19	1				
15	Toponce Creek, SF	113	7.2	D	31	31-32	1987	154	150-159	2000	29	147	2	7				
								Blackfoot River drainage										
16	Blackfoot River	4720	NA	D/MR	1	1-1	1988	14	12-17	2000	1	13	0	2				
17	Blackfoot River	1712	NA	MR	15	12-19	1988	44	39-48	2000	15	37	0	7			0	0
18	Blackfoot River	1760	NA	D/MR	6	6-7	1988	20	13-27	2000	6	13	0	6			0	1
19	Diamond Creek	180	4.8	D	10	10-11	1988	11	11-12	2000	8	11					1	0
20	Diamond Creek	147	5.5	D	135	131-140	1980	69	69-70	2000	130	62	0	7			5	0
21	Diamond Creek	150	4.1	D	176	172-180	1980	67	67-69	2000	174	61	0	6			1	0
22	Diamond Creek	165	3.4	D	27	25-33	1987	71	70-73	2000	25	64	0	7			3	0
23	Diamond Creek	87	3.3	D	12	12-15	1987	48	48-49	2000	9	44	0	5			2	0
24	Diamond Creek	75	2.4	D	52	52-54	1987	56	47-77	2000	51	44	0	12			1	0
25	Diamond Creek	165	2.8	D	23	23-23	1988	48	44-54	2000	18	29	0	19			5	0
26	Sheep Creek	161	2.7	D	5		1987	6	6-7	2000	5	6						
								Willow Creek drainage										
27	Willow Creek	886	8.2	MR	25	19-32	1984	5	3-6	2000	21	4	1	0	3	1		
28	Willow Creek	571	NA	MR/D	92	75-109	1984	25	21-30	2000	67	23	1	0	24	2		
29	Brockman Creek	93	NA	D	10	10-10	1983	27	25-34	2000	8	27			2	0		
30	Corral Creek	71	1.2	D	65	52-89	1982	6	6-8	2000	65	6						
31	Corral Creek	127	2.0	D	28	28-29	1982	15	15-16	2000	28	15						
								Mainstem Snake River drainage										
32	Snake River	7300	79.0	MR	21	6-55	1988	41	8-135	2000	8	8	3	3	10	30		
								South Fork Snake River drainage										
33	Snake River, SF	4800	46.0	MR	64	11-186	1989	147	30-300	1999	21	34	0	1	42	112		
34	Snake River, SF	2900	66.0	MR	95	25-200	1989	260	58-463	2000	48	73	0	2	47	185		
35	Snake River, SF	4900	71.0	MR	180	52-303	1989	282	58-514	1999	160	177	7	55	12	51		

Table 7. Continued.

		Study site			Total trout abundance						Trout abundance							
					1980s			1999-2000			YCT		RT/HY		BNT		BKT	
Site	Stream	Length (m)	Width (m)	Estimate	Est.	95% CI	Year	Est.	95% CI	Year	1980s	1999-2000	1980s	1999-2000	1980s	1999-2000	1980s	1999-2000
36	Burns Creek	85	5.9	D	57	53-65	1980	54	45-71	2000	57	33	0	20				
37	Burns Creek	86	5.3	D	7	7-8	1980	37	37-39	2000	7	31	0	2	0	4		
38	Pine Creek	66	11.0	D	52	50-57	1980	77	74-85	2000	52	71	0	6				
39	Pine Creek	90	10.6	D	78	78-79	1988	24	24-27	2000	78	24						
40	Pine Creek	74	5.1	D	155	135-182	1980	152	129-178	2000	155	147	0	5				
41	Pine Creek	80	4.9	D	54	54-56	1988	90	90-92	2000	54	83	0	8				
42	Pine Creek, NF	72	5.4	D	22	22-24	1982	18	18-19	2000	22	18						
43	Pine Creek, NF	80	7.9	D	44	44-47	1981	10	10-13	2000	44	9	0	1				
44	Rainey Creek	160	5.7	D	1		1980	39	34-48	2000	1	38			0	2		
45	Rainey Creek	123	6.1	D	7	7-9	1980	4	4-7	2000	7	4						
46	Rainey Creek	167	7.8	D	13	13-14	1980	53	53-54	2000	9	40	0	2	4	11		
47	Fall Creek	133	6.0	D	13	13-15	1988	61	54-71	2000	13	61						
48	Bear Creek	246	8.3	D	18	10-42	1980	72	70-74	2000	18	72	0	0				
49	Elk Creek	146	3.6	D	25	19-38	1980	36	36-39	2000	25	36						
50	Big Elk Creek	97	6.9	D	8	8-9	1980	33	32-37	2000	8	33						
51	Big Elk Creek	146	7.7	D	20	17-27	1980	61	58-66	2000	20	61						
52	McCoy Creek	375	9.3	MR	73	47-100	1986	37	33-40	2000	72	36	0	0	1	1		
53	McCoy Creek	388	8.7	MR	109	85-132	1986	118	79-156	2000	108	118			1	0		
54	McCoy Creek	144	3.3	D	53	50-58	1986	57	55-61	1999	53	57						
55	Jensen Creek	49	3.6	D	163	92-304	1986	0		1999	163	0						
56	Fish Creek	79	1.9	D	48	45-57	1986	167	163-173	1999	48	167						
57	Fish Creek	92	3.2	D	44	42-47	1986	90	86-97	1999	44	90						
58	Barnes Creek	99	2.7	D	24	24-26	1986	34	28-45	1999	24	34						
59	Barnes Creek	76	3.2	D	8	8-10	1986	11		1999	8	11						
60	Clear Creek	122	3.2	D	62	38-107	1986	31	30-34	1999	62	31						
61	Iowa Creek	97	3.6	D	26	26-27	1986	31	31-33	2000	26	31						
62	Jackknife Creek	107	5.7	D	30	30-31	1987	14	14-15	1999	29	14			1	0		
63	Tincup Creek	155	6.3	D	64	56-75	1987	77	73-84	1999	63	76	1	0	1	1		
64	Tincup Creek	117	6.8	D	133	128-139	1987	64	62-68	1999	129	64	1	0	3	0		
65	Tincup Creek	100	5.1	D	66	65-69	1987	21	21-23	1999	66	21						
66	Bear Canyon Creek	52	1.8	D	88	88-92	1987	34	34-37	1999	88	32	0	2				
67	Stump Creek	441	7.0	MR	54	43-66	1986	149	135-163	2000	44	124			10	26	1	0
68	Horse Creek	86	2.2	D	41	41-43	1986	75	75-77	1999	41	71			0	5		
69	Crow Creek	309	5.3	MR	9	8-10	1986	43	38-47	2000	4	10			5	32		
70	Crow Creek	111	4.2	D	85	82-90	1986	126	126-128	1999	84	117			1	9		
71	Sage Creek	215	5.7	D	120	107-132	1987	140	139-141	1999	19	31			100	109		
72	Deer Creek	157	NA	D	45	38-56	1986	85	85-86	1999	37	79	0	1	8	6		
73	White Dugway Creek	84	1.8	D	14	14-17	1986	6		1999	13	6			1	0		
								Teton River drainage										
74	Teton River	4900	26.0	MR	69	8-363	1987	18	5-66	1999	12	8	46	7			12	3
75	Teton River	5500	37.0	MR	59	10-196	1987	25	4-105	2000	16	14	29	7	0	0	14	4
76	Teton River	7100	37.0	MR	54	10-174	1987	25	4-116	2000	25	15	17	7			12	4
77	Teton River	5800	42.0	MR	78	10-338	1987	19	6-45	1999	42	11	5	2			31	6
	AVERAGE				51			54			41	41	5	4	4	8	1	1

Table 8. Temporal comparison of YCT size structure from stream survey sites sampled in the 1980s and again in 1999-2000. Missing sites (from those included in Table 7) did not contain enough YCT to report size structure data for that time.

		Percent of Yellowstone cutthroat trout catch per size category (cm)							
Site		1980s				1999-2000			
no.	Stream name	10-20	20-30	30-40	> 40	10-20	20-30	30-40	> 40
	Portneuf River drainage								
5	Pebble Creek	92	8	0	0	97	3	0	0
6	Pebble Creek	90	10	0	0	68	30	2	0
7	Pebble Creek	97	3	0	0	74	26	0	0
8	Pebble Creek NF	100	0	0	0	95	5	0	0
14	Toponce Creek, SF	74	26	0	0	83	17	0	0
15	Toponce Creek, SF	91	9	0	0	93	7	0	0
	Blackfoot River drainage								
16	Blackfoot River	14	50	14	21	15	53	5	27
17	Blackfoot River	91	6	3	0	95	2	1	2
18	Blackfoot River	35	27	25	13	43	8	18	31
20	Diamond Creek	94	6	0	0	92	8	0	0
21	Diamond Creek	98	2	0	0	97	3	0	0
22	Diamond Creek	97	3	0	0	99	1	0	0
24	Diamond Creek	97	3	0	0	96	0	4	0
25	Diamond Creek	93	7	0	0	98	2	0	0
	Willow Creek drainage								
27	Willow Creek	22	67	7	3	14	36	45	5
28	Willow Creek	76	23	1	0	51	45	4	0
31	Corral Creek	97	3	0	0	100	0	0	0
	Mainstem Snake River drainage								
32	Snake River	1	31	54	14	4	45	36	15
	South Fork Snake River drainage								
33	Snake River, SF	3	24	51	23	5	22	63	11
34	Snake River, SF	2	19	59	20	6	32	55	7
35	Snake River, SF	2	8	78	13	4	34	59	3
36	Burns Creek	89	11	0	0	96	0	4	0
38	Pine Creek	91	9	0	0	98	2	0	0
39	Pine Creek	84	13	3	0	100	0	0	0
40	Pine Creek	97	3	0	0	87	12	1	0
41	Pine Creek	83	14	2	0	94	6	0	0
48	Bear Creek	100	0	0	0	94	5	0	1
49	Elk Creek	96	4	0	0	92	8	0	0
51	Big Elk Creek	12	44	36	8	4	11	62	24
52	McCoy Creek	93	6	0	1	80	16	4	1
53	McCoy Creek	95	5	0	0	93	5	2	0
54	McCoy Creek	94	6	0	0	91	8	1	0
56	Fish Creek	100	0	0	0	46	53	1	0
58	Barnes Creek	88	13	0	0	93	7	0	0
60	Clear Creek	93	7	0	0	95	5	0	0
61	Iowa Creek	96	4	0	0	100	0	0	0
63	Tincup Creek	88	12	0	0	42	47	11	0
64	Tincup Creek	93	7	0	0	80	17	3	0
65	Tincup Creek	97	3	0	0	81	14	5	0
67	Stump Creek	86	13	1	0	67	30	2	0
68	Horse Creek	86	14	0	0	90	10	0	0
70	Crow Creek	78	22	0	0	83	17	0	0
71	Sage Creek	72	28	0	0	34	64	2	0
72	Deer Creek	80	18	2	0	80	19	1	0
	Teton River drainage								
74	Teton River	45	43	8	5	2	40	39	19
75	Teton River	42	51	5	2	4	15	56	26
76	Teton River	50	43	6	1	9	20	50	22
77	Teton River	53	42	4	1	16	41	32	11
	AVERAGE	74.0	15.9	7.5	2.6	66.2	17.7	11.8	4.2

The number of sites that contained rainbow trout and hybrids rose from 23 to 37, but the average proportion of the catch composed of rainbow trout and hybrids did not increase (7% in 1980s and 7% in 1999-2000). Results from this study indicate that YCT abundance and size structure in Idaho remained relatively stable at a large number of locations over a recent 10-20 year period. The expanding distribution of rainbow trout and hybrids in portions of the upper Snake River basin, however, emphasized the need for additional monitoring and management actions.

YCT Genetics in Idaho

Genetic studies on YCT to date have focused on assessing 1) the extent of hybridization in populations of YCT in the Upper Snake River Basin; and 2) YCT genetic diversity and population structure; and 3) the level to which fragmentation of YCT populations has influenced current genetic population structure.

YCT Hybridization

For more detailed explanations of efforts to assess the extent of YCT hybridization in Idaho, see Meyer and Lamansky (2005) and Meyer et al. (2006). Essentially, an assessment of hybridization was made visually at each of the study sites used to estimate population abundance within YCT GMUs (see YCT Abundance in Idaho section above). A simple calculation was made of the proportion of rainbow trout and hybrids captured to the total number of *Oncorhynchus* captured, based on phenotypic characteristics. YCT were considered pure when the fish 1) had red throat slashes, 2) lacked white margins on the pelvic fins, 3) lacked a red band of color along the lateral line, and 4) contained fewer, larger spots concentrated posterior (Meyer et al. 2003a). Any fish in the genus *Oncorhynchus* that had white fin margins, numerous spots toward the anterior of the body (especially the head area), and/or had no or a faint red slash on the throat were pooled into a category of rainbow trout and hybrids.

To check the accuracy of the visual assessment of hybridization, we collected fin clips randomly from individuals of the genus *Oncorhynchus* at all study sites where YCT were encountered, and selected 52 study sites for genetic hybridization analysis based on 1) whether there were roughly 30 fin clips available to analyze, and 2) the study design of the genetic population structure study. The level of rainbow trout introgression occurring at these study sites was assessed genetically using three codominant nuclear DNA markers (RAG3', Occ38, and Occ42) diagnostic between rainbow trout and cutthroat trout (Baker et al. 2002; Ostberg and Rodriguez 2002).

The level of hybridization and introgression at a study site was calculated two ways. To compare with our visual assessment, hybridization was calculated as the proportion of *Oncorhynchus* samples that contained at least one rainbow trout allele. However, for a more accurate look at population-level rates of introgression, we also calculated the percentage of rainbow trout alleles observed out of the total number of alleles examined (the allele level). Our sample size objective of 30 fish per site gave us 84% confidence in detecting 1% hybridization, or 99% confidence of detecting 5% hybridization. We assessed the amount of agreement we achieved between methods, and at study sites where both phenotypic and genotypic introgression were detected, we compared the estimates of the percentage of the population that were hybrids with a correlation coefficient.

Our results indicated high concordance between phenotypic (i.e., visual) and genetic identification of hybridization. Phenotypic identification correctly classified the presence or absence of hybrids in 43 of the 51 sites genetically tested (Table 9). At seven sites of the eight

Table 9. Comparison of the proportion of Yellowstone cutthroat trout (YCT), rainbow trout (RBT), and their hybrids (HYB) at 51 study sites in the Upper Snake River Basin in Idaho, based on morphological and molecular DNA analyses, and subsequent percent genetic introgression.

		Morphological fish identification				Molecular DNA fish identification				Percent genetic
		No. of	Percent:			No. of	Percent:			intro-
GMU	Study site	fish	YCT	RBT	HYB	alleles	YCT	RBT	HYB	gression
Blackfoot River	Miner Creek	71	100	0	0	182	100	0	0	0
Dry Creek	East Fork Dry Creek	30	100	0	0	174	100	0	0	0
Goose Creek	Ecklund Creek	31	100	0	0	182	100	0	0	0
Palisades/Salt River	Barnes Creek	48	100	0	0	180	100	0	0	0
Palisades/Salt River	Big Elk Creek	30	100	0	0	122	100	0	0	0
Palisades/Salt River	Clear Creek	42	100	0	0	244	100	0	0	0
Palisades/Salt River	Crow Creek	84	100	0	0	246	100	0	0	0
Palisades/Salt River	Fish Creek	168	100	0	0	248	100	0	0	0
Palisades/Salt River	Horse Creek	80	100	0	0	248	100	0	0	0
Palisades/Salt River	McCoy Creek	119	100	0	0	234	100	0	0	0
Palisades/Salt River	South Fork Tincup Creek	31	100	0	0	244	100	0	0	0
Palisades/Salt River	Tincup Creek	69	100	0	0	246	100	0	0	0
Portneuf River	Bell Marsh Creek	31	100	0	0	176	100	0	0	0
Portneuf River	Gibson Jack Creek	31	100	0	0	168	100	0	0	0
Portneuf River	Goodenough Creek	31	100	0	0	176	100	0	0	0
Portneuf River	Harkness Creek	31	100	0	0	248	100	0	0	0
Portneuf River	Inman Creek	34	100	0	0	186	100	0	0	0
Portneuf River	Robbers Roost Creek	31	100	0	0	246	100	0	0	0
Raft River	Almo Creek	23	100	0	0	184	100	0	0	0
Raft River	Cottonwood Creek	39	100	0	0	172	100	0	0	0
Raft River	Eightmile Creek	20	100	0	0	80	100	0	0	0
Raft River	Green Creek	31	100	0	0	174	100	0	0	0
Raft River	New Canyon Creek	30	100	0	0	180	100	0	0	0
South Fork Snake River	Corral Canyon	29	100	0	0	174	100	0	0	0
South Fork Snake River	Garden Creek	28	100	0	0	166	100	0	0	0
South Fork Snake River	North Fork Palisades Creek	30	100	0	0	104	100	0	0	0
South Fork Snake River	North Fork Rainey Creek	31	100	0	0	182	100	0	0	0
South Fork Snake River	Palisades Creek	109	100	0	0	246	100	0	0	0
Willow Creek	Lava Creek	31	100	0	0	184	100	0	0	0
Willow Creek	Mill Creek	28	100	0	0	184	100	0	0	0
Willow Creek	Sellars Creek	31	100	0	0	224	100	0	0	0
Willow Creek	South Fork Sellars Creek	24	100	0	0	156	100	0	0	0
Willow Creek	Willow Creek	31	100	0	0	288	100	0	0	0
Teton River	North Moody Creek	34	100	0	0	176	97	0	3	<1
Portneuf River	North Fork Rapid Creek	56	100	0	0	186	97	0	3	<1
Teton River	Mike Harris Creek	92	100	0	0	188	97	0	3	<1
South Fork Snake River	Fall Creek	54	100	0	0	186	94	0	6	1
Teton River	South Fork Badger Creek	74	100	0	0	176	94	0	6	1
Sinks drainages	Middle Dry Creek	66	100	0	0	184	87	0	13	3
Portneuf River	North Fork Pebble Creek	24	100	0	0	92	96	0	4	3
Bannock/Rock creeks	Midnight Creek	94	100	0	0	204	60	0	40	23
Portneuf River	Big Springs Creek	108	98	0	2	192	94	0	6	2
Blackfoot River	Lower Blackfoot River	249	96	2	2	170	97	3	0	3
Blackfoot River	Timothy Creek	104	95	1	4	156	70	0	30	14
Portneuf River	Webb Creek	35	91	6	3	178	58	0	42	19
South Fork Snake River	Burns Creek	116	91	3	5	182	94	0	6	3
Portneuf River	Rapid Creek	80	88	0	13	190	76	3	21	17
Blackfoot River	Rawlins Creek	170	87	1	12	164	94	0	6	6
Teton River	Teton River	229	82	12	6	226	74	13	13	6
Blackfoot River	Blackfoot River	213	68	15	18	94	75	0	25	10
Portneuf River	Middle Fork Toponce Creek	29	45	7	48	156	3	10	87	42

sites where morphological identification failed to correctly identify the presence of rainbow trout, hybrids, or both, rainbow trout introgression was 3% or less. The remaining site (Midnight Creek) that was incorrectly classified as pure YCT contained mostly (90%) juvenile fish (< less than 100 mm), making morphological assessments difficult. Of the 11 sites where hybridization was detected both phenotypically and genotypically, phenotypic and genotypic rates of introgression were positively correlated (correlation coefficient $r = 0.80$).

We assumed that the strong agreement we found between our phenotypic characterization of hybridization and the subsequent results obtained from genetic analyses would allow us to characterize hybridization based on phenotypic characteristics throughout the rest of the Upper Snake River Basin where genetic analysis were not available. Subsequently, within the 10 GMUs where YCT were present and abundance estimates were made, YCT were classified phenotypically as "pure" at 341 (81%) out of the 420 study sites where they were found, and "≥ 90% pure" at 379 sites (90%) (Table 10). Among these 10 GMUs, hybridization was proportionally most common in the Portneuf River (21 of 47 sites) and Blackfoot River (19 of 45 sites) drainages, least common in the Palisades/Salt (7 of 148 sites), Raft River (6 of 35 sites), and Teton River (8 of 45 sites) drainages, and completely absent in the Willow Creek (0 of 21 sites) and Dry Creek (0 of 3 sites) drainages. Average phenotypic hybridization of YCT among all study sites within these GMUs was 5% (Table 10).

In addition to this more recent genetic analysis, IDFG previously assessed YCT hybridization at a number of other locations (Table 11). Methods for determining hybridization were similar to those above.

Taken together, there seemed to be no pattern to where or how much introgression was found. For example, the Blackfoot River (including the reservoir) has received about 25,000 catchable equivalents (CEQ) (see section on Stocking below) annually of rainbow trout for many years, yet in 1997, no introgression was found. However, another sample taken later found 25% introgression. The extent that this hybridization has spread throughout the GMU remains unclear. North Fork Pebble Creek had no introgression although Pebble Creek has been stocked most years with about 1,000 CEQ of rainbow trout until 1992. In three tributaries to Henrys Lake—Targhee Creek, Howard Creek, and Duck Creek—only Henrys Lake cutthroat have been stocked, but all three YCT populations are introgressed with rainbow trout (22%, 12%, and 2%, respectively). No pure rainbow trout have been stocked in Henrys Lake since about 1982. Only hybrids and Henrys Lake YCT have been stocked. Fertile hybrids were stocked until 1998, and sterile hybrids have been planted since then.

No introgression was found in any of the samples taken from the Palisades/Salt GMU, but there has been no stocking of rainbow trout in any of the streams tested. Crow, Horse, and McCoy creeks were all stocked with cutthroat trout, but they were apparently not the Henrys Lake strain. On the Raft River, Sixmile Creek was 100% introgressed, whereas Eightmile Creek and Almo Creek were 0% introgressed. None has received stocked rainbow trout from the IDFG. One of nine YCT sampled on Big Cottonwood Creek had identifiable rainbow trout genes, yet it has not been stocked with rainbow trout since 1988. However, Goose Creek, which also has 0% introgression, received about 5,000 CEQ annually of rainbow trout through 1989. Big Cottonwood Creek no longer flows into Goose Creek due to dewatering from irrigation demands, and Goose Creek downstream of Oakley Reservoir is no longer considered a stream by the Idaho of Water Resources. None of the sites sampled on Willow Creek demonstrated any introgression, although Grays Lake Outlet and Mill Creek were stocked with rainbow trout in the late 1960s.

Table 10. Summary of YCT phenotypic hybridization at study sites in the Upper Snake River Basin within GMUs where YCT were widely distributed.

GMU	Sites with YCT	Sites where YCT are: > 90% pure	Pure	Percent hybridization at YCT sites: Mean	Range
Sinks drainage	10	6	5	31.7	0-93
Teton River	45	40	37	6.2	0-98
Palisades/Salt	148	147	142	0.2	0-1
South Fork Snake River	46	43	36	3.2	0-57
Willow Creek	21	21	21	0.0	
Blackfoot River	45	38	26	4.8	0-59
Portneuf River	47	34	26	11.6	0-81
Raft River	35	30	29	11.8	0-94
Goose Creek	20	17	16	9.1	0-79
Dry Creek	3	3	3	0.0	

Table 11. Estimates of YCT hybridization at 18 additional locations in the Upper Snake River Basin (adapted from IDFG 2000).

GMU	Study site	Year	N	Percent RT/HY by fish
Henry's Lake	Duck Creek	1998	60	2
Henry's Lake	Howard Creek	1998	60	12
Henry's Lake	Targhee Creek	1998	60	22
Henry's Lake	Tyghee Creek	1999	60	0
Palisades/Salt River	Jensen Creek	1999	30	0
Palisades/Salt River	Squaw Creek	1999	27	4
South Fork Snake River	Palisades	1999	43	0
South Fork Snake River	Pine Creek	1999	48	23
South Fork Snake River	Pritchard Creek	1999	48	2
Willow Creek	Grays Lake Outlet	1999	6	0
Willow Creek	Homer Creek	1999	4	0
Willow Creek	Tex Creek	1999	10	0
Blackfoot River	Blackfoot River	1997	42	0
Blackfoot River	Blackfoot River	2000	22	68
Portneuf River	Big Springs Creek	1999	48	4
Raft River	Sixmile Creek	1999	20	100
Goose/Big Cottonwood/Dry creeks	Big Cottonwood Creek	1999	9	11
Goose/Big Cottonwood/Dry creeks	Goose Creek	1999	37	0

Thus, it seems that introgression is site-dependent and to some extent unpredictable. Stocking fertile rainbow trout in YCT streams does not ensure that introgression will occur. Even if the IDFG has not stocked fertile rainbow trout in particular YCT water does not guarantee that there will be no introgression due to migration from elsewhere in a drainage or incidental transfer of rainbow trout.

May et al. (2003) recommended a 25% level of introgression as the maximum that would categorize the individual fish as "pure." May et al. (2003) also raised the issue of genetic risk but were unable to define it clearly. Essentially, they were attempting to estimate the risk to the population under consideration of having a level of introgression > 25%. However, they did not indicate how that risk level should be assessed. Utah Division of Wildlife Resources (2000), on the other hand, indicates that "in general" core populations should have < 1% introgression and conservation populations should have no more than 10% introgression.

YCT Diversity and Population Structure

In addition to the level of introgression, another measure of genetic integrity of a population is heterozygosity. Maintenance of heterozygosity (H) is a function of selection, mutation, number of breeding individuals, and rates of immigration, among other things. Wright (1969) showed that under ideal conditions (random mating, equal sex ratio, etc.) loss of heterozygosity per generation was equal to $1/(2N_e)$, where N_e is the number of breeding adults. For example, if the number of breeding adults in a stream is 100, the loss of H per generation is 0.5%. In addition, where N_e is low and where there is no immigration, the population may suffer from inbreeding depression. Therefore, for long-term maintenance of naturally breeding YCT populations, it is essential to ensure either that N remains high, or where it is low, that some immigration of new individuals is ensured. Thus, for each population, we would ideally know H and the effective population size (N_e) as well as levels of migration.

If N_e is known, it will allow estimation of loss of genetic diversity through the formula $H_t = H_0 \cdot [1 - (1/2\ N_e)]^t$ (Crow and Kimura 1970). Unfortunately, N_e is often not easy to estimate because of incomplete or uncertain population data. Hedrick (2000) calculated the ratio between N_e and N for Sacramento River Chinook salmon and found it to be 1.21 and 0.51 in 1994 and 1995, respectively. In general, however, the ratio seems to vary from about 0.2 to 0.5 (Mace and Lande 1991). Rieman and Allendorf (2001) estimated N_e for bull trout (*Salvelinus confluentus)*, by the formula:

$$N_e = (1/2)*(1-e^{\log eHt/t}).$$

where H_t is heterozygosity at time *t*. They then simulated change in heterozygosity over 200 years. For bull trout, they found that it took about 500 breeding adults in order to maintain close to 100% of the heterozygosity for a period of 200 years. They also demonstrated that variability of heterozygosity (due to genetic drift) decreased markedly as the number of adults approached 500, especially when environmental variability was not taken into account. Unfortunately, there is little information in the scientific literature or in reports on heterozygosity in YCT. Allendorf and Leary (1988) reported total genetic diversity in YCT to be 0.014 and average gene diversity to be 0.013. Allozyme data generally reveals lower levels of diversity compared to microsatellite data and may underestimate estimates of N_e and population status.

Gene flow is also an important consideration because isolated populations will lose genetic diversity at a greater rate. Understanding patterns of gene flow can also guide management by determining the spatial scale at which reproductively isolated populations exist. For example, a GMU may contain many populations that do not exchange migrants with other populations and would be managed independently from one another or may contain one large demographic population that would be managed at a larger scale. This information can more accurately estimate population abundance and status since it defines the scale of a population and helps determine isolated populations in need of genetic augmentation, candidate source populations for translocation, and the probability of natural recolonization in fragmented habitats. Given the importance of these genetic matters, IDFG has initiated a comprehensive evaluation of genetic diversity and gene flow using both mitochondrial and nuclear microsatellite DNA to identify the proper scale for management as well as to understand the extent of isolation and gene flow of populations in more fragmented habitats. For a more detailed analysis of genetic diversity and genetic population structure of YCT, see Cegelski et al. (2006).

For the nuclear DNA analysis of YCT, 1,330 samples were analyzed with six microsatellite loci representing 45 populations within 11 GMUs in the Upper Snake River Basin. Results of this study suggest that genetic diversity is strongly partitioned among the drainages. A neighbor-joining tree based on Cavalli-Sforza and Edward's (1967) genetic distance estimates strongly clustered populations according to the drainage in which they were sampled and indicated that no current gene flow was apparent among the drainages (Figure 20).

Additionally, results of an analysis of molecular variance (AMOVA) suggest that genetic diversity of YCT may be even more finely partitioned at the stream level. Although a significant portion of the diversity was partitioned among drainages (8%), the greatest amount of diversity was partitioned among populations (81%). This indicates that most drainages can be divided into several reproductively isolated populations of YCT. However, levels of genetic differentiation varied extensively and this conclusion was not applicable to all of the sampled drainages (Table 12). One notable exception was in the Salt River drainage, where F_{ST} estimates indicated substantial gene flow among the eight geographic locations sampled. The Salt River drainage is representative of the least impacted migration corridors in Idaho and had the lowest levels of genetic differentiation of those surveyed. High levels of gene flow were also evident among the sampled populations in the Blackfoot River and Willow Creek basins. Therefore, these data support the concept that YCT are structured at a drainage level within high-quality habitat as originally proposed by Allendorf and Leary (1988) and that a major drainage may naturally constitute a single population.

Lower levels of gene flow were found among populations in areas where the habitat was more degraded (Table 13) and geographic barriers were present. This was mainly seen in portions of the South Fork Snake River and Teton River drainages and throughout the Portneuf River and Raft River drainages. This indicates that habitat fragmentation has significantly altered drainage-level structuring and has led to reduced gene flow among populations. Geographic barriers can include both natural (e.g., waterfalls) and anthropogenic structures (large dams, water diversions, culverts, habitat degradation) and act similarly in promoting genetic differentiation by preventing upstream migration (Neville et al. in press). In the Upper Snake River Basin, some or all of these types of barriers are interacting to limit gene flow among YCT populations. In the Teton River drainage, a hydroelectric dam (Felt Dam) may seasonally impede upstream migration to Mike Harris Creek and Mahogany Creek from the other sampled populations. Water diversions present in both of these streams limit connectivity as well.

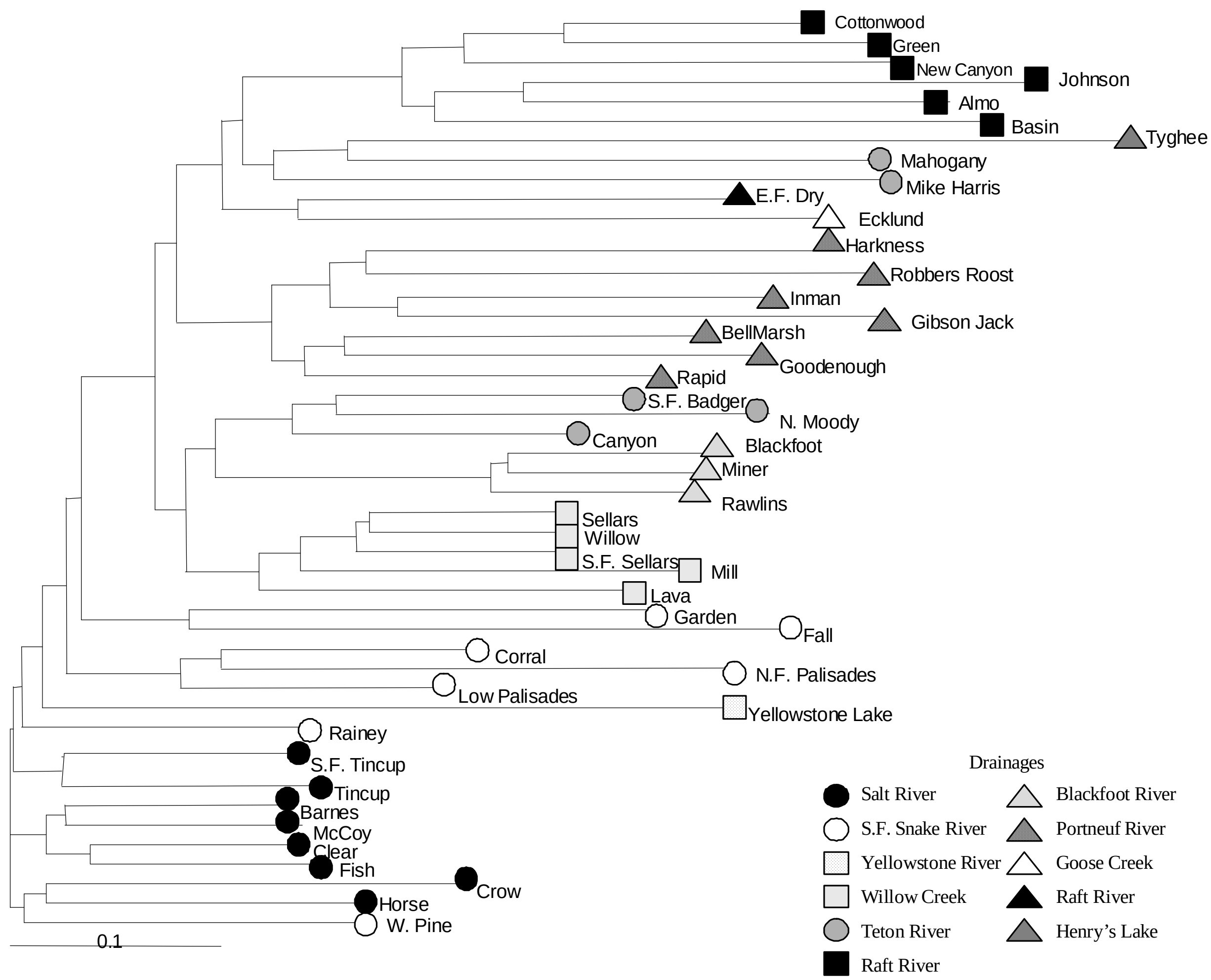


Figure 20. Neighbor-joining dendrogram (unrooted) of the genetic relationships among 45 Yellowstone cutthroat trout populations based on Cavalli-Sforza and Edward's (1967) chord distance. Symbols correspond to drainage location (GMU) listed in Table 11. Numbers at branch points represent bootstrap percentages from 1000 replicates. Bootstrap values greater than 50% are presented.

Table 12. Average levels of genetic differentiation for Yellowstone cutthroat trout populations sampled in each drainage (GMU) measured by F_{ST}, range of pairwise F_{ST} estimates observed, and range of geographic distance separating populations within drainages. Hydrologic integrity values are listed for each drainage as reported by Van Kirk and Benjamin (2001).

	Drainage						
Parameter	Blackfoot River	Portneuf River	Raft River	Salt River	South Fork Snake River	Teton River	Willow Creek
Average F_{ST}	0.008	0.15	0.18	0.02	0.1	0.21	0.01
Range of F_{ST}	0.00 - 0.01	0.05 - 0.23	0.06 - 0.29	0.0 - 07	0.02 - 0.19	0.01 - 0.29	0.0 - 0.06
Distance among sites	13 – 33 km	9 - 58 km	10 -142 km	8 -140 km	7 – 61 km	37 -214 km	6 -64 km

Table 13. Sample locations within Geographic Management Units (GMUs), collection year, and sample size (N) for YCT populations in Idaho along with genetic diversity estimates across six loci. H_e is average expected heterozygosity; A is average number of alleles; R_t = average allelic richness.

GMU	Location	Year	N	He	A	Rt
Henry's Fork Snake River	Tyghee Creek	1999	24	0.38	2.67	2.58
Teton River	N. Moody Creek	2000	30	0.64	4.83	4.39
Teton River	Canyon Creek	1999	30	0.65	8.17	6.96
Teton River	S.F. Badger Creek	2000	29	0.73	7	6.25
Teton River	Mahogany Creek	2000	31	0.55	3.67	3.45
Teton River	Mike Harris Creek	2000	30	0.58	5.33	4.51
South Fork Snake River	Garden Creek	2002	28	0.6	5.5	4.91
South Fork Snake River	Fall Creek	2000	29	0.5	5	4.31
South Fork Snake River	W. Pine Creek	2000	25	0.81	9	8.12
South Fork Snake River	N.F. Rainey Creek	1999	31	0.76	9	8.04
South Fork Snake River	low Palisades Creek	2002	31	0.74	7.83	6.67
South Fork Snake River	N.F. Palisades Creek	2002	23	0.59	4	3.92
South Fork Snake River	Corral Canyon	2002	29	0.74	6.5	6.16
Palisades/Salt River	McCoy Creek	2000	31	0.74	9.83	8.36
Palisades/Salt River	Fish Creek	1999	31	0.78	8.67	7.44
Palisades/Salt River	Barnes Creek	2000	31	0.76	9.67	8.08
Palisades/Salt River	Clear Creek	2000	31	0.72	9.5	8.08
Palisades/Salt River	Tincup Creek	2000	31	0.77	9.67	8.29
Palisades/Salt River	S.F. Tincup Creek	1999	31	0.76	9.67	7.9
Palisades/Salt River	Horse Creek	2000	31	0.76	8.83	7.67
Palisades/Salt River	Crow Creek	2000	31	0.73	8.17	6.93
Willow Creek	Willow Creek	1999	31	0.72	7.83	6.94
Willow Creek	Mill Creek	1999	26	0.68	7.17	6.29
Willow Creek	Sellars Creek	1999	31	0.73	8.33	7.05
Willow Creek	S.F. Sellars Creek	2001	30	0.75	9	7.78
Willow Creek	Lava Creek	1999	31	0.73	6.83	5.91
Blackfoot River	Miner Creek	2000	31	0.61	6.17	5.39
Blackfoot River	Rawlins Creek	2000	29	0.64	6.17	5.5
Blackfoot River	Blackfoot Creek	1999	30	0.6	6.5	5.69
Portneuf River	Gibson Jack Creek	2003	29	0.61	5.67	5.04
Portneuf River	Bell Marsh Creek	2000	31	0.68	7.83	6.9
Portneuf River	Goodenough Creek	2003	31	0.67	6.17	5.19
Portneuf River	Rapid Creek	2000	30	0.65	8.67	7.41
Portneuf River	Inman Creek	2000	30	0.72	7.17	6.34
Portneuf River	Robbers Roost Creek	2000	31	0.67	6.17	5.38
Portneuf River	Harkness Creek	2003	30	0.73	6.33	5.84
Raft River	Cottonwood Creek	2001	30	0.69	6	5.45
Raft River	Green Creek	2001	30	0.64	6	5.36
Raft River	New Canyon Creek	2001	30	0.49	4.5	3.87
Raft River	Almo Creek	1999	24	0.47	3.5	3.35
Raft River	Johnson Creek	2001	31	0.45	4.17	3.69
Raft River	Basin Creek	2001	30	0.64	4.83	4.54
Goose/Big Cottonwood/Dry creeks	Ecklund Creek	2001	31	0.62	6.67	5.62
Goose/Big Cottonwood/Dry creeks	E.F. Dry Creek	2003	31	0.66	6	5.31
Yellowstone River	Yellowstone Lake	2000	24	0.67	7.83	6.99

The YCT population in North Moody Creek resides above a waterfall and an impassable irrigation diversion and is isolated from the rest of the Teton River drainage. In the South Fork Snake River drainage, Garden Creek is isolated due to water diversions and habitat degradation, while the population in Fall Creek resides above a major waterfall. The lower end of Rainey Creek in the South Fork Snake River drainage is diverted and movement between Rainey Creek and other populations may only occur during high water years. Habitat degradation and water diversions also disconnect all of the sampled tributaries in the Portneuf River and Raft River drainages from the main river corridors. Our genetic data confirms that these populations are not connected to adjacent populations and the presence of anthropogenic and natural barriers has resulted in reduced gene flow.

Genetic diversity levels appear to be linked to habitat conditions (Tables 12 and 13). The populations in the Salt River, Blackfoot River, and Willow Creek drainages, which appear to exchange more migrants, also have higher levels of diversity compared to populations in the Raft River, Teton River, and Portneuf River drainages that are more isolated. A loss of diversity observed with high levels of differentiation further suggests that gene flow is not large enough to counter the forces of genetic drift and that some populations may be at risk to inbreeding and stochastic influences which may eventually reduce population size without the possibility of natural recolonization.

The data presented in this study reveal several implications for management of YCT. First, populations within all drainages should be identified and prioritized in order to preserve the maximum amount of genetic variation present within the subspecies. Second, where YCT are structured as panmictic units within less fragmented habitats (e.g., Salt River drainage in Idaho); populations can be managed as singular demographic units. However, the designation of discrete demographic units based on a geographic scale is complicated by habitat fragmentation. For un-sampled populations, demographic units should conservatively be identified at the level of individual streams until genetic analyses prove otherwise. Third, the high levels of genetic differentiation and associated low levels of genetic diversity among some populations in the Portneuf River, South Fork Snake River, Teton River, and Raft River drainages suggests that gene flow is limited in degraded habitats and that there is an overall decline in the migratory life-history component. This further emphasizes the importance of connected habitat in promoting natural processes such as gene flow and the expression of all life-history variation. Future management actions may include restorative habitat manipulations and improvements. However, translocations may be a preferable option due to the risks of introducing nonnative trout that have displaced or hybridized with native YCT in other areas. Translocation of fish among major drainages is not recommended due to the large genetic differences observed among drainages, but instead should occur among adjacent populations within drainages when possible. Lastly, the presence of hybrids within some of the populations suggests that hybridization also needs to be evaluated prior to any proposed management action and will also determine which groups of populations or individual populations should be prioritized for near-term management decisions.

Prioritization of populations should also consider population size. A minimum effective population size of 500 individuals may be needed to maintain fitness and buffer against localized extinctions in the long term (Frankham 1980). If this is not biologically possible within isolated, low order streams, and they represent a significant component of the genetic diversity of the species, then management strategies should be developed that include regular genetic monitoring. The data presented in this Plan and other demographic data indicate that many of the sampled populations are small with fewer than 500 adult spawners (K. Meyer, unpublished data), have significantly lower levels of genetic diversity, and are isolated from adjacent populations. Long-term persistence and viability of these small, isolated populations is questionable. Conversely, large populations of fish in the Salt River, Willow Creek, and

Blackfoot River drainages (35,000 to 200,000 spawners; K. Meyer, unpublished data), exhibiting relatively high levels of gene flow, indicate that these local populations will persist as long as habitat conditions are adequate. Such findings, and the implementation of appropriate management actions for these populations, will help ensure the near- and long-term viability of YCT in Idaho.

HABITAT

Thurow et al. (1988), Behnke (1992), Gresswell (1995), and BLF (1998) all provided a rangewide description of YCT habitat requirements and status. Moore et al. (1986) described YCT habitat in the Snake River. LaBolle and Schill (1988) described YCT habitat in general terms in the upper Blackfoot system. Irving (1954) gave an early account of habitat in Henrys Lake. YCT are found in a wide diversity of habitats, from small ponds to reservoirs and large lakes and from first-order streams to large rivers.

Current habitat conditions vary widely. However, streams in upper parts of GMUs typically are in better condition than streams in lower parts of GMUs. This is a function in part of cooler conditions as a result of higher elevations and more shade, partly because of non-proximity relative to agricultural land, and partly because much of the higher land is in federal ownership. No systematic analysis of YCT habitat conditions in Idaho have been made to date. However, K. Meyer of IDFG (personal communication) has measured a number of habitat parameters on nearly 1,000 YCT stream sampling sites over the last several years, and is assessing those parameters.

An extensive body of published scientific literature exists on effects of human-caused disturbance to salmonid habitat (see for example Beschta et al. 1987; Chamberlin et al. 1991; Furniss et al. 1991; Meehan 1991; Sedell and Everest 1991; Frissell 1993; Henjum et al. 1994; McIntosh et al. 1994; Wissmar et al. 1994; U.S. Department of Agriculture and U.S. Department of the Interior 1996; Gresswell 1999; Trombulak and Frissell 2000). Declines in populations of native salmonids including YCT can result from combined effects of habitat degradation and fragmentation, blocked migration corridors, degraded water quality or quantity, angler harvest and poaching, entrainment into diversion canals and dams, non-native species interactions, and other factors (U.S. Fish and Wildlife Service 2002). Examples of land and water management activities that could degrade habitat and depress salmonid populations include dams and other diversion structures, forestry management, livestock grazing, intensive agriculture, road construction and maintenance, mining, and urban/rural landscape development.

The FWS determined that the best scientific and commercial information available indicated that present or threatened destruction, modification, or curtailment of habitat or range has not affected the status of YCT to the extent that listing was warranted under the Endangered Species Act as a threatened or endangered species (U.S. Fish and Wildlife Service 2006).

HISTORY OF ENDANGERED SPECIES ACT ACTIONS

In August 1998, a group of three organizations and one individual submitted a petition requesting that the FWS list YCT as a threatened species under the Endangered Species Act (BLF 1998). For the Idaho portion of the subspecies, they believed that the threats included hybridization, habitat degradation, especially dewatering and sedimentation from erosion, and fragmentation. For the subspecies as a whole, they summarized the threats as stocking, angling pressure, habitat degradation and fragmentation, whirling disease, and the New Zealand mud snail (BLF 1998).

The FWS met with agency representatives from all involved states in August 2000. In October 2000, IDFG provided comments to the FWS (Idaho Department of Fish and Game 2000) and appended additional information to that document with a further submission in November 2000. IDFG responded to the allegations in the original petition by showing that populations in major river systems were well connected with substantial numbers of individuals. IDFG also argued that many pure populations were documented in Idaho and that numerous donor stocks existed in case of local extirpation. Petitioners also listed efforts of the IDFG and other agencies that were ongoing and focused on many of the threats listed in the petition.

On February 23, 2001, the FWS published a finding of not warranted (Federal Register 2001). As their primary reason for rejecting the petition, the FWS stated that the petitioners did not provide substantial information that the subspecies as a whole was declining toward extinction in the near future or that the extinction risk for the subspecies was high. Subsequent to this finding, several environmental organizations filed a complaint alleging the FWS had used the wrong procedures and standards to assess the petition as part of the 90-day finding process. The Court ruled in favor of the plaintiffs (environmental organizations) and ordered the FWS to complete a status review of YCT by February 14, 2006. After a thorough review of all available scientific and commercial information, the FWS found that listing of the YCT as either threatened or endangered is not warranted (Federal Register Doc. 06-1539, Filed 2-17-06).

THREATS

Potential threats to YCT in Idaho have been identified by Thurow et al. (1988) and Gresswell (1995). Other threats identified but not listed in any particular order include genetic introgression with rainbow trout, impoundments, water diversion, road culverts, improper livestock grazing, mineral extraction, angling, and competition with non-native species. Whirling disease has been identified as a more recent potential threat.

Hybridization/Introgression

Because YCT did not evolve with rainbow trout, they did not develop any isolating mechanisms as apparently did the westslope cutthroat trout (Behnke 1992). Thus, when non-native rainbow trout were introduced into YCT habitat, the potential for hybridization or genetic introgression was high. Allendorf and Leary (1988) speculated, “Introgression is the most important factor responsible for the loss of native cutthroat trout populations.” There have been several definitions of what constitutes a “pure” YCT population or individual. They range from having 99% or more YCT genetic materials to having as much as 25% non-YCT genetic materials. Dufek et al. (1999) cited an agreement between the states of Colorado and Wyoming on conservation of Colorado River cutthroat trout, which, while it does not indicate which populations are “pure,” does provide fish managers a way of identifying populations which are priority for preserving genetic material. This issue, more than any other, is the primary driver in ongoing legal actions surrounding a potential listing of YCT under the Endangered Species Act.

Impoundments

As pointed out by Thurow et al. (1988), impoundments present several difficulties for YCT. Perhaps the most obvious effect is increased fragmentation by preventing migration. Most of the dams in the Idaho YCT distribution area do not provide for fish passage. Several dams in Idaho have fish ladders including Felt, Buffalo, Marysville, and the Yellowstone Canal. Unfortunately, we do not know how much the impoundments impacted YCT movement because many of them were built before current assessment tools (e.g., radio telemetry) to study movement were available. In addition, until recently, we did not know the extent of movement of some cutthroat trout populations.

In addition to increased fragmentation and the associated reduction in gene flow, impoundments also change the basic ecological processes and conditions of riverine environments. Some of these effects include: 1) the environment changes from flowing to lacustrine; 2) there is typically an increase in nutrient loading and subsequent eutrophication; 3) sediment is trapped versus transported and deposited; 4) sediment is trapped which creates a benthic structure composed of very fine sediments rather than a more diverse substrate; 5) impoundments cause changes in annual temperature cycles; 6) riparian vegetation communities are inundated; and 7) in many if not most cases, non-native fish species are stocked which may compete either directly or indirectly with YCT.

Major impoundments (those that impede 100% of YCT migration) are found in most of the GMUs: Ashton and Island Park reservoirs on the Henrys Fork, Palisades Reservoir on the South Fork Snake, American Falls Reservoir and Lake Walcott on the mainstem Snake River, Ririe Reservoir on Willow Creek, Blackfoot Reservoir on the Blackfoot River, Chesterfield and Twenty-four Mile reservoirs on the Portneuf, and Oakley Dam on Goose Creek. It is unlikely that the dams holding these impoundments will be removed and equally unlikely that fish passage will be constructed around them. Therefore, other mechanisms of restoring connectivity should be considered where YCT populations would benefit from translocations.

Water Diversions

There are literally hundreds, perhaps thousands, of water diversions throughout YCT habitat in Idaho. The negative effects of irrigation and hydropower water diversions are apparent especially in the lower portion of YCT range (Thurow et al. 1988). The most affected systems include the Teton River, Blackfoot River, Henrys Fork Snake River, Willow Creek, Portneuf River, Raft River, and Goose Creek. All are highly modified in the lower reaches, most have diversion dams that are complete barriers, and several are completely dry in their lower sections for much if not the entire year. Thus, water diversions are also important in causing population fragmentation. Water diversions can lead to entrainment and loss of both adult and juvenile fish into unscreened irrigation ditches or where existing screens are not maintained properly. Periodic cleaning of canals and ditches with herbicides can kill fishes in streams with irrigation return water.

Even where streams inhabited by YCT are not completely dewatered, water storage and diversions can alter natural flow regimes and reduce discharge to the point where the loss of suitable instream habitat is profound and results in significant negative impacts. Moller and Van Kirk (2003) suggest that altered flow regimes in the South Fork Snake River above Heise have caused the recent decline in YCT and the increase in rainbow trout. Below Heise, discharge may drop precipitously. These reduced flows, combined with canal entrainment, can cause substantial mortality of age-0 YCT. Low flows also concentrate fish, which may increase angler catch rates and expose more fish to predators. Low flows may also exacerbate problems caused by warm water temperatures and reduce available food production by reducing the wetted bottom area. A similar problem occurs in the Snake River below American Falls Dam. This river has a mean annual flow of 254 m^3/second (8,957 cubic feet/second) but is reduced to 9.9 m^3/second (350 cubic feet/second) during winter in low precipitation years in order to refill American Falls Reservoir. The Snake River below American Falls Dam is also prone to anchor ice formation, which adversely affects wintering habitat.

Culverts

Improperly placed road culverts impact fish movement and thus can increase watershed fragmentation. The extent of fragmentation caused by barrier road culverts on watershed connectivity throughout the range of YCT in Idaho is unknown. However, improperly placed road culverts, particularly in forested watersheds, are increasingly being identified as significant limiting factors for migratory native salmonids. The types of extensive surveys necessary to assess this potentially important problem have not been conducted in Idaho GMUs.

Mineral Extraction

Several authors have suggested that mineral extraction poses a threat to YCT (e.g., BFR 1998, Gresswell 1995, Thurow et al. 1988, Van Kirk and Hill 2006). Thurow et al. (1988) cite Platts and Martin (1978) as indicating that phosphate mining has caused elevated levels of sedimentation in streams. Thurow (1981) also cites Platts and Partridge (1980) as observing that open pit mining has caused sedimentation and an influx of petroleum products into Angus Creek in the Blackfoot River GMU. A report issued by Van Kirk and Hill (2006) focused on modeling populations of YCT as a function of selenium in fish tissues. The report implied that the Environmental Protection Agency proposed aquatic life criterion for selenium based on fish tissue concentration was not stringent enough and could lead to population level declines of YCT. Selenium is potentially an issue in the Blackfoot River and in the Salt River side of the Palisades/Salt River GMUs, but at this time, there is no information documenting adverse impacts to YCT populations. While selenium poisoning should not be minimized as a threat to conservation populations of YCT in the Blackfoot and Salt River watersheds, it remains a localized threat and would not be expected to cause range-wide losses of YCT conservation populations (FWS 2006, Federal Register, Vol. 71, No. 34, February 21, 2006, p. 8821). The effects of selenium poisoning on YCT trout have been investigated by several scientists and efforts to better define toxicity thresholds continue for this subspecies.

Exploitation

Historically, YCT fell under general trout regulations that started near the beginning of the last century at a 7.4 kg bag limit. Current regulations are much more restrictive and are two fish none < 406 mm or catch and release in many streams (Table 14). There were also several periods or special areas where size restrictions were applied. A slot limit (no fish between 203 mm and 406 mm) was imposed for several years to protect fish until they could spawn at least once.

YCT have provided very important angling opportunities in much of their range. For example, in 1979, about 3,100 YCT were harvested from Blackfoot Reservoir in spite of the fact that 81% of the catch consisted of hatchery-reared rainbow trout (Thurow 1981). In addition, as fishing pressure increased, catch rates declined, in some cases by more than 50%. In Palisades Reservoir, anglers harvested more than 7,500 YCT annually in the mid-1970s (Jeppson 1976). In Henrys Lake, there was an increase in angling pressure of 300% from the 1950s until the 1970s. At the same time, catch rates were down by 50%, harvest rates were up 130%, and mean weight of YCT dropped from 1.2 kg to 0.8 kg.

It is generally agreed that YCT are vulnerable to angling. Schill et al. (1986) showed that in the Yellowstone River below the lake in Yellowstone National Park, individual YCT were captured an average of 9.7 times each year and some were taken several times each day. These fish were released rather than harvested, but where harvest is allowed, angling can

Table 14. Examples of trout regulations in Idaho as they relate to Yellowstone cutthroat trout.

1912	No trout <100 mm; no drugs or explosives; 7.4 kg bag limit, 30 in possession; season closed
1941	Open year-round South Fork Snake; season May 25-Nov 1; 25 fish or 5.6 kg plus one fish
1945	Season May 21 to Nov 15; 20 fish or 5.6 kg plus one; no more than 5 less than 152 mm; South Fork Snake open year round
1947	Season June 4 to Oct 31; 20 fish or 5.6 kg plus one; no more than 5 less than 152 mm; South Fork and parts of Henrys Fork Snake open year round
1948	Season June 4 to Oct 31; South Fork and parts of Henrys Fork Snake open year round; 3.7 kg and one fish, but no more than 20 fish per day or in possession; no more than 5 less than 152 mm; lower S.F. Snake open year round
1950	Season June 4 to Oct. 31; parts of Henrys Fork Snake open year round; South Fork on same season as rest of state; 2.6 kg plus one fish, but no more than 20 fish per day in possession; no more than 5 less than 152 mm
1951	2.6 kg plus one fish, but no more than 15 fish
1953	Mink Creek limit 5 fish
1957	Mink Creek limit same as rest of state
1959	Henrys Fork season June 4 to Sept. 30; parts of mainstem Snake and parts of Henrys Fork open year round; Island Park Reservoir closed
1960	Henrys Fork open all year
1970	Goose Creek open year round below Oakley Dam; Blackfoot River season July 1 to Nov 30; Henrys Lake July 15 to Nov 30; lower Willow Creek open year round
1971	Season May 29 to Nov 30; 2.6 kg plus one and no more than 10 fish
1976	10 fish with no than five > 305 mm and no more than two > 457 mm
1977	Six fish with no more than two > 406 mm
1990	203 mm-406 mm slot in Upper Snake Region on cutthroat; six trout limit, no size restrictions; Blackfoot Reservoir, only hatchery cutthroat
1992	Blackfoot upstream, no bait, none < 457 mm; Magic Valley and Southeast regions, 2 cutthroat, none between 203 mm and 406 mm
1996	Magic Valley and Southeast regions, 2 cutthroat; Portneuf River 2 cutthroat, none < 406 mm; Region 6, 2 cutthroat, none between 203 mm and 406 mm
2000	Upper Snake Region, two cutthroat, none < 406 mm

cause substantial impacts on YCT populations. Moore and Schill (1984) found that annual angling mortality ranged from 0.21 for age-3 YCT to 0.62 for ages 4-7. Moore et al. (1986) indicated that excessive harvest of YCT in areas easily accessible to the public caused their replacement by less-vulnerable species, such as rainbow, brook, and brown trout. Corsi (1986) noted the same phenomenon. In the Willow Creek drainage, "large" fish declined from comprising 20% of the catch to only 4% of the catch and densities of > 200 mm fish declined by nearly an order of magnitude as fishing pressure increased (Moore et al. 1986).

Selective harvest of older, larger fish has led to declines of YCT in the Upper Snake River Basin (Thurow et al. 1988). Moore et al. (1986) stated, "Overexploitation has been identified as the primary limiting factor to increased [YCT] densities" in the South Fork Snake River, Blackfoot River, and Willow Creek. Fortunately, regulation changes can affect a reversal in decreasing numbers and changes in population structure attributed to angling. Moore et al. (1986) found that implementation of a slot limit on YCT led to increases in size of fish caught, on catch rate, and on number of spawners observed. Perhaps the classic case of the effect of angling is on the Yellowstone Lake YCT populations. In the late 1960s, even with a 3-fish limit, there was a substantial deviation from historic ranges of size and catch rates (Gresswell 1995). However, with implementation of a regulation allowing harvest only of fish less than 330 mm, there was a dramatic reversal of that trend.

Competition and Predation

Competition occurs when populations are limited by something (e.g., food, space, mates, spawning habitat). It is rarely demonstrated directly. However, there are several indirect indications that competition is a problem for YCT. As already indicated, two studies alleged that where non-native species have been introduced and where angling pressure is substantial, YCT, which are more vulnerable to angling, may be displaced by these non-natives: brook trout, brown trout, and rainbow trout. While the IDFG documented that YCT were the only salmonid species present in about half the sites we examined from 1999-2003, non-native salmonids appear to have at least in part, played a role in declining YCT abundance elsewhere. Some authors have identified non-native species as one of the greatest threats to cutthroat trout of the Intermountain West (Gresswell 1995; Kruse et al. 2000; Dunham et al. 2004). In the Teton River in Wyoming, YCT have experienced broad declines (Koenig 2005) and reportedly are being replaced by brook trout.

The classic case of non-native species introduction is now in Yellowstone Lake, where lake trout (*Salvelinus namaycush)* were introduced, probably by anglers, in the mid 1990s or earlier (Schullery 1996). Introduced lake trout have resulted in the decline of YCT (Koel et al. 2005). Bioenergetics modeling suggests that an average-sized mature lake trout in Yellowstone Lake will consume 41 cutthroat trout per year (Ruzycki et al. 2003). The National Park Service initiated intensive gill netting to determine the spatial and temporal distribution of lake trout within Yellowstone Lake (Koel et al. 2005). This has led to a long-term lake trout removal effort for the protection of YCT (Mahony and Ruzycki 1997; Bigelow et al. 2003).

Non-native trout like brown trout and brook trout that do not hybridize with YCT undoubtedly have caused historical reductions in the size and distribution of conservation populations of YCT across its range. However, most of these introduced trout populations have been in place for many decades, if not a century or more, and have not caused widespread extirpation of YCT. Although YCT declines appear to be associated with the spread of non-native trout in some watersheds, the causes of YCT population decline often includes multiple ongoing operating factors such as habitat loss, dewatering, etc. Therefore, it is often difficult to determine whether non-native species like brook trout are the cause of YCT decline in such cases or merely a symptom of broader ecosystem disturbances (Rieman et al. 2006).

Additional discussions of interspecific competition can be found in Fausch and White (1981), Rose (1986), Hearn (1987), Fausch (1988) and Allendorf (1988)...

Whirling Disease

The whirling disease organism (*Myxobolus cerebralis*) has been identified in YCT from Yellowstone Lake (Whirling Disease News 2001) as well as from portions of the Upper Snake River drainage (Elle 1998). Elle and Schill (1999) showed that all wild trout fry from Teton Creek were infected with the whirling disease organism and that 60% of these were high-grade infections. Fry from Fox Creek, however, were only 33% infected, with only one fish with a grade-4 infection. Because the fry were too small to be identified to species, researchers were unable to compare rates of natural infection between rainbow trout and YCT. However, in exposure trials of hatchery-produced fry, both rainbow trout and YCT showed >90% infection rates (Hiner 1999). Hedrick et al. (1999) found that cutthroat trout were intermediate in their susceptibility to whirling disease between rainbow trout and bull trout.

Grazing

Thurow et al. (1988) state “livestock grazing impacts are widespread in the upper Snake River basin, particularly in the Blackfoot, Portneuf, South Fork Snake, and Teton rivers; Henrys Lake tributaries; and Willow Creek.” Moeller (1981) indicated that the Willow Creek drainage was among the 20 worst agricultural erosion areas in the nation. Thurow (1981) observed introduction of sediment via improper livestock grazing on several tributaries of the Blackfoot River. He also cited Platts and Partridge (1980) who noted that on two Blackfoot River tributaries, livestock had altered vegetation and bank structure. He also noted that riparian vegetation in some cases was eradicated by herbicide treatment to facilitate grazing.

Livestock grazing has had a substantial impact on portions of Goose Creek, Raft River, Rock Creek, and Bannock Creek. In many places, all woody vegetation in the riparian zone has been denuded, and cattle graze in the riparian zone causing sedimentation, nutrient inputs, and further loss of riparian vegetation.

Fish Stocking

To compare stocking rates when stocking size categories varied, LeBar and Frew (2004) converted all salmonid and whitefish from pounds stocked to a standard unit called a catchable equivalent (CEQ). The IDFG’s management of salmonids has a goal to have each weight unit stocked yield the same number of weight units to the creel. Since the minimum weight of stocked fish when they are available to anglers is about 0.33 lb, they set CEQ to pounds stocked/0.33. We used this standard unit for converting all salmonid stocking that historically occurred in YCT GMUs. For most GMUs, especially those with small numbers of reservoir fisheries, annual stocking rates have decreased since 1968 when the stocking database began (Figures 21 and 22). One exception to this is the Portneuf River, where stocking rate decreased from the 1960s through the 1980s but increased again into the 1990s. In contrast to GMUs with dominant stream habitat, in those with significant reservoir resources, stocking rates have generally increased. For example, in the Snake River, which includes American Falls and Lake Walcott, stocking increased from 216,000 CEQ annually in the late 1960s to 431,000 CEQ in the 1990s (Figure 23). In Henrys Fork, which includes Island Park and Ashton reservoirs, stocking doubled from just over 100,000 CEQ in the late 1960s and 1970s to more than 220,000 CEQ in the 1980s and 1990s (Figure 23). In the Blackfoot River GMU, including Blackfoot Reservoir, although stocking dropped from more than 30,000 CEQ in the 1960s, from the 1970s through the 1990s, stocking increased from about 19,000 to 24,000 CEQ (Figure 23).

In those GMUs with fewer reservoir fisheries, stocking has generally decreased in recent decades (Figure 23). In the Portneuf River GMU, stocking decreased from nearly 60,000 CEQ in the late 1960s to only 20,000 in the 1980s (Figure 23). However, in the 1990s, it increased more than 30% to 27,000 CEQ. The Willow Creek GMU showed the greatest reduction in stocking rates, decreasing steadily from 34,000 CEQ in the late 1960s to only 6,000 in the 1990s (Figure 23).

Rainbow trout have dominated the species stocked in YCT waters. Since the 1960s when rainbow trout were stocked at a rate at least an order of magnitude greater than cutthroat trout. Numbers of brown trout stocked have also increased since the 1960s, but at rates far

Figure 21. Catchable equivalents (CEQ) of salmonids stocked by decade in all YCT watersheds. Data for the 1960's were derived by extrapolating from data for 1968 and 1969. BK-brook trout, BN-brown trout, CT-cutthroat trout, RB-rainbow trout (all forms of *O. mykiss*). No data were available for brook trout for the 1960's.

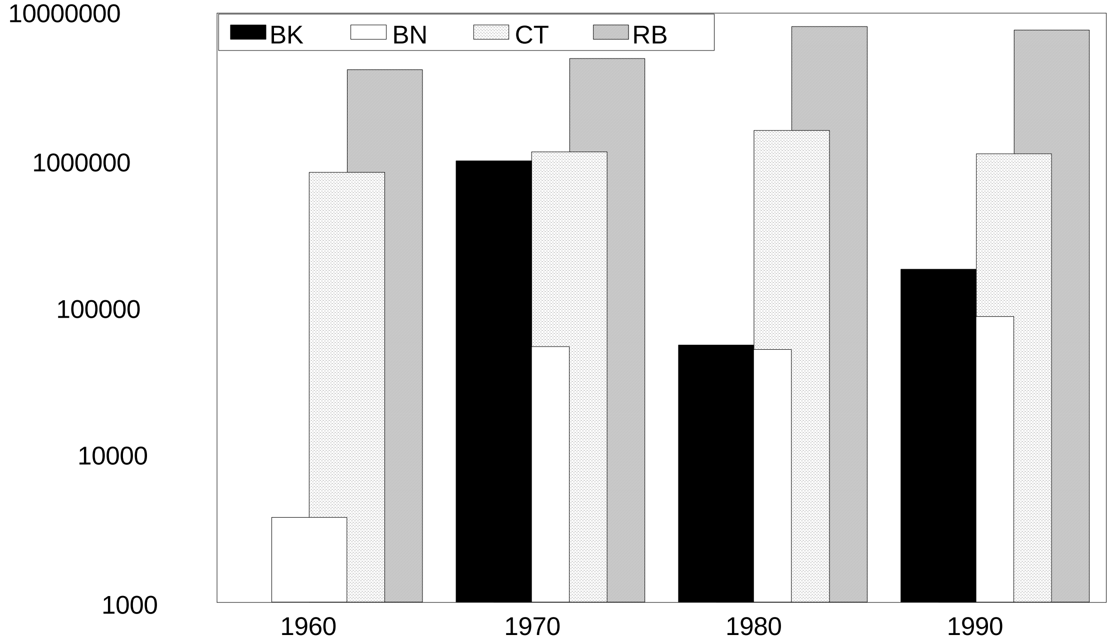


Figure 22. Annual catchable equivalents (CEQ) of all species (rainbow, brook, brown and cutthroat trout) stocked for reservoirs and for streams by decade in YCT range in Idaho.

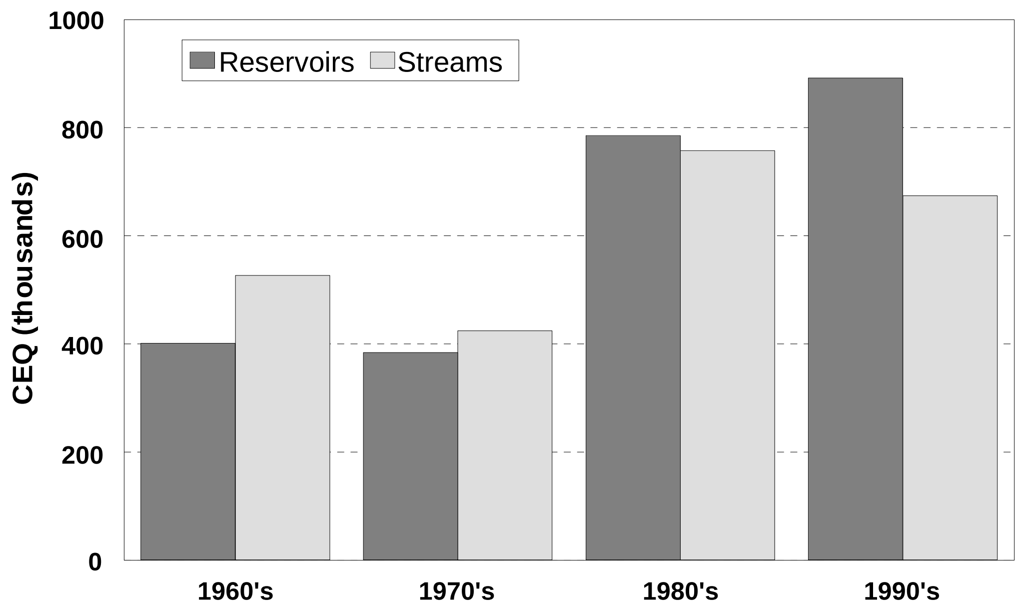
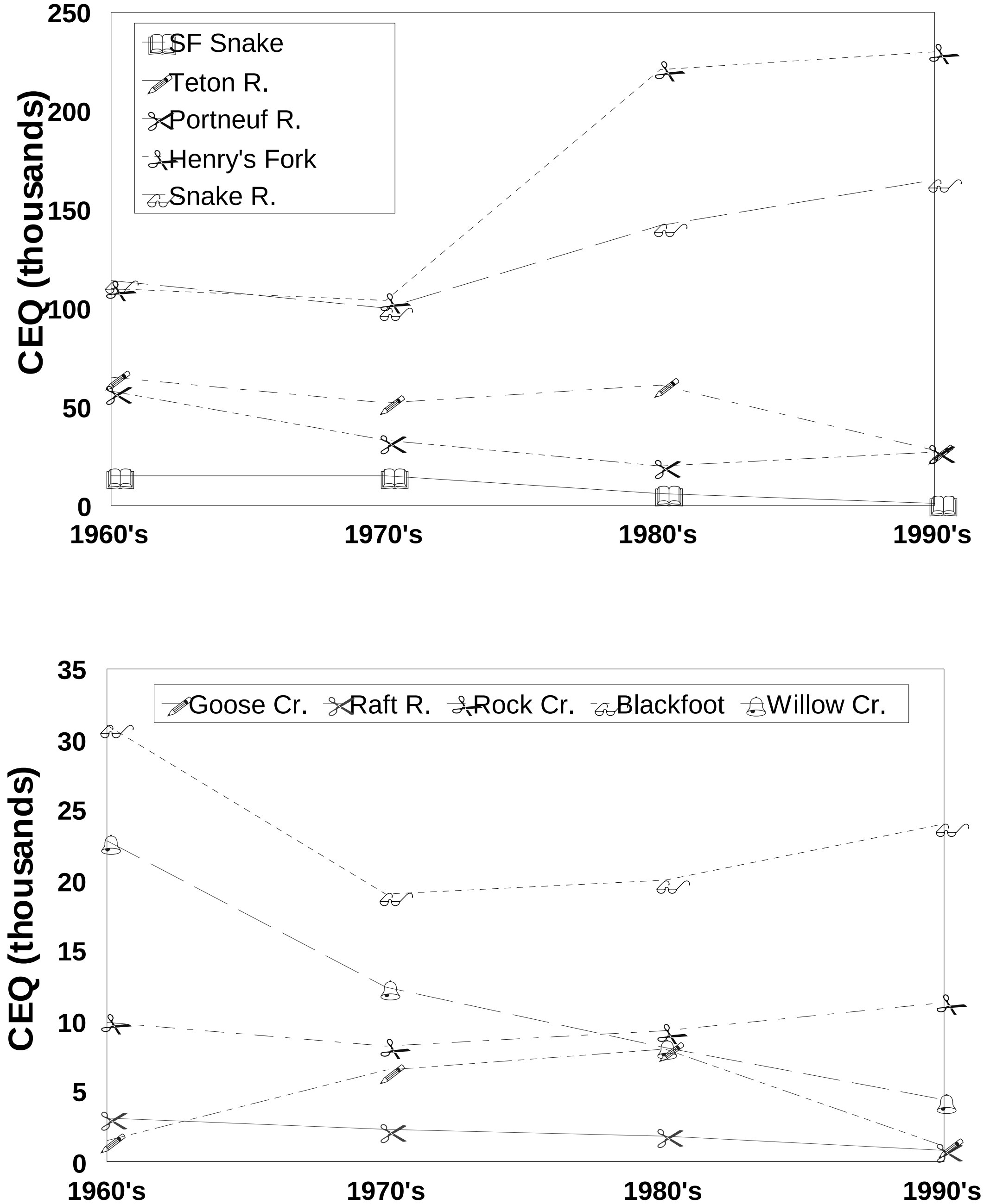


Figure 23. Average annual catchable equivalent (CEQ) stocked of all salmonids combined in each GMU by decade.



lower than for rainbow trout. In the 1990s, brown trout were stocked at a rate of about 87,000 CEQ per year. Statewide, brook trout stocking was eliminated in 1998 except for Henrys Lake.

Stocking in streams has accounted for about 60% of all stocking and of that, 95% is rainbow trout. Cutthroat trout account for only 2% of stream stocking. In reservoirs, 81% of the fish stocked are rainbow trout and 17% are cutthroat. In both habitats, brook and brown trout each make up less than 2% of the fish stocked.

The IDFG discontinued stocking brook trout in 1998 and brown trout in 1999. In addition, IDFG stocking policy changed in 1999 so that only triploid rainbow trout are stocked in waters not indigenous to rainbow trout. For example, in 2000, more than 300,000 triploid fish were stocked in YCT waters such as Island Park Reservoir.

The IDFG's Fisheries Management Plan 2007-2012 states, "hatchery-reared fish will be stocked as appropriate to preserve, establish, or reestablish depleted fish populations and to provide angling opportunity to the general public" (IDFG 2007). The Fisheries Management Plan also indicates that emphasis will be placed on protection and enhancement of native trout, especially through habitat maintenance or improvement and regulation to control harvest. At the same time, IDFG will continue to emphasize catchable programs on streams with good angler access, where return to the creel is good, and where stocked fish do not affect persistence of native fish. Hatchery fish are also used extensively to maintain reservoir fisheries.

In order to maintain catchable trout programs where they are appropriate, introgression risk is being minimized by stocking few waters containing YCT, and in the few that are stocked to provide angler harvest opportunities, catchable rainbow trout are treated via either heat or pressure shock to induce triploidy with resultant high rates of sterility, typically >96% (Dillon et al. 2000). This statewide policy was initiated by the IDFG in 2000.

To minimize the potential for hatchery trout mating with native trout stocks, the IDFG implemented a program to produce and stock only sterile rainbow trout from the hatchery system. To be consistent and to further reduce hybridization risks, we will require stocking fish that have been treated for sterility to be used in private ponds located within drainages where YCT exist.

Although less than 4% of Idaho's stream miles are currently stocked with non-native hatchery trout, there are some locations where hatchery trout can interact with native trout. By applying heat or pressure shock to fertilized eggs, the resultant fish possess three sets of chromosomes (known as a triploid). Triploid trout fish are functionally sterile. Eggs in triploid females never fully mature and triploid males only produce dilute, infertile milt.

At Hayspur Hatchery, the IDFG's only rainbow trout broodstock facility, both heat and pressure shocks are used to induce triploidy. In our most robust assessment of techniques, both methods were determined to be highly effective; however, pressure provided slightly higher mean triploidy induction rates. Both of these treatments are currently being used on all rainbow trout produced at Hayspur.

A monitoring program was developed to ensure that overall triploidy induction rates are precisely estimated each year and monitored over time. From this monitoring program, annual triploidy induction rates have ranged from a low of 94.8 % in 2002 to a high of 97.1 % in 2005, with a mean over the five years of 96.3%. Other species the IDFG is working on to induce triploidy include cutthroat trout.

The IDFG will only stock rainbow trout that have been treated for sterilization where there is a risk to native trout. In a limited number of waters, the IDFG will continue stocking fertile trout where there is no risk to native trout. A small percentage, roughly 3% to 4%, potentially are not sterile since the sterilization process is 95-99% effective. So even with treatment a small number of fertile fish exist.

The IDFG does not stock brook trout in native trout waters, and brook trout harvest was liberalized as well. The exception to this policy is Henrys Lake, where up to 200,000 brook trout continue to be stocked annually; however, for several years no brook trout were stocked. Stocking of brook trout resumed in Henrys Lake in 2003 and they were subsequently showing up in the recreational fishery. IDFG acquired sterile brook trout eggs from Kootenay Hatchery in British Columbia that are raised at the Ashton Hatchery for release as fingerlings beginning in 2006.

<u>Private Ponds</u>

Stocking of private fish ponds with non-native species has been widespread throughout the YCT range. IDFG attempts to regulate this activity have been limited due to social and political concerns over enforcement of fish stocking criteria on private property. Several options have been identified to reduce concerns associated with private pond stocking: 1) educate pond owners on the threats posed by non-native species, 2) prohibit stocking of fertile rainbow trout in YCT GMUs, and 3) pursue additional legislation that prohibits stocking of any water in Idaho with non-native organisms without a valid pond permit or stocking permit, and 4) find a readily available source of sterile fish for private pond owners.

LONG-TERM ASSESSMENT

Long-term assessment of many populations over large landscapes is difficult to sustain. However, as became readily apparent during the review of the YCT petition for ESA listing, it is also extremely important. Therefore, it is imperative that systematic long-term monitoring and assessment is initiated and sustained. As a minimum, four factors should be assessed periodically: habitat quality, population status, connectivity, and genetic introgression.

MANAGEMENT ACTIONS

Along with an ongoing assessment, the IDFG must develop and implement necessary management actions. Although there are many potential management actions, they should focus on achieving the goal of YCT conservation management, i.e., providing for the “long-term persistence of the subspecies, at levels capable of providing angling opportunities” and restoring populations into their historical range where feasible and practical.

The following sections describe some of the suggested actions to achieve the goal of YCT management in Idaho.

<u>Fishing Regulations</u>

In most streams with the potential to grow larger fish, current fishing regulations for YCT are a bag limit of two cutthroat trout with none under 406 mm. The general stream limit of two cutthroat trout applies on many of the smaller streams where fish rarely exceed 305 mm in length, with most fish being less than 200 mm in length, and these streams often have limited angling pressure. In Blackfoot Reservoir, only adipose-clipped YCT can be harvested and some streams are catch and release. In general, fishing rules are protecting the populations with good access and the ability to produce larger cutthroat.

Protective fishing rules that effectively eliminate most harvest will remain on small, depressed YCT populations where angling could limit spawning adults to less than 500 fish. In general, fishing rules will be designed to allow YCT to maintain healthy productive populations within the confines of their habitat limitations.

Fish Stocking

As indicated earlier, stocking has been and is an integral part of the Idaho fisheries management program in YCT habitat. It is difficult to provide a sport fishery for self-sustaining YCT in reservoirs. Many of these reservoirs are dewatered during droughts, and most fish are lost. In reservoirs, 81% of stocked fish are rainbow trout. One of IDFG's guiding principles states that, "fish will be stocked as appropriate to preserve, establish, or reestablish depleted fish populations and to provide angling opportunity to the general public." In addition, non-native species of fish will be introduced only in waters where they are not expected to adversely impact stocks of native fish.

As several authors have pointed out, perhaps the most pervasive threat to YCT is introgression with non-native rainbow trout. In addition, the level of competition for food or space between stocked rainbow trout and native YCT will need continuing analysis. Idaho will continue to stock triploid rainbow trout into areas where angler benefits justify the minimal risk to native salmonids. IDFG will monitor introgression levels in adjoining YCT populations and adjust stocking if needed to maintain or reduce introgression levels.

YCT have largely evolved in stream habitats. Furthermore, it is more likely that habitat restoration or changes in land use practices in streams and watersheds will effect positive changes in YCT fluvial populations than in reservoirs. There is no reason to introduce fertile hatchery-origin YCT or fertile rainbow trout into those areas. Idaho will also explore the opportunities to use triploid YCT to promote the uniqueness of cutthroat fishing in selected waters while maintaining the genetic status of connected populations. Brook trout will not be stocked where they have access to YCT habitat or where there is a possibility of restoration of YCT in the future. This simply reflects current state policy and actions.

One further application of stocking YCT would be to restore YCT populations in streams within the native range by translocating or transferring YCT from another adjacent stream. Translocations will only be done after assessing the level of risk for both the donor population and the receiving population. Where non-native fish can be eliminated and habitat has been restored to the point where it has a high likelihood of being able to support a healthy population of YCT, translocation can be an effective means of restoring cutthroat. Examples would include elimination of brook trout populations in isolated streams where chemical renovation can be done with low risk and at reasonable cost. Evaluation of restoration efforts should become a part of the long-term monitoring and assessment strategies for YCT management.

Restoring Connectivity

It is likely that prior to intensive land and water management in Idaho, YCT had fairly unconstrained access to much of their historical range. There are at least two impassable falls on Henrys Fork Snake River (Upper and Lower Mesa Falls). However, it is certain that YCT had dispersed into streams above those falls prior to their becoming impassable barriers. Similarly, there are probable barriers on Snow Creek, Fish Creek, Dempsey Creek, and the main Portneuf River. However, native YCT are found above each of these barriers. On the main Snake River between American Falls and the South Fork Snake River, although there were seasonal barriers such as at Eagle Rock (Idaho Falls), it is likely that during periods of high water, YCT could ascend them.

Connectivity cannot feasibly be restored to conditions that existed historically. Many large dams and irrigation diversions will remain in place and many large river systems are degraded to the point where habitat and water temperatures will likely prevent fish from utilizing these areas. At best, we can restore connectivity between several populations within a specific drainage and perhaps connect a few major drainages in the future. It is not realistic to believe IDFG and others can restore all historical YCT habitat.

Loss of genetic diversity can lead to inbreeding depression, which may be expressed by lowered fecundity, higher juvenile mortality, reduced growth rates, etc.; i.e., loss of genetic diversity can lead to lowered fitness. However, Caro and Laurenson (1994) challenged this dogma with the example of cheetahs. Cheetahs are essentially genetically monomorphic with only two polymorphisms in 49 allozymes tested. Yet Caro and Laurenson (1994) showed that although there was very high cub mortality, the cause was largely predation by lions and almost no deaths could be linked to genetic defects. They concluded, “Genetic considerations … may only be relevant to free-living populations in limited circumstances because they impact populations on a slower time scale than environmental or demographic problems.” They argued that human disturbance operates at such a rapid time scale that it should be assessed before addressing genetic concerns. However, they cited no evidence from studies of fish populations to support their claim. Therefore, it behooves us to operate in a manner that, while practicable, is conservative relative to the best long-term management of the subspecies.

Idaho is a participant in a multistate position paper on genetic considerations concerning cutthroat trout management (Utah Division of Wildlife Resources 2000). The position paper indicates that cutthroat trout management includes two distinct but equally important components that must be addressed. These components include the conservation element and the sport fishery or recreational fishery element of cutthroat trout management. Further, this position paper indicates that there are two components of cutthroat trout conservation: preservation and management of genetically pure populations (known as core conservation populations) and conservation of populations that may be slightly introgressed but which maintain the appropriate phenotypic characteristics for the subspecies with unique ecological, behavioral, or genetic traits as well (known as conservation populations).

The primary management goal for core populations is to facilitate the long-term persistence of each subspecies in a genetically pure condition. Core populations will serve as the primary sources of gametes for introductions and reintroductions through transplants and broodstock development, and are comprised of individuals that have been determined to be >99% pure from a genetic standpoint, and phenotypically true. For range expansion purposes, care should be taken to utilize only those populations that exhibit desirable population characteristics such as large population size, full representation of age classes, and successful annual reproduction. Potential management options related to the conservation and preservation of core populations may include 1) prevention of all non-native fish stocking or alternately the stocking of only sterile hatchery fish; 2) managing sport fishing and harvest; 3) removal or suppression of non-native competitors; 4) habitat restoration and enhancement; 5) removal of gametes and individuals for genetic founders in range expansion efforts; and 6) collection of gametes for brood stock development.

In order to ensure long-term persistence of core populations, the IDFG will strive to maintain or create metapopulations. High quality habitat is an essential component contributing towards the survival of metapopulations, and optimization of habitat is imperative.

For conservation populations, the primary management goal is to preserve and conserve unique ecological and behavioral characteristics of the subspecies that exist on a population-by-population basis. Conservation populations retain all of the phenotypic attributes associated with the subspecies, although they exist in a slightly introgressed condition. In general, these populations have less than 10% introgression, but introgression may extend to a greater level depending upon circumstances and the values and attributes to be preserved (Utah Division of Wildlife Resources 2000). The unique ecological, behavioral, and genetic attributes may include 1) the presence of fluvial or adfluvial life histories; 2) genetic predisposition for large size; and 3) ecological adaptations to extreme environmental conditions. There is a high probability that certain of these attributes are genetically linked to some degree.

Potential management options for conservation populations are the same for core populations. Conservation populations may be considered as sources for introductions or reintroductions if the objective is to duplicate the unique genetic, ecological, or behavioral attributes. As with core populations, long-term persistence of conservation populations will be enhanced by the development of metapopulations and optimizing habitat conditions. Conservation populations may be targeted for conversion to core populations by eradication of existing fish and reintroduction or genetic replacement.

A third group of fish constitutes the “sportfish” populations. The focus of this group of fish is recreational benefit to the public. Genetic requirements of this group are much less stringent than for core or conservation populations. These populations generally meet the species phenotypic expression defined by morphological and meristic characters of cutthroat trout. Furthermore, either wild or hatchery-enhanced populations can maintain this group. Maintenance of genetic diversity for sportfish populations is secondary to providing a recreational fishery either through natural production or hatchery enhancement where needed.

Genetic research suggests that YCT are naturally structured at the major river drainage level, with relatively low levels of genetic differentiation observed among connected populations due to successful dispersal (gene flow). However, habitat fragmentation has isolated populations in many drainages throughout the species range in Idaho. These alterations can potentially effect the viability of populations if gene flow is reduced by leading to inbreeding, losses in genetic diversity and, ultimately, to local extirpations through stochastic environmental perturbations (Lande 1993). Connectivity should be restored via habitat restoration whenever possible to minimize losses in genetic diversity and to preserve historical processes of gene flow, life history variation, and metapopulation dynamics. However, restoring connectivity may be impossible in some areas, given the realities of water development, extensive habitat fragmentation (Hilderbrand 2002), and invasions by non-natives (Harig et al. 2000). Alternative strategies for reducing extinction risks in small, fragmented populations may include increasing carrying capacity by improving habitat quality and habitat length (Hilderbrand 2003) or by supplementing populations with wild fish from nearby populations and creating artificial migration (Hilderbrand 2002).

Translocation of fish between major drainages is not recommended because of the substantial genetic differences observed between drainages, but instead if necessary, should occur among adjacent populations within drainages. The detection of hybrids within some of the populations suggests that hybridization also needs to be evaluated before any proposed translocation. This will also determine which groups of populations or individual populations are considered viable source or donor populations. Supplementation may be logistically difficult in areas where there are few fish within source populations and may lead to reductions in effective population size and genetic diversity (Ryman and Laikre 1991; Policansky and Magnuson 1998). Because of the risks associated with either restoring connectivity or translocation, a risk assessment should be undertaken to determine appropriate near-term management actions to ensure the genetic viability of YCT.

Management Priorities and Actions

A number of specific management actions for each GMU in the Upper Snake River Basin have been identified for enhancing YCT populations in Idaho. This will be an ongoing assessment and management actions will evolve over time. The IDFG will consider genetic status (core, conservation, or sport fishery populations), the connectivity between populations, the population status, habitat quality, and risks posed by non-native species. Core and conservation populations, because they are the repositories of genetic material for the subspecies, will receive high conservation priority, along with important sport fishery populations. In most cases, current cutthroat trout regulations provide ample protection for YCT populations. However, it is strongly recommended that depressed populations, except those with adequate connectivity, whether core or conservation, should be protected from harvest.

The top priority of IDFG for YCT conservation is habitat protection and enhancement, particularly for core and conservation populations. The IDFG regional fishery managers will work with other agencies and parties to identify and implement habitat enhancement measures across the range of YCT in Idaho. Headquarters staff will assist with identifying funding to assist with cost-sharing in project development and implementation. There are a number of sources of federal funding that can be leveraged to assist with these efforts (e.g. Farm Bill).

Where connectivity can feasibly be restored between populations, it should be done except where it may significantly increase the risks to core populations from non-native species invasions. Where it is not practical to reconnect small, isolated populations, or where establishing connectivity creates a risk of non-native fish invasion, translocations may be considered. For example, because of the factors discussed in the section on stocking, some small, isolated populations (fewer than 500 individuals) may need to receive a minimum of 10 adult YCT from healthy populations in similar habitat once each five years or until connectivity is restored. Monitoring of genetic diversity from streams with these types of transfers compared to streams without any transfers would allow us to assess the success of such an operation. Ideally, the transfers should take place prior to the spawning season and into parts of drainages thought or known to contain spawning adults. The population most at risk from inbreeding depression is probably Eightmile Creek in the Raft River GMU. Other Raft River streams also have small isolated populations.

Decisions on whether to leave a population isolated will be made by examining the overall risk factors to all populations within the drainage and weighing the likelihood of future connectivity against the risks of isolation. Fausch et al. (2006) provide a review of the state of knowledge regarding factors that affect the tradeoff between invasion by non-native salmonids and isolation (from constructed barriers), and present a framework for analyzing and prioritizing conservation actions.

One of the possible management actions for core, connected, depressed populations is limiting upstream movement. Most of the streams falling into this category are on the South Fork Snake River where weirs are in place. Others are in the Palisades/Salt GMU where there are naturalized rainbow trout. Installing upstream migration barriers should only be used on a temporary basis to protect core populations, and then only after a complete genetic inventory of the GMU. Maintaining migratory behavior is likely as important as maintaining introgression levels over the long term.

Supplementing depressed populations is something that will be considered only after very careful analysis of the stocking source to ensure that no rainbow trout alleles are present that could be introduced with those fish. Secondly, the reason for having a depressed population in the first place needs to be addressed for long-term population recovery.

Current IDFG hatchery technology produces triploid rainbow trout that are < 1% viable. Because sport fishery populations are already >10% introgressed, the risk of further genetic impact of the few rainbow trout that are viable and survive to spawn is small. Although stocking of viable or triploid YCT into sport fishery populations is a possibility, because of decreased return to the creel of triploid YCT, triploid rainbow trout will likely be stocked to supplement sport fishery populations where risks are deemed acceptable.

Where there is no genetic information on particular populations, they should be managed conservatively; i.e. where it is suspected that there is no introgression with rainbow trout in the YCT population, it should be managed as a core population until that information is available. Similarly, where introgression is a possibility or likely, the population should be managed as a conservation population until genetic information is obtained.

While conservation actions to benefit YCT populations should be done on a prioritized basis, the IDFG and other partners in YCT restoration should continue to undertake important opportunistic conservation actions (e.g., an opportunity to improve riparian habitat on a section of stream surrounded by privately owned land). The actions proposed in the following GMU-specific sections of the plan are by no means comprehensive, and further opportunities will be sought. Conservation actions and accomplishments by GMU will be updated annually, both to outline actions accomplished and to identify new actions that need to be addressed. Priority rankings are meant only to provide some guidance for the importance of specific management actions within and among GMUs, and are not meant to convey any quantitative value.

Beaver/Camas/Medicine Lodge creeks

This GMU contains a number of sub-populations of YCT, but most are small and isolated, and threatened by non-native salmonids. Recent surveys indicate that, with the exception of isolated populations of YCT in Dry Creek, Patelzick, and Corral creeks, all streams in the GMU contain non-native salmonids. Conservation actions proposed for this GMU are found in Table 15. Of primary importance in this GMU is to eradicate non-native salmonids where they overlap with YCT. Many of these streams become intermittent at their lower reaches, before they connect to other tributaries making it easier to treat the stream to remove the non-natives without risking reinvasion from nearby untreated streams. However, the lower reaches of many of these streams are on private land, potentially complicating chemical treatment. Candidate streams for eradication include East Threemile, West Fork Rattlesnake, East Fork Rattlesnake, West Dry, and Moose creeks, among others. Before decisions are made on eradication projects in some tributaries, we will require more accurate assessments of fish distribution and fish barriers. In the long-term, because of the small size of these populations of YCT, genetic diversity will be monitored and maintained through translocations, if necessary. The IDFG will also need to assess angler tolerance in some instances before suppressing or eradicating non-native salmonids such as brook and rainbow trout since anglers desire these species in many situations.

Table 15. Conservation actions for YCT in the Beaver/Camas/Medicine Lodge creeks GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Medicine Lodge, Beaver, and Camas tributaries	Absent - Present	1	More accurately determine the distribution, abundance, and connectivity of YCT within these drainages.	Ongoing
Medicine Lodge, Beaver, and Camas tributaries	Absent - Present	1	Remove non-native salmonids such as rainbow trout and brook trout from 3 streams in the next 10 years and restore YCT from donor populations (determined from genetic analysis). Stream selection will be based on sampling outlined above.	Short- to long-term
Medicine Lodge, Beaver, and Camas tributaries	Absent - Present	2	Determine genetic purity throughout drainages, and where hybridization occurs, explore whether population-level genetic purity can be increased through selective electrofishing removals of rainbow trout and hybrids.	Short- to long-term
Entire drainage	Present	2	Continue monitoring genetic diversity in small isolated populations.	Long-term
Entire drainage	Present	1	Continue restrictive cutthroat trout harvest regulations to ensure spawner protection	Long-term

Blackfoot River

Although YCT distribution within the Blackfoot River GMU is relatively widespread, so is the presence of non-native salmonids. Few streams within the GMU contain YCT that are isolated from non-native trout. This includes headwater reaches on public land where YCT are more likely to occur. Conservation actions proposed for this GMU are found in Table 16. YCT conservation strategies within the Blackfoot River GMU should focus on controlling non-native trout expansion. Several tributaries below Blackfoot River, such as Rawlins Creek and Miner Creek, have had considerable habitat deterioration and are in need of rehabilitation. Of primary importance to the IDFG is controlling avian predation on the adfluvial Blackfoot River YCT migration run from Blackfoot Reservoir, which has decimated the adfluvial component in recent years. This adversely impacts the recreational fishery for these large sought after fish. Resolving this conflict will involve close coordination internally with wildlife staff and externally with the FWS.

Table 16. Conservation actions for YCT in the Blackfoot River GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Blackfoot River	Present	1	Improve riparian habitat through increased winter flows below Blackfoot Reservoir. Due to water storage rights, increased flows during the storage season (fall through early summer) are unlikely unless Blackfoot Reservoir is predicted to easily refill.	Ongoing
Blackfoot River and tributaries	Present	2	Improve riparian habitat through livestock grazing agreements, riparian fencing projects, and long-term monitoring program.	Ongoing
Blackfoot River	Present	1	Minimize the impact of avian predators on YCT adfluvial spawning migration from Blackfoot Reservoir.	Ongoing
Blackfoot River	Present	2	Determine drainage-wide genetic purity of YCT in the upper Blackfoot River system, and compare to purity of adfluvial spawning migration from Blackfoot Reservoir.	Ongoing
Miners Creek	Present	3	Improve passage over headcut near road crossing with permanent habitat improvement structure or restoration. Funds are available; a landowner agreement is still needed	Short-term
Blackfoot River	Present	2	Monitor the expansion of brook trout throughout the drainage and curtail expansion as needed through chemical and/or other removal methods.	Short- to long-term
Blackfoot River	Present	2	In cooperation with landowner, improve passage over mainstem irrigation dam on Allen Ranch with fish ladder.	Short- to long-term
Entire drainage	Present	1	Monitor potential effects from phosphate mining on YCT populations in cooperation with other parties.	Long-term

Goose/Big Cottonwood/Dry creeks

YCT within this GMU are primarily limited to three isolated but relatively large populations; an isolated and possibly pure population in the headwaters of the Dry Creek drainage; an isolated yet slightly hybridized population in the Big Cottonwood drainage; and an isolated population in the headwaters of Goose Creek that also contains rainbow trout, hybrids, and brook trout. Conservation actions proposed for this GMU are found in Table 17. In terms of risk, Dry Creek probably is least at risk if the population is truly pure, but more genetic analysis is needed to verify its purity. The remaining populations should be conserved in part through eradication of non-native salmonids if necessary. However, a more accurate determination of the distribution of YCT and non-native salmonids is needed before any eradication projects should be considered. The extent of hybridization in Big Cottonwood Creek is currently being determined to avoid the spread of hybridization throughout the population. Habitat within the Goose/Big Cottonwood/Dry creeks GMU has been altered by long-term grazing and has probably had an impact on YCT distribution within the GMU. Any improvement in habitat conditions through fencing projects in riparian areas would probably have positive benefits for YCT.

Table 17. Conservation actions for YCT in the Goose/Big Cottonwood/Dry creeks GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Big Cottonwood Creek	Present	1	Determine genetic purity and extent of hybridization.	Short-term
Upper Goose Creek	Present	1	Determine the genetic purity and distribution of Yellowstone cutthroat trout and their overlap with brook trout. .	Short-term
Dry Creek	Present	1	Accurately determine the distribution, abundance, and genetic purity of YCT.	Short-term
Piney Creek	Unknown	1	Reconnaissance level assessment; remove brook trout and translocate YCT.	Short-term
Trout Creek	Present	1	Research will assess whether a highly introgressed population of YCT can be restored to pure or nearly pure status by selectively removing rainbow trout and hybrids.	Short-term
Entire drainage	Present	1	Continue monitoring genetic diversity in small isolated populations.	Long-term
Entire drainage	Present	1	Work with federal agencies, state agencies, and private landowners to preserve existing habitat and enhance degraded habitat. Explore opportunities for restoring connectivity.	Long-term

Henrys Fork Snake River

In the Henrys Fork Snake River GMU, broad-scale stocking and subsequent establishment of self-reproducing populations of non-native salmonids has reduced the distribution of YCT to a few small, isolated headwater streams. Furthermore, only Tygee Creek appears to contain an allopatric population of YCT. Proposed conservation actions for this GMU are found in Table 18. A more definitive description of the distribution of cutthroat trout in Twin, Boone, Squirrel, and Conant creeks would help define management actions that could be implemented for protective and restorative purposes.

Nevertheless, a number of action strategies have been undertaken or are underway, and a number of others should be implemented. More projects such as the eradication of brook trout and reintroduction of YCT in Sawtell Creek should take place wherever recolonization from non-native salmonids can be prevented. The IDFG will also need to assess angler tolerance in some instances before suppressing or eradicating non-native salmonids such as brook trout since anglers desire them in many places. Before such reintroductions of YCT can occur, adequate donor populations must be established or located, and the potential for recolonization by non-native salmonids from nearby populations must be eliminated. The best candidate streams for non-native removal include West Dry, Icehouse, Taylor, and Schnieder creeks.

Table 18. Conservation actions for YCT in the Henry's Fork Snake River GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Sawtell Creek	Absent	1	Non-native salmonids chemically removed in 2003 and 2004, habitat work beginning in 2005, and reintroduction of YCT completed in 2006. Assess success of translocation in 2007.	Ongoing
Henry's Fork tributaries	Absent – Unknown	1	Remove non-native salmonids from 3 streams in the next 10 years and restore YCT.	Short- to long-term
Entire drainage	Present	1	Continue restrictive cutthroat trout harvest regulations to ensure spawner protection.	Long-term

Henrys Lake

Henrys Lake YCT management is focused on 1) increasing natural production in tributaries, and 2) minimizing introgression with hybrid trout. Natural production is being enhanced by improving habitat through riparian fencing and stream channel restoration, removing upstream migration barriers, and minimizing entrainment of juvenile outmigrants. Conservation actions proposed for this GMU are found in Table 19. In 2005, the Idaho Department of Transportation replaced two impassable road culverts located where State Highway 287 crosses Targhee Creek and Howard Creek. This action should allow for rebuilding of YCT populations in these tributaries to Henrys Lake. IDFG is currently working with the Henrys Lake Foundation on a project aimed at restoring the Duck Creek stream channel. Finally, IDFG conducts annual maintenance of several riparian fences and nine diversion screens.

Introgression is being minimized by phenotypic selection of pure YCT at the hatchery and induction of triploidy of all hybrid eggs through pressure treatment. Pressure treatment has been used since 2003 and is proving to be an effective method to insure triploidy induction. In 2005, random testing indicated IDFG achieved 100% induction of triploidy with hybrids eggs.

Table 19. Conservation actions for YCT in the Henry's Lake GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Henrys Lake tributaries	Present	1	Improve riparian habitat through livestock grazing agreements, riparian fencing projects, and long-term monitoring program.	Ongoing
Henrys Lake tributaries	Present	1	Maintain irrigation diversion screens to prevent losses of juvenile YCT during outmigration	Ongoing
Henrys Lake tributaries	Present	1	Continue restrictive cutthroat trout harvest regulations to ensure spawner protection	Long-term

Palisades/Salt River

The southern perennial tributary to the Salt River is Crow Creek. It has a healthy population of YCT as well as mountain whitefish and brown trout. Many of the northern tributaries to Crow Creek have been physically impacted by phosphate mining and potentially by the byproduct of elevated levels of dissolved selenium. Mine expansion has been proposed and as of 2006 is being analyzed by the U.S. Forest Service. Lower Crow Creek is mostly in private ownership, some of which is managed to maximize fish and wildlife resources and some is managed for traditional livestock grazing. Upper Crow Creek is within the Caribou-Targhee National Forest. Federal grazing leases affect riparian areas, but multi-agency monitoring and allotment management plans moderate impacts. The IDFG works with federal and private land managers to improve conditions and seek to prevent future deterioration of water quality. The lower reach of Crow Creek is in Wyoming where most of the irrigation withdrawals occur. Conservation actions proposed for this GMU are found in Table 20.

The Stump Creek watershed is adjacent to Crow Creek and the watershed is managed similarly to that of Crow Creek.

Tin Cup Creek has a paved road adjacent to it for several miles and much of the lands between the road and creek are within the Caribou National Forest. This reach is heavily fished and is stocked annually at the request of IDFG with YCT from Wyoming's Auburn Fish Hatchery. Tin Cup Creek has similar land and water management to other Salt River tributaries and additionally has some habitat deterioration associated with highway placement.

McCoy Creek forms the boundary between the Southeast and Upper Snake administrative regions of IDFG. This stream is tributary to Palisades Reservoir and is a spawning tributary for both naturally spawned and Jackson Hatchery produced YCT. The large spawning population led to the current special fishing rule that prohibits angling until July 1, after cutthroat trout have completed spawning. As with all native cutthroat trout streams in the Southeast Region, the harvest limit is two fish. Additionally, in McCoy Creek only trout at least 406 mm long may be harvested.

Table 20. Conservation actions for YCT in the Palisades/Salt River GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Crow Creek	Present	1	Establish selenium sampling and analysis standards through a multi-agency process to ensure that mine-generated selenium is not having population level effects on cutthroat trout	Short-term
Crow Creek	Present	2	Work with private landowners to improve habitat for cutthroat trout	Long-term
Entire drainage		1	Assess and restore fish passage in cooperation with other parties	Long-term
Entire drainage		1	Assess and mitigate entrainment losses from unscreened irrigation diversions.	Long-term

Portneuf River

Streams within the Portneuf River GMU that are isolated from the Portneuf River and its tributaries but still contain YCT (e.g., Goodenough, Bell Marsh, Walker, Robbers Roost, and Harkness creeks) often do not contain non-native salmonids, whereas streams more connected to the Portneuf River, such as Rapid, Pebble, and Toponce creeks, tend to contain non-native salmonids, including rainbow trout. Conservation actions proposed in this GMU are found in Table 21. At the present time, isolated streams in the Portneuf River drainage that still contain YCT should be protected as core conservation populations, and long-term monitoring of the genetic risk those populations face (due to their isolation) should be undertaken. For those tributaries containing non-native salmonids, the extent of hybridization occurring should be more fully assessed, and where possible, methods to control the spread of hybridization should be developed. Little is currently known of Fish and Dempsey creeks, but they both appear to contain large populations of YCT and may lack non-native salmonids. The ability to reduce genetic introgression in the Pebble and Toponce populations by selective electrofishing removal should be studied to determine if such removals could be useful in changing sportfish populations (those with ≥ 10% hybridization) to conservation populations (those with 1 – 10% hybridization), or conservation populations to core populations (< 1% hybridization).

Table 21. Conservation actions for YCT in the Portneuf River GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Disconnected Portneuf River tributaries	Present	1	Monitor the genetic diversity of YCT in Bell Marsh Creek, Walker Creek, Goodenough Creek, Harkness Creek, Robber's Roost Creek, Gibson Jack Creek, Middle Fork Mink Creek, and East Bob Smith Creek, and other isolated populations. Maintain diversity through translocations if necessary.	Short- to long-term
Pebble and Toponce creeks	Present	2	Determine genetic purity throughout these drainages, and explore whether population-level genetic purity can be increased through selective electrofishing removals of rainbow trout and hybrids.	Short- to long-term
Fish and Dempsey creeks	Present	1	Accurately determine the distribution, abundance, and purity of YCT.	Short-term
Entire drainage		1	Assess and restore fish passage in cooperation with other parties	
Entire drainage		1	Assess and mitigate entrainment losses from unscreened irrigation diversions.	

Raft River

Populations of YCT in the Raft River GMU are either small or isolated, or occur sympatrically with non-native salmonids. However, there are 11 known YCT populations within the GMU, which provides opportunities to develop protection plans and strategies. Conservation actions proposed for this GMU are found in Table 22. YCT conservation efforts within this GMU should be focused on four areas: 1) assessing more accurately the distribution and abundance of YCT in several small, isolated streams; 2) assessing the rate of loss of genetic diversity and the potential ability of occasional translocations in preventing genetic bottlenecking, inbreeding depression, etc.; 3) controlling the expansion of non-native salmonids as much as is feasible; and 4) seek opportunities to reconnect isolated populations where possible. Connecting Almo and Edwards creeks, two adjacent tributaries that are currently completely diverted before joining, could restore gene flow to these currently isolated streams and serve as a model for stream reconnections. Considering that several isolated YCT populations exist mostly in the Utah portion of drainages that eventually flow into Idaho, cooperative protection and restoration projects should be investigated with the Utah DNR.

Table 22. Conservation actions for YCT in the Raft River GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Almo, Edwards, and Eightmile creeks	Present	1	Accurately determine the distribution and abundance of YCT in these streams. Evaluate potential habitat threats.	Short-term
Almo and Edwards creek	Present	2	Explore the potential of connecting these two YCT populations.	Long-term
Cassia Creek and tributaries	Present	2	Monitor the expansion of brook trout within the YCT population in the drainage; control expansion of brook trout with removals or barriers if necessary and feasible.	Short- and long-term
Entire drainage	Present	1	Continue monitoring genetic diversity in small isolated populations.	Long-term
Entire drainage	Present	1	Work with federal agencies, state agencies, and private landowners to preserve existing habitat and enhance degraded habitat.	Entire drainage
Grape Creek	Present	2	Reconnaissance level assessments for YCT distribution and abundance	Short-term
Edwards Creek	Present	2	Reconnaissance level assessments for YCT distribution and abundance	Short-term
Six-mile Creek	Not Present	1	Remove rainbow trout and translocate YCT	Short-term
Entire drainage	Present	1	Continue monitoring genetic diversity in small isolated populations.	Long-term
Entire drainage	Present	1	Work with federal agencies, state agencies, and private landowners to preserve existing habitat and enhance degraded habitat. Explore opportunities for restoring connectivity.	Long-term

Rock/Bannock creeks

YCT exist only within two small streams in this GMU, Crystal and Bannock creeks. Conservation actions proposed for this GMU are found in Table 23. It appears that YCT have been eliminated from the Rock Creek drainage, although the distribution of YCT was probably historically limited within this drainage due to inadequate stream flows throughout most of the drainage. East Fork Rock Creek is a popular local fishery but could be chemically treated to remove the current population of rainbow trout and hybrids. Restocking and establishing YCT in the stream could be done simultaneously with continued stocking of sterile rainbow trout in an attempt to assess the potential impact on native YCT. The YCT population in Bannock Creek was genetically tested and is hybridized. If hybridization could be controlled, the joining of Crystal and Bannock creeks may benefit the local YCT populations and reestablish gene flow between these two currently isolated populations.

Table 23. Conservation actions for YCT in the Rock/Bannock Creek GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Bannock and Crystal creeks	Present	1	Accurately determine the distribution and genetic purity of YCT.	Short-term
Bannock and Crystal creeks	Present	2	Explore the potential of connecting these two YCT populations. A migration barrier on Bannock Creek just south of Highway 86 prevents connectivity between Bannock Creek and other American Falls Reservoir and Snake River tributaries. It also prevents upstream movement of rainbow and brown trout. A determination should be made about whether or not to improve migration at this site. This area of Bannock Creek is on the Fort Hall Indian Reservation so coordination with the Shoshone Bannock Tribe is necessary.	Long-term
East Fork Rock Creek	Absent	2	Consider eradication of rainbow trout using chemical treatment, and restocking of YCT along with continued stocking of sterile hatchery rainbow trout.	Long-term

Snake River Proper

Numerous tributaries including the Blackfoot and Portneuf Rivers that are discussed in separate sections feed the Snake River between Gem Lake Reservoir and American Falls Reservoir. Many of the tributaries to the Snake River in this reach are spring fed. However, except for the section that is on the Fort Hall Indian Reservation, tributaries of any size are mostly captured for irrigation, have migration barriers, and have been degraded in terms of substrate and riparian habitat. Tributaries on the Fort Hall Indian Reservation are likely in good condition and provide spawning and rearing habitat for cutthroat trout. Downriver from American Falls Reservoir there are several tributaries, but they are significantly utilized for irrigation. Also riparian communities and stream substrates have been degraded. Native cutthroat have likely been extirpated from these streams. If land and water practices could be addressed to improve habitat conditions for cutthroat trout, then it would be useful to improve passage at barriers and transfer cutthroat trout to rebuild populations. Conservation actions proposed for this GMU are found in Table 24.

The Snake River from Shoshone Falls upstream to Massacre Rocks is significantly impounded with variable flows. Flows are controlled at Milner and Minidoka dams. Very little quantitative data are available regarding current YCT abundance, movement, and life history within this reach of Snake River Proper GMU. Vinyard Creek is the only tributary within this reach with a weak but self-sustaining cutthroat trout population. However, this population is heavily introgressed with rainbow trout and has seen decline over the past decade despite instream habitat and water quality improvements.

Table 24. Conservation actions for YCT in the Snake River Proper GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Snake River between Gem Lake Reservoir and American Falls Reservoir	Present	3	Improve passage at irrigation diversion migration barriers	Long-term
Vinyard Creek	Present	2	Continue work to protect and enhance habitat to maximize spawning potential	Long-term
Snake River below Milner Dam	Present	3	Work with federal agencies, state agencies, and private landowners to preserve existing habitat and enhance degraded habitat. Preserve streamflow through Milner bypass.	Long-term
Snake River below Minidoka Dam	Present	2	Work with federal agencies, state agencies, and private landowners to preserve existing habitat and enhance degraded habitat. Preserve streamflow through Minidoka bypass.	Long-term

South Fork Snake River

The South Fork Snake River contains one of the few remaining and most likely the strongest fluvial population of YCT in Idaho. Although rainbow trout and rainbow x cutthroat hybrids have increased in abundance in the mainstem, their presence in most of the tributaries is sparse and where they are found, IDFG is exerting much effort to reduce their numbers. Considering that YCT occur in nearly every fish-bearing stream surveyed in this GMU, distribution does not appear to be limited. However, because of the highly connected nature of this drainage, and the fact that rainbow trout or hybrids were found at 14% of the study sites, the potential for expansion of hybridization is cause for concern. Significant efforts are ongoing to control hybridization expansion in the major tributaries such as Burns, Pine, Rainey, and Palisades. Conservation actions proposed for this GMU are found in Table 25. Future YCT conservation efforts in this GMU should be focused on controlling rainbow-cutthroat trout hybridization.

In the mainstem, rainbow trout were a negligible component of the trout population until the late-1980s. In the past 10 years, angler and electrofishing surveys have shown a steady increase in rainbow trout. Based on annual electrofishing surveys, rainbow trout were as abundant as YCT in the upper reaches of the river by 2003. In cooperation with other agencies and non-governmental organizations, the IDFG is working on three fronts to protect and maintain the health of the cutthroat population. First, weirs and fish collection traps have been constructed on the four main tributaries to allow collection of YCT and rainbow trout spawners. Based on phenotypic examination, YCT are passed upstream, whereas rainbow and hybrid trout are removed. Second, IDFG has been working with Idaho State University and the Bureau of Reclamation to identify and implement flow regimes that are beneficial to YCT and detrimental to rainbow trout. A comprehensive analysis suggests the magnitude and shape of the spring runoff flows may have a significant effect on the ratio of rainbow to cutthroat trout recruits. From 2004 through 2006, Palisades Dam discharge has been shaped to provide flows beneficial to YCT and detrimental to rainbow trout. Preliminary analysis of the YCT: rainbow trout recruitment indicates the shaped flows may be an important tool in YCT management. Finally, we implemented an aggressive program combining regulation changes and public outreach in 2003 to encourage harvest of rainbow trout. Harvest of rainbow trout has increased from near negligible levels in the late 1990’s to several thousand in 2003 through 2005. Future conservation actions will continue to develop this three-prong approach to benefit YCT while suppressing the rainbow population.

Table 25. Conservation actions for YCT in the South Fork Snake River GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Pine, Burns, Rainey, and Palisades creeks	Present	1	Continue to weir these important YCT spawning tributaries to protect them from rainbow trout invasion and hybridization. Improve weir effectiveness.	Ongoing
Burns, Rainey, and Palisades creeks	Present	1	Maintain irrigation diversion screens to prevent losses of juvenile YCT during outmigration	Ongoing
South Fork Snake River	Present	1	Continue no-harvest regulations for YCT and liberalized rainbow trout and hybrid harvest regulations (no-limit) to encouraged angler harvest of rainbow trout to reduce their abundance.	Ongoing
South Fork Snake River	Present	1	Implement naturally shaped discharge flows from Palisades Reservoir to benefit YCT spawning and hinder successful rainbow trout spawning	Ongoing
Garden and Pritchard creeks	Present	1	Channel restoration, irrigation system modification with Instream flow agreement, and culvert replacement for YCT connectivity restoration.	Ongoing
Rainey Creek	Present	2	Obtain minimum stream flows and improve habitat below USFS boundary to improve stream connectivity for migratory YCT population.	Long-term
Entire drainage		1	Assess and restore fish passage in cooperation with other parties	
Entire drainage		1	Assess and mitigate entrainment losses from unscreened irrigation diversions.	

Teton River

YCT are relatively widespread in the Teton River GMU, but not as widespread as brook trout. In fact, of the stream surveys performed to date by IDFG, USFS, and Friends of the Teton River, brook trout existed in almost all stream locations that also contained YCT. Most streams in this drainage subside underground or are diverted for irrigation when they reach the Teton Valley floor in the upper portion of the drainage. After an intermittent stretch of stream channel, they emerge again from springs before reaching the mainstem of the Teton River. Considering that YCT still exist in most perennial stream segments in the Teton River drainage, and that rainbow trout were relatively absent from Teton River tributaries, brook trout may pose the biggest threat to YCT persistence. Monitoring efforts should be established in allopatric populations to track population dynamics of both species and monitor any expansions or contractions for either species. Conservation actions for this GMU are found in Table 26.

That rainbow trout are well established throughout the mainstem of the Teton River, and dominate YCT in abundance in certain areas, does indicate that they too pose a threat to YCT in this GMU. This is also true in perennial streams that are consistently connected to the Teton River, and in more-intermittently connected streams that nevertheless are known or suspected to provide spawning grounds for migratory fish from the mainstem, such as Canyon Creek. The IDFG will explore opportunities for removing non-native brook trout and rainbow trout from tributaries; however, we will also need to assess angler tolerance in some instances before suppressing or eradicating non-native salmonids since they are desired by anglers.

Table 26. Conservation actions for YCT in the Teton River GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Teton River and tributaries	Present	1	Implement restrictive harvest regulations (catch-and-release) for Teton River and possibly tributaries	Short-term Completed 2006
Teton River tributaries	Unknown - Present	2	Remove brook trout *as feasible* from tributaries where brook trout expansion threatens YCT. Candidate streams include Trail, Horseshoe, Mahogany, Packsaddle, Canyon, Moody, and North Twin creeks, and others.	Short- to long-term
Upper Teton River and tributaries.	Present	1	Assess abundance and factors limiting production of YCT in upper Teton valley	Ongoing
Teton River and tributaries.	Present	1	Installation and maintenance of electric fencing to protect tributary and mainstem riparian habitat	Ongoing
South Fork Teton River	Present	1	Annual maintenance and operation of fish ladder over large irrigation diversion	Ongoing
Entire drainage		1	Assess and restore fish passage in cooperation with other parties	
Entire drainage		1	Assess and mitigate entrainment losses from unscreened irrigation diversions.	

Willow Creek

Non-native salmonids do not appear to pose a serious threat to YCT within the Willow Creek GMU. Brook trout have a narrow distribution and rainbow and brown trout (despite widespread stocking in the past) have not been found to date. However, Willow Creek has been listed by the Soil Conservation Service as one of the most serious soil erosion areas in the United States and nearly every segment of the mainstem of Willow Creek and its tributaries are listed on Idaho's 303(d) list due to high sediment levels within the streams. IDFG found more fine sediment per study site within the Willow Creek drainage than in any other drainage. Furthermore, since the collection of our fish distribution data in 2001, drought conditions have more severely restricted the distribution of YCT in the Willow Creek drainage, compounding what were already poor habitat conditions. YCT conservation strategies within this drainage should focus on habitat improvement, working with water managers and users, and riparian zone fencing in an effort to reduce fine sediment loads in streams (Table 27). As the distribution of YCT becomes more limited due to habitat fragmentation and drought, their distribution should be monitored, especially in the Sellars and Brockman drainages.

Table 27. Conservation actions for YCT in the Willow Creek GMU.

Stream name	YCT status	Priority	Required Actions	Time-table
Sellars and Mill creeks	Present	1	Accurately determine the distribution, abundance, and connectivity of YCT within these two streams.	Ongoing
Lava and Brockman creeks	Present	1	Accurately determine the distribution, abundance, and connectivity of YCT within these two streams.	Ongoing
Willow Creek and tributaries	Present	2	Improve riparian habitat through increased streamflow by minimizing out-of-basin transfers of water.	Long-term
Willow Creek and tributaries	Present	1	Improve riparian habitat through livestock grazing agreements, riparian fencing projects, and long-term monitoring program to decrease sediment in streams.	Long-term
Entire drainage	Present	1	Continue restrictive cutthroat trout harvest regulations to ensure spawner protection	Long-term

PROGRAM MEASURES

In order to gauge the effectiveness of conservation actions implemented over time, the IDFG proposes two metrics that we will monitor over time: 1) the number of miles of habitat occupied by core and conservation populations, and 2) the number of respective core and conservation populations. Undoubtedly, other metrics will be considered over time. The IDFG will report on these metrics as requested and when this Plan is updated, which is anticipated every five years or so.

OUTREACH EFFORTS

To adhere to the objectives of the interagency MOA described earlier in this plan, the IDFG will do the following:

1) Develop and implement a public outreach effort specifically addressing YCT conservation. This will include media contacts, writing articles for public circulation, posting informational signs at public access sites, giving presentations at schools, giving presentations before a host of audiences, educating elected officials, and providing information on the IDFG website (http://fishandgame.idaho.gov).
2) The IDFG will summarize existing distribution, genetics, and conservation accomplishments data that allows data summaries and comparisons between and among jurisdictions. We will employ the protocols prescribed by May (2007) in the rangewide status assessment. On an annual basis, IDFG staff will meet with agency counterparts, signatory to the MOA, to update the YCT database.
3) IDFG will meet with staff of agencies signatory to the MOA at least once annually to review accomplishments toward conservation of YCT.

CONCLUSION

Idaho is in a good position to ensure that YCT are a sustained part of the fish fauna with most populations capable of providing angling opportunity. Because of past and current work done on YCT related to documenting changes that have occurred in YCT populations, we know a good deal about the status of Idaho's YCT resource. This work confirmed that there are problem areas and that management actions are required over the long-term to ensure the viability and persistence of populations. As the state fish and wildlife agency, the IDFG is committed to assuming a leadership role in the conservation of YCT. Habitat protection and restoration will be our highest priority. This will require the support and assistance of many parties since IDFG's regulatory function is limited in scope. As much as possible, we will work with state and federal land managers, FWS, private landowners, industry, utilities, water managers and users, irrigators, and non-governmental organizations to collaborate on habitat restoration projects. There is much that needs to occur across the range of YCT and no one party has enough staff or funding to accomplish the workload. The IDFG is exploring options for enhancing its involvement in habitat restoration activities for native fish species. However, this will require additional personnel and funding to capitalize on available federal programs to assist in habitat restoration efforts. Priorities need to be established for this work; however, opportunistic projects will also be entertained on a case-by-case basis. Some individual drainages within particular GMUs are so altered by anthropogenic factors that it is very unlikely that restoration attempts will be successful. IDFG will focus its efforts in GMUs and in drainages where the likelihood of success is moderate to high.

The IDFG will also track and respond to any effort to list the YCT under the Endangered Species Act. At this time, we do not believe listing the YCT is warranted. The FWS, after a thorough review of all available scientific and commercial information, found that listing of the YCT as either threatened or endangered was not warranted (Federal Register Doc. 06-1539, Filed 2-17-06). Despite our opinion that listing of YCT is not warranted at this time, we must be continually proactive in our efforts to increase the number of core populations across Idaho and enhance the persistence of this subspecies across its historical range.

The southernmost GMUs in the range of YCT in Idaho are not in good ecological condition and YCT populations reflect that situation. This includes much of the Goose Creek, Raft River, Rock/Bannock creeks, and Portneuf River GMUs. Much of the Willow Creek GMU habitat is in poor ecological condition. If habitat could be appreciably restored in the Willow Creek GMU, it would be a good source of sustained, pure YCT populations. Because of past management practices, especially stocking of hybrids, as well as continued public demand for non-natives, it will be very difficult to return Henrys Lake and the Henrys Fork Snake River to pure, sustaining YCT populations. YCT populations are in good to excellent condition in many parts of their range in Idaho. This includes much of the Palisades/Salt, the South Fork Snake River, and the Teton River GMUs. Although it is thought that the Beaver/Camas/Medicine Lodge YCT populations are the result, at least in part, of natural processes rather than stocking, that needs to be further explored.

In the Blackfoot River GMU, there are some anomalies in the genetic status of YCT that need to be assessed and genetic status for most streams is unknown. In addition, a system for differentiating between a cutthroat population that is 10% introgressed and a pure cutthroat population that is intermixed with 10% pure rainbow trout needs to be identified, not just for the Blackfoot River system, but others as well, especially the South Fork Snake River.

Sample sites where YCT were historically present but not found in the latest monitoring should be evaluated in more detail to see if the entire stream is devoid of YCT and whether the habitat is of sufficient quality to support YCT. Where possible, habitat restoration should be implemented using the tools that already exist. Where YCT populations are depressed (<50 adults) but seemingly stable, a program of translocations from adjacent drainages should be initiated to avoid inbreeding depression. At the same time, the possibility of reconnecting isolated populations should be pursued, bearing in mind that in some situations, that may not be an option because of increased risk of introgressive hybridization.

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LITERATURE CITED

Allendorf, F. W., and R. F. Leary. 1988. Conservation and distribution of genetic variation in a polytypic species, the cutthroat trout. Conservation Biology 2:170-184.

Baker, J., P. Bentzen, and P. Moran. 2002. Molecular markers distinguish coastal cutthroat trout from coastal rainbow trout/steelhead and their hybrids. Transactions of the American Fisheries Society 131:404-417.

Ball, K., and P. W. Jeppson. 1980. Regional Fisheries Management Investigations. Upper Snake Region (6). Job Performance Report. Project F-71-R-04. Idaho Department of Fish and Game, Boise, ID.

Behnke, R. J. 1988. Phylogeny and classification of cutthroat trout. Pages 1-7 in R.E. Gresswell, editor: Status and management of interior stocks of cutthroat trout. American Fisheries Society Symposium 4, Bethesda, MD.

Behnke, R. J. 1992. Native trout of western North America. American Fisheries Society Monograph 6, Bethesda, MD.

Bell, R. J. 1979. Regional Fisheries Management Investigations. Magic Valley Region (4). Job Performance Report. Project F-71-R-03. Idaho Department of Fish and Game, Boise, ID.

Bell, R. J. 1981. Regional Fisheries Management Investigations. Magic Valley Region (4). Job Performance Report Project F-71-R-05. Idaho Department of Fish and Game, Boise, ID.

Benjamin, L. 2000. Groundwater hydrology of the Henrys Fork springs. Intermountain Journal of Science 6:119-142.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. Pages 191-232 in E.D. Salo and T.W. Cundy, editors: Streamside Management Forestry and Fisheries Interactions. Institute of Forest Resources, University of Washington, Contribution No. 57, Seattle, WA.

Bigelow, P.E., T.M. Koel, D. Mahony, B. Ertel, B. Rowdon, and S.T. Olliff. 2003. Protection of native Yellowstone cutthroat trout in Yellowstone Lake, Yellowstone National Park, Wyoming. Technical Report NPS/NRWRD/NRTR-2003/314. National Park Service, Water Resources Division, Fort Collins, CO.

BioAnalysts, Inc. 2006. An analysis of Yellowstone cutthroat trout in the Salt River Watershed, specifically Crow, Deer, and Sage creeks. Unpublished Report prepared for J.R. Simplot Company by Robert House.

Biodiversity Legal Foundation (BLF), Alliance for the Wild Rockies, Montana Ecosystems Defense Council, and G. Wuerthner. 1998. Petition to list naturally spawning Yellowstone cutthroat trout as threatened, submitted to U.S. Fish and Wildlife Service, August 14, 1998.

Brostrom, J., and L. Watson. 1988. Evaluation of Henrys Lake trout stocking program, Project F-71-R-11, Subproject IV, Study iii, Job 1. Idaho Department of Fish and Game, Boise, ID.

Caro, T. M., and M. K. Laurenson. 1994. Ecological and genetic factors in conservation: a cautionary tale. Science 263:485-486.

Casey, O. E. 1966. Tests for increasing the returns of hatchery trout. Job 2. American Falls Reservoir, Blackfoot Reservoir, and Snake River fisheries investigations. Job Performance Report. Project F-32-R-08. Idaho Department of Fish and Game, Boise, ID.

Casey, O. E., R. J. Bell, D. R. Corley, P. W. Jeppson, and J. L. Mallet. 1969. Tests for increasing the returns of hatchery trout, 1967. Job Performance Report F-32-R-11. Idaho Department of Fish and Game, Boise, ID.

Casey, O. E., R. J. Bell, D. R. Corley, J. L. Mallet, and W. E. Webb. 1968. Tests for increasing the returns of hatchery trout. Job Performance Report F-32-R-09. Idaho Department of Fish and Game, Boise, ID.

Cavalli-Sforza, L. L., and A. W. F. Edwards. 1967. Phylogenetic analysis: models and estimation procedures. Evolution 32:550-570.

Cegelski, C. C., M. R. Campbell, K. A. Meyer, and M. S. Powell. 2006. Large-scale and fine-scale genetic structure of Yellowstone cutthroat trout *Oncorhynchus clarkii bouvieri* in Idaho. Transactions of the American Fisheries Society 135:711-726

Chamberlin, T.W., R.D. Harr, and F.H. Everest. 1991. Timber harvesting, silviculture and watershed processes in: influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19: 181-205.

Cochnauer, T. 1980. East Fork of Rock Creek stream flow study. Unpublished Report. Idaho Department of Fish and Game, Boise, ID.

Colyer, R. 2006. Upper Teton River Tributary Trout Population Assessment Final Report. Friends of the Teton River, Driggs, ID.

Corning, R. V. 1961. Creel census summary. Fisheries Management Area 6. Unpublished Report. Idaho Department of Fish and Game, Boise, ID.

Corsi, C. E. 1984. Regional Fisheries Management Investigation. Upper Snake Region (6). Willow Creek drainage fish inventory. Job Performance Report. Project F-71-R-08. Idaho Department of Fish and Game, Boise, ID.

Corsi, C. 1986. Regional Fisheries Management Investigations: Willow Creek investigation. Job Performance Report. Project F-71-R-9. Idaho Department of Fish and Game, Boise, ID.

Corsi, C. E. 1989. Regional Fisheries Management Investigations. Upper Snake Region (6). Job Performance Report. Project F-71-R-12. Idaho Department of Fish and Game, Boise, ID.

Corsi, C. E., and S. Elle. 1986. Regional Fisheries Management Investigations. Upper Snake Region (6). Job Performance Report. Project F-71-R-10. Idaho Department of Fish and Game, Boise, ID.

Corsi, C. E., and S. Elle. 1989. Regional Fisheries Management Investigations. Upper Snake Region (6). Job Performance Report. Project F-71-R-12. Idaho Department of Fish and Game, Boise, ID.

Corsi, C. E., and S. Elle. 1994. Regional Fisheries Management Investigations. Upper Snake Region (6). Job Performance Report. Project F-71-R-14. Idaho Department of Fish and Game, Boise, ID.

Corsi, C. E., R. Spateholts, V. K. Moore, and T. Williams. 1986. Regional Fisheries Management Investigations. Upper Snake Region (6). Job Performance Report. Project F-73-R-08. Idaho Department of Fish and Game, Boise, ID.

Coziah, C., and W. S. Platts. 1964. Henrys Lake-Its fish and its fishing. Idaho Wildlife Review, March-April 1964.

Crow, J. F., and M. Kimura. 1970. An introduction to population genetics theory. Harper and Row, New York City, NY.

Der Hovanisian, J.A., 1997. Irrigation diversion fish loss reduction. Annual Performance Report, F-73-R-19. Idaho Department of Fish and Game, Boise, ID.

De Rito, J. and A.M. Emery-Miller. 2006. Yellowstone cutthroat trout survey and population assessment—2005. Final Report. Henrys Fork Foundation, Ashton, ID.

Dufek, D., J. Kiefling, B. McDowell, and R. McKnight. 1999. Historical management applications in the management of Yellowstone cutthroat trout. Wyoming Game and Fish Department Publication, Cheyenne, WY.

Dunham, J.B., D.S. Pilliod, and M.K. Young. 2004. Assessing the consequences of nonnative trout in headwater ecosystems in western North America. Fisheries 29: 18-26.

Elle, S. 1998. Wild Trout Investigations. Whirling disease studies. Annual Performance Report. Project F-73-R-18. Idaho Department of Fish and Game, Boise, ID.

Elle, S., and C. Corsi. 1994. Regional Fisheries Management Investigations, Job Performance Report. Project F-71-R-13. Idaho Department of Fish and Game, Boise, ID.

Elle, S., and M. Gamblin. 1993. Regional Fisheries Management Investigations. Job Performance Report. Project F-71-R-15. Idaho Department of Fish and Game, Boise, ID.

Elle, S., and D. Schill. 1999. Wild Trout Investigations. Whirling disease studies. Annual Performance Report. Project F-73-R-20. Idaho Department of Fish and Game, Boise, ID.

Elle, S., M. Gamblin, and J. Thorpe. 1993. Regional Fisheries Management Investigations. Job Performance Report. Project F-71-R-16. Idaho Department of Fish and Game, Boise, ID.

Fausch, K. D., and R. J. White. 1981. Competition between brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) for positions in a Michigan stream. Canadian Journal of Fisheries and Aquatic Sciences 38:1220-1227.

Fausch, K. D. 1988. Tests of competition between native and introduced salmonids in streams: what have we learned? Canadian Journal of Fisheries and Aquatic Sciences 45:2238-2246.

Fausch, K.D., B.E. Rieman, M.K. Young, and J.B. Dunham. 2006. Strategies for conserving native salmonid populations at risk from nonnative fish invasions: tradeoffs in using barriers to upstream movement. General Technical Report RMRS-GTR-XX. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Boise, ID.

Federal Register. 2001. Endangered and threatened wildlife and plants: 90-day finding for a petition to list the Yellowstone cutthroat trout as threatened. Volume 66, Number 57, 50 CF Part 17, pp. 11244-11249.

Frankham, R. 1980. Evolutionary changes in small populations. Pages 135-150 in M. E. Soule and B. A. Wilcox, editors. Conservation biology: an evolutionary-ecology perspective. Sinauer Associates, Sunderland, MA.

Frankham, R. 1995. Effective population size/adult population size ratios in wildlife: a review. Genetical Research 66:95-107.

Frissell, C.A. 1993. Topology of extinction and endangerment of native fishes in the Pacific Northwest and California. Conservation Biology 7: 342-354.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and maintenance. American Fisheries Society Special Publication 19: 297-323.

Gamblin, M. 1980. Aquatic habitat inventory within the BLM Twin Falls Planning Unit. Unpublished Report, Idaho Department of Fish and Game, Boise, ID.

Gamblin, M., R. Scully and others. 1997. Yellowstone cutthroat trout (*Salmo clarkii bouvieri*) management guide for Eastern Idaho. Unpublished Report, Idaho Department of Fish and Game, Boise, ID.

Garren, D., W. C. Schrader, D. Keen, and J. Fredericks. 2006. Regional fisheries management investigations. Job Performance Report. Project F-71-R-30, Idaho Department of Fish and Game, Boise, ID.

George, B. 1988. Henrys Lake fishing enhancement. Project Report F75-R-03. Subproject 2: Coldwater fish investigations. Study 2: Henrys Lake hatchery enhancement. Idaho Department of Fish and Game, Boise, ID.

Gresswell, R. E. 1995. Yellowstone cutthroat trout. Pages 36-54 in Conservation assessment for inland cutthroat trout. M. K. Young, editor. General Technical Report RM-256. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Gresswell, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128: 193-221.

Greider, F. L. 1986. Lake and reservoir investigations. Study 4: Evaluation of Henrys Lake management programs. Job 1: Evaluation of Henrys Lake trout stocking program. Project Report F75-R-07. Idaho Department of Fish and Game, Boise, ID.

Grunder, S.A. 1986. Evaluation of Henrys Lake management programs. Job Performance Report. Project F-73-R-8. Idaho Department of Fish and Game. Boise, ID.

Grunder, S. A., L. Barrett, and R. J. Bell. 1987. Regional Fisheries Management Investigations. Magic Valley Region (4). Job Performance Report. Project F-71-R-11. Idaho Department of Fish and Game, Boise, ID.

Grunder, S.A., S. Elam, and R.J. Bell. 1989. Regional Fisheries Management Investigations. Magic Valley Region. Job Performance Report. Project F-71-R-11. Idaho Department of Fish and Game. Boise, ID.

Harig, A. L., K. D. Fausch, and M. K. Young. 2000. Factors influencing success of greenback cutthroat trout translocations. North American Journal of Fisheries Management 20: 994–1004.

Hearn, W. E. 1987. Interspecific competition and habitat segregation among stream-dwelling trout and salmon: a review. Fisheries 12:24-31.

Hedrick, P. W. 2000. Applications of population genetics and molecular techniques to conservation biology. Chap. 7 IN A. G. Young and G. M. Clarke, eds. Genetics, demography and viability of fragmented populations. Cambridge University Press.

Hedrick, R. P., T. S. McDowell, K. Mukkatira, M. P. Georgiadis, and E. MacConnell. 1999. Susceptibility of selected inland salmonids to experimentally induced infections with *Myxobolus cerebralis*, the causative agent of whirling disease. Journal of Aquatic Animal Health 11:330-339.

Heimer, J. T. 1972. Blackfoot River fishery investigation. Idaho Department of Fish and Game, Boise, ID.

Heimer, J. T. 1979. Regional Fisheries Management Investigations. Southeast Region (5). Job Performance Report. Project F-71-R-03. Idaho Department of Fish and Game, Boise, ID.

Heimer, J. T. 1980. Study 9. Portneuf River fisheries investigations. Job Completion Report Project F-73-R-02. Idaho Department of Fish and Game, Boise, ID.

Heimer, J. T. 1986. Regional Fisheries Management Investigations. Southeast Region (5). Job Performance Report. Project F-71-R-09. Idaho Department of Fish and Game, Boise, ID.

Heimer, J. T. 1987. Regional Fisheries Management Investigations. Southeast Region (5). Job Performance Report. Project F-71-R-10. Idaho Department of Fish and Game, Boise, ID.

Heimer, J. T., and R. Ratzlaff. 1987. Portneuf River and tributaries channel stability evaluation. Unpublished Report. Idaho Department of Fish and Game, Boise, ID.

Heimer, J. T., D. J. Schill, M. Harenda, and T. Ratzlaff. 1987. Regional Fisheries Management Investigations. Southeast Region (5). Job Performance Report. Project F-71-R-11. Idaho Department of Fish and Game, Boise, ID.

Henderson, R. 1999. Spawning strategies and hybridization potential of cutthroat, rainbow, and hybrid trout in a large river. Masters Thesis. Utah State University, Logan, UT.

Henderson, R., J. L. Kershner, and C. A. Toline. 2000. Timing and location of spawning by nonnative wild rainbow trout and native cutthroat trout in the South Fork Snake River, Idaho, with implications for hybridization. North American Journal of Fisheries Management 20:584-596.

Henjum, M.G., J.R. Karr, D.L. Bottom, D.A. Perry, J.C. Bednarz, S.G. Wright, S.A. Beckwitt and E. Beckwitt. 1994. Interim protection for late-successional forests, fisheries, and watersheds. National forests east of the Cascade Crest, Oregon, and Washington. A report to the Congress and President of the United States Eastside Forests Scientific Society Panel. American Fisheries Society, American Ornithologists Union Incorporated, The Ecological Society of America, Society for Conservation Biology, The Wildlife Society. The Wildlife Society Technical Review 94-2.

Hilderbrand, R. H. 2002. Simulating supplementation strategies for restoring and maintaining stream resident cutthroat trout populations. North American Journal of Fisheries Management 22:879–887.

Hiner, M. 1999. Epidemiological modeling of *Myxobolus cerebralis* infections in Idaho. Masters. Thesis, University of Idaho, Moscow, ID.

Idaho Department of Fish and Game. 2000. Comments to the U.S. Fish and Wildlife Service regarding petition to list Yellowstone cutthroat trout as threatened under ESA. Unpublished Report.

Idaho Department of Fish and Game. 2001. Fisheries Management Plan 2001-2006. Idaho Department of Fish and Game, Boise, ID.

Idaho Department of Fish and Game. 2007. Fisheries Management Plan 2007-2012. Boise, ID.

Irving, R. B. 1954. Ecology of cutthroat trout in Henrys Lake, Idaho. Transactions of the American Fisheries Society 84:275-296.

Irving, R. G. 1955. Creel census summary of some streams, lakes, and reservoirs within south Central Idaho fishery management area. Unpublished Report. Idaho Department of Fish and Game, Boise, ID.

Isaak, D.J. and W.A. Hubert. 2001. Management issues confronting fish populations in mountain tributaries in the Salt River. Report prepared for the Wyoming Game and Fish Department, U.S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY.

Jaeger, M. E., R. W. Van Kirk, and T. Kellogg. 2000. Distribution and status of Yellowstone cutthroat trout in the Henry's Fork Watershed. Intermountain Journal of Science 6:197-216.

Jeppson, P. 1976. Palisades Reservoir Fisheries Investigations. Job Performance Report. Project F-53-R-11. Idaho Department of Fish and Game, Boise, ID.

Jeppson, P. 1981. Teton River Fisheries Investigations. Job Completion Report. Project F-73-R-3. Idaho Department of Fish and Game, Boise, ID.

Jeppson, P. 1982. South Fork Snake River Fisheries Investigations. Job Completion Report. Project F-73-R-4. Idaho Department of Fish and Game, Boise, ID.

Jeppson, P. W., and K. Ball. 1979. Regional Fisheries Management Investigations. Upper Snake Region (6). Job Completion Report. Project F-71-R-03. Idaho Department of Fish and Game, Boise, ID.

Jeppson, P. W., O. E. Casey, D. R. Corley, J. L. Mallet, and W. S. Platts. 1965. Tests for increasing the returns of hatchery trout. Annual Completion Report. Project F-32-R-07. Idaho Department of Fish and Game, Boise, ID.

Kemmerer, G., J. F. Bovard, and W. R. Boorman. 1924. Northwestern lakes of the United States: biological and chemical studies with reference to possibilities in production of fish. Bulletin of the U.S. Bureau of Fisheries 39:51-140.

Koel, T.M., P.E. Bigelow, P.D. Doepke, B.D. Ertel, and D.L. Mahony. 2005. Nonnative lake trout result in Yellowstone cutthroat trout decline and impacts to bears and anglers. Fisheries 30: 10-19.

Koenig, M. K. 2005. Habitat and biotic factors influencing the distribution and recruitment of juvenile cutthroat trout in the Teton River, Idaho. Masters Thesis, Utah State University. Logan, UT.

Kruse, C. G., W. A. Hubert, and F. J. Rahel. 1997. Geomorphic influences on the distribution of Yellowstone cutthroat trout in the Absaroka Mountains, Wyoming. Transactions of the American Fisheries Society 126:418-427.

Kruse, C. G., W. A. Hubert, and F. J. Rahel. 2000. Status of Yellowstone cutthroat trout in Wyoming waters. North American Journal of Fisheries Management 20:693-705.

LaBar, G.W. and T. Frew. 2004. Using a fish-stocking database to demonstrate temporal changes in stocking patterns. Pages 113-118 in Nickum, M.J., P.M. Mazik, J.G. Nickum, and D.D. MacKinlay, editors. Propagated fish in resource management. American Fisheries Society, Symposium 44, American Fisheries Society, Bethesda, MD. http://www.fisheries.org.

LaBolle, L., and D. Schill. 1988. Upper Blackfoot system fishery management plan. Idaho Department of Fish and Game, Unpublished Report.

Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist 142:911–927.

Leary, R.F., F.W. Allendorf, S. R. Phelps, and K.L. Knudsen. 1987. Genetic divergence and identification of seven cutthroat trout subspecies and rainbow trout. Transactions of the American Fisheries Society 116: 580-587.

Lentsch, L.D., C.A. Toline, J. Kershner, J.M. Hudson, and J. Mizzi. 2000. Range-wide conservation agreement and strategy for Bonneville cutthroat trout. Utah Division of Wildlife Resources, Publication 00-19, Salt Lake City, UT.

Loudenslager, E.J. and R.M. Kitchin. 1979. Genetic similarity of two forms of cutthroat trout, Salmo clarki, in Wyoming. Copeia 1979: 673-678.

Mace, G. M., and R. Lande. 1991. Assessing extinction threats: towards a reevaluation of IUCN threatened species categories. Conservation Biology 5:148-157.

Mahony, D.L. and J.R. Ruzycki. 1997. Initial investigations towards the development of a lake trout removal program in Yellowstone Lake. Pages 153-162 in R. Hamre, editor, Wild Trout VI. Trout Unlimited and Federation of Fly Fishers, Fort Collins, CO.

Mallet, J. L. 1975. Hatchery trout/wild trout interactions. Unpublished Report. Idaho Department of Fish and Game, Boise, ID.

May, B. E. 1996. Yellowstone cutthroat trout, *Oncorhynchus clarkii bouvieri*. Pages 11-34 *in* D. A. Duff, editor. Conservation assessment for inland cutthroat trout: distribution, status and habitat management implications. U.S. Forest Service, Ogden, UT.

May, B. E., W. Urie, and B. B. Shepard**.** 2003. Range-Wide Status of Yellowstone Cutthroat Trout (*Oncorhynchus clarkii bouvieri*): 2001.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Management history of eastside ecosystems: Changes in fish habitat over 50 years, 1935 to 1992. U.S. Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR 321.

Meehan, W.R. (Ed.). 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19.

Mende, J. 1987. Regional Fisheries Management Investigations. Portneuf River Habitat Enhancement. Job Performance Report. Project F-71-R-11. Idaho Department of Fish and Game, Boise, ID.

Mende, J. 1989. Regional Fisheries Management Investigations. Portneuf River Assessment. Job Performance Report. Project F-71-R-12. Idaho Department of Fish and Game, Boise, ID.

Mende, J., R. J. Scully and M. Arms. 1993. Regional Fisheries Management Investigations. Job Performance Report. Project F-71-R-15. Idaho Department of Fish and Game, Boise, ID.

Meyer, K. A., and J. T. Lamansky. 2002a. Assessment of native salmonids above Hell's Canyon Dam, Idaho. Idaho Department of Fish and Game 2001 Annual Report, No. 02-57. Boise, ID.

Meyer, K. A., and J. T. Lamansky. 2002b. Assessment of native salmonids above Hell's Canyon Dam, Idaho. Idaho Department of Fish and Game 2000 Annual Report, No. 02-04. Boise, ID.

Meyer, K. A., and J. T. Lamansky. 2005. Assessment of native salmonids above Hell's Canyon Dam, Idaho. Idaho Department of Fish and Game 2003 Annual Report, No. 04-26. Boise, ID.

Meyer, K. A., D. J. Schill, F. S. Elle, and J. A. Lamansky. 2003a. Reproductive demographics and factors that influence length at sexual maturity of Yellowstone cutthroat trout in Idaho. Transactions of the American Fisheries Society 132:183-195.

Meyer, K. A., D. J. Schill, F. S. Elle, and W. C. Schrader. 2003b. A long-term comparison of Yellowstone cutthroat trout abundance and size structure in their historical range in Idaho. North American Journal of Fisheries Management 23:149-162.

Meyer, K. A., D. J. Schill, and J. A. Lamansky. 2006. Status of Yellowstone cutthroat trout in Idaho. Transactions of the American Fisheries Society 135: 1329-1347.

Moeller, J. 1981. Water quality status report: Willow Creek report. Idaho Department of Health and Welfare, Division of Environment, WQ-47, Boise, ID.

Moller, S., and R. Van Kirk. 2003. Hydrologic alteration and its effect on trout recruitment in the South Fork Snake River. Project completion report for Idaho Department of Fish and Game, Idaho Falls, ID. Department of Mathematics, Idaho State University, Pocatello, ID.

Moore, V. 1980. South Fork Snake River Fisheries Investigations. Job Performance Report. Project F-73-R-02. Idaho Department of Fish and Game, Boise, ID.

Moore, V. 1981. South Fork Snake River Tributary Inventory. Job Performance Report. Project F-73-R-3. Idaho Department of Fish and Game, Boise, ID.

Moore, V. K., and D.A. Andrews. 1983. Fishery productivity and economic value changes as a result of the Teton flood modifying streambeds. Unpublished Report. Idaho Department of Fish and Game, Boise, ID.

Moore, V., and D. Schill. 1984. South Fork Snake River Fisheries Inventory. Job Completion Report. Project F-73-R-5. Idaho Department of Fish and Game, Boise, ID.

Moore, V.K., C.E. Corsi, and R. Thurow. 1986. Yellowstone cutthroat trout (*Salmo clarkii bouvieri*) status, ecology and management in the Snake River drainage, Idaho. Pp 47-56 In: The ecology and management of interior stocks of cutthroat trout. Special Publication of the Western Division of the American Fisheries Society Special Publication. American Fisheries Society, Bethesda, MD.

Moore, V. K., K. Aslett, and C. E. Corsi. 1981. Regional Fisheries Management Investigations. South Fork Snake Fisheries Investigations. Job Performance Report. Project F-73-R-03. Idaho Department of Fish and Game, Boise, ID.

Neve, L.C., and V. K. Moore. 1983. Population estimates and size regimes of cutthroat and brook trout in Diamond, Kendall, and Spring Creeks, Idaho. Northwest Science 57:85-90.

Neville, H., J. Dunham, and M. Peacock. In press. Assessing connectivity in salmonid fishes with DNA microsatellite markers. In K. Crooks, and M. A. Sanjayan, editors. Connectivity conservation: maintaining connections in nature, Cambridge University Press. Boston, MA.

Ostberg, C. O., and R. J. Rodriguez. 2002. Bi-parentally inherited species-specific markers identify hybridization between rainbow trout and cutthroat trout subspecies. Molecular Ecology Notes 4:26-29.

Partridge, F. E., and C. E. Corsi. 1990. Regional Fisheries Management Investigations. Magic Valley Region (4). Job Completion Report. Project F-71-R-14. Idaho Department of Fish and Game, Boise, ID.

Partridge, F.E., C. Warren, and K.A. Frank. 2002. Regional Fisheries Management Investigations. Magic Valley Region. Job Completion Report. Project F-71-R-24. Idaho Department of Fish and Game, Boise, ID.

Platts, W. S., and S. B. Martin. 1978. Hydrochemical influences on the fishery within the phosphate mining area of eastern Idaho. USDA, Forest Service, Research Note INT-246.

Platts, W. S., and F. E. Partridge. 1980. Geomorphic and riparian conditions of streams in the phosphate mining area of Idaho. USDA, Forest Service, Intermountain Station Research Laboratory, Boise, ID,

Policansky, D., and J. J. Magnuson. 1998. Genetics, metapopulations, and ecosystem management of fisheries. Ecological Applications 8:S119–S123.

Reiland, E.W., 1997. Fish loss to irrigation canals and methods to reduce these losses on the West Gallatin River, Montana. Masters Thesis, Montana State University, Bozeman, MT.

Rieman, B.E., and F.W. Allendorf. 2001. Effective population size and genetic conservation criteria for bull trout. North American Journal of Fisheries Management 21:756-764.

Rieman, B.E., J.T. Peterson, and D.L. Myers. 2006. Have brook trout (*Salvelinus fontinalis*) displaced bull trout (*Salvelinus confluentus*) along longitudinal gradients in central Idaho streams? Canadian Journal of Fisheries and Aquatic Sciences 63:63-78.

Rohrer, R. L. 1983. Lake and Reservoir Investigations. Study 4: Evaluation of Henrys Lake management programs. Job 1: Evaluation of Henrys Lake trout stocking program. Project Report F75-R-05. Idaho Department of Fish and Game, Boise, ID.

Rohrer, R. L., and J. C. Coon. 1979. Lake and Reservoir Investigations. Study III. Henrys Lake fisheries investigations. Project Report F73-R-01. Idaho Department of Fish and Game, Boise, ID.

Rohrer, R. L., and G. H. Thorgaard. 1986. Evaluation of two hybrid trout strains in Henrys Lake, Idaho, and comments on the potential use of sterile triploid hybrids. North American Journal of Fisheries Management 6:367-371.

Rose, G. A. 1986. Growth decline in subyearling brook trout (*Salvelinus fontinalis*) after emergence of rainbow trout (*Salmo gairdneri*). Canadian Journal of Fisheries and Aquatic Sciences 43:187-193.

Ryman, N., and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology 5:325–329.

Schill, D. J., and J. T. Heimer. 1988. Regional Fisheries Management Investigations. Southeast Region (5). Job Performance Report. Project F-71-R-12. Idaho Department of Fish and Game, Boise, ID.

Schill, D. J., and L. D. LaBolle. 1990. Regional Fisheries Management Investigations. Southeast Region (5). Job Performance Report. Project F-71-R-13. Idaho Department of Fish and Game, Boise, ID.

Schill, D. J., J. S. Griffith, and R. E. Gresswell. 1986. Hooking mortality of cutthroat trout in a catch-and-release segment of the Yellowstone River, Yellowstone National Park. North American Journal of Fisheries Management 6:226-232.

Schill, D. J., J. Mende, and L. D. LaBolle. 1990. Regional Fisheries Management Investigations. Southeast Region (5). Job Performance Report. Project F-71-R-14. Idaho Department of Fish and Game, Boise, ID.

Scheaffer, R. L., W. Mendenhall, and L. Ott. 1996. Elementary survey sampling, fifth edition. Duxbury Press. Belmont, CA.

Schrader, W. C., and J. Fredericks. (In press). South Fork Snake River investigations. Idaho Department of Fish and Game, 2006 Annual Progress Report to U.S. Bureau of Reclamation, Grant #1425-05-FG-10-1188, Boise, ID.

Schrader, W. C., and R. G. Griswold. 1994a. Winter habitat availability and utilization by juvenile cutthroat trout, brown trout, and mountain whitefish in the South Fork Snake River, Idaho. Idaho Department of Fish and Game Fishery Research Report IDFG 94-23a, Boise, ID.

Schrader, W. C., and R. G. Griswold. 1994b. Winter habitat availability and utilization by juvenile cutthroat trout, brown trout, and mountain whitefish in the South Fork Snake River, Idaho. Idaho Department of Fish and Game Fishery Research Report IDFG 94-23b, Boise, ID.

Schullery, P. 1996. More than a fish story. Trout 37:18-25.

Scully, R. J., J. Mende, and M. Arms. 1993. Regional Fisheries Management Investigations. Job Performance Report. Project F-71-R-16. Idaho Department of Fish and Game, Boise, ID.

Sedell, J.R. and F.H. Everest. 1991. Historic changes in pool habitat for Columbia River Basin salmon under study for TES listing. Draft U.S. Department of Agriculture Report, Pacific Northwest Research Station, Corvallis, OR.

Soule, M. E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 135-150 *in* M. E. Soule and B. A. Wilcox, editors. Conservation Biology: an evolutionary-ecological perspective. Sinauer Associates, Sunderland, MA.

Teuscher, D. 2001. Lake and Reservoir Research. Job Performance Report. Project F-73-R-23. Idaho Department of Fish and Game, Boise, ID.

Thurow, R. 1980a. Blackfoot River Fisheries Investigations. Job Performance Report. Project F-73-R-1. Idaho Department of Fish and Game, Boise, ID.

Thurow, R. 1980b. Blackfoot River Fisheries Investigations. Job Performance Report. Project F-73-R-2. Idaho Department of Fish and Game, Boise, ID.

Thurow, R. 1981. Blackfoot River Fisheries Investigations. Job Performance Report. Project F-73-R-3. Idaho Department of Fish and Game, Boise, ID.

Thurow, R. F., C. E. Corsi, and V. K. Moore. 1988. Status, ecology and management of Yellowstone cutthroat trout in the upper Snake River drainage, Idaho. American Fisheries Society Symposium 4:25-36.

Thurow, R. F., D.C. Lee, and B. E. Rieman. 1997. Distribution and status of seven native salmonids in the interior Columbia River Basin and portions of the Klamath River and Great Basins. North American Journal of Fisheries Management 17:1094-1110.

Thurow, R. F., P. B. Aebersold, L. Wishard, and W. Christensen. 1981. Blackfoot River fisheries investigations. Job Performance Report. Project F-73-R-03. Idaho Department of Fish and Game, Boise, ID.

Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14: 18-30.

Utah Division of Wildlife Resources and Six Other State Agencies. 2000. Cutthroat trout management: a position paper. Genetic considerations associated with cutthroat trout management. Publication No. 00-26, Utah Division of Wildlife Resources, Salt Lake City, UT.

USDA and USDI (U.S. Department of Agriculture and U.S. Department of the Interior). 1996. Status of the Interior Columbia Basin, Summary of Scientific Findings. Interior Columbia River Basin Ecosystem Management Project.

USFWS (U.S. Fish and Wildlife Service). 2002. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR.

USFWS. 2006. Status Review Yellowstone Cutthroat Trout (*Oncorhynchus clarkii bouvieri*). U.S. Fish and Wildlife Service, Portland, OR.

Van Kirk, R. W., and M. Gamblin. 2000. History of fisheries management in the Upper Henrys Fork watershed. Intermountain Journal of Science 6:263-284.

Van Kirk, R. W., and L. Benjamin. 2001. Status and conservation of salmonids in relation to hydrologic integrity in the Greater Yellowstone Ecosystem. Western North American Naturalist 61:359-374.

Van Kirk, R. W., J.M. Capurso, and B.L. Gamett, editors. 2003. The Sinks Symposium: exploring the origin and management of fishes in the Sinks Drainages of Southeastern Idaho. Idaho Chapter American Fisheries Society.

Van Kirk, R.W. and A. Jenkins. 2005. Hydrologic alteration in the upper Teton watershed and its implications for cutthroat trout restoration. Project completion report for Friends of the Teton River, Driggs, ID. Department of Mathematics, Idaho State University, Pocatello, ID.

Van Kirk, R.W., J.M. Capurso, and M.A. Novak, editors. 2006. Exploring differences between fine-spotted and large-spotted Yellowstone cutthroat trout. Symposium Proceedings, Idaho Chapter American Fisheries Society.

Varley, J. D., and R. E. Gresswell. 1988. Ecology, status, and management of Yellowstone cutthroat trout. American Fisheries Society Symposium 4:13-24.

Wallace, R. C., J.C. Coon, and R. L. Rourke. 1978. Lake and Reservoir Investigations. Job 14a. Separation of Henrys Lake cutthroat and hybrid trout by morphological characteristics and by electrophoresis. Job Performance Report. Project F-53-R-12. Idaho Department of Fish and Game, Boise, ID.

Warren, C. D., and F. E. Partridge. 1994. Regional Fisheries Management Investigations. Magic Valley Region. Job Performance Report. Project F-71-R-17. Idaho Department of Fish and Game, Boise, ID.

Whirling Disease News. 2001. Whirling disease found in another Yellowstone tributary. http://water.montana.edu/programs/fish/WD/WDYellowstone.htm.

Wiley, Robert W. 1969. An ecological evaluation of the Snake River cutthroat trout fishery with emphasis on harvest. Masters Thesis, University of Wyoming, Laramie, WY.

Wissmar, R.C., J.E. Smith, B.A. McIntosh, H.W. Li, G.H. Reeves, and J.R. Sedell. 1994. A history of resource use and distribution in riverine basins of eastern Oregon and Washington (Early 1800s-1900s). Northwest Science Special Issue 68: 1-34.

Wright, S. 1931. Evolution in Mendelian populations. Genetics 16:97-159.

Wright, S. 1969. Evolution and the genetics of populations, Volume 2. The theory of gene frequencies. University of Chicago Press, Chicago, IL.