YELLOWSTONE CUTTHROAT TROUT

Oncorhynchus clarki bouvieri

By Certified Mail

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IN THE OFFICE OF ENDANGERED SPECIES

U.S. FISH AND WILDLIFE SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR

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Petitioners

Petition for a Rule to List the Yellowstone Cutthroat Trout (Oncorhynchus clarki bouvieri as Threatened under the Endangered Species Act, 16 U.S.C. § 1531 et seq. (1973 as Amended)

Introduction

The Biodiversity Legal Foundation, the Alliance for the Wild Rockies, the Montana Ecosystems Defense Council, and ecologist George Wuerthner hereby petition to list as "threatened" the naturally spawning Yellowstone Cutthroat Trout (Oncorhynchus clarki bouvieri) in United States riverine and lacustrine ecosystems where it presently continues to exist within its known historical range and to designate its occupied habitat as "critical habitat" under the Endangered Species Act (ESA) within a reasonable period of time following the listing, 16 U.S.C. § 1531-1543 (1982). This petition is filed under 5 U.S.C. § 553(e), 16 U.S.C. § 1533(b)(3)(A) and 50 C.F.R. § 424.19 (1987) which give interested persons the right to petition for issuance of a rule.

Endangered Species Act Implementing Regulations

Several sections of the regulations implementing the Endangered Species Act (50 C.F.R.) are applicable to this petition. Those concerning the listing of the Yellowstone Cutthroat Trout as a threatened species are:

> 424.02(e) "Endangered species" means a species that is in danger of extinction throughout all or a significant portion of its range … (k) "species" includes any species or subspecies that interbreeds when mature.
>
> "Threatened species" means a species that "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (16 U.S.C. § 1532(20)).
>
> 424.11(c) "A species shall be listed … because of any one or a combination of the following factors:
>
> 1. The present or threatened destruction, modification, or curtailment of habitat or range;
> 2. Overutilization for commercial, recreational, scientific, or educational purposes;
> 3. Disease or predation;
> 4. The inadequacy of existing regulatory mechanisms; and
> 5. Other natural or manmade factors affecting its continued existence."

All five of the factors set out in § 424.11(c) are applicable to the present status of Yellowstone Cutthroat Trout.

Sections relevant to the designation of critical habitat are:

> 424.12(a)(2) Critical habitat is not determined when one or both of the following situations exist: … (ii) The biological needs of the species are not sufficiently well known to permit identification of an area as critical habitat.
>
> 424.12(b) In determining what areas are critical habitat, the Secretary shall consider those physical and biological features that are essential to the conservation of a given species and that may required special management considerations or protection. Such requirements include, but are not limited to the following: (1) Space for individual and population growth, and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and generally (5) Habitats that are protected from disturbances or are representative of the historic, geographical, and ecological distributions of a species.
>
> 424.14(d) … Upon receiving a petition to designate critical habitat … to provide for the conservation of a species, the Secretary shall promptly conduct a review in accordance with the Administrative Procedures Act (5 U.S.C. 553) and applicable Department regulations, and take appropriate action.

This petition documents the need for the designation of critical habitat within a reasonable period of time following the ESA listing to provide for the conservation of the Yellowstone Cutthroat Trout.

After careful review of the best available scientific and commercial information, petitioners have concluded that the Yellowstone cutthroat trout warrants listing as a "threatened" species under the Endangered Species Act. Consequently, based on the documentation provided below, petitioners contend that the provisions of 50 C.F.R. compel the expeditious listing of the Yellowstone Cutthroat Trout as “threatened” where it still occupies habitat within United States riverine and lacustrine ecosystems and a review and appropriate action to designate “critical habitat” for the species.

Petitioners

The Biodiversity Legal Foundation (BLF) is a non-profit, science-based conservation organization dedicated to the preservation of all native wild plants and animals, communities of species, and naturally functioning ecosystems. Through reasoned educational, administrative, and legal actions, the BLF endeavors to encourage improved public attitudes and policies for all living things.

Alliance for the Wild Rockies ("Alliance") is a tax-exempt, non-profit public interest organization dedicated to the protection and preservation of the native biodiversity of the Northern Rockies Bioregion, its native plant, fish, and animal life, including the natural features of the region, and its naturally functioning ecosystems.

Its registered office is in Missoula, Montana, and the Alliance also maintains an office in Boise, Idaho. The Alliance has nearly 1,000 member businesses and organizations, and approximately 3,600 individual members. The Alliance's mission and goals include promoting protection for the native wildlife and fish species in the region and their habitat, establishment of wilderness areas, parks, wild and scenic rivers, and other designations to protect the natural and primitive qualities of the landscape of the Northern Rockies Bioregion, as well as protection of the currently established wildernesses, national parks, wild and scenic rivers, and other natural areas of the region. The Alliance also serves as a watchdog organization which reviews the policies and programs of federal land management agencies including the management of the natural resources of these park and wilderness areas, and provides the public with information on issues which affect the parks, wildernesses, and other natural landscapes of the Northern Rockies Bioregion, including the greater Yellowstone area.

Members of the Alliance hike, hunt, fish, camp, observe wildlife and natural features, including the natural features and native species of the greater Yellowstone region and the surrounding area, photograph, and otherwise enjoy the landscape in its primitive and natural condition for both professional reasons as well as spiritual fulfillment and sustenance.

Members of the Alliance currently work, or have worked, as park and forest rangers, naturalists, researchers, hiking guides, photographers, and nature writers who are directly affected by any activities which threaten or alter the natural qualities of the Northern Rockies Bioregion, including the management of the natural features and native fish and wildlife, and their habitat, of the greater Yellowstone area, and policies and plans which affect the laws that govern management of Yellowstone National Park and its resources.

Montana Ecosystems Defense Council (MEDC) is a non-profit Montana corporation, with its principal place of business at Bozeman, Gallatin County, Montana. MEDC is concerned with the national and international interest of maintaining the biological diversity and integrity of all natural ecosystems, and has a strong interest in the enforcement and administration of environmental laws, including the Endangered Species Act, Clean Water Act, Administrative Procedures Act, National Environmental Policy Act, and National Forest Management Act. Its members use Yellowstone National Park and the national forests surrounding the park for recreation of all kinds, including fishing, hunting, hiking, cross country skiing, and camping. MEDC has an organizational interest in the protection and recovery of the Yellowstone cutthroat trout (YCT). MEDC is concerned about the threats to YCT, its shrinking range, dangerously low population numbers, degraded habitat, and the inadequacy of regulatory mechanisms which currently fail to protect YCT and its habitat. MEDC brings this action on its own behalf and on behalf of its immediate and adversely affected members.

George Wuerthner is a freelance photographer, writer, ecologist, guide, and part-time university instructor. He lives in Livingston, Montana, adjacent to Yellowstone National Park, and within the heart of Yellowstone cutthroat trout natural range. He has written several natural history guides on cutthroat trout. He has a long-term interest in the aesthetics and population viability of Yellowstone cutthroat trout from many perspectives as a guide, ecologist, and sometime fisherperson of the trout. There is a tremendous amount of documented scientific evidence that suggests significant decline in numbers and distribution of the Yellowstone cutthroat trout, and he believes the fish warrants listing under the Endangered Species Act.

Endangered and Threatened Species Listing Criteria Applicable to the Current Status of the Yellowstone Cutthroat Trout

1. The present or threatened destruction, modification, or curtailment of habitat and range;

2. Overutilization for commercial, recreational, scientific, or educational purposes;

3. Disease or predation;

4. The inadequacy of existing regulatory mechanisms; and

5. Other natural or manmade factors affecting its continued existence.

Nomenclature

Formerly classified as Salmo clarki bouvieri, the Yellowstone cutthroat trout (Oncorhynchus clarki bouvieri) is one of a number of inland cutthroat trout subspecies.[1] O. c. bouvieri is considered to be one of the four “major” cutthroat trout subspecies (Behnke 1988). The subspecies is believed to have two forms, a large-spotted form and a fine-spotted form (sometimes referred to as the fine-spotted Snake River cutthroat trout) (May 1996, USDA FS 1997 - attached as Exhibit 1). The subspecies is in the class Osteichthyes, the order Salmoniformes, and the family Salmonidae.

Substantial variation exists between individual populations of the Yellowstone cutthroat trout, a factor discussed more fully in the following section. This variation is of such magnitude that Varley and Gresswell (1988) suggest that the traditional trinomial system of nomenclature “partially fails” as a management tool because it fails to capture the genetic distinctiveness of each individual Yellowstone cutthroat trout population. The consequences of this nomenclature failure, in the case of the Yellowstone cutthroat trout, are significant:

> When a highly variable species is known only by a single name, the institutional tendency seems to be to recognize and manage for the variation manifest in one entity. Legal and administrative protection available for those population segments representing the remaining unnamed (and often unknown) variation is significantly lessened. This variation is subject to loss by well-known factors such as nonnative species introductions, exploitation, and pollution, but more likely hazards are genetic dilution or hybridization.

[1] Some of the quotations included in this document precede the reclassification of Yellowstone cutthroat trout from genus Salmo to genus Oncorhynchus. The original text with the outdated classification is retained in such quotations.

> Managers interested in the survival and perpetuation of the remaining genetic variability in the Yellowstone cutthroat trout complex need to acquire a tool beyond the classic taxonomic approach. To date, it seems that evidence of life history and behavioral variability in these forms has advanced faster than knowledge of their genetic or phenotypic traits.
>
> Varley and Gresswell (1988:20)

These failings play heavily in the plight of the Yellowstone cutthroat trout.

Description of Species and Natural Ecology

The Yellowstone cutthroat trout is characterized by considerable intra-subspecific variation. Gresswell (1995:36) explains that “[i]ndividual populations have evolved numerous life history characteristics in response to the diverse environments in which they have been isolated since the last glacial retreat.”

> Reproductive isolation between populations of Yellowstone cutthroat trout has magnified behavioral differences and given rise to wide divergence in coloration, morphology (Cope 1957[]; Bulkley 1963; Behnke 1979), and biochemical-genetic factors (Loudenslager and Gall 1981).
>
> Varley and Gresswell (1988:13)

This significant variation (racial differences) even extends to populations occurring within the same body of water, probably as a consequence of the reproductive isolation caused by the return of fish to their natal streams for spawning (Varley and Gresswell 1988). In fact, this variation is of a magnitude “commonly found between subspecies or even species of trout” (Gresswell and Varley 1989:36).

This means that simply transplanting individuals from one stream segment to another, or from a hatchery to a stream segment, is likely to result in a) the relocation of individual fish to places for which they are not well adapted, and b) the destruction of the locally-adapted gene pool of any populations still remaining in such places. In other words, our ability to ensure the viability of the Yellowstone cutthroat trout will depend, in part, on our ability to protect as many existing individual populations (and their habitat), with their unique genetic and behavioral adaptations, as possible (in addition to ensuring adequate connectedness and metapopulation functioning); relying on hatchery programs (or naturally occurring source populations) to reintroduce fish to previously occupied (or underutilized) stream segments is a recipe for disaster.

<u>Description</u>

> The Yellowstone cutthroat trout is usually yellow-brown and dark olive-green or steel-grey color on the back; sides are generally lighter. The belly ranges from yellow to beige or off-white. A reddish cast along the middle of the side typically becomes darker from the caudal fin toward the head, and the operculum varies from rose to scarlet red. Large round, black spots are profuse on the caudal, adipose, and dorsal fins; spots on the back and sides are noticeably less numerous anteriorly.

> The head, which lacks spots, is short and relatively blunt, and the lower jaw is long, typically reaching past the rear margin of the eye. Small teeth on the tongue (basibranchial teeth) are always present. A red slash on each side of the lower jaw is characteristic. Lateral line scales vary from 150-200, usually 165-180. There are 10-11 dorsal fin rays and 10-11 anal fin rays.
>
> Gresswell and Varley (1989:35)

<u>Reproduction</u>

All Yellowstone cutthroat trout spawn "exclusively in running water" (Gresswell 1995:36), but there are three distinct life history forms. Resident populations only migrate within a river or stream home range, and do not enter tributary streams. Fluvial populations migrate from streams and rivers into tributaries, and adfluvial populations live in lakes and spawn in inlet or outlet streams (Gresswell 1995, USDA FS 1997).[2] Regardless of the life history form, Gresswell (1995:37) observes that "[s]traying during the spawning migration is low."

The timing of migrations varies considerably across tributaries (Gresswell 1995 citing Gresswell et al. 1994), and occurs over a seven month period (Gresswell and Varley 1989). Migrations are correlated to changes in water temperature. "In most tributaries to Yellowstone Lake, Yellowstone cutthroat trout spawners remain in streams from 6 to 25 days (Varley and Gresswell 1988), but in some larger tributaries, adfluvial spawners may not return to the lake for many months (Jones et al. 1982)" (Gresswell 1995:37).

Yellowstone cutthroat trout are commonly repeat spawners (Gresswell 1995 citing Clancy 1988, Thurow et al. 1988, and Varley and Gresswell 1988), but Gresswell notes that "the prevalence of iteroparity can be affected by angler harvest (Varley and Gresswell 1988)" (Gresswell 1995:38). The repeat spawning pattern "is probably related to growth, parasitic infection, and other physiological factors (Ball and Cope 1961)" (Gresswell 1995:39).

Gresswell (1995:37) explains that "[i]n tributaries to Yellowstone Lake, older and larger Yellowstone cutthroat trout migrate first (Ball and Cope 1961; Jones et al. 1990). Data suggest that older and larger individuals also migrate farther upstream (Cope 1957; Dean and Varley 1974); this behavior has been noted for other fishes (Briggs 1955). Nevertheless, fish usually spawn earlier at lower elevation sites" (Gresswell 1995:37). The age of maturation varies geographically for Yellowstone cutthroat trout, although most seem to mature between the ages of three and five (Gresswell 1995). Similarly, the "[a]verage size of Yellowstone cutthroat trout spawners is also variable," generally ranging from about 200 mm and 500 mm, although "[i]n small subalpine lakes and streams Yellowstone cutthroat trout may mature between 100 and 130 mm" (Gresswell 1995:38).

Spawning depends on the presence of gravel substrate of a particular size (0.5-3.4 in [12-85 mm]) and suitable water temperatures (42-65ºF [5.5-15.5ºC]) (Gresswell and Varley 1989). They explain that "[a] typical female of approximately 16 in (400 mm) from Yellowstone Lake will deposit about 1,300 eggs (1,073 eggs/lb or 2,633 eggs/kg). Egg mortality estimates in natural redds have ranged between 12 and 42%;

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[2] At least one report (Varley and Gresswell 1988) suggests that there are four distinct life history forms instead of only three: the "adfluvial" form is understood to be comprised of lacustrine adfluvial populations (residing in lakes and ascending tributaries to spawn) and allacustrine populations (residing in lakes and migrating downstream to spawn). This latter form is the rarest type of migratory behavior exhibited by Yellowstone cutthroat trout (Varley and Gresswell 1988).

surviving eggs typically hatch in 25-30 days, and juveniles emerge about 2 weeks later" (Gresswell and Varley 1989:35).

Fecundity and Early Development

Gresswell (1995:39) explains that:

> [f]ecundity is related to length, weight, or age of fish (Bagenal 1978), and changes in mean length and age affect population fecundity (Bagenal 1978). Although relative fecundity has remained unchanged … [a]verage fecundity of female Yellowstone cutthroat trout has risen in associated with increases in mean length.
>
> (parenthetical omitted)

He also explains that:

> [e]ggs generally hatch in 25-49 days … and juveniles emerge from the gravel 2 weeks later (Ball and Cope 1961; Mills 1966; Kelly 1993). Juveniles often move to shallow, slow-flowing areas, and migratory individuals soon begin to emigrate (Varley and Gresswell 1988).
>
> Gresswell (1995:39)

Growth

The growth rate of Yellowstone cutthroat trout is highly variable depending on the particular population (genetic stock) and the environmental conditions (Gresswell and Varley 1989, Gresswell 1995). The "[g]rowth rate generally increases as elevation decreases [and] migratory stocks grow faster than do nonmigratory stocks because of the greater growth potential in higher-order mainstem reaches" (Gresswell 1995:39-40). Also, the growth and potential maximum size from cutthroats varies from stock to stock and is directly linked to environmental factors (Hadley 1984, see Exhibit 2).

Foraging

Young Yellowstone cutthroat trout feed primarily on insects and zooplankton, while adult fish feed on a wide variety of fish, crustaceans, and insects (USDA FS 1997).

Habitat

Yellowstone cutthroat trout are well adapted to coldwater riverine and lacustrine environments (Gresswell and Varley 1989, Gresswell 1995). The elevational range of historically occupied habitat is from about 900 ft (275 m) to at least 8,500 ft (2,590 m) (Gresswell and Varley 1989). Optimum water temperatures for Yellowstone cutthroat trout seem to be between 4.5 and 15.5ºC (Gresswell and Varley 1989, Gresswell 1995 citing Carlander 1969). It is important to note that "water temperatures within portions of the historical range exceeded 26ºC" (Gresswell 1995:41). Unfortunately, most of the extant populations are adapted to cold-water conditions; most of these larger-river, warmwater populations have already been extirpated. Several warmer-water populations, located in geothermally heated streams (with an ambient water temperature of 27ºC) within Yellowstone National Park, still survive (Gresswell and Varley 1989, Gresswell 1995 citing Varley and Gresswell 1988).

In research conducted on thirteen cutthroat trout streams in Wyoming, nine environmental attributes explained more than 90% of the variation in standing crops:

late summer streamflows, annual streamflow variation, water velocity, trout cover, stream width, eroding stream banks, stream substrate, nitrate-nitrogen concentration, and maximum summer water temperature (Varley and Gresswell 1988 citing Binns and Eiserman 1979). Although the subspecies seems to be able to tolerate a broad range of chemical conditions (Gresswell 1995), it seems to be have been precluded in streams characterized by “widely fluctuating pH resulting from poor buffering capacity” (Gresswell 1995:41 citing Kelly 1993). Specifically, Yellowstone cutthroat trout are found in waters where the pH ranges from about 5.6 to over 10.0, and where total dissolved solids range between about 10 and 700 mg/L (Varley and Gresswell 1988).

Varley and Gresswell (1988) also report that spawning streams are typically fed by groundwater and snowmelt with gradients below 3%. Forest cover may not affect the distribution of redds (Gresswell 1995 citing research by Cope 1957 on redds in Yellowstone Lake tributaries) but the concentration of spawning gravel, water depth, and water velocity seem to play important roles (Varley and Gresswell 1988, Gresswell 1995 citing Thurow and King 1994). Thurow and King (1994, cited by Gresswell 1995) determined that the mean size of 66 redds studies was 1.58 m long by 0.60 m wide; they encompassed an area of approximately 1 m^2. Redd depth seems to vary from about 9 cm to about 55 cm, while water velocity at redds seem to range between 0 to 73 cm/s (Gresswell 1995). Redds are sometimes superimposed on one another (Gresswell 1995).

Research conducted by the U.S. Forest Service, Idaho State University, and Henrys Fork Foundation indicates that concealment cover is extremely important for winter survival of young-of-the-year (YOY) cutthroat trout; that “winter cover was commonly lacking in many areas, particularly the Henrys Fork (many streams have naturally low levels of cover, but this condition is exacerbated by degraded riparian habitat condition and artificially low winter flows);” that brook trout and rainbow trout YOY exhibit a competitive advantage over Yellowstone cutthroat trout YOY during winter (due to their larger size); and that although “some habitat improvements increase winter cover … this alone may not be sufficient to maintain populations of Yellowstone cutthroat trout where they co-exist with non-native salmonids (Griffith 1993 …)” (USDA FS 1997:6).

<u>Biotic Interactions</u>

Yellowstone cutthroat trout are of considerable ecological importance. For example, in Yellowstone Lake:

> the cutthroat trout decline will also cause severe disruption in the food supply for two species listed under the Endangered Species Act - the threatened grizzly bear and the endangered bald eagle - and will likewise affect many species of special concern, including the white pelican, otter, black bear, mink, osprey, and loon; an estimated 42 species of mammals and birds in all.
>
> Varley and Schullery (1995:3, see Exhibit 3)[3]

Species like white pelican, grizzly bear, and bald eagle commonly feed on the subspecies (Gresswell 1995). Additionally:

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[3] Schullery and Varley (1995:12) report elsewhere that "there are 42 species of mammals and birds that are known or suspected of using cutthroat trout for food in the Yellowstone Lake area."

> Sixty-four parasitic species are associated with cutthroat trout (Hoffman 1967; Heckmann and Ching 1987), and 18 of these have been collected from Yellowstone cutthroat trout from Yellowstone Lake (Heckmann 1971; Heckmann and Ching 1987).
>
> Gresswell (1995:43)

There seems to be widespread consensus in the literature that the introduction of non-native trout has had more impact on Yellowstone cutthroat trout than any other specific human activity. Of primary concern are brown trout (Salmo trutta), brook trout (Salvelinus fontinalis), rainbow trout (Oncorhynchus mykiss), and lake trout (Salvelinus namaycush). All four are known to depredate on Yellowstone cutthroat trout as well as directly compete with them for food, spawning habitat, and cover (USDA FS 1997, Kaeding et al. 1996, Varley and Schullery 1995). The propensity of Yellowstone cutthroat trout to hybridize with rainbow trout poses another, perhaps even more serious threat. "It is unlikely that rainbow and Yellowstone cutthroat trout can co-exist long-term without hybridization (Gamblin, personal communication 1996)" (USDA FS 1997:3).

Current Legal Status of the Yellowstone Cutthroat Trout

Federal

The Yellowstone cutthroat trout is not currently designated under the provisions of the ESA. The fact that it is not even designated as a candidate species is of considerable concern to petitioners. The subspecies is designated as a sensitive species by the U.S. Forest Service in the Northern, Intermountain (fine-spotted form), and Rocky Mountain Regions. The Inland Native Fish Strategy (INFISH) for FS and BLM lands in the Upper Columbia Basin, although directly widely at native fish, has very little bearing on the Yellowstone cutthroat trout or its habitat.

The subspecies has no formal designation within the National Parks, despite that the majority of its current range (91%) lies within the boundary of Yellowstone National Park (Gresswell 1995 citing Gresswell and Liss, in press).

Natural Heritage Programs

The Natural Heritage Program lists the Yellowstone cutthroat trout as a G4T2 species, where G refers to the global ranking for the overall species and T refers to the global ranking for the subspecies. This indicates that the Yellowstone cutthroat trout is understood to be "imperiled globally because of rarity or because of other factors demonstrably making it very vulnerable to extinction throughout its range." It is listed by the Montana Natural Heritage Program, the Wyoming Natural Diversity Database, and the Idaho Data Conservation Center as an S2 species. These state rankings of "2" are analogous to the global ranking of "2" (G4T2) at the statewide level (i.e., imperiled statewide because of rarity of because of other factors demonstrably making it very vulnerable to extinction throughout its range).

Montana

The Montana Department of Fish, Wildlife, and Parks classifies the Yellowstone cutthroat trout as a "species of special concern" (Clancy 1988). The department also "has legal authority for management, protection, preservation and propagation of fish within Montana" (Darling et al. 1993:10, see Exhibit 4).

Wyoming
Wyoming Game and Fish Department, in a draft native species status report (February 2, 1998) lists the Yellowstone cutthroat trout as Native Species Status 3 (on a scale of 1 to 7, where 1 is the most imperiled and the 7 the least). This report further identifies "Habitat decline or vulnerable" as a major concern. See Exhibit 45.

Idaho
Yellowstone cutthroat trout is listed as a species of special concern in Idaho (Gresswell 1995).

In addition to the U.S. Forest Service, the National Park Service, and the state governments, Yellowstone cutthroat trout habitat is also managed by the Bureau of Land Management, Tribal Governments, and private landowners.

Finally, the American Fisheries Society has designated the Yellowstone cutthroat trout as a "Species of Special Concern-Class A" (Gresswell 1995 citing Johnson 1987), and the Montana Department of Fish, Wildlife, and Parks has formally recognized this status (Gresswell 1995 citing Darling et al. 1994).

It is important to note that none of these designations provide any explicit habitat protection. In fact, because these various designations provide very little in the way of substantive protections for the trout, most conservation efforts have focused on largely superficial (although sometimes important) management measures. For example, while hatchery and restocking programs can create the illusion that trout populations are stable (or even increasing), they do nothing to restore and protect the habitat itself. Moreover, as described later in this petition, such programs involve the substantial risk of severely undermining recovery efforts (destruction of locally-adapted gene pools, spread of whirling disease, etc.). Similarly, while aggressively combating the lake trout invasion of Yellowstone lake is critical to the trout's recovery, the trout cannot be recovered until habitat is restored and connected so that healthy metapopulations across the historic range can become reestablished. The various designations noted above have done very little to further the restoration and protection of habitat, something that is essential to preventing the Yellowstone cutthroat trout's continuing demise.

Historic Status of the Yellowstone Cutthroat Trout

The Yellowstone cutthroat trout was one of several cutthroat trout subspecies that, historically, comprised the primary trout occupying western United States lakes and streams (May 1996, Behnke 1992). After becoming established in Yellowstone Lake approximately 8,000 years ago, the Yellowstone cutthroat trout began to spread throughout the region (Hadley 1984). Some researchers believe that the Yellowstone cutthroat trout was native to the entire Snake River system, but that it has since "been replaced by redband trout below Shoshone Falls of the Snake River and by the westslope cutthroat in the Salmon and Clearwater drainages (Behnke 1979 …)" (Hadley 1984:5).

Minimally, the historical range of the Yellowstone cutthroat trout included the upper portion of the Yellowstone River and the upper portion of the Snake River (upstream from Shoshone Falls, Idaho), in the Missouri River and Columbia basins, respectively (Behnke 1992, Gresswell 1995, May 1996). The occupied Yellowstone River drainage included portions of Wyoming and Montana, while the occupied Snake River drainage included portions of Wyoming, Idaho, Utah, Nevada, and probably Washington (Gresswell 1995, Varley and Gresswell 1988, and Behnke 1992). Reports from historic exploration expeditions and settlements (1800 to 1900) indicate that the Yellowstone cutthroat trout was abundant in this range (Behnke 1992).

In Idaho, May (1996) estimated that there were 3,797 miles of historic Yellowstone cutthroat trout riverine habitat, including approximately 210 stream miles that are occupied by the fine-spotted Snake River cutthroat form. This figure also includes 58 miles of stream habitat located in Nevada and Utah. May (1996:16) notes that "[t]here is little historical information that quantifies trout abundance; most historic references provide an indication that trout were very abundant in upper stream reaches and common in lower areas (Gilbert and Evermann 1892; Rollins 1935)" (May 1996:16).

May (1996) estimated that Wyoming contained 10,949 miles of historical Yellowstone cutthroat trout riverine habitat, including approximately 1,569 miles of stream habitat probably occupied by the fine-spotted Snake River cutthroat trout. These estimates are probably inflated, however, because stretches were included that were not likely to have been occupied. The historic range also included 113 lakes (including, most significantly, Yellowstone Lake) (May 1996). May notes that "[t]here was considerable uncertainty regarding how much of the mainstem Bighorn and Tongue Rivers, within Wyoming, supported cutthroat trout," but that "actual historic trout habitat probably extended downstream to somewhere between Worland and Thermopolis" (May 1996:18). As far as abundance, May (1996:18) observes that:

> [w]ithout exception, the early records of cutthroat trout, in and around Yellowstone National Park, refer to the populations as abundant to extremely abundant (Evermann 1891; Jordan 1891; Gilbert and Evermann 1894; Kendall 1914; Trotter and Bisson 1988).

Regarding Montana, May (1996) estimates that there was approximately 1,927 miles of historic Yellowstone cutthroat trout riverine habitat, in addition to two lakes. May (1996) concludes that the historic range probably did not include the mainstem Yellowstone River downstream from about where its confluence with the Bighorn River is located. It also did not include the lower portion of the mainstem Bighorn River or the Tongue River drainage below the state line. Hadley (1984) discusses the historical abundance of Yellowstone cutthroat trout in Montana. She states that "[t]he Yellowstone cutthroat trout in Montana was at one time abundant in most of the waters of the Yellowstone river basin from the Montana-Wyoming border to the Tongue River system" Hadley (1984:12). She notes Evermann's (1894) report that Yellowstone cutthroats were quite abundant in Montana's Tongue River basin. For example, Evermann (1894) offered this account of the Tongue River basin in Montana:

> Small parties have reported as many as 800 fish taken with hook and line in a few days. There is so much fishing done now in that region that most residents are of the opinion that if something is not done to stock the stream its fame as a fishing resort will soon be lost.
>
> Hadley (1984:12) citing Evermann (1894)

The Yellowstone cutthroat trout seems to have evolved as a distinct metapopulation (May 1996). Under such a scenario, "[p]opulations within the larger tributary streams and the mainstem rivers at times would have acted as 'sources' and at other times 'sinks' (Pulliam, 1988; Stacey and Taper, 1992)" (May 1996:22). These metapopulation dynamics have been largely disrupted by the loss of connectivity between populations and their habitats and by the dramatic declines in occupied historic riverine range. Documented declines in the Yellowstone cutthroat trout occurred as early as 1894, and were attributed at that time to fishing pressure and increased water and land use (Hadley 1984 citing Hanzel 1959). Continued declines were also associated with egg removal for hatchery operations, genetic mixing, and "greatly reduced natural spawner escapement" (Gresswell and Varley 1988:45). Such declines are characteristic of most native cutthroat trout:

> The impact of European civilization on cutthroat trout was rapid and devastating. In less than 100 years after the first settlements in the West, the cutthroat trout vanished from most of its vast range, except for the coastal subspecies, to be replaced by rainbow trout *Salmo gairdneri*, brown trout *S. trutta*, and brook trout *Salvelinus fontinalis* (and by lake trout *Salvelinus namaycush* and kokanee *Oncorhynchus nerka* in many large lakes).
>
> Behnke (1988:1)

Present Biological Status of the Yellowstone Cutthroat Trout in the States Comprising its Historic Range

The story of the Yellowstone cutthroat trout is the same as the story of all the native inland cutthroat trout: "Western trout (Behnke [and Zarn] 1976) and salmon (Nehlsen et al. 1991) have suffered catastrophic declines in abundance due to essentially similar factors (e.g., exotic species introduction, habitat degradation and over harvest)" (May 1996:11). Hadley (1984:1) notes that, as of 1984, "<u>[a] conservative estimate is that 99% of the original populations of S. clarki in the interior regions of the United States have been lost in the last 100 years</u>" (emphasis added).

Although the Yellowstone cutthroat trout seems to have fared better than most of the inland cutthroat, it, too, has experienced dramatic reductions in range and it, too, faces serious threats to its continued survival.

> Within the historic range, the subspecies is presently estimated to exist in pure form in about 38,500 hectares of lakes and 2,400 km of streams … it means about 85% of the minimum estimate of the original habitat (44,500 hectares) is still occupied. By contrast, only about 10% of the estimated original stream range of about 24,000 km remains inhabited.
>
> Varley and Gresswell (1988:14)

Gresswell (1995) also notes, citing Hanzel (1959), that the declines and extirpations of Yellowstone cutthroat trout have occurred with the greatest magnitude in low-elevation, high-order (three or larger) streams.

Those populations that still exist are substantially imperiled. For one thing, connectivity between these populations, critical for genetic interchange and for adequate metapopulation dynamics (e.g., the recolonization of locally extirpated populations), has been decimated by water impoundments and diversions, by reduced instream flows, and by habitat degradation. Many of these remaining populations "currently exist as localized remnants of original sub-populations with little or no connectivity" (May 1996:23, emphasis added). Similarly, habitat fragmentation may disrupt critical life history migration processes.

Another severe problem is that introgression has occurred throughout the historic range of the Yellowstone cutthroat trout (and beyond). In other words, many of these remaining populations, in addition to being cut off from critical interactions with other populations, can not be considered pure Yellowstone cutthroat trout populations because they have been genetically contaminated by non-native cutthroat and other trout.

Ironically, in some cases it is the very impediments to connectivity that have protected the few remaining pure populations from hybridization. For example, "[e]xcept where barriers limited access (e.g., Waha Lake, Idaho, and Crab Creek, Washington), rainbow trout have replaced the Yellowstone cutthroat trout in the Columbia River Basin below Shoshone Falls on the Snake River (Behnke 1992)" (Gresswell 1995:42). Gresswell (1995) also notes that reproductive isolation seems to have been averted in four tributaries to the upper Blackfoot (citing Wishard et al. 1980) and in the Yellowstone River below the Lower Falls.

One of the most challenging management considerations relative to this introgressive hybridization is that many of the existing populations presumed to be pure Yellowstone cutthroat trout have never been conclusively tested, and as a consequence it is expected that current estimates substantially inflate the actual numbers of remaining pure populations:

> Caution should be applied before developing conclusions relative to overall Yellowstone cutthroat status. With the exception of populations in Montana, most populations have not received sufficient testing for a definitive assessment of genetic status.
>
> May (1996:23)

The remaining pure populations, in addition to the hurdles posed by degraded habitat and the loss of connectivity, are threatened by continued habitat degradation (including inadequate flow regimes), competition with and predation by introduced non-native fish species, fishing pressure, and a recent and extremely disconcerting development, the spread of whirling disease among hatchery stocks and in the wild.

For instance, Shepard (1997) reports that "[t]he discovery of lake trout in Yellowstone Lake has placed a much higher risk on a portion of their range which we all considered as a core refuge area. This finding places the subspecies more at risk" (Letter of Brad Shepard, Fisheries Biologist, Montana Department of Fish, Wildlife and Parks, to Mimi Mather, 6/16/97, emphasis added, see Exhibit 5). The rapid expansion of the lake trout population within Yellowstone Lake and into other segments of the Yellowstone River drainage is a critical concern. Other populations, May (1996) notes, exist only because of continued hatchery programs, a situation which hardly constitutes a sustainable and viable population. Furthermore, many of these hatchery-dependent populations might not even consist of genetically pure Yellowstone cutthroat trout. Not surprisingly, many remaining populations may still be in decline. For instance, data collected in Yellowstone National Park indicates "a general trend of fewer upstream migrants is evident since 1987" on Clear Creek (Yellowstone Center for Resources 1996:39-40, attached as Exhibit 24). Similarly, a recent report by the Henrys Fork Foundation and the Targhee National Forest identified significant concerns throughout the Henrys Fork watershed including local extinctions of populations identified in previous surveys (Van Kirk et al. 1997, attached as Exhibit 12).

Montana

Only 18% of the streams and only 11% of the total stream miles in Montana reviewed by Hadley (1984) were thought to contain allopatric populations of Yellowstone cutthroat trout. These figures may well be overestimates, however, as Hadley's review was based on external morphological characteristics and not on the genetic assessments required to conclusively establish genetic purity (Darling et al. 1993). Moreover, rainbow-cutthroat hybrids were thought to be present in 60% of the streams where Yellowstone cutthroat trout was sympatric with rainbow trout (Hadley 1984). In short, Hadley (1984:19) reports:

> [t]hese data indicate that the decline in geographical distribution of the Yellowstone cutthroat trout observed by many investigators continues … If only 24% of the total stream kilometers examined in this study contain what we tentatively believe are pure strain Yellowstone cutthroat trout, then a strategy for management of this subspecies becomes all the more important.
>
> (emphasis added)

Subsequent to Hadley's (1984) report, a concerted effort to identify genetically pure populations in the state was initiated, and based on this effort, May (1996) estimates that approximately 625 miles of stream habitat (about 32% of the historic riverine habitat) are currently occupied by Yellowstone cutthroat trout in Montana. He notes that "[o]f the three states, Montana's assessment of current occupancy of historic habitat is likely the most accurate" (May 1996:21). As of that study, 65 streams had been identified as being occupied by genetically pure populations of Yellowstone cutthroat trout, and it is likely that genetic validation efforts have surveyed 80 to 90% of current riverine populations (May 1996).[4] Of the 28 stream segments identified by the

[4] These figures differ from those of a slightly earlier Forest Service research report. Gresswell (1995:45) concludes that, "[c]onsidering only genetically unaltered populations in Montana, it appears that only 10% of the historical range (stream km) in that state still sustains Yellowstone cutthroat trout." Darling et al. (1992) also reports different figures, indicating that of the 63 streams sampled and visually identified as potentially pure Yellowstone cutthroat trout, only 44 (70%) were subsequently thought to be pure on the basis of genetic testing. Even these results are qualified, however, because the sample sizes in some of the populations thought to be pure were to small to provide statistically reliable conclusions (because the density of the subspecies in those populations was too low). A further qualification is that the study was biased toward the stream segments most likely to contain pure populations (and is thus not a representative sample of stream segments across the currently occupied historical range). The report concludes that "[e]ven with this bias, of the 41 streams sampled during 1989 and 1990 only 24 (59%) of these streams actually supported pure populations" (Darling et al. 1992:4).

Montana Natural Heritage Program as containing what appear to be genetically pure populations, only 19 were in segments that seemed to be completely free of hybrids and contaminants. The summary of this data is attached as Exhibit 6, and the original data is attached as Exhibit 7. In fact, exotic species are known to be present in <u>every</u> <u>one</u> of Montana's 13 subbasins, and are viewed as a threat in 11 (85%) of the subbasins (May 1996). It is unknown to petitioners how many of these populations identified as genetically pure and free from an immediate risk of hybridization continue to exist under these conditions.

Although Montana's lake populations may be in better condition, they do not seem to be adequate to ensure viability for the subspecies across its historic range. Only 40% of the lakes reviewed by Hadley (1984) contained what were believed to be allopatric Yellowstone cutthroat trout populations. As noted above, this determination was not based on genetic assessments and, consequently, may well be inflated (Darling et al. 1993). In fact, preliminary results of the genetic analysis conducted by the Yellowstone Cutthroat Trout Working Group (YCTWG, cited as Darling et al. 1992, 1993, and 1994) for pure population surveys indicated that only 77% of those thought to be pure based on meristic analysis appeared to be genetically pure, and, even more disconcerting, this effort focused specifically on streams "where there was a high probability that pure populations occurred (Hadley 1984)" (Darling et al. 1993). "Even with this bias," the report notes, only 59% "of those streams actually supported pure populations" (Id.). Another 40% contained the cutthroat but also had a history of stocking with contaminant species, predominantly other cutthroat trout subspecies. An additional and very serious concern is the expansion of the lake trout population in Yellowstone Lake to its current magnitude; the lake trout pose a serious threat to the entire Yellowstone River system. This issue is addressed in detail below (in the section on the present biological status in Wyoming).

The concern is not simply limited to the proportion of presently occupied historical habitat and the presence of exotic species in each of the subbasins; it extends to the actual status of the remaining populations as well:

> The population status of the stream dwelling Yellowstone cutthroat within the stream reaches examined was found to be in a relatively unhealthy state. In approximately 70% of the streams examined, the populations were characterized by the field biologists as being uncommon, rare, abundance unknown or presence not verified but expected. The remaining populations were characterized as being common and/or abundant. In only one case was a population classified as being common and having a significant number of large-sized fish.
>
> Hadley (1984:17)

May's (1996:32) assessment was similar. Of Montana's 13 subbasins, he concluded that nine (70%) were "at risk" and that status of two was unknown. Only one of the 13 subbasins was thought to be "secure – stable."

Numerous factors, as detailed elsewhere in this petition, have served to decimate Montana's Yellowstone cutthroat trout populations. The stocking of species with a propensity for hybridizing with or outcompeting the Yellowstone cutthroat has been an especially serious concern in the state. For instance:

> In Montana, virtually all drainages where rainbow trout have been stocked in the historical range of Yellowstone cutthroat trout now support hybrid populations of the two species (Hanzel 1959). Allendorf and Leary reported evidence of hybridization and introgression in 8 of 16 samples from tributaries to the Yellowstone River in Montana. Because there tributaries were selected at random, Allendorf and Leary (1988) asserted that the results were a reliable representation of hybridization in the Yellowstone River drainage.
>
> Gresswell (1995:45)

The results of these impacts have been dramatic: One researcher reports that "native fluvial populations are restricted to the Yellowstone River drainage, primarily upstream of Big Timber, Montana" (Clancy 1988). "The majority of riverine cutthroat trout populations were determined to be stable but at risk," in part because all sub-basins in Montana are occupied by exotic species and in eleven of thirteen sub-basins these exotic species are characterized as a threat to Yellowstone cutthroat trout (May 1996:21). "Competing species such as brown trout (e.g., Bad Canyon Creek, Stillwater drainage) and brook trout (e.g., Smith Creek, Shields River drainage) have replaced cutthroat to a significant degree in many streams. Within Little Mission Creek there has been recent (since 1986) rainbow trout hybridization of the genetically pure cutthroat population" (May 1996:21). However, 143 mountain lakes in Montana currently support discrete Yellowstone cutthroat trout populations that are probably genetically pure (May 1996).

A large volume of water is diverted from the Montana portion of the Yellowstone River and its tributaries for commercial cattle operations. Berg (1975, cited by Clancy 1988:40) concluded that "the complete diversion of most major tributaries of the upper Yellowstone River for irrigation was a significant factor in the decline of the Yellowstone cutthroat trout," while other researchers have concluded that such water diversions continue to be another particularly significant factor in the continuing decline of Montana's Yellowstone cutthroat trout populations (Gresswell 1995, Hadley 1984). These diversions occur, and thus numerous streams are dewatered, during the spawning and early life stages of the Yellowstone cutthroat trout and usually exceed eight weeks in length (Clancy 1988). Clancy (1988) concluded that the Montana Yellowstone cutthroat trout populations appear to be limited by this considerable water diversion from spawning tributaries.

Mineral extraction is yet another concern in Montana. Gresswell (1995:47) notes that:

> An abandoned gold mine in the headwaters of Soda Butte Creek (near Cooke City, Montana, upstream from Yellowstone National Park) caused extensive pollution through the 1960s (Jones et al. 1982) … A planned expansion of mining near Cooke City poses a renewed threat to the Yellowstone cutthroat trout population in Soda Butte Creek (Jones et al. 1992).

Angling pressure, habitat degradation, and other threats discussed elsewhere in this petition have also made their mark on Montana's Yellowstone cutthroat trout populations. The consequences, as noted above, have been devastating. For instance, on both the Gallatin and Custer National Forests, May (1996:22) identifies "[r]oad construction, logging, and grazing as having the greatest the greatest impact to channel modification, dewatering, limited large woody debris and increases of sediment." Hadley (1984:1) reports that "[f]or at least the last 20 years, fishery biologists in the state have been aware of a continuing loss of Montana's native cutthroat trout populations." Hadley explains further that:

> These data indicate that the decline in the geographic distribution of the Yellowstone cutthroat observed by many investigators continues. If it is assumed that the ... data provided by the Department [of Fish, Wildlife and Parks] ... accurately [reflects] ... Yellowstone cutthroat distribution in the state, then it can be concluded that there has been a continual, significant loss in Yellowstone cutthroat.
>
> Hadley (1984:19)

Gresswell (1995:44-45) sums up the situation:

> In contrast to declines of other cutthroat trout subspecies, the decline of Yellowstone cutthroat trout has been well documented. In a summary of the distribution of Yellowstone cutthroat trout in Montana, Hadley (1984) reported a continued loss of Yellowstone cutthroat trout populations from a previous assessment by Hanzel (1959). More recently, biologists estimated that the subspecies historically occupied approximately 4,800 ... km of streams in Montana ... ([Darling et al.] 1994). Habitat suitability for Yellowstone cutthroat trout was not verified for all locations identified in Wyoming, thus these may be overestimates. Approximately 965 km of streams in Montana ... were assumed to currently support Yellowstone cutthroat trout. These estimates may also be inflated because populations are introgressed in 42-50% of the current habitat in Montana ... ([Darling et al.] 1994). Considering only genetically unaltered populations in Montana, it appears that only 10% of the historical range (stream km) in that state still sustains Yellowstone cutthroat trout ... Significantly, 54% of the existing fluvial habitat of Yellowstone cutthroat trout supports introduced salmonids, e.g., brown trout and brook trout, that are potential competitors or predators.

When considered in light of severe dewatering, timber harvesting, road-building, mining, water impoundments, and the numerous additional impacts to Yellowstone cutthroat trout and its habitat across Montana, it is clear that the subspecies is substantially imperiled. In other words, agency management allowing the continued degradation of trout habitat for the sake of commodity interests, while generally not acting to protect or restore this habitat, has meant a severe management imbalance in favor of the former and placing the cutthroat trout at risk of extinction.

Idaho

Yellowstone cutthroat habitat in Idaho includes the Snake River drainage from Shoshone Falls upstream to the border between Idaho and Wyoming. This includes the mainstem Snake River, major tributaries and numerous smaller tributary streams. The Sawtooth, Caribou and Targhee National Forests lie within this area. May (1996) determined that approximately 1,622 miles of stream are presently inhabited by

Yellowstone cutthroat trout, approximately 43% of the historic habitat estimate. However, this figure is likely an overestimate, as "[o]nly a minor amount of genetic verification has occurred to date and there is a possibility that many populations have been influenced by rainbow trout hybridization" (May 1996:16). The populations in the headwater portion of Goose Creek, Eight Mile Creek, and the headwater tributaries to the Blackfoot River have been verified as genetically pure, but rainbow trout presence and probable hybridization occurs in 16 of the 21 identified sub-basins in the state (May 1996).

Some of the Yellowstone cutthroat trout in Idaho are of the fine-spotted Snake River form:

> [T]he fine-spotted Snake River form is confined to the South Fork of the Snake River below Jackson Lake downstream to, and including, Palisades Reservoir, and all tributaries of the Gros Ventre River to the Salt River. Notable exceptions are Pacific Creek, Buffalo Fork, and Spread Creek, all tributaries to the South Fork Snake below Jackson Lake, which are inhabited by the large-spotted form. The fine-spotted Snake River form has also been introduced into the South Fork of the Snake River, Jackson Lake, and into the Snake River above Jackson Lake. In addition, eleven high lakes within the Teton River and South Fork Snake drainages have been stocked with the fine-spotted and/or large-spotted form. Endemic populations of both forms are found in the Gros Ventre drainage with the large-spotted form inhabiting the tributaries and the fine-spotted Snake River form inhabiting the rest of the drainage (Behnke 1992).
>
> USDA FS (1997:4)

The major threats to Idaho's Yellowstone cutthroat trout are the same as the major threats throughout the range. As noted above, hybridization with introduced populations is perhaps the most significant threat, and confirmed or probable hybridization has occurred throughout Snake River basin (e.g., Thurow et al. 1988). Similarly, the subspecies also faces substantial threats from introduced competitors (e.g., Thurow et al. 1988). Differential angling mortality (in part due to selective angling for larger, older Yellowstone cutthroat) has led to significant angler exploitation and has contributed to the decline of native cutthroat in the upper Snake River basin (Thurow et al. 1988).

Habitat degradation is another major threat to Idaho's Yellowstone cutthroat trout (Thurow et al. 1988:31), and a passage from that article is worth citing in full:

> Construction of dams and reservoirs has severely restricted the range of viable wild Yellowstone cutthroat trout populations. Dams have isolated migratory cutthroat trout from tributary spawning and rearing areas in the Blackfoot, Portneuf, South Fork Snake, Teton, Henrys Fork Snake, and main-stem Snake rivers. Lack of adequate spawning and rearing areas in reached below dams has contributed to the decline of migratory cutthroat trout ... Dams and reservoirs have also indirectly contributed to the decline of native Yellowstone cutthroat trout. A majority of the reservoirs in the upper Snake River system are relatively shallow and eutrophic, with no temperature stratification. Substrates are predominantly silt and contain few vascular plants ... Diversion of water

> for irrigation is very detrimental to cutthroat trout in the upper Snake River drainage. The greatest impacts result from channel dewatering, sever flow reductions, movements of trout into unscreened irrigation ditches, and degraded water quality. Low flows especially limit cutthroat trout populations in reaches of the Blackfoot, Henrys Fork Snake, Portneuf, Raft, Teton, and main-steam Snake rivers and Willow Creek. Large numbers of cutthroat trout enter unscreened ditches in the South Fork Snake River, Willow Creek, and tributaries to Henrys Lake ... Intensive livestock grazing has contributed to the deterioration of riparian areas by stream bank sloughing, channel instability, erosion, and sedimentation. In the Blackfoot River and Willow Creek tributaries, stream reaches altered by livestock display unstable banks and predominantly silt substrate (Platts and Martin 1978). Altered reaches sustained fewer spawning cutthroat trout and had smaller densities of rearing juveniles (Thurow 1982; Corsi 1988). 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. Impacts occur on private lands as well as lands administered by the Bureau of Land Management, U.S. Forest Service, and the Idaho Department of Lands. Within the upper Blackfoot River and Willow Creek, extensive areas of riparian willow habitat have been eradicated with herbicides. Dry-land wheat farming has contributed to large sediment inputs, particularly in the Willow Creek drainage, which is considered one of the 20 worst agricultural erosion areas in the nation (Moeller 1981).

These threats are consistent with the results of May (1996:17), who reported that "[s]pecific comments pointed to channel dewatering, changes to channel morphology and increased sediment as major factors influencing habitat." A substantial portion of Idaho's Yellowstone cutthroat trout habitat is managed by the U.S. Forest Service. The patterns described above are similar for these lands as well. May (1996:17) reports that:

> [f]or the National Forests, in general, dewatering, changes in temperature, channel modification, limited large woody debris and sediment were viewed as the factors with the greatest affect on habitat condition. The land-use that was identified as having the greatest influence was grazing, followed by logging, road construction and mining.

The Forest Service reports that, on most streams of the Targhee National Forest, "non-native fish have partially or completely replaced Yellowstone cutthroat trout. This trend has been documented in many other areas outside the Forest (Griffith 1988)" (USDA FS 1997:6).

According to May (1996), 20% of the 10 sub-basins on the Caribou National Forest are in good condition, 40% are in fair condition, and 20% are in poor condition. On the Sawtooth National Forest, 33% of the three sub-basins are fair and 33% are poor. On the Targhee, 86% of the seven sub-basins are good and 43% are fair. It is unclear to petitioners if these assessments take into account factors such as sediment loading and dewatering.

Additional information is available regarding the Yellowstone cutthroat trout on the Targhee National Forest. There are 55 creeks on the Targhee National Forest occupied by the Yellowstone cutthroat trout (USDA FS 1997). The Biological Evaluation notes that seven of these creeks (Rainey, Targhee, Duck, Pine, Leigh, Teton, and Bitch Creeks) have been improved (changes in livestock grazing practices, road closures or obliterations, and structural habitat improvements) but it does not indicate what the current habitat conditions are (i.e., how much they were improved) and how this has affected the resident Yellowstone cutthroat trout populations. Regardless of the improvement of specific habitats on the Targhee, as is the case throughout the current range, remaining pure populations are increasingly and disturbingly fragmented. The Biological Evaluation reports that:

> The level of connectivity within rivers and their tributaries, as well as between the aquatic, riparian, and terrestrial (riparian) ecosystems, has steadily decreased following European settlement … This habitat fragmentation increased genetic isolation and reduces genetic diversity among remnant populations and has contributed to localized extinctions on the Forest.
>
> USDA FS (1997:7)

The Targhee National Forest Biological Evaluation on Yellowstone cutthroat trout indicates that within the Forest boundaries are 394 miles (13%) of the total historical river and stream habitat. It includes the following information on the presence of pure populations of Yellowstone cutthroat trout:

Sinks drainage – “none detected, surveys ongoing” and introduced populations in Aldous and Hanncock Lakes (5)

Henrys Fork Snake River system – Henrys Fork Snake River (below Falls River-outside Forest boundary), Falls River (below Conant Creek-outside of Forest boundary), Robinson, Targhee, Duck, Timber, Tygee, and Reas Pass Creeks, and Henrys Lake. Introduced populations in Grassy Lake Reservoir (USDA FS 1997)

Teton River System – Bithc, South Bitch (Wyoming), South Boone (Wyoming), Conant (Wyoming), North and South Moody, Darby, Moose, South Badger (Wyoming), Jackpine, Teton, North and South Leigh, Squirrel (Wyoming), and Trail Creeks (Wyoming) and Falls River (Wyoming), and Camp, Fish, Grassy, Lower Green, and Teton Lakes. Introduced populations in Moose, Hidden, Treasure, South Leigh, Basin, Packsaddle, and Granite Lakes. (USDA FS 1997).

South Fork Snake River system – Salt River, South Fork Snake River, Antelope, Palisades, Rainey, King, Burns (Idaho), Bear, Burns (Wyoming), Garden, Granite, Trout, McCoy, Big Elk, Sidoway Fork (of Big Elk), Little Elk, Indian (of Palisades Reservoir), Indian (of main stem South Fork), Pine, Fall, Landslide, Yeaman, Pritchard, Black Canyon, Williams, Wolverine, Sulfur Bar, Van, Edwards, and Big Springs Creeks, Upper and Lower Palisades Lakes. (USDA FS 1997)

Drainage-by-drainage analysis (from May 1996 unless otherwise noted)

Snake River (Shoshone Falls to American Falls)

This segment is 5% Sawtooth National Forest, 30% Bureau of Land Management, and 60% private. None of the 373 miles of historic stream habitat is currently occupied and none of the 25 miles of historic stream habitat on FS land is currently occupied. Gresswell (1995:47) notes that "[i]n Idaho, the Blackfoot, Henrys Fork Snake, Portneuf, Raft, Teton, and mainstem Snake rivers and Willow Creek are seriously affected by irrigation removals (Thurow et al. 1988)."

Goose Creek

This segment is 25% Sawtooth National Forest, 30% Bureau of Land Management, and 40% private. Eleven percent of the 265 miles of historic stream habitat is currently occupied and 0% of the 25 miles of historic stream habitat on FS land is currently occupied. This includes information from Nevada and Utah.

Raft Creek

This segment is 25% Sawtooth National Forest, 40% Bureau of Land Management, and 33% private. Three percent of the 375 miles of historic stream habitat currently is occupied and 0% of the 53 miles of historic stream habitat on Forest Service land is currently occupied. This includes information from Nevada and Utah. Gresswell (1995:47) reports that "[i]n Idaho, the Blackfoot, Henrys Fork Snake, Portneuf, Raft, Teton, and mainstem Snake rivers and Willow Creek are seriously affected by irrigation removals (Thurow et al. 1988)."

Snake River (American Falls to Henrys Fork)

This segment is 2% Caribou National Forest, 15% Bureau of Land Management, and 64% private. All of the 245 miles of historic stream habitat is currently occupied. Gresswell (1995:47) reports that "[i]n Idaho, the Blackfoot, Henrys Fork Snake, Portneuf, Raft, Teton, and mainstem Snake rivers and Willow Creek are seriously affected by irrigation removals (Thurow et al. 1988)."

Bannock Creek

This segment is 20% Bureau of Land Management and 29% private. None of the 116 miles of historic stream habitat is currently occupied.

Portneuf River

This segment is 15% Caribou National Forest, 10% Bureau of Land Management, and 65% private. None of the 323 miles of historic stream habitat is currently occupied and 0% of the 38 miles of historic stream habitat on FS land currently occupied.

There is a considerable amount of information available on this habitat area. Gresswell (1995:45, 47) reports that "[i]n the upper Snake River drainage, hybridization with rainbow trout has resulted in the virtual disappearance of Yellowstone cutthroat trout in the Henrys Fork Snake River (Griffith 1988) and lower portions of the Blackfoot, Portneuf, and Teton rivers (Varley and Gresswell 1988)," and that "[i]n Idaho, the Blackfoot, Henrys Fork Snake, Portneuf, Raft, Teton, and mainstem Snake rivers and Willow Creek are seriously affected by irrigation removals (Thurow et al. 1988)." In fact, as a result of these low streamflows (related to an extended drought) and high fishing pressures in the Blackfoot River and Portneuf drainages (Caribou National Forest), "YCT populations are probably at an all time low in this area" (Letter from Robert Leffert, Fisheries Biologist, Caribou National Forest to Mimi Mather, 7/22/97, attached as Exhibit 8).

1. Lower Portneuf (PWI Watershed 20)

A Forest Service reports notes that the Lower Portneuf "contains limited fisheries … [and] is heavily impacted by recreationists" (USDA FS n.d. d:1, attached as Exhibit 9). Thurow et al. (1988) reports that rainbow trout have displaced Yellowstone cutthroat trout in the lower reaches of the Portneuf river. Mink Creek, to which the Forest Service report devotes considerable attention, is reported to contain a cold water fishery with "[l]imited densities of wild cutthroat, brook, brown and rainbow trout [that] are supplemented by the stocking of hatchery rainbow" (USDA FS n.d. d:6). Surveys by the Idaho Game and Fish Department in 1991 and 1994 and surveys conducted by Griffith observed declining numbers and, in fact, no cutthroat trout were observed in 1994 (USDA FS n.d. d).

The problem in Mink Creek, as across the entire Yellowstone cutthroat trout range, seems to be that "[m]any of the channels … have been altered by a variety of influences that have affected fisheries habitat, including road building, recreation, livestock use, and natural events" (USDA FS n.d. d:7). Specifically, "[r]ecreation use from a variety of activities contributes to trails deterioration, stirring of the streambed at trail crossings, and bacteria and oil/grease pollution of streams. Recreation use contributes to sediment movement, garbage, bacteria, and viruses and chemical forms of pollution" (USDA FS n.d. d:3). This (in addition to other factors) results in the identification of sediment and turbidity as the major problems to water quality in this waterway (USDA FS n.d. d:3).

2. Upper Portneuf East (PWI Watershed 17)

Toponce and Pebble Creeks, both tributaries of the Portneuf, are the major streams in this part of the drainage. Toponce Creek is "virtually isolated from the Portneuf River" while Pebble Creek has a "limited passage" (USDA FS n.d. b:1, attached as Exhibit 10). Both "are good fisheries and support both native and stocked Rainbow Trout and native Cutthroat Trout" (USDA FS n.d. b:1). Furthermore, water quality is thought to be sufficient to "support and maintain a cold water fisheries in each of the streams and their tributaries" (USDA FS n.d. b:1). Pebble Creek is classified as "highly critical" in the Forest Plan, meaning that it contains "depressed fishery stocks of statewide significance (Yellowstone Cutthroat Trout). Fishery is of value on a statewide basis, though local anglers may contribute heavily to the total angling pressure" (USDA FS n.d. b:1).

The Forest Service report notes that:

> Toponce Creek contains a small resident Cutthroat population and is a satisfactory fishery. It is expected that riparian and channel improvements implemented over the past years will continue to improve overall habit [sic] and fishing potential. Pebble Creek is a heavily used fisheries and habitat remains in satisfactory condition. Recent riparian and channel stabilizing projects are expected to improve overall habitat by reducing the sediment loading on the stream thus improving pool and substrate quality.
>
> USDA FS n.d. (b:2)

Toponce Creek is classified as “critical” in the Forest Plan, which explains that the “fishery [is] utilized by anglers from a three to four county area. This minimum level of production is necessary to maintain a stable, self-sustaining fish population” (USDA FS n.d. b:1).

Despite these optimistic projections, however, “the sedimentation potential of Toponce and Pebble Creeks is high, unless adequate measures are taken to reduce soil erosion and delivery to stream channels” (USDA FS n.d. b:1).

3. Upper Portneuf West (PWI Watershed 18)

Inman and Webb Creeks are the major streams in this watershed (USDA FS n.d. c). "None of the drainages within the watershed provides sufficient perennial water to support viable salmonid populations, though some individual fish may be found" in a few of the small streams (USDA FS n.d. c:1, attached as Exhibit 11). Moreover, brook trout and brown trout are both known to exist in the watershed (USDA FS n.d. c).

Blackfoot River

This segment is 10% Caribou National Forest and 63% private. Although Thurow et al. (1988) identify the Blackfoot as home to a population of genetically pure Yellowstone cutthroat trout, May (1996) concludes that none of the 393 miles of historic stream habitat is currently occupied and 0% of the 57 miles of historic stream habitat on FS land is currently occupied. Problems on the Blackfoot River mirror those elsewhere across the subspecies’ range. Introgressive hybridization is a serious concern. Gresswell (1995:45) reports that:

> [i]n the upper Snake River drainage, hybridization with rainbow trout has resulted in the virtual disappearance of Yellowstone cutthroat trout in the Henrys Fork Snake River (Griffith 1988) and lower portions of the Blackfoot, Portneuf, and Teton rivers (Varley and Gresswell 1988).
> (see also Thurow et al. 1988)

Non-native brook trout are common in this drainage (Thurow et al. 1988).

A Forest Service report concludes that "[t]he Blackfoot drainage has been impacted by timber harvesting, roads, recreation, farming, ranching, livestock grazing and mining" (USDA FS n.d. a:1, attached as Exhibit 25). The literature identifies mining as a particular problem on the Blackfoot River as well (Gresswell 1995, USDA FS n.d. a). Gresswell (1995) discusses the substantial influence of mineral extraction in the Blackfoot River drainage, and both Gresswell (1995) and Platts and Martin (1978) specifically identify phosphate mining as a concern.

Inadequate flows are also a serious concern. Gresswell (1995:47) reports that, “[i]n Idaho, the Blackfoot, Henrys Fork Snake, Portneuf, Raft, Teton, and mainstem Snake rivers and Willow Creek are seriously affected by irrigation removals (Thurow et al. 1988).” In fact, as a result of both low streamflows (related to an extended drought) and high fishing pressures in the Blackfoot River and Portneuf drainages (Caribou National Forest), “YCT populations are probably at an all time low in this area” (Letter from Robert Leffert, Fisheries Biologist, Caribou National Forest to Mimi Mather, 7/22/97). Furthermore, "[d]rought conditions have reduced water flows, further reducing in-stream habitat. Reduced flows have allowed additional sediment to accumulate in the channels rather than flushing the sediment through the system" (USDA FS n.d. a:2).

Willow Creek

This segment is 5% Caribou National Forest and 74% private. All of the 286 miles of historic stream habitat is currently occupied, but Thurow et al. (1988) reported declining Yellowstone cutthroat trout populations. Non-native brook trout are common in this drainage (Thurow et al. 1988). Gresswell (1995) identifies irrigation dewatering as having a serious affect on habitat quality.

Henrys Fork Snake River (confluence to St. Anthony)

This segment is 30% Bureau of Land Management and 65% private. All of the 44 miles of historic stream habitat is currently occupied. Hybrids are a major concern, of course. In the Henrys Fork Snake River, native Yellowstone cutthroat trout are nearly extinct and the abundant rainbow trout exhibit evidence of hybridization with the cutthroat trout (Thurow et al. 1988). Gresswell (1995) reaches a similar conclusion. Non-native brook trout are common in this drainage (Thurow et al. 1988). Gresswell (1995) also reports that dewatering has seriously affected this river segment.

Teton River

This segment is 33% Targhee National Forest and 55% private. Thurow et al. (1988) reported a genetically pure but declining population, but May (1996) concluded that none of the 443 miles of historic stream habitat is currently occupied. Moreover, Gresswell (1995) reports that hybridization with rainbow trout has led to the virtual disappearance of Yellowstone cutthroat trout here (see also Thurow et al. 1988), and that irrigation dewatering has also had a serious impact. Non-native brook trout are common in this drainage (Thurow et al. 1988).

Henrys Fork Snake River (St. Anthony to Henrys Lake)

This segment is 50% Targhee National Forest, 8% Bureau of Land Management, 21% National Park Service, and 15% private. Ten percent of the 279 miles of historic stream habitat is currently occupied and 0% of the 127 miles of historic stream habitat on FS land is currently occupied. Thurow et al. (1988) reports that, in the Henrys Fork Snake River, native Yellowstone cutthroat trout are nearly extinct and the abundant rainbow trout exhibit evidence of hybridization with the cutthroat trout. The severity of the decline of the Henrys Fork Snake River population is exacerbated by the extensive hybridization with rainbow trout and the severe irrigation dewatering, both reported by Gresswell (1995), and by the presence of non-native brook trout populations (Thurow et al. 1988). In the Centennial Mountains, population surveys indicate that Yellowstone cutthroat trout have been replaced by brook trout, regardless of habitat condition. (USDA FS 1997 citing Griffith, personal communication). Cutthroat hybridized with rainbow trout are found downstream from Henrys Lake (Van Kirk et al. 1997).

Falls River

This segment is 35% Targhee National Forest and 64% private. None of the 100 miles of historic stream habitat is currently occupied and none of the 27 miles of historic stream habitat on Forest Service land is currently occupied.

Warm River

This segment is 80% Targhee National Forest and 13% National Park Service. All of the 97 miles of historic stream habitat is currently occupied.

Buffalo River

This segment is 89% Targhee National Forest and 5% private. None of the 19 miles of historic stream habitat is currently occupied and none of the 19 miles of historic stream habitat on Forest Service land is currently occupied.

Henrys Fork (above Henrys Lake)

This segment is 63% Targhee National Forest and 25% private. All of the 58 miles of historic stream habitat is currently occupied and all of the 35 miles of historic stream habitat on Forest Service land is currently occupied. Brook trout and rainbow-cutthroat hybrids are present in Henrys Lake (Van Kirk et al. n.d., attached as Exhibit 13). Van Kirk et al. (1997:8) report that "[r]esident Yellowstone cutthroat trout currently occupy only a few spatially disjoint headwater streams in the upper Henrys Fork watershed." Brook trout and rainbow-cutthroat hybrids are present in Henrys Lake (Van Kirk et al. n.d.). Van Kirk et al. (1997) report that Tygee Creek supports a large, isolated population, and that Wyoming Creek supports a small, isolated population. However, they also report that Robinson and Targhee Creeks contain mixed populations, and that Warm River contains no viable population at all. Cutthroat trout were not observed in a series of creeks in which they were reported during a 1983 survey (Robinson Creek above a barrier falls and Rock, Snow, Fish, and Little Robinson Creeks) (Van Kirk et al. 1997).

South Fork Snake River (Henrys Fork to Pallisades Reservoir)

This segment is 50% Targhee National Forest and 40% private. All of the 171 miles of historic stream habitat is currently occupied and all of the 98 miles of historic stream habitat on Forest Service land is currently occupied (May 1996), but studies have identified a declining cutthroat trout population throughout the South Fork Snake drainage (Thurow et al. 1988). Surveys of the South Fork Snake River by the Idaho Department of Fish and Game raised concerns over possible interactions, including hybridization, between rainbow trout and Yellowstone cutthroat trout (USDA FS 1997)

South Fork Snake River (above Pallisades Reservoir)

This segment is 59% Caribou National Forest and 34% private. All of the 100 miles of historic stream habitat and 50% of historic lake habitat (1 lake) is currently occupied. All of the 96 miles of historic stream habitat on Forest Service land is currently occupied (May 1996), but studies have identified a declining cutthroat trout population throughout the South Fork Snake drainage (Thurow et al. 1988). This drainage supports both large- and fine-spotted forms. Surveys of the South Fork Snake River by the Idaho Department of Fish and Game raised concerns over possible interactions, including hybridization, between rainbow trout and Yellowstone cutthroat trout (USDA FS 1997)

Jackknife Creek

This segment is 90% Caribou National Forest and 10% private. All of the 17 miles of historic stream habitat is currently occupied and all of the 13 miles of historic stream habitat on Forest Service land is currently occupied. This drainage supports both large- and fine-spotted forms.

Tincup Creek

This segment is 90% Caribou National Forest and 10% private. All of the 36 miles of historic stream habitat is currently occupied and all of the 31 miles of historic stream habitat on Forest Service land is currently occupied. This drainage supports both large- and fine-spotted forms.

Stump Creek

This segment is 50% Caribou National Forest and 42% private. All of the 17 miles of historic stream habitat is currently occupied and all of the 11 miles of historic stream habitat on Forest Service land is currently occupied. This drainage supports both large- and fine-spotted forms.

Crow Creek

This segment is 75% Caribou National Forest and 20% private. All of the 40 miles of historic stream habitat is currently occupied and all of the 33 miles of historic stream habitat on Forest Service land is currently occupied. This drainage supports both large- and fine-spotted forms.

Wyoming

May (1996) estimates that there are approximately 4,624 miles of stream habitat in Wyoming currently occupied by Yellowstone cutthroat trout, including 1,751 miles of the fine-spotted form. This figure (42% of the historic habitat) is likely an overestimate, however, as subspecies identification was generally based on meristic analysis and/or other visual techniques, "which have limited ability to detect hybridization with rainbow trout" (May 1996:19), and "there is no information available concerning the genetic purity of Yellowstone cutthroat trout populations in Wyoming ([Darling et al.] 1994)" (Gresswell 1995:45). Given that "96% of the sub-basins have exotic species present, including rainbow trout, or they have received past plants of rainbow trout" (May 1996:19), the probability that this estimate is inflated is quite high. In fact, May (1996:13) specifically identifies 48% of the state's 25 subbasins as threatened by exotic species.

An assessment of current habitat conditions in Wyoming (May 1996) indicates that only a minor portion of the occupied habitat reflects excellent habitat conditions. Across the occupied range in Wyoming, "[g]razing, mining, logging, road construction and agriculture were the land-uses identified as contributing to channel dewatering, channel modification, limited large wood and increased sediment" (May 1996:19). On National Forest lands, the report rated 74% of the habitat as good and 26% as fair. There was considerable uncertainty about habitat conditions on the Bighorn National Forest, but "[g]razing and road construction were viewed as the primary land-uses contributing to increased sediment" (May 1996:20). On the Shoshone National Forest, half of the habitat was rated as good and half as fair. Channel dewatering/hydrograph alteration, channel modification, limited woody debris, and elevated sediment were all identified as major habitat condition factors, and grazing, mining, and logging were the land-uses associated with the degradation of habitat quality. Most of the habitat on the Bridger-Teton was rated as good and stable, and "[l]imited woody debris, elevated sediment levels, channel modification and channel dewatering were the factors identified and grazing was the most significant land use" (May 1996:20).

With respect to the presence of the fine-spotted form (also cited earlier), a Forest Service Biological Evaluation reports that:

> [T]he fine-spotted Snake River form is confined to the South Fork of the Snake River below Jackson Lake downstream to, and including, Palisades Reservoir, and all tributaries of the Gros Ventre River to the Salt River. Notable exceptions are Pacific Creek, Buffalo Fork, and Spread Creek, all tributaries to the South Fork Snake below Jackson Lake, which are inhabited by the large-spotted form. The fine-spotted Snake River form has also been introduced into the South Fork of the Snake River, Jackson Lake, and into the Snake River above Jackson Lake. In addition, eleven high lakes within the Teton River and South Fork Snake drainages have been stocked with the fine-spotted and/or large-spotted form. Endemic populations of both forms are found in the Gros Ventre drainage with the large-spotted form inhabiting the tributaries and the fine-spotted Snake River form inhabiting the rest of the drainage (Behnke 1992).
>
> USDA FS (1997:4)

In fact, <u>hatchery programs have posed a particular threat to the Yellowstone cutthroat trout in Wyoming</u>. In addition to the widespread introductions of non-native trout throughout the range of the Yellowstone cutthroat trout, hatchery stocks of the cutthroat trout subspecies have been introduced into lakes and stream segments with locally-specific distinct gene pools, introgressing and thus contaminating those gene pools. The Wyoming Game and Fish Department's introduction of fine-spotted Snake River cutthroat trout noted above "poses unknown risks and consequences to Yellowstone cutthroat trout inhabiting the Teton River and its tributaries" (USDA FS 1997:3). This is a serious concern throughout the entire range.

Reports concerning Yellowstone National Park identify numerous concerns throughout the Park. For example, the Lamar River populations are characterized by high levels of rainbow trout introgression (Boltz et al. 1993, attached as Exhibit 14). Soda Butte Creek, in the Lamar River drainage, has been heavily impacted by high angler harvest, historical mining activity, mine tailing erosion, introgression from westslope cutthroat trout and rainbow trout, and competitive exclusion by brook trout (Boltz et al. 1993, Kaeding et al. 1995b, attached as Exhibits 14 and 15 respectively). FWS reports that in Reese Creek "agricultural irrigation withdraws water from these tributaries, often limit[] the reproductive success of resident and fluvial-adfluvial salmonid populations" (Kaeding et al. 1994:35, attached as Exhibit 16). Although Mist Creek is reported to possibly contain a pure population, the Cougar Creek population is significantly hybridized with westslope cutthroat trout (Boltz et al. 1993).

<u>Lake trout</u>

The severity of the threat posed to Yellowstone cutthroat trout by the illegal introduction of lake trout into Yellowstone Lake cannot be overstated. Yellowstone Lake contains the largest inland population of cutthroat trout in the world (Gresswell and Varley 1988), and has been widely characterized as the core refuge for this imperiled subspecies (e.g., Kaeding et al. 1996; Schullery and Varley 1995; Letter of Brad Shepard, Fisheries Biologist, Montana Department of Fish, Wildlife and Parks, to Mimi Mather, 6/16/97, see Schullery and Varley 1995 attached as Exhibit 3). Yellowstone Lake sustains 80% of all remaining Yellowstone cutthroat trout and 90% of Yellowstone National Park's river fish winter in the lake (Gresswell and Varley 1988).

While “Yellowstone Lake is the last great refuge of the once widespread Yellowstone cutthroat trout,” (Schullery and Varley 1995:12, emphasis added), the lake’s population is “is threatened with destruction” (Varley and Schullery 1995:2, emphasis added). The National Park Service, as early as in their 1994 Fishery and Aquatic Management Program Annual Report (for Yellowstone National Park) noted that "[t]he presence of nonnative, piscivorous lake trout, represents a potentially serious threat to this population. Whether the Yellowstone cutthroat trout population will maintain its resilience as the lake trout population expands in unknown" (USDI NPS 1995:15). Kaeding et al. (1996:16) explain that:

> [t]he perception of Yellowstone Lake as a secure refuge for Yellowstone cutthroat trout changed abruptly on 30 July 1994, when an angler on a guided fishing trip on the lake caught a lake trout …

This report suggested that lake trout in Yellowstone Lake number in the thousands or tens of thousands. That this species is capable of rapid population growth (Kaeding et al. 1996 citing Curtis 1990), that “lake temperatures and water quality are ideal for lake trout” (Kaeding et al. 1996:19), that there seem to be many suitable spawning locations, that the lake trout is highly piscivorous (Kaeding et al. 1996, Varley and Schullery 1995), and that Yellowstone cutthroat trout have life history characteristics that make them especially vulnerable to lake trout predation (Kaeding et al. 1996) all point to the enormity of the threat. Mahoney and Ruzycki note that "[c]utthroat trout were found to be the primary prey of large lake trout" (n.d.:1, attached as Exhibit 17). A single lake trout may eat as many as 90 cutthroat trout per year,[5] and it is estimated that between 25,000 and 27,000 cutthroat trout might have been consumed by the total number of lake trout captured in 1996 (Yellowstone Center for Resources 1996:38). Ruzycki and Beauchamp (n.d., attached as Exhibit 18) estimate that:

> a population of 1,000 piscivorous lake trout ... would consume 59,000 cutthroat trout/yr. If the population were a magnitude of order greater, and if density dependence was not yet operating, the 10,000 piscivores would be consuming nearly 600,000 cutthroat trout/yr. A population size of 10,000 piscivores is not an unreasonable population size for a system the size of Yellowstone Lake.

The problems stem, in part, from the fact that "[f]ew cutthroat trout are invulnerable to the largest lake trout predators in the lake," and that "lake trout are capable of ingesting prey at least half their body length" (Ruzycki and Beauchamp n.d.).

A team of expert scientists convened by the National Park Service in 1995 concluded that “the lake trout population in Yellowstone Lake is likely to expand and cause precipitous decline in the cutthroat trout population” (Varley and Schullery 1995:2). Specifically, they concluded “that there is little chance lake trout can be eliminated from Yellowstone Lake” and that “a decline of 90% or more in Yellowstone

[5] Ruzycki and Beauchamp (n.d.:1) estimate that "[a]n average piscivorous lake trout (>300 mm TL) is estimated to consume 59 cutthroats each year," and that "[t]his analysis demonstrates the potential negative impact of an introduced predator into an ecologically isolated ecosystem" (Id.). They add that their "modeling simulations indicated that predation by lake trout can substantially impact the cutthroat trout population" (Id.:6).

cutthroat trout numbers in 20 years – 100 years" was likely "if the lake trout population were not controlled" (Kaeding et al. 1996:20). Unfortunately, the ability of current control technologies and methodologies to control the lake trout population in Yellowstone Lake is unknown. This team estimated the chance that control of the lake trout population's expansion was feasible "to be at least 50%," hardly encouraging odds (McIntyre 1995:28, attached as Exhibit 3).

Moreover, if efforts to control the invader are unsuccessful, the consequences will likely be grave: "[I]f control measures are ineffective on these large predators and if smaller cohorts continue to recruit to this size class, they will have the ability to seriously impact the cutthroat trout population" (Ruzycki and Beauchamp n.d.:6). In fact, wherever lake trout have appeared in places with wild cutthroat populations the cutthroat trout are virtually eliminated (e.g., Heart Lake and Jackson Lake) (Gresswell and Varley 1988 and Kaeding et al. 1996, respectively).

Although the threat posed by lake trout to the single most important surviving population of pure Yellowstone cutthroat trout is clearly severe, of even greater concern is the potential impact to other pure populations in the Yellowstone River drainage. This is because "91% of the remaining range of the Yellowstone cutthroat trout is located in Yellowstone National Park, and practically all of that is in the Yellowstone Lake and River" and is thus vulnerable to the catastrophic impacts of lake trout colonization (Schullery and Varley 1995:14). In other words, a large percentage of the remaining pure populations in historic habitat may be severely threatened by lake trout colonization, and the largest and most important core refuge for the subspecies (Yellowstone Lake) has already suffered substantial impacts. The most important Yellowstone cutthroat trout stronghold is biologically imperiled. It is clear (as discussed elsewhere in this petition) that control of the Yellowstone Lake population of lake trout, if it is even possible, will require an enormous long-term commitment of funding and other resources.[6] The presence of longnose sucker (Catostomus catostomus) and other exotics may, in the long-term, have additional adverse impacts.

In short, the literature is generally unanimous on the centrality of hybridization as the major threat to the continued persistence of the Yellowstone cutthroat trout, and although legal stocking has been discontinued, remaining pure populations still face significant risks due to the possibility of illegal stocking and due to the continued spread of exotics and hybrids (including stocking Yellowstone cutthroat trout). The existence, possible continued illegal stocking, and spread of competing exotics are serious related threats. The most graphic example of this threat is the lake trout crisis in Yellowstone Lake. Lake trout are already having a substantial impact on the single most important native cutthroat population and have the potential to severely impact the entire Yellowstone River drainage.

Additional Wyoming concerns are identical to those elsewhere across the Yellowstone cutthroat trout range. For instance, on the Snake River, Gresswell (1995) reports that numerous impoundments have altered historical fish migration patterns. Gresswell (1995:48) also reports that "Thurow et al. (1988) suggested that angler harvest had contributed to the decline of Yellowstone cutthroat trout in the upper Snake River basin" (Gresswell 1995:48). Similarly, regarding the South Fork Snake, Gresswell (1995) reports that "Elle and Gamblin (1993) suggested that reduced winter flows below

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[6] In addition to the enormous impact that the rapid growth and potential spread of lake trout are likely to have on the future of the Yellowstone cutthroat trout, the lake trout catastrophe is also likely to have enormous adverse ecological and economic impacts (Varley and Schullery 1995).

a damn on the South Fork Snake River resulted in significant mortality of age 0 Yellowstone cutthroat trout."

One pure population was identified in the Bighorn basin on South Paintrock Creek, and it is thought that a population in Lodgegrass Creek (tributary to West Fork Little Bighorn) might be pure, although petitioners do not know if genetic verification has occurred (Behnke 1990).

Stream segments of concern

The following are stream segments that have been identified by biologists as streams where a management regime emphasizing the Yellowstone cutthroat trout is needed based on May (1996):

Bighorn River (state line to Thermopolis): 24% (14 miles) of historic stream habitat is currently occupied (20% Bighorn NF, 70% BLM). "Stream mileages for both historic and currently occupied habitat are likely over estimates and include stream segments which would not support fish."

Shoshone River: 30% (525 miles) of historic stream habitat is currently occupied (40% Shoshone NF, 50% private). "Stream mileages for both historic and currently occupied habitat are likely over estimates and include stream segments which would not support fish."

Shell Creek: 17% (24 miles) of historic stream habitat is currently occupied (20% Bighorn NF, 70% private).

Bighorn tributaries (east side): 23% (9 miles) of historic stream habitat is currently occupied.

Greybull River: 25% (399 miles) of historic stream habitat is currently occupied, 60% (155 miles) of historic habitat on Forest Service land is currently occupied (20% Shoshone NF, 50% BLM, 25% private). "Stream mileages for both historic and currently occupied habitat are likely over estimates and include stream segments which would not support fish." On the basis of eletrophoretic analysis, Kruse (1995) concluded that this population was hybridized with fine-spotted Snake River cutthroat trout (suggesting stocking-induced contamination). In other words, this is not a pure population.

Nowood River: 8% (22 miles) of historic stream habitat is currently occupied, 55% (22 miles) of historic habitat on Forest Service land is currently occupied (10% Bighorn NF, 50% BLM, 35% private).

Painted Rock Creek: 31% (33 miles) of historic stream habitat is currently occupied and 29% (13 miles) of historic habitat on Forest Service land is currently occupied.

Wind River: 1% (26 miles) of historic stream habitat is currently occupied and 1% (10 miles) of historic habitat on Forest Service land is currently occupied (20% Shoshone NF, 10% BLM, 25% private). "Stream mileages for both historic and currently occupied habitat are likely over estimates and include stream segments which would not support fish."

Little Bighorn River: 39% (47 miles) of historic stream habitat is currently occupied, 26% (20 miles) of historic habitat on Forest Service land is currently occupied, and 0% of historic lake habitat (1 lake) is currently occupied (80% Bighorn NF, 11% private).

Tongue River (state line to headwaters): 10% (33 miles) of historic stream habitat is currently occupied and 29% (26 miles) of historic habitat on Forest Service land is currently occupied (25% Bighorn NF, 71% private). "Both spotting patterns present as a result of hatchery stocking" suggesting that the historic populations with their locally-specific genotypes have been contaminated.

Goose Creek: 13% (18 miles) of historic stream habitat is currently occupied and 46% (18 miles) of historic habitat on Forest Service land is currently occupied (40% Bighorn NF, 57% private). "Both spotting patterns present as a result of hatchery stocking" suggesting that the historic populations with their locally-specific genotypes have been contaminated.

Present Biological Status of the Yellowstone Cutthroat Trout Outside of its Historic Range

One of the factors complicating the assessment of the Yellowstone cutthroat trout is its widespread stocking across the historic range and beyond:

> Waters in over one-half of the 50 United States, most of the Canadian provinces, in several other countries received shipments of Yellowstone cutthroat trout between 1899 and 1957. Virtually all of these fish were from highly specialized, lacustrine Yellowstone Lake stock. In contrast to the success of brown trout *Salmo trutta*, rainbow trout *S. gairdneri*, and brook trout *Salvelinus fontinalis* transplanted throughout North America, the present scarcity of Yellowstone cutthroat outside their native range suggests an inherent lack of adaptability.
>
> Despite the widespread failure of these transplants, Yellowstone cutthroat trout populations have been established outside the original range in Montana, Wyoming, Idaho, Nevada, Washington, Utah, Oregon, Colorado, and probably some other western states (Sigler and Miller 1963; Carlander 1969; Baxter and Simon 1970; Brown 1971; Simpson and Wallace 1978). Introduced populations also exist in British Columbia, Alberta, and perhaps Quebec (Scott and Crossman 1973).
>
> Varley and Gresswell (1988:14-15)

<u>This stocking has resulted in widespread hybridization between Yellowstone cutthroat trout and other native cutthroat trout, undermining the status of all the subspecies involved</u> (e.g., the Bonneville cutthroat trout). The stocking has also resulted in the implantation of Yellowstone cutthroat trout in waters where no trout (and often no fish) existed previously. A large number of lakes that never contained Yellowstone cutthroat trout populations across the historic range have been and continue to be stocked. For instance, May (1996:23) reports that:

> there are about 450 lake environments, within the historical range, that currently support Yellowstone cutthroat trout. The number of lake environments currently supporting Yellowstone cutthroat populations represents a 380% increase over historic levels. Additionally, there are now numerous riverine and lake populations in existence outside of the historic range (Hadley 1984; Varley and Gresswell 1988) resulting from extensive stocking.

These populations cannot be considered in the assessment of the subspecies across its historic range because such waters are not included in the historic range. Any such populations should be considered exotic species and managed accordingly.

Summary of Threats to the Yellowstone Cutthroat Trout

There are four major types of threats to the continued persistence of the Yellowstone cutthroat trout: the continuing impact of legal and illegal introductions and stocking of non-native fish (hybridization, competitive exclusion, and predation), angling pressure, habitat degradation and fragmentation, and whirling disease. There is an additional and potentially serious threat, the invasion of New Zealand mud snail. These threats are pervasive and ongoing, and while some management efforts attempt to mitigate narrow components of this suite of threats, the majority of these threats remain inadequately addressed (if addressed at all). Each of these major threats will be reviewed in turn, followed by a summary discussion of the ways in which these distinct threats operate interactively and synergistically in such a manner that the Yellowstone cutthroat trout is presently seriously imperiled.

1. Stocking (Hybridization, Competitive Exclusion, and Predation)

One of the most important factors in understand the current imperilment of Yellowstone cutthroat trout is its propensity for hybridizing with other trout species:

> Throughout their present range, Yellowstone cutthroat trout commonly hybridize with other subspecies of cutthroat trout, with rainbow trout, and, in some cases, with golden trout *Salmo aguabonita*, and hybridization has been blamed for the decline in genetic integrity of the Yellowstone cutthroat trout.
>
> Varley and Gresswell (1988:15) citing Behnke and Zarn (1976)[7]

Because of the extent and magnitude of the stocking of species known to hybridize with Yellowstone cutthroat trout, stocking has played an enormous role in the subspecies' current plight. In fact, introgressive hybridization and genetic contamination of native Yellowstone cutthroat trout with non-indigenous or mixed strains, rainbow, and golden trout is widely identified as the single most significant threat to its continued persistence (e.g., Hadley 1984, Gresswell 1995, USDA FS 1997, Allendorf and Leary 1988):

[7] As another example, Thurow et al. (1988) indicates that hybridization between Yellowstone cutthroat trout and rainbow trout is highly likely when the two are present in the same area.

> Hybridization resulting from introductions of rainbow trout, nonnative subspecies of cutthroat trout, or nonindigenous stocks of Yellowstone cutthroat trout is the primary cause of the decline and extirpation of Yellowstone cutthroat trout throughout its historical range (Allendorf and Leary 1988; Varley and Gresswell 1988).
>
> Gresswell (1995:45)

The problems with introduction of exotics, particularly rainbow trout, are complex, extend beyond hybridization. Upon introduction, the rainbow trout also directly compete with the Yellowstone cutthroat trout for food, spawning habitat, and cover. It is unlikely that rainbow and Yellowstone cutthroat trout can co-exist without hybridization (USDA FS 1997).

The severity of the impacts of this stocking are exacerbated by the genetic distinctiveness of individual populations of the subspecies: “At the metapopulation level, Gresswell and Varley (1988) suggested that planting fry in the lake and its tributaries led to the potential mixing of up to 68 historically distinct genetic entities” (Gresswell 1995: 45). Consequently, concerns about the deterioration of the gene pool and the dilution of locally-adapted genotypes are substantially magnified. In other words, <u>even when the stocked fish were themselves Yellowstone cutthroat trout, the stocking led to a contamination of the native and locally-specific gene pools</u>.

The challenges of introgressed Yellowstone cutthroat trout populations are even further complicated by the difficulty in determining whether such introgression has actually occurred. Meristic or morphological analysis is simply inadequate to assess the presence of hybrid genes in an individual trout. Gresswell (1995:45) explains:

> Hybrids between rainbow trout and Yellowstone cutthroat trout are developmentally successful, and progeny may appear as morphological and meristic intermediates between parental types or virtually identical to a single parental type (Ferguson et al. 1985). Consequently, it is virtually impossible to verify genetic integrity with morphological data alone.

The only way in which one can make a relatively confident determination about whether a given individual is a pure Yellowstone cutthroat trout or a hybrid is to use much more sophisticated and expensive genetic/molecular analysis techniques (Shiozawa and Evans 1997, attached as Exhibit 19). The consequences have been a consistent pattern of overestimating the abundance and vitality of pure Yellowstone cutthroat populations. Even the most recent surveys must be generally qualified by their bias toward identifying populations as pure that are not, in fact, pure. The significance of hybridization in the continuing decline of Yellowstone cutthroat trout is widely cited in the literature and discussed in more detail in the section of this petition entitled "Present Biological Status of the Yellowstone Cutthroat Trout in the States Comprising its Historic Range."

In some cases the stocking was of brown and brook trout, species that do not typically hybridize with the Yellowstone cutthroat trout but are known to consistently outcompete them. Brook trout are less of a direct threat to the Yellowstone cutthroat, but their introduction is still problematic for cutthroat populations. Griffith (1972) suggested that brook trout may not effectively displace cutthroat trout. However, interactive segregation, in which one species is more efficient in one habitat than another (Nilsson 1963) does occur in sympatric populations of Yellowstone cutthroat and brook trout. For example, brook trout are more efficient in meadow and headwater reaches and thereby replace the Yellowstone in these areas. Moreover, in the presence of disturbed habitat conditions, as noted earlier in this petition, brook trout can display a significant competitive advantage, and Van Kirk et al. (n.d.) note that "[c]age [sic] studies in small streams in the upper [Henrys Fork Snake River] watershed show that young-of-the-year cutthroat display significantly lower overwinter survival in the presence of brook trout than they do alone" (see also Van Kirk et al. 1997, Gregory and Griffith 1997).

However, more recent research seems to place greater emphasis on the importance of non-hybridizing invaders. For example, Gresswell (1995) reports that competitive exclusion is a common outcome of brook trout invasion:

> Griffith (1988) reported that cutthroat trout are less likely to coexist with brook trout than with other nonnative salmonids even in undisturbed habitats, and Yellowstone cutthroat trout have been extirpated from most areas in Yellowstone National Park where brook trout have been introduced (Gresswell 1991).
>
> Gresswell (1995:46)

Competitive exclusion is often thought to be the primary replacement mechanism (Gresswell 1995).

In other cases, the concern has also to do with the predatorial behavior of the introduced and stocked species. The most dramatic example, of course, is the introduction and spread of lake trout in Yellowstone Lake, and the considerable risk that lake trout will begin to expand throughout the Yellowstone River drainage (including Montana). In the case of lake trout the concern primarily has to do with its ability to outcompete and prey on the Yellowstone cutthroat trout.

As discussed more fully earlier in this petition (in the "Wyoming" subsection of the section entitled "Present Biological Status of the Yellowstone Cutthroat Trout in the States Comprising its Historic Range"), <u>the threat posed to the Yellowstone cutthroat trout by the illegal introduction of lake trout in Yellowstone Lake and the spread of this lake trout population into the Yellowstone River drainage cannot be overstated</u>.

In short, the literature is generally unanimous on the centrality of hybridization as the major threat to the continued persistence of the Yellowstone cutthroat trout, and although legal stocking of non-native trout has been discontinued (while stocking of fish thought to be pure Yellowstone cutthroat trout, regardless of the origin of the brood stock, continues, and is, in fact, a major component of current recovery programs), remaining pure populations still face significant risks due to the possibility of illegal stocking, other forms of human transfer (see, for example, USDI FWS 1994) and due to the continued spread of exotics and hybrids (including stocking Yellowstone cutthroat trout). The agencies often appear to ignore the very real potential for continued spread even when stocking of exotics itself is prohibited. For instance, FWS reports that "[g]enetic integrity of the Yellowstone cutthroat trout upstream from the falls will be protected as long as introductions of non-native salmonids are prohibited" (Kaeding et al. 1994).[8] Perhaps the most graphic example of this type of threat, with respect to Yellowstone cutthroat trout, is the lake trout crisis in Yellowstone Lake. Lake trout are already having a substantial impact on the single most important native cutthroat

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[8] Occasionally, the agencies make the opposite admission. For instance, the FWS concedes that "unauthorized stocking is difficult to prevent" (Boltz et al. 1993:110).

population and have the potential to severely impact the entire Yellowstone River drainage.

2. Angling Pressure

As the FWS acknowledges, "[r]elatively high levels of angler effort can negatively affect fisheries unless fish populations are protected from excessive harvest," (Kaeding et al. 1994 citing Van Den Avyle 1993). Fishing pressure poses a severe threat to the Yellowstone cutthroat trout largely because of the subspecies' particularly pronounced susceptibility to overfishing, a widely reported phenomenon:

> Yellowstone cutthroat trout are extremely vulnerable to angling, and angler harvest has contributed to substantial declines in population abundance throughout the historical range of the subspecies (Binns 1977; Hadley 1984; Gresswell and Varley 1988; Thurow et al. 1988).
> Gresswell (1995:47) (see also USDA FS 1997)

High angler exploitation actually results in the increase of natural mortality rates (Ricker 1975). It should also be noted that, in addition to the impacts associated with direct angling mortality, "[a]ngler wading can be a significant source of disturbance (Roberts and White 1992)" (Gresswell 1995:46).

As far as assessing the relative importance of angling as a threat to the Yellowstone cutthroat trout, "[e]xamples from Yellowstone National Park have special relevance because anthropogenic habitat alterations have been minimal" (Gresswell 1995:47). Even in the absence of severe habitat degradation and maintenance stocking, <u>it is clear from research in the Park that angling can have a substantial influence</u>. Varley and Gresswell (1988:21) concluded that "[a]lthough angler harvest may not be the primary cause of a diminished fishery resource, special regulations should be incorporated into any program to restored [sic] native or introduced populations of Yellowstone cutthroat trout to their former abundance." In some situations, it may even be the case that any angler harvest is detrimental: "Continued rise in angler use is cause for concern, however, because overharvest may occur even under regulations that allow only a minimal creel limit" (Gresswell and Varley 1988:51). When occurring in conjunction with a population already depleted by predation (e.g., lake trout), hybridization (e.g., rainbow trout), dewatering and other habitat degradation, or similar impacts, angling can make a pronounced contribution to the continued dramatic decline of the species.

3. Habitat Fragmentation and Degradation

The critical role played by habitat degradation and fragmentation in the demise of the Yellowstone cutthroat trout is highly evident throughout this petition. Gresswell (1995:46) unequivocally concludes that "Human activities such as dam construction, water diversions, grazing, mineral extraction, road construction, and timber harvest have substantially degraded lotic environments (Meehan 1991)," and that this has resulted in "barriers to migration, reduced flows, sediment deposition, ground-water depletion, streambank instability, erosion, and pollution. Efforts to curtail human activities and restore degraded stream segments are increasing, <u>but habitat degradation continues at an alarming rate</u>" (Gresswell 1995:46, emphasis added).

The significant role that water impoundments and water diversions have played in the demise of the Yellowstone cutthroat trout is evident throughout this petition. Dewatering causes at least two types of problems for the trout:

> During low-water years, observation has shown that, under some circumstances, adults either do not spawn or interrupt their spawning to leave the stream as flows become inadequate. At other times, fish appear to spawn successfully but flows then drop to levels that expose the redds to desiccation.
>
> Clancy (1988:40)

These effects of dewatering on the ability of the trout to successfully spawn are an especially prominent concern. For instance, Hadley (1984:22 citing a personal conversation with Chris Clancy) notes that "[i]n the Yellowstone River cutthroat population, <u>the most urgent problem is the dewatering of tributary streams used for spawning</u> (emphasis added)." For example, some investigators "have observed that complete dewatering of redds for periods of less than 1 d can result in high mortality of recently emerged salmonid fry (Becker et al. 1982, Reiser and White 1983)" (Kaeding et al. 1994). Numerous researchers have identified dewatering as such an important cause of the decline of the Yellowstone cutthroat trout, throughout the entire historical range (e.g., Clancy 1988, Thurow et al. 1988), that Varley and Gresswell (1988:21) contend that, "<u>[o]f all possible enhancement activities, maintenance of adequate streamflow may be the most essential but most difficult to attain</u>" (Varley and Gresswell 1988:21, emphasis added).

Water impoundments and water diversions also contribute to the severe fragmentation and isolation of surviving pure Yellowstone cutthroat trout populations and their habitat. While the impacts of non-native fish species are probably the most significant of any related to human activity,

> [t]he second greatest human induced impact [to Yellowstone cutthroat trout] is the fragmentation of habitats and populations associated with the construction of dams and diversions. These structures may de-water river and stream channels and, unless properly fitted with fish passage structures, block migration corridors needed for spawning of for movement between summer and winter habitats. Such habitat fragmentation physically reduces patch size [and] reduces genetic fitness through inbreeding.
>
> USDA FS (1997:3)

Thurow et al. (1988) expresses similar concerns, citing reduced flows, blocked passages and entrainment of fish and degradation of riparian areas as threats to cutthroat trout arising from hydropower developments. Gresswell (1995:46) also notes that "[c]ulverts can also alter or totally block fish migration (Belford and Gould 1989), and culverts are widespread throughout the range of the Yellowstone cutthroat trout."

The degraded condition of riparian habitat throughout the historical range of the trout is another serious habitat quality concern. Gresswell (1995:49) suggests that "[i]mproved riparian management may be the most critical habitat issue facing fishery managers in areas where natural flow regimes are unaffected by water diversions." For example, grazing is one land use well-known to adversely impact riparian conditions and fish habitat (Armour 1977, Behnke 1977, Chaney et al. 1990, Claire and Storch

1983, Duff 1983, Kennedy 1977, Leopold 1975, Marcuson 1977). Loss of streamside vegetation can lead to increased summer temperatures, sedimentation, and bank instability. Bank instability reduces the availability of lateral habitat and pools by shallowing and widening streams (Moore and Gregory 1988). The availability of spawning gravels and selection of spawning sites often occur in or near lateral habitats, and they are important in cutthroat early life history (Id.). Survival rates of Yellowstone cutthroat trout, which prefer colder water temperatures, can be greatly reduced by increased summer stream temperatures associated. According to numerous studies, trout populations increased dramatically after removal of livestock grazing (Fleischner 1994). Varley and Gresswell (1988) point out that, because much of the Yellowstone cutthroat trout's current range lies within areas used for summer livestock grazing, restoration and protection of these riparian areas is an important and attainable goal. The loss of appropriate riparian vegetation also adversely affects the cutthroat trout by reducing important winter concealment cover.

A Trout Unlimited report notes that:

> Because western riparian and stream ecosystems are particularly vulnerable to harm from overgrazing, the [American Fisheries Society] conservatively estimates that grazing has damaged more than 50% of the habitat in these ecosystems (Armour et al. 1992).
>
> Trout Unlimited n.d.:31, attached as Exhibit 20

This report summarizes many of these concerns in this way:

> Wherever livestock grazing occurs in western North America, it poses a potential threat to the integrity of salmonid habitats. Twenty of 21 studies were recently summarized (Platts 1991) and showed that stream and riparian habitats can be degraded by livestock grazing, and that these habitats improved when grazing was prohibited. Grazing effects on biological diversity are comprehensive, affecting landscape, ecosystems, species, and genetic diversity. In uplands, soil is compacted and the vegetative composition is changed, which increase runoff and erosion. Closer to the stream, streambank vegetation and stability decline when livestock concentrate near water. The combination of upland erosion, loss of riparian canopies, and breakdown of streambanks lowers local water tables and causes streams to become wider and shallower, warmer in summer but cooler in winter, and poorer in instream structure but richer in nutrients and bacterial populations (Platts 1991). The result of these effects is the reduction of salmonid biodiversity. The Riparian Committee of the AFS Western Division estimated degradation of 19,000 miles of trout streams on federal lands in the 11 western states due to livestock grazing. The actual amount is probably greater because many once excellent streams have become so degraded they are shown on maps as intermittent, and are not capable of supporting fish (Behnke 1989). The threats of this grazing to many native trout species of the western region are well-documented.
>
> Trout Unlimited n.d.:32.

In short, any land use that results in degraded stream and riparian habitat is likely to be producing these sorts of impacts, and it is clear that the Yellowstone cutthroat trout is suffering in many or most of these ways.

Additional important habitat concerns have to do with sedimentation and substrate disruption, and are related to many of the land uses occurring in occupied Yellowstone cutthroat trout habitat. For example, Gresswell (1995:47) points out that:

> Effects of livestock grazing on riparian habitats are well documented (Gresswell et al. 1989, Platts 1991). In the range of the Yellowstone cutthroat trout, Thurow et al. (1988) reported that intensive livestock grazing has caused degradation of riparian areas and subsequent stream bank sloughing, channel instability, erosion, and siltation.

Furthermore, "[i]n tributaries supporting moderate to heavy livestock grazing, the stream banks tend to be destabilized and the riparian vegetation reduced or destroyed," resulting in higher levels of siltation, a reduced number of pools, fewer undercut banks, minimal riparian vegetation, detrimental changes in channel morphology (channels characterized by slow, deep water with abundant cover are converted to shallow, high-velocity flows without cover), and substantially reduced trout abundance and biomass" (Hadley 1984:24 citing also Thurow 1982 and Behnke 1979).

Similarly, Hadley (1984:24 citing MDFWP 1975) observes that "[e]xtensive clearcutting of forested areas has occurred on both private and U.S. Forest Service lands in the headwater basin of the Shields River," resulting in increased peak discharges, reduced late summer flows, increased stream temperatures, soil erosion, increased stream turbidities and sediment loads, and reduced light penetration (resulting in reduced primary productivity). Timber harvesting, even when it doesn't involve even-aged management, can have significant impacts to the cutthroat trout (Chamberlain et al. 1991, Meehan 1991). Even fire suppression activities can have an adverse impact (Norris et al. 1991).

The road construction associated with grazing, logging, mining, recreation, and other land uses also contributes to excessive sediment loads and related problems. Roads also provide access for anglers, increasing legal and illegal (e.g., exceeding catch limits) angling pressures and increasing the likelihood of illegal introductions of exotic or impure Yellowstone cutthroat trout into the few remaining strongholds of pure populations. The numerous and often severe impacts of roads are reviewed in Noss (1992) and USDA FS (1998). <u>All of these factors negatively impact the Yellowstone cutthroat trout's ability to spawn and survive</u>.

Hadley (1984) also identifies mining activities as a significant threat to the trout. Many mines are poorly operated and tailed ponds often fail, sending sometimes highly contaminated sediment, mining waste, and chemicals into the watershed. The potential impacts include:

> 1) releasing acids; 2) increasing suspended and bed-loaded sediments; and 3) releasing toxic heavy metals. In addition to these water quality effects, mining can directly degrade fish habitat by modifying stream channels and water flow (Nelson et al. 1991).
>
> Trout Unlimited n.d.:21

Increasing acidity is associated with abnormal fish behavior, reduced salmonid reproductive capacity, and reduced fish detoxification capabilities (for other poisons)

(Trout Unlimited n.d.:21 citing Meehan 1991). Increased sedimentation is associated with a wide range of adverse impacts, some already mentioned, including altered light and temperature regimes, degrading spawning habitat, and altered nutrient cycling (Trout Unlimited n.d., Nelson et al. 1991). Accumulations of toxins in the water can lead to increased aquatic mortality and reduced reproductive abilities (Trout Unlimited n.d., Nelson et al. 1991).

It should be emphasized, as noted elsewhere in this petition, that the Yellowstone cutthroat trout historically survived in a metapopulation (May 1996). The disruption of these metapopulation dynamics is likely to be have severe consequences for the long-term persistence of the cutthroat trout. Even the YCTWG concedes that "[p]opulation fragmentation probably increases reproductive isolation among remnant populations" (Darling et al. 1993). Not only is reproductive isolation increased, with all of its attendant problems (e.g., inbreeding depression), but the vulnerability of the subspecies to demographic or environmental stochasticity increases dramatically:

> Aquatic habitat destruction associated with extractive land uses can reduce a population to a point where extinction from a stochastic even, such as drought or random variation in sex ratio, is virtually inevitable (Nehlsen et al. 1991).
>
> Trout Unlimited n.d.:5

(See also Bengtsson 1991, Caswell 1989, Foley 1994, Gabriel and Burger 1992, Goodman 1987, Lande 1993, Lande and Orzack 1988, Leigh 1981, Mangel and Tier 1994a, Mode and Jacobson 1987, Strebel 1987, and Tuljapurkar 1990).

The land use activities that have contributed to the dramatic demise of the Yellowstone cutthroat trout occur widely on the lands managed by federal agencies, including primarily the FS and the BLM. This has been the case despite that these agencies possess the authority and the mandate to restrict these activities in ways that will prevent the continued decline and possible extinction of the subspecies.

4. Whirling Disease

Whirling disease, caused by a myxosporean parasite (Myxobolus cerebralis) is a potentially devastating threat to the conservation of Yellowstone cutthroat trout. Until recently, it was widely believed among researchers that wild trout populations were not vulnerable to this disease, but recent findings disprove this view. In fact, "[n]ew research has shown that in some situations it can have catastrophic effects, including complete loss of year classes. Many native trout species appear to be vulnerable to the disease, making the continued spread of the parasite an especially grave concern" (Nehring and Nickum n.d.:1, attached as Exhibit 21). According to Montana Governor Marc Racicot's Whirling Disease Task Force, "whirling disease is the most significant threat to the survival of wild, naturally reproducing trout populations in Montana" (MDFWP Annual Report 1995).

Concern over the potential for devastating impacts from whirling disease are substantially exacerbated by at least two factors. First, current Yellowstone cutthroat conservation programs exhibit a heavy reliance on hatchery operations, and hatcheries are known to play a critical role in the growth and spread of the disease.

Second, although rainbow trout seem to be particularly susceptible to the disease, cutthroat trout subspecies appear to be substantially at risk. Nehring and Nickum (n.d.:3) report that "with the possible exception of the Snake River cutthroat trout, all cutthroat trout subspecies were at least as vulnerable to the ambient levels of TAM spores as similarly exposed rainbow trout, and far more vulnerable than the brown trout." As this petition has discussed, brook trout, rainbow trout, rainbow trout hybrids currently occupy a substantial proportion of the historic and occupied range of the Yellowstone cutthroat trout. In fact, the disease has been implicated in dramatic declines (and in some cases collapses) of rainbow trout and brook trout fisheries in five major Colorado trout streams (including extensive segments of the Cache la Poudre, Colorado, Gunnison, Rio Grande, and South Platte rivers) and the entire upper Madison River population (Montana) (Nehring and Nickum n.d.).

At least one national forest has already expressed serious concerns about whirling disease: "[W]hirling disease has been detected in several habitat within the range of the Yellowstone cutthroat trout … there is a strong possibility that it could spread to the [Targhee National] Forest over time" (USDA FS 1997:4). Whirling disease is responsible for a 90% decline in the Madison River rainbow trout population in just three years. "The task force believes that whirling disease is likely, over time, to spread to every major river drainage in Montana where both trout and the parasite's alternative host - small, stream-dwelling worms - are found" (MDFWP Annual Report 1995).

One of the management strategies being considered in the struggle against the devastating impacts of this disease is the stocking of cutthroat trout strains with life histories rendering them less susceptible to infection (Nehring and Nickum n.d.). However, it should be clear that such strategies further heighten the concern about the stocking of any given locally-adapted strain into stream segments other than those from which the strain was derived. Although the stocked fish may be better able to resist the potentially devastating impacts of whirling disease, they may be poorly adapted for other characteristics of that particular stream segment, and may be more susceptible to hybridization, predation, angling pressure, and outcompetition as a result. If such fish are stocked into areas already occupied by locally-adapted strains, the stocking will likely destroy those strains. In short, <u>whirling disease is a severe threat to the Yellowstone cutthroat, and current management efforts seem unlikely to successfully contain this disease</u>, especially when the impacts of the disease (and management efforts to contain it) are considered in the context of the numerous other threats to the subspecies described in this petition.

Whirling disease poses a potentially severe threat to the continued persistence of the Yellowstone cutthroat trout (as well as most other cutthroat trout subspecies). Not only are its effects devastating when trout are afflicted, and not only do native inland cutthroat trout appear to be susceptible, but whirling disease can spread rapidly in a multitude of ways, including through hatchery programs and (as discussed elsewhere in this petition) by way of bait bucket or other forms of human transfer.

5. New Zealand Mud Snail

Very little is known about the New Zealand mud snail, but what is known is disconcerting. The snail is extremely small (approximately 5mm to 1/4 inch), and has become established in YNP and in the Snake River of Idaho, and is starting to appear in the Henrys Fork (personal communication, Dan Mahoney, 5/6/98). There is also what appears to be a disjunct population near the mouth of the Columbia River (Id.).

Among the concerns posed by this exotic invader for Yellowstone cutthroat trout are the fact that they appear to all be parthogenic clones, such that only a single individual would be necessary for dispersal to another stream. This means that the dispersal potential may be quite high (Id.). Another concern is that they appear to be undergoing exponential population growth, although, fortunately, they seem to be expanding more slowly (at least downstream) than might have been expected (Id.). The snail has established extremely large and dense populations in the Firehole and Madison Rivers, with an estimated density of up to 1/2 million/square meter (Id.). Yet another concern is that there may not be any obvious controls except possibly heavy-dosage poisoning, which is itself extremely problematic for various reasons (Id.).

The major concern has to do with the potential impact of New Zealand mud snail invasion on the food webs and ultimately the forage and prey base of the cutthroat trout. If nothing else, the snail, by virtue of its sheer population density, physically displaces preexisting invertebrates (Id.). However, the snail is also thought to be a grazer, such that it might severely impact algae and other similar forage (Id.). The impact this will have on cutthroat trout populations is unknown and speculative, but there is some concern that, in addition to whatever impact they have on forage, they may also have significant impacts to entire aquatic invertebrate communities (Id.). This concern is heightened by research suggesting that, although fish may consume the snail in place of traditional prey, it may provide very little in the way of nutritional value (Id.).

The new and unexpected threat posed by the New Zealand mud snail may not prove to be a unique event. In fact, in recent years, it has become apparent that a widespread redistribution of species is occurring (Lodge 1993, Mills et al. 1993, Mills et al. 1996, Ricciardi 1998). Exotic invaders known to be threats in other places may expand into the habitat of the Yellowstone cutthroat trout, and entirely new threats may appear as well: "We are likely to witness the arrival of more exotic species to our lakes and rivers every year" (Ricciardi 1998:47). The importance of dispersal mechanisms involving human transfer, especially in an ecosystem with such a great deal of human activity (recreational and otherwise), must be seriously considered (USDI FWS 1994), even when it is unclear that such a species could pose a threat to pure cutthroat trout populations by way of natural dispersal (e.g., New Zealand mud snail).

In addition to the substantial impact each of these distinct threats has had and continues to have on the Yellowstone cutthroat trout, it is crucial to recognize that these threats often act in ways that mutually reinforce each other. For example, Clancy (1988:41) explains that “[d]ewatering of spawning tributaries contributes to the need to restrict angler harvest … Reduced recruitment from spawning tributaries has led to reduced numbers of adult fish and, thus, the capacity of the population to sustain angler harvest” (Clancy 1988:41).

Fishing mortality also contributes to the replacement of Yellowstone cutthroat trout by invading brook trout. Studies have demonstrated that cutthroat trout are more than twice as likely to be caught by anglers than brook trout (MacPhee 1966). The non-migratory nature of brook trout also contributes to its indirect displacement of cutthroat trout. Yellowstone cutthroat are migratory and, therefore, require a wider range of habitats. Due to this larger range, Yellowstone cutthroat are more vulnerable to isolation from and degradation of habitat than the brook trout.

Similarly, dewatering and other forms of habitat fragmentation can result in Yellowstone cutthroat trout being more susceptible to being outcompeted and preyed upon. Reductions in riparian vegetation, for instance, can result in higher water temperatures, which can result, in turn, in increased stress levels and reduced reproductive success. In other words, for most of the threats described above and throughout this petition, the effects of one threat are substantially magnified by the contemporaneous presence of other threats.

For the Yellowstone cutthroat trout, the interaction effects of habitat degradation and fragmentation, reproductive isolation, and small population size offer a particularly dramatic example of mutually reinforcing impacts. Although the severity of current habitat degradation is alarming in its own right, degraded habitat can also function as a movement and dispersal barrier; the more degraded habitat becomes, the more difficult it will be for individual trout to travel through it. When the functional barriers presented by degraded habitat are considered in combination with the more obvious dispersal barriers (e.g., dams), it is clear that surviving Yellowstone cutthroat trout populations have become extremely fragmented and isolated. This is problematic because, in part, many of the remaining populations are small, and small, isolated populations are particularly vulnerable to inbreeding depression and other genetic problems. Furthermore, these populations are far less likely to be able to adapt to changing environmental conditions.

This situation is also problematic because the small size of most of the remaining Yellowstone cutthroat trout populations and the extent of their isolation from one another dramatically increase the chances of local extinctions. As Shaffer (1987) points out, "extinction may often be the result of chance events, and ... the likelihood of extinction may increase dramatically as population size diminishes." Anthropogenic and stochastic events could easily decimate individual populations. If the subspecies' metapopulation dynamics were functioning normally, a severe decline in (or even a complete loss of) an individual population was not generally a serious concern, as the connectivity between populations would be likely to assure that these populations were quickly replenished or their habitat recolonized (in addition to preventing the genetic deterioration associated with small, reproductively isolated populations). However, the current level of fragmentation generally precludes replenishment and recolonization. If an anthropogenic or stochastic event dramatically reduces the size of a surviving population of Yellowstone cutthroat trout, that population will face the problems of small population size to an even greater extent, and if such an event wipes out a population, that habitat will almost certainly not be recolonized.

Thus, not only do small populations have a very limited genetic pool from which to draw upon in the face of changing environmental conditions, and not only are they at greater risk of genetic problems like inbreeding depression, but they are also more likely to be wiped out in a single anthropogenic or stochastic event and much less likely to be replenished or their habitat recolonized by other populations. In short, the impacts to Yellowstone cutthroat trout described in this petition are likely to be that much more severe because the ability to disperse and recolonize has been precluded by the extensive habitat degradation and fragmentation and because of the resulting isolation (and small size) of most of the remaining populations.

Current Management of the Yellowstone Cutthroat Trout

Current management of the Yellowstone cutthroat trout is fraught with severe deficiencies. Perhaps most importantly, “[c]urrent management emphasizes populations sustained by natural reproduction and by stocking (Varley and Gresswell 1988; [Darling et al.] 1994)” (Gresswell 1995:48), and is not about protecting and restoring the habitat necessary to provide for self-sustaining and viable populations.

Management of imperiled native cutthroat trout in Colorado has followed a similar pattern. A recent report evaluating the risks of extinction for Greenback and Rio Grande cutthroat trout in that state observed that "[m]anagement to date has consisted mainly of locating remnant populations and establishing new populations through translocations of genetically pure cutthroat trout into waters that were previously barren of fish or treated with fish toxicants to remove nonnative species" (Harig and Faush 1998 citing Stuber et al. 1988, attached as Exhibit 23). Although preliminary, this report concludes that "[e]mperical evidence suggests that this strategy may not ensure long-term persistence" (Harig and Faush 1988:3). Even as hatchery and stocking programs continue, the federal agencies managing land within the historic range of the Yellowstone cutthroat trout generally take very little action on behalf of the subspecies' habitat, while continuing to allow those activities known to have led to such dramatic habitat degradation. In the absence of a serious commitment to substantial habitat protection and restoration across the trout's historical range, under the best of circumstances, the current hatchery-based conservation efforts can only provide for the maintenance of disconnected and non-viable populations as long as these existing populations are indefinitely stocked. In the long run, the "[p]rotection of habitat may be the most cost-effective form of habitat management" (Gresswell 1995:49, emphasis added), and is certainly critical to long-term persistence, but it is also the most politically contentious (e.g., Gresswell 1995).

A second major deficiency in current management programs is the overt bias towards protecting only those Yellowstone cutthroat trout populations that have been conclusively verified as genetically pure. Gresswell (1995) explains that "[m]ost management agencies require positive genetic identification before protecting populations of Yellowstone cutthroat trout." The federal agencies charged with preventing this subspecies' extinction (the Fish and Wildlife Service, the Forest Service, and the Bureau of Land Management) manage the subspecies under the presumption that populations are not worth protecting unless their genetic purity can be conclusively established. When all known populations have been adequately tested, this approach might be reasonable, but until such testing has been completed, such a management approach risks irreversibly impacting one of the few remaining pure populations. This does not constitute prudent and responsible management of a rapidly declining and imperiled subspecies by the responsible and accountable management agencies.

Falling agency budgets (at least with respect to non-timber resources) have played a role as well. For example, the continued loss of biology specialists (such as fish biologists) makes it that much more difficult for the agencies to carefully ascertain what activities are having what impacts, where pure populations are found, what the status and trend of known pure populations are, and so on. Similarly, much of the needed habitat restoration and protection will require financial and other agency resource.

U.S. Forest Service

Generally speaking, National Forests within the historic range of the Yellowstone cutthroat trout do not have Yellowstone cutthroat trout management plans or substantial management provisions in place. General Forest guidelines are sometimes intended to provide the necessary protection, but these guidelines, where they are found at all, are too vague and discretionary to be of much use. Moreover, they do little to stem the habitat degradation, destruction, and fragmentation that is central to the recovery of the Yellowstone cutthroat trout. The Forest Service's facilitation of hatchery and stocking programs only adds to the crisis. The failure of National Forest management with respect to the cutthroat trout is clearly evidenced by the continued declines in pure populations, connectivity between these populations, and the quality of trout habitat.

Bureau of Land Management

The failure of the Bureau of Land Management to manage adequately for the Yellowstone cutthroat trout is equally clear. Land use plans contain a near total absence of substantive and enforceable measures designed to protect the trout, and grazing and land use activities known to severely degrade cutthroat trout habitat continue at high levels.

National Park Service

Management of National Parks compares slightly favorably to that of the Forest Service and Bureau of Land Management. The primary difference is that "Yellowstone contains one of the most significant, near-pristine aquatic ecosystems found in the United States" (USDI NPS 1997:43), and that some of the highly destructive land use activities occurring on surrounding public lands do not occur within the Parks. However, because some land use activities have the potential to adversely affect Yellowstone cutthroat trout populations, because of the severe threat posed by the presence of lake trout, because of the as yet unclear but potentially devastating threats posed by whirling disease and New Zealand mud snail pose, and because of the potential for overharvest (by way of legal and illegal angling activities, see USDI NPS 1997:43), the cutthroat trout populations within the Parks are by no means secure.

The lake trout invasion alone is sufficient to cast grave doubts about the ability of the National Park Service to protect the Yellowstone Lake cutthroat trout population. Even the most optimistic accounts suggest that lake trout will never be removed, and it is highly unclear just how successful efforts to control lake trout will be. In any case, it is clear that control of this invading species, if it is even possible in the long-term, will require a long-term commitment of resources. In fact, optimistic projections of the ability to control lake trout in Yellowstone lake seem to take no account of the potential for human-facilitated spread of lake trout into other lacustrine environments. As the National Park Service and the Fish and Wildlife Service are well aware, humans seem to have a propensity for the deliberate introduction of such species into uninfested waters as well as the phenomenon known as bait bucket transfer and other forms of human transfer (see, for example, USDI FWS 1994 and studies cited therein).

Wyoming

To the best of petitioners ability to determine, Wyoming's Yellowstone cutthroat trout conservation efforts have primarily involved the development and utilization of pure hatchery stocks. For instance, Wyoming Game and Fish Department is developing a brood stock from the trout population in the Yellowstone River from Yellowstone Lake to Upper Falls. “The intent of this brood stock will be restoration of the endemic range of the Yellowstone River cutthroat in Wyoming and Montana” (USDI NPS 1996:1). Such an effort, as explained elsewhere in this petition, is likely to do more to harm than good for the Yellowstone cutthroat trout. Any such stocking that occurs in stream segments where other native, locally-adapted populations remain will likely destroy those existing locally-specific gene pools. This is in addition to the exacerbated risk of spreading whirling disease through a reliance on hatchery programs. Finally, in the absence of substantive, accountable management provisions to protect and restore habitat, the most vigorous hatchery program in the western United States will not result in viable, self-sustaining populations of genetically pure native Yellowstone cutthroat trout.

Montana

The Yellowstone Cutthroat Trout Working Group (YCTWG), comprised of representatives of the Montana Department of Fish, Wildlife and Parks, the Montana Natural Heritage Program, the U.S. Fish and Wildlife Service, the American Fisheries Society, and the U.S. Forest Service, developed a draft Management Guide for the Yellowstone River Drainage for the Yellowstone Cutthroat Trout. This plan consists of six major emphases:

1. Identify and protect existing populations and their habitat within the historic range.
2. Enhance existing populations and habitat within the historic range.
3. Restore populations within the historic range.
4. Manage populations currently established outside of historic range.
5. Support research needed to address important factors such as population fragmentation, genetic isolation, small population size, and habitat requirements.
6. Develop an Information and Education program associated with Yellowstone cutthroat trout management.

Darling et al. 1992:12-13 (attached as Exhibit 22)

Although many of the plan's provisions are sensible components of a Yellowstone cutthroat trout management plan, it contains little in the way of substantive mandates and implementation and enforcement mechanisms. In the absence of explicit management standards to which the participating agencies are legally accountable, there is no guarantee, or even a reasonable assurance, that the Yellowstone cutthroat trout will not continue to decline into extinction. Moreover, the plan has not even been formally adopted - it is merely a draft plan circulated by the Working Group. Thus, the plan lacks even whatever limited and inadequate authority might be conferred should it be formally adopted. Finally, the plan lacks a substantive (and accountable) emphasis on the protection and restoration of habitat. This failure, as discussed repeatedly throughout this petition, is a fatal flaw.

As noted earlier, the state of Montana designated the subspecies as a “species of special concern;” unfortunately, this designation does convey any substantive and accountable protections. Most of what the state has done involves efforts to identify and track the status of pure populations. However, some substantive measures have been taken. For instance, in order to address concerns about fishing pressure, the state (in 1994) extended its catch-and-release regulation to included all Yellowstone River system waters from the Yellowstone National Park boundary to Springdale, Montana (Gresswell 1995; letter of Brad Shepard, Fisheries Biologist, Montana Department of Fish, Wildlife and Parks, to Mimi Mather, 6/16/97). The state modified its stocking guidelines to emphasize wild trout populations (Gresswell 1995). Finally, according to a state fisheries biologist, “[w]e have worked on numerous conservation and restoration projects, usually in cooperation with the landowner or manager (i.e., the Forest Service), to protect and expand existing populations of YCT. We have constructed barriers to prevent the invasion by non-native fishes; have done habitat enhancement; and removed competing and potentially hybridizing non-native fishes" (letter of Brad Shepard to Mimi Mather, 6/16/97). The extent of these efforts, and, more important, their effectiveness, are unclear.

Finally, "[i]n Montana, the Department of Fish, Wildlife, and Parks was recently granted the legal right to lease water rights from agricultural interests" (Gresswell 1995:49). This is important because "[w]ater diversion continues to be a critical aspect of habitat management for the Yellowstone cutthroat trout; unfortunately, it is also one of the most contentious" (Gresswell 1995:49). Unfortunately, "the use of this strategy has been limited" (Gresswell 1995:49).

Idaho

As elsewhere, to the best of petitioner's knowledge, the major emphasis of Idaho's management efforts on the Yellowstone cutthroat trout seems to be on hatchery-based stocking programs. For example:

> In Idaho, stocking in the upper Snake River basin is restricted to waters that do not support viable populations of genetically unaltered Yellowstone cutthroat trout. In areas that still receive nonnative fish introductions, tactics to prevent introgressions are being investigated (Thurow et al. 1988).
>
> Gresswell (1995:48)

The problems and severe limitations of such an emphasis have already been discussed at length.

In addition to the hatchery efforts, Idaho makes use of some angling restrictions. For instance, "[s]pecial regulations including size limits and adjustments of angling season length have been implemented on the South Fork Snake and Blackfoot rivers to reduce the effect of angler harvest … In the Blackfoot River, however, a reduced harvest (3-fish limit) without size restrictions did not accomplish management goals (Thurow et al. 1988)" (Gresswell 1995:48). While potentially important, limited angling restrictions, even in combination with hatchery and stocking efforts, will not result in the recovery of the Yellowstone cutthroat trout.

Uncertainties in Present Knowledge

In many cases our estimates of the number and extent of pure Yellowstone cutthroat trout populations have not been verified with procedures capable of conclusively determining whether introgression has occurred, so it is likely that these estimates are generally inflated. The ability to contain the major threats posed by the expansion of lake trout and other depredating or outcompeting exotics, continued hybridization, and whirling disease is largely unknown. The continuing impacts of habitat degradation and fragmentation, especially the long-term effects of reproductive isolation, are not entirely understood, except that it is clear that such impacts have led to dramatic declines in the Yellowstone cutthroat trout across its historical range. In short, management responses to the continued demise of the Yellowstone cutthroat trout are characterized by uncertainty and unpredictability. While the agencies often appear confident in their ability to contain these threats, the scientific research and the continued expansion of each of these threats suggests that this confidence is severely misplaced.

Recovery of Yellowstone Cutthroat Trout

Preventing the extinction and ensuring the recovery of Yellowstone cutthroat trout will require numerous management actions on the part of the Federal and state agencies. These agencies are engaging in some of these actions, but most of the necessary actions have not yet been initiated, and the efforts that have been initiated are generally only half-hearted and not especially vigorous. Preventing the extinction and ensuring the recovery of the trout, based on our analysis of the available scientific data and literature, will probably require all of the following steps (in no specific order):

1. Conclusively identify all remaining pure populations.
2. Cease all stocking of exotics and hybrid Yellowstone cutthroat trout in waterways where pure populations might remain or where such stocked fish might disperse into areas with pure cutthroat populations.
3. Cease all stocking of pure Yellowstone cutthroat trout except where the threat of disease/predator transmission (e.g., whirling disease being spread by hatchery stock) is extremely small and the stocked brood is genetically identical or similar to the existing population (although limited exceptions to this might be acceptable where such stocking is essential to meeting biological recovery goals).
4. Implement aggressive educational programs designed to severely reduce the threat of illegal/inadvertent stocking and bait-bucket and other human transfer of exotic/hybrid species and diseases/parasites.
5. Implement and aggressively enforce strong anti-stocking measures and measures to prevent bait-bucket and other human transfer of exotic/hybrid species and diseases/parasites.
6. Prohibit angler harvest of pure Yellowstone cutthroat trout and prohibit catch-and-release angling where the impacts (e.g., incidental mortality) may have an adverse effect on the population in question or on subspecies recovery.
7. Protect and restore all occupied habitat, connections of suitable or potential habitat between remaining pure populations, and other habitat important for subspecies recovery:
   - prohibit new road construction and obliterate existing roads with adverse impacts to aquatic ecosystems (e.g., sedimentation, hydrological disruptions);
   - insure adequate instream flows and provide screening of water diversion devices where appropriate;
   - prohibit disturbance (logging, grazing, etc.) within a substantial (biologically credible) riparian buffer area; and
   - prohibit all disturbance near occupied habitat and identified restoration areas where such disturbances (even outside riparian areas) may adversely affect habitat conditions.
8. Aggressively control lake trout, whirling disease, New Zealand mud snail, and all other potential biological threats.

Benefits of ESA Listing for the Yellowstone Cutthroat Trout

It is clear, based on current efforts to manage for and recover the Yellowstone cutthroat trout, and based on the social and political environment in which state and federal agencies are operating, that the steps necessary to prevent extinction and ensure recovery (noted above) will not occur in the absence of an ESA listing. In other words, without an ESA listing, the state and federal agencies are unwilling to or incapable of managing Yellowstone cutthroat trout on the basis of the best available scientific information and in such a manner that will prevent the subspecies' continued decline and ultimate extinction.

For one thing, the widespread and complicated character of habitat degradation and fragmentation cannot be adequately addressed on an agency-by-agency basis. Even the Forest Service recognizes, at least in print, this critical consideration: "The long-term well-being of Yellowstone cutthroat trout will require a comprehensive and well coordinated conservation approach" (May 1996). The fact that the historic range spans multiple states only exacerbates these complexities. Some of these impacts, such as the dramatic dewatering that has occurred rangewide and the reproductive isolation (habitat fragmentation) that has resulted from the combination of numerous management practices (dewatering, water impoundments, riparian degradation, etc.) must necessarily be addressed at a large scale. Other impacts, because they occur across the range and are not constrained by administrative boundaries (e.g., pollution and sedimentation from mining, logging, and roadbuilding) are best addressed, similarly, in a coordinated fashion.

The impacts of angler harvest must also be addressed at a large scale. Angling regulations that vary across state boundaries cannot ensure that the impacts of angler harvest will be contained. A listing under the ESA would provide additional enforcement mechanisms to ensure higher compliance with these regulations. Moreover, the synergistic interactions that angler harvest has with other threats can best be understood and addressed at a large-scale.

The growing threat of exotics presents an even more compelling case for the coordinated and legally accountable management that would occur under the ESA. The containment of exotics already present necessarily depends on large-scale coordinated management; in fact, as noted earlier, even the FS insists it has no authority to manage stocking activities on National Forests. Management actions by any given agency can have substantial impacts on the actions of other agencies. Additionally, listing under the ESA would provide for stiffer penalties and more substantial enforcement mechanisms to address illegal stocking (one result of which is the severe impacts of lake trout on the most important remaining Yellowstone cutthroat trout population). With respect to the lake trout invasion of Yellowstone Lake (and potentially elsewhere), if control efforts are to have any chance of succeeding, "[p]reservation of the cutthroat trout in Yellowstone Lake will require a permanent commitment by NPS to remove lake trout" (Mahoney and Ruzycki n.d.:10). An ESA listing would facilitate such efforts and dramatically increase the likelihood that such a permanent commitment could be sustained.

A provincial approach to whirling disease is almost certain to fail. The impacts of this disease also span administrative boundaries, the impacts are severe, and the Yellowstone cutthroat trout is in no condition to withstand a catastrophic decline as a result of the rapid spread of the pathogen.

In the absence of ESA protection, conservation efforts will almost certainly emphasize short-term (and ultimately counter-productive) approaches such as hatchery stocking. Even the hatchery programs are minimally coordinated, if at all. Continued reliance on hatchery programs will only further the loss of genetic variation within the subspecies and the resulting site-specific adaptivity (due to continued stock transfer), heighten the risk of widespread whirling disease infection, and fail to address the critical long-term issue of habitat protection and restoration. An ESA listing is almost certainly required before consistent and accountable habitat protection measures, sufficient to prevent continued extirpation and subsequent extinction, will be fully implemented.

Finally, an ESA listing is probably critical to securing the necessary financial resources, long-term policy commitments, and accountable and enforceable management measures designed to both protect remaining pure populations and to protect and restore the habitat critical for the subspecies' recovery. In the absence of a compelling federal mandate, preventing the extinction of the Yellowstone cutthroat trout will fall prey to the whims of whatever political considerations are most pressing to the federal and state agencies at any given moment.

The absence of an ESA listing will preclude effective coordinated action on the Yellowstone cutthroat trout. Such action has not yet occurred, and the current patchwork of piecemeal state and federal regulation has failed to halt the decline in the remaining populations of this increasingly imperiled cutthroat trout subspecies, once endemic to an extensive area of the northern Rocky Mountains. Although current management efforts may have reduced the rate of habitat degradation, such degradation continues, and the more serious threats to the trout's persistence are left inadequately addressed. Declines in the populations and in the habitat continue at a rate far exceeding the ability of current conservation mechanisms to mitigate and restore the damage. Furthermore, adequate funding to support this patchwork of conservation efforts and the accountability necessary to ensure that these efforts are adequately implemented is not assured over the medium- or long-term; listing under the Endangered Species Act provides tangible and accountable management responsibilities and obligations with substantive enforcement mechanisms. Under the current (unlisted) management framework, the federal agencies and the states have utterly failed to end the subspecies precipitous decline, much less recover it to a stable and viable level. Only the coordinated planning and enforcement by the U.S. Fish and Wildlife Service of an effective management and recovery strategy can save native Yellowstone cutthroat trout from extinction across its historical range.

Applicability of Listing Criteria

The criteria for the listing of a species under the ESA are:

1. The present or threatened destruction, modification, or curtailment of habitat or range;

2. Overutilization for commercial, recreational, scientific, or educational purposes;

3. Disease or predation;

4. The inadequacy of existing regulatory mechanisms; and

5. Other natural or manmade factors affecting its continued existence.

Petitioners understand that if a species' circumstances fit any one of the five criteria, congressional mandate requires its listing under the ESA. It can be demonstrated that the present status of the Yellowstone cutthroat trout fits all five of these criteria.

1. <u>The present or threatened destruction, modification, or curtailment of habitat or range</u>

The ability of the Yellowstone cutthroat trout to reproduce and survive is significantly affected by the substantial degradation and destruction of habitat across the trout's range. It is clear that in the absence of substantial habitat protection and restoration, the cutthroat trout will continue its slide toward extinction. The literature clearly documents the severity of the degradation resulting from extensive water impoundments and diversions (e.g., Clancy 1988, Gresswell 1995, Thurow et al. 1988, Letter from Robert Leffert, Fisheries Biologist, Caribou National Forest to Mimi Mather, 7/22/97); grazing, logging, and road-building (and the sedimentation, water temperature impacts, alteration of natural stream flows, and related results of these activities) (e.g., May 1996, Gresswell 1995, Hadley 1984, Varley and Gresswell 1988); mining (e.g., Gresswell 1995, Platts and Martin 1978); and other land management activities and development. It is critical to observe that habitat improvement projects, if they only address a limited number of factors limiting habitat quality, cannot provide for improved conditions for the Yellowstone cutthroat trout. Not only does the subspecies require adequate winter cover, for instance, but instream flows must be adequate, adequate spawning substrate must be available and not disrupted by sedimentation, water temperatures must be adequate, etc. Although some improvement in habitat conditions has occurred, "<u>habitat degradation continues at an alarming rate</u>" (Gresswell 1995:46, emphasis added).

Additionally, it is abundantly clear that the Yellowstone cutthroat trout has suffered a severe curtailment of its range. Simply put, "[h]uman activities and angler harvest have resulted in widespread extirpation of populations of this subspecies" (Gresswell 1995: 44). In short, the Yellowstone cutthroat trout has suffered massive declines throughout its historical range (e.g., May 1996, Hadley 1984, USDA FS 1997). Although, due to stocking activities, the number of lakes currently occupied by the subspecies is larger than that occupied historically, this dramatic reduction in occupied range is especially true for riverine habitats.

Finally, what habitat remains has been severely fragmented, preventing crucial genetic exchanges between populations, severely disrupting migratory activities, and adversely impacting metapopulation dynamics (e.g. May 1996, USDA FS 1997). Ironically, many of the dispersal barriers have actually served to protect surviving pure Yellowstone cutthroat trout populations from being exclusively outcompeted or hybridized. In the long-term, however, such barriers and the introduced species from which they protect the Yellowstone cutthroat trout are a substantial impediment to the subspecies' recovery.

Ultimately, the mere presence of Yellowstone cutthroat trout in various small portions of its historic range is not adequate to ensure the persistence of the subspecies or to meet the legal requirements of the ESA. The size and health of those populations, the degree to which they are fragmented, the quality of their habitat, and similar concerns are critical considerations. The dramatic Yellowstone cutthroat trout population and distribution declines from historical conditions alone are reason enough for an ESA listing; in conjunction with the massive degradation and fragmentation of the habitat and the generally small and widely separated populations the necessity is clear.

2. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>

The literature makes clear that angler harvest has played a critical role in the widespread extirpation of Yellowstone cutthroat trout populations across its historical range (e.g., Gresswell 1995, Binns 1977, Hadley 1984, Gresswell and Varley 1988, Thurow et al. 1988). This is partially a consequence of the subspecies' considerable vulnerability to angling activities. Even with the most highly restrictive angling regulations, depending on the circumstances, angling impacts can be substantial (Gresswell and Varley 1988). Where present angling restrictions and their enforcement are not adequate to protect remaining Yellowstone cutthroat trout from overharvest, the continued existence of these populations is threatened.

3. <u>Disease or predation</u>

Whirling disease has the potential to provide the final blow to the imperiled Yellowstone cutthroat trout. Its signs are just now becoming apparent in the cutthroat trout's range, and it has left a series of severe declines in its wake. As noted elsewhere, whirling disease is thought to be the cause of a 90 percent decline in the Madison River's rainbow trout decline (USDA FS 1997:4, Nehring and Nickum n.d. citing Vincent 1996 and MacConnell 1996), and recent evidence strongly suggests that Yellowstone cutthroat trout may be similarly vulnerable (Nehring and Nickum n.d.). The Yellowstone cutthroat trout simply may not be able to sustain the type of declines associated with this disease, and the current management approach shows little evidence of being able to contend with this threat.

New Zealand mud snail may pose an additional threat to the Yellowstone cutthroat trout. Information provided by the National Park Service indicates that the snail is known to be present in the Firehole, Madison, Henrys Fork, and Snake Rivers (personal communication, Dan Mahoney 5/6/98). Although discussions of potential impacts to Yellowstone cutthroat trout are speculative, this exotic mollusk appears to dramatically alter the entire invertebrate community in stretches where it has become established, and it is spreading. The details and the potential severity of impacts to the cutthroat trout are discussed more fully earlier in the petition. The potential for inadvertent human-facilitated dispersal of this snail and other exotics and diseases (e.g., bait-bucket transfer, aquarium releases) has also been largely ignored by management agencies.

In the case of lake trout, the threat has already substantially materialized (e.g., Schullery and Varley 1995, Kaeding et al. 1996, Gresswell and Varley 1988). Lake trout have already had a substantial impact on the Yellowstone cutthroat trout population of Yellowstone Lake, widely considered to be the most important core pure population remaining. The ability of fisheries managers to prevent its spread throughout the throughout the Yellowstone River basin is unknown, but its spread into the Snake River basin is ominous and itself damaging. Predation by other exotics, including those deliberately stocked by state agencies (as well as inadvertently and illegally by anglers and other recreationists), is also a continuing threat to the existence of this trout subspecies.

4. The inadequacy of existing regulatory mechanisms

Existing regulatory mechanisms are wholly inadequate to ensure even that current pure Yellowstone cutthroat trout populations are protected, much less that the subspecies persists in a viable, self-sustaining fashion. First, these mechanisms strongly emphasize the use of hatchery stocking programs to supply trout to streams thought to be able to sustain populations, including those with existing pure populations. This stocking, as discussed elsewhere at length, destroys the genetic integrity of these existing populations, which may well have an adverse impact on their long-term viability. The stocking also dramatically increases the threat of a potentially devastating whirling disease epidemic among any number of the few surviving pure populations.

Second, the FS is unwilling to unequivocally take the necessary actions to address even these stocking issues. For example, the Supervisor of the Targhee National Forest, in a common refrain among FS staff, while acknowledging that the cessation of damaging stocking practices and the elimination of exotics that pose threats "are necessary to prevent extinction," insists that "[f]ish stocking and elimination of fish is the responsibility of the states." (Letter of Jerry Reese to Mimi Mather, July 3, 1997, attached as Exhibit 1).

Moreover, this emphasis on stocking, and, in some cases, on angling restrictions (which often may not be restrictive enough) conceals the failure of existing mechanisms to address critical concerns about instream flows, habitat quality, and connectivity between populations. In the absence of a vigorous effort to protect and restore habitat (including the re-establishment of minimum flow levels across trout habitat), even the most enthusiastic stocking effort will be insufficient to provide for a viable, self-sustaining subspecies.

The bias of existing programs toward protecting only those populations that have been conclusively ascertained to be pure is another problem with existing mechanisms. Pure populations that have not yet been confirmed as such tend to remain unprotected and are unlikely to remain pure for any length of time. At the same time, estimates of remaining pure populations are consistently optimistic, and when genetic testing actually occurs, the pattern has consistently been one of recognizing that even fewer pure populations exist than had been assumed.

Conservation efforts are uncoordinated across administrative and governmental boundaries. The threats facing the Yellowstone cutthroat trout are complex and occur at much larger scales, and the consistently inconsistent management provisions cannot adequately address them.

Moreover, existing conservation efforts do not generally include attempts to preserve the remaining genetic variation of the subspecies. Biologist John Varley observes that "managers generally believe in the species concept but do not have an appreciation for the variation within a species (or subspecies in this case). In the case of the Y. cutthroat, the variation (their looks, their behavior, their physiology) WITHIN the subspecies in unequivocly [sic] immense, and its [sic] that aspect that is being incrementally lost" (email of John Varley to Mimi Mather July 25, 1997, attached as Exhibit 26).

Finally, existing regulatory mechanisms do not, and can not, incorporate the substantive and accountable management provisions, addressing all of the major threats, that are absolutely essential to ensure the persistence of the subspecies. The agencies have demonstrated a clear unwillingness to take substantive and accountable actions toward removing all of the existing threats to the continued persistence of the Yellowstone cutthroat trout, especially with respect to habitat threats. Even with respect to the illegal or accidental stocking of threatening exotic fish species or the transfer of other exotics and diseases (e.g., New Zealand mud snail), the agencies are unwilling to take the strong and definite action required to minimize these threats.

In short, the survival of the Yellowstone cutthroat trout is threatened by the absence of a comprehensive, accountable, and enforceable conservation strategy to protect and restore populations and habitat. The various designations afforded the subspecies by federal and state agencies, and the unaccountable and unenforceable conservation strategies adopted (or under consideration) by these agencies, have done little to control activities that degrade habitat and threaten remaining pure populations.

5. <u>Other natural or manmade factors affecting its continued existence</u>

The impacts of hybridization, and, to a lesser extent, competitive exclusion, are widely cited in the literature as the major contribution to the current status of the Yellowstone cutthroat trout (e.g., Behnke 1992, Gresswell 1995, Allendorf and Leary 1988, Clancy 1988, Griffith 1988, Varley and Gresswell 1988). The impacts are severe and continuing, and pose a serious threat to the continued existence of the Yellowstone cutthroat trout. In the case of hybridization and competitive exclusion, as with <u>all</u> of the threats described in this petition, the impacts are mutually exacerbated when these threats interact. These impacts are closely tied to the dramatic inadequacies of existing regulatory mechanisms.

Critical Habitat

This petition requests that critical habitat be designated for the Yellowstone cutthroat trout within a reasonable period of time following ESA listing once it is determined to do so. “Service regulations (50 C.F.R. 424.12(a)(2)) state that critical habitat designation is not determinable if information sufficient to perform required analyses of the impacts of the designation is lacking or if the biological needs of the species are not sufficiently well known to permit identification of an area as critical habitat” (<u>Federal</u> <u>Register</u>, 1991, p. 49656). If, in light of these considerations, critical habitat cannot be determined and designated within the prescribed one-year period following listing, petitioners understand that listing will, in itself, set in motion “protection of this species’ habitat [which] will be addressed through the recovery process and through the section 7 jeopardy standard” (<u>Federal</u> <u>Register</u>, 1991, p. 49656, re: Gulf Sturgeon).

Summary

The Yellowstone cutthroat trout, like most other native inland cutthroat trout, has experienced devastating declines across its historical range. Although some of the trout's threats are being partially addressed, these efforts are simply inadequate to compensate for the continuing rate of decline, and, of course, are severely inadequate for the restoration activities that are critical to the subspecies' long-term persistence.

Populations of the Yellowstone cutthroat trout were decimated by heavy angling pressure. Most of the surviving populations were further destroyed by the stocking of competitors and hybridizers, so that only a handful of the remaining populations are genetically pure. The threats from hybridizing, competing, and predating non-native trout continue to expand in geographic scope and intensity. The few populations that have managed to survive also face continued and severe habitat degradation as a result of sedimentation, excessive water temperatures, inadequate cover, water pollution, and especially dewatering. These remaining populations also face additional severe threats to viability from reproductive isolation as a consequence of this habitat degradation and the construction of numerous water impoundments creating actual and effective dispersal barriers.

Habitat degradation has often resulted in the trout being more susceptible to the adverse effects of continued (legal and illegal) introductions of non-native species and the continued range expansion of non-native populations already existing. Habitat degradation and pressure from non-native fish serve to make the few surviving pure Yellowstone cutthroat trout populations even more susceptible to adverse impacts from angling pressure.

Even efforts to conserve the subspecies have contributed to its decline. The stocking of specific Yellowstone cutthroat trout stocks into stream segments other than those from which the strain was developed has resulted in the contamination and destruction of locally-adapted pure populations, further exacerbating many of the threats above and rapidly depleting the immense intra-subspecific genetic variability characterizing the trout. These hatchery programs, which are themselves largely uncoordinated among states and agencies, also substantially heighten the risk that the Yellowstone cutthroat trout will face yet another devastating threat - the spread of whirling disease into pure trout populations. Although some hatchery efforts seem to have been successful at maintaining wild stocks of Yellowstone cutthroat trout, and some such efforts may be important to the long-term recovery of the subspecies,[9] the use of hatchery programs must be handled with extreme prudence and caution, and the risks of inbreeding depression and related genetic deterioration must be fully addressed.

As May (1996:23) points out, "[t]he long-term well-being of Yellowstone cutthroat trout will require a comprehensive and well-coordinated conservation approach." That management has been so dispersed and disjointed among so many agencies has been a major obstacle to the protection and recovery of the Yellowstone cutthroat trout. The threats to the trout's persistence span administrative and governmental boundaries, and need to be addressed in a comprehensive, coordinated, and consistent manner. Only listing under the Endangered Species Act can provide the necessary level of multi-state management coordination. Moreover, only an ESA listing can provide the

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[9] One example may be the McBride Lake strain, maintained by the Montana Department of Fish, Wildlife, and Parks, and discussed in Varley and Gresswell (1988).

enforcement mechanisms and accountable management standards critical to the Yellowstone cutthroat trout's recovery.

In summary, it is clear that the remaining populations of Yellowstone cutthroat trout are not secure, that management efforts to date have been insufficient, and that the threats to the subspecies' continued persistence are continuing to drive it toward extinction. In the view of NPS biologist John Varley, existing conservation measures are "probably not" adequate; they are probably not "keeping pace with the losses to populations and habitats … The losses (genetic dilution, habitat loss, exotic disease epidemics, subdivisions, overfishing, etc. etc.) are occurring too rapidly" (email of John Varley to Mimi Mather July 25, 1997, attached as Exhibit 26).

<u>Conserving and restoring the Yellowstone cutthroat trout</u>

The reasons the surviving pure populations of Yellowstone cutthroat trout have survived suggest a great deal about what will be required to conserve and restore the subspecies. Remaining pure populations are located in remote, inaccessible headwater areas; most have been retained in public ownership as national parks and national forests, affording them at least some measure of protection not provided to those existing on private land; they largely have not been exposed to large-scale harvesting activity (e.g., commercial fishing); and some efforts have been made during the last century to restrict the degree to which Yellowstone cutthroat trout have been exposed to genetic contamination from other trout species (Varley and Gresswell 1988).

These factors strongly suggest that an adequate conservation and restoration strategy for the Yellowstone cutthroat trout must be characterized by a strong commitment to preserve and restore critical habitat areas from the degrading effects of various land management activities described earlier in this petition: “Perpetuation of Yellowstone cutthroat trout depends on continued protection of unaltered habitats, but enhancement activities are urgently needed in many portions of the current and historical range of the subspecies” (Varley and Gresswell 1988:21). Degraded riparian areas must be restored (and currently intact riparian areas must be fully protected). Activities and structures which disrupt the spawning areas, reduce critical cover, reduce critical instream flows, cause increases in the sediment load, lead to water temperature increases, increase bank instability, etc. must be prohibited in important Yellowstone cutthroat trout habitat. Hadley (1984), for instance, advocates vigorous protection of pure strain Yellowstone cutthroat trout waters from mining, logging, and grazing abuses. Large-scale habitat restoration must also be undertaken; this must occur in a coordinated fashion across the entire range, and not in piecemeal fashion by individual agencies and states. Gresswell and Varley (1989:36) indicate that “[p]reserving adequate instream flows and altering livestock grazing strategies are integral to the perpetuation of native and introduced wild populations of the Yellowstone subspecies.” Similar expressions are found throughout the literature.

However, as the Forest Service indicates in a report on the Targhee National Forest, “[h]abitat protection and restoration alone will not ensure future healthy populations … Halting the causes of the decline in population health is critical to species recovery” (USDA FS 1997:9). For instance, angling pressure must be managed, and angling impacts must be prohibited in areas where it is having a deleterious effect on Yellowstone cutthroat trout survival or recovery. It is especially important that all remaining pure populations be fully protected from genetic introgression, competition with, and predation by non-native fish, and that they be fully protected from whirling disease.

Finally, a conservation strategy must take full account of the considerable intraspecific variation among Yellowstone cutthroat trout populations, even among populations occupying the same geographic area. Gresswell et al. (1994:298) note that the "[l]oss of diversity at any hierachichal level jeopardizes the long-term ability of the species to adapt to changing environments, and it may also lead to increased fluctuation in abundance and yield and increase the risk of extinction," and that "[n]umerous studies suggest that life-history variation has adaptive significance on other polytypic fish species (Healey 1986, Taylor 1991, Hankin et al. 1993, Quinn and Unwin 1993), and phenotypic plasticity can be a key component of evolutionary change (Thompson 1991)" (Id.:306).

Not surprisingly, May's (1996) description of an appropriate conservation strategy closely resembles these recommendations. May emphasizes protecting pure Yellowstone cutthroat trout populations from non-native fish and overharvesting, maintaining and enhancing Yellowstone cutthroat habitat, and expanding the distribution of pure populations within the historic range. In fact, May (1996:25) points out that:

> [p]rotection and maintenance of existing populations will likely be insufficient to insure long-term Yellowstone cutthroat existence in some of the smaller streams. There is a very real need to increase population numbers and distribution as an effective hedge against localized extinctions.

Preventing continued declines, extirpations, and the ultimate extinction of the Yellowstone cutthroat trout will depend on a vigorous effort to eliminate any future stocking of non-native species or Yellowstone cutthroat trout stocks, to fully protect native populations from angling and other pressures, to protect and restore habitat, and to manage that habitat on a watershed or ecosystem basis. Anything less will almost certainly result in the continued decline of this native subspecies. In short, not only does the Yellowstone cutthroat trout warrant full protection under the Endangered Species Act on the basis of the statute's listing provisions, but such a listing is probably critical if there is any hope of restoring viable populations of the subspecies across its historic range and preventing its continued demise. There is little doubt that, as a result of the ongoing accumulation of myriad threats, and the failure of management agencies to alleviate these threats, Yellowstone cutthroat trout persistence in the foreseeable future is highly uncertain. After thorough analysis, then, Petitioners believe there is no doubt that the Yellowstone cutthroat trout is biologically threatened in a significant portion or throughout its known historic range.

Petitioners will expect to receive a formal acknowledgment of this petition and a decision within 90 days of its receipt on whether a listing of the Yellowstone cutthroat trout under the Endangered Species Act may be warranted.

Respectfully submitted,

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Yellowstone cutthroat trout - Bibliography

Albin, D.P. 1979. Fire and stream ecology in some Yellowstone tributaries. California Fish and Game 65:216-238.

Allendorf, Fred W. 1986. Genetic drift and the loss of alleles versus heterozygosity. Zoo Biology 5:181-190.

Allendorf, Fred W. 1988. Conservation biology of fishes. Conservation Biology 2:145-148.

Allendorf, Fred W. 1988. Conservation and distribution of genetic variation in a polytypic species, the cutthroat trout. Conservation Biology 2, 2 (June):170-184.

Allendorf, F.W., and M.M. Ferguson. 1990. Genetics. In C.B. Schreck and P.B. Moyle (eds.). Methods for fish biology. American Fisheries Society, Bethesda, Maryland. Pp. 35-64.

Allendorf, F.W., and R.F. Leary. 1986. Heterozygosity and fitness in natural populations of animals. In M.E. Soulé (ed.). Conservation biology: The science of scarcity and diversity. Sunderland, Massachusetts: Sinauer Associates.

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.

Allendorf, F.W. and S.R. Phelps. 1980. Loss of genetic variation in a hatchery stock of cutthroat trout. Transactions of the American Fisheries Society 109:537-543.

Allendorf, F.W., and N. Ryman. 1987. Genetic management of hatchery stocks. In N. Ryman and F. Utter (eds.). Genetics and fishery management. Seattle: University of Washington Press.

Allendorf, F.W., and G.H. Thorgaard. 1984. Polyploidy and the evolution of salmonid fishes. In B.J. Turner (ed.). The evolutionary genetics of fishes. New York: Plenum Press. Pp. 1-53.

American Fisheries Society. 1989. Fishes of North America, endangered, threatened, or of special concern. Fisheries 14, 6:2-38.

American Fisheries Society. 1991. Influences of forest and rangeland management on salmonid fishes and their habitat. American Fisheries Society Special Publication 19, W.R. Meehan (ed.), Bethesda, Maryland. 751 pp.

Anderson, B. 1981. How the river runs: A study of potential changes in the Yellowstone River basin. Montana Department of Natural Resources and Conservation, Final Report, Helena.

Anderson, H.W., M.D. Hoover, and K.G. Reinhart. 1976. Forests and water: Effects of forest management on floods, sedimentation, and flood supply. U.S. Department of Agriculture, Forest Service General Technical Report PSW-18.

Anderson, R.M., and R.B. Nehring. 1984. Effects of a catch-and-release regulation on a wild trout population in Colorado and its acceptance by anglers. North American Journal of Fisheries Management 4, 3:257-265.

Angradi, T., and C. Contor. 1989. Henrys Fork fisheries investigations, Project F-1-R-12, Subproject III, Jobs 7A and 7B. Idaho Department of Fish and Game, Idaho Falls, Idaho.

Anonymous. 1988. Whirling disease management in North America: An emergency conference, Denver, Colorado, April 13-14, 1988. Sponsored by the Fish Health Subcommittee of the Colorado River Wildlife Council.

Armour, C.L. 1977. Effects of deteriorated range streams on trout. U.S. Department of the Interior, Bureau of Land Management, Boise, Idaho.

Armour, C.L., D.A. Duff, and W. Elmore. 1992. The effects of livestock grazing on riparian and stream ecosystems. Fisheries 16:7-11.

Arnold, B.B., and F.P. Sharpe. 1967. Summary report of lake and stream investigations for 1966. U.S. Fish and Wildlife Service, Yellowstone National Park, Wyoming.

Associated Press. 1997. Whirling disease invades Yellowstone. Bozeman Chronicle (July 11, 1997).

Athern, J.B. 1973. Migratory behavior of cutthroat trout fry with respect to temperature, water flow, and food. Master's theses, University of Idaho, Moscow.

Bagenal, T.B. 1978. Aspects of fish fecundity. In S.D. Gerking (ed.). Ecology of freshwater fish production. Oxford: Blackwell Scientific Publications. Pp. 75-101.

Ball, O.P. 1955. Some aspects of homing in cutthroat trout. Proceedings of the Utah Academy of Science, Arts, and Letters 32:75-80.

Ball, O.P., and O.B. Cope. 1961. Mortality studies on cutthroat trout in Yellowstone Lake. U.S. Fish and Wildlife Service Research Report 55.

Bangham, R.V. 1951. Parasites of fish in the upper Snake River drainage and in Yellowstone Lake, Wyoming. Zoologica 36:213-217.

Baxter, G.T., and J.R. Simon. 1970. Wyoming fisheries. Wyoming Game and Fish Commission Bulletin 4.

B.C. Habitat Conservation Foundation. 1986. Yellowstone Cutthroat trout sampling program East Kootenay, B.C. Prepared by Artech Consulting, Ltd. File No. 86-T349.

Beach, D.R. 1971. Survival and growth of resident and stocked cutthroat trout in Priest and Upper Priest Lake (survey). Idaho Department of Fish and Game, Boise,. Annual Completion Report, Project F-53-R-6, Job I-a.

Becker, C.D., D.A. Neitzel, and C.S. Abernathy. 1982. Effects of dewatering on chinook salmon redds: Tolerance of four developmental phases to one-time dewatering. North American Journal of Fisheries Management 3:373-382.

Behnke, R.J. 1971. The Zoogeography, systematics and management of cutthroat trout. American Fisheries Society Exhibit - Salt Lake City, Sept., 1971.

Behnke, Robert J. 1972. The rationale of preserving genetic diversity. Proceedings of the annual Conference Western Association of Game and Fish Commissioners 52:559-561.

Behnke, Robert J. 1977. Fish faunal changes associated with land-use and water development. Great Plains-Rocky Mountain Geological Journal 6, 2:133-136.

Behnke, Robert J. 1979. The native trouts of the genus *Salmo* of western North America: Report to the U.S. Fish and Wildlife Service. Denver, Colorado.

Behnke, Robert J. 1983. Impact of livestock grazing on stream fisheries: Problems and solutions. Proceedings of Workshops on Livestock and Wildlife-Fisheries relationships in the Great Basin. J.W. Menke (ed.). University of California Agricultural Sciences, Special Publication 3301, Berkeley.

Behnke, Robert J. 1988. Phylogeny and classification of cutthroat trout. American Fisheries Society Symposium 4:1-7.

Behnke, Robert J. 1989. Summary of progress in wild trout management 1974-1989. Wild Trout IV. F. Richardson and R. Hamre (eds.). Trout Unlimited.

Behnke, Robert J. 1990. Identification of Wyoming cutthroat trout collections made in 1989.

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

Behnke, Robert J. 1994 (March). Analysis of trout collected in Wyoming during 1993.

Behnke, Robert J., and M. Zarn. 1976. Biology and management of threatened and endangered western trout. U.S. Forest Service Technical Report RM-28. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Belford, D.A., and W.R. Gould. 1989. An evaluation of trout passage through six highway culverts in Montana. North American Journal of Fisheries Management 9:437-445.

Bengtsson, J. 1991. Interspecific competition in metapopulations. In M.E. Gilpin and I. Hanski (eds.). Metapopulation dynamics. London: Academic Press: Pp. 219-237.

Benson, N.G. 1960. Factors influencing production of immature cutthroat in Arnica Creek, Yellowstone Park. Transactions of the American Fisheries Society 89:168-175.

Benson, N.G. 1961. Limnology of Yellowstone Lake in relation to the cutthroat trout. U.S. Fish and Wildlife Service, Research Report 56.

Benson, N.G., and R.V. Bulkley. 1963. Equilibrium yield and management of cutthroat trout in Yellowstone Lake, Wyoming. U.S. Fish and Wildlife Service, Research Report 62.

Benson, N.G., J.R. Greeley, M.I. Huish, and J.H. Kuehn. 1961. Status of management of natural lakes. Transactions of the American Fisheries Society 90:218-224.

Berg, R.K. 1975. Fish and game planning, upper Yellowstone and Shields river drainages. Montana Department of Fish, Wildlife and Parks, Helena. Project F-3-R, Job 1-c.

Bergersen, E.P., and D.E. Anderson. 1997. The distribution and spread of Myxobolus cerebralis. Fisheries 22, 8:6-7.

Berkman, H.E., and C.F. Rabeni. 1987. Effect of siltation on stream fish communities. Environmental Biology of Fishes 18:285-294.

Biesinger, K.E. 1961. Studies on the relationship of the redside shiner (Richardsonius balteatus) and the longnose sucker (Catostomus catostomus) to the cutthroat trout (Salmo clarki) population in Yellowstone Lake. Master's Thesis, Utah State University, Logan.

Binns, N.A. 1977. Present status of indigenous populations of cutthroat trout, Salmo clarki, in southwest Wyoming. Wyoming Game and Fish Department, Cheyenne. Fisheries Technical Bulletin 2.

Bischoff, C.M. 1995. Introgression between Colorado River cutthroat trout and rainbow trout in an isolated drainage system. Master's Thesis, Utah State University, Logan, Utah.

Bisson, P.A., K. Sullivan, and J.L. Nielson. In press. Channel hydraulics, habitat utilization, and body form of coho salmon, steelhead trout, and cutthroat trout in streams. Canadian Journal of Fisheries and Aquatic Sciences.

Bjornn, T.C., and G.A. Liknes. 1986. Life history, status and management of westslope cutthroat trout. Pages 57-64 in J.S. Griffith, (ed.). The ecology and management of interior stocks of cutthroat trout. Western Division, American Fisheries Society, Bethesda, Maryland. Special Publication.

Bjornn, T.C., T.H. Johnson, and R.F. Thurow. 1977. Angling versus natural mortality in northern Idaho cutthroat trout populations. Pages 89-98 in R.A. Barnhart and T.D.

Roelofs (eds.). Proceedings of the catch and release fishing symposium, Humbolt State University, Arcata, California.

Biesinger, K.E. 1961. Studies on the relationship of redside shiner (*Richardsonius balteatus*), and the longnose sucker (*Catostomus catostomus*) to the cutthroat trout (*Salmo clarki*) population in Yellowstone Lake. Master's Thesis. Utah State University, Logan.

Binns, N.A. 1977. Present status of indigenous populations of cutthroat trout, Salmo clarki, in southwest Wyoming. Wyoming Game and Fish Department, Cheyenne. Fisheries Technical Bulletin 2.

Binns, N.A., and F.M. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215-228.

Bock, C.E., V.A. Saab, T. D. Rich, and D.S. Dobkin. 1992. Effects of livestock grazing on neotropical migratory landbirds in western North America. USDA Forest Service, General Technical Report RM-229. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Boltz, Glenn, Daniel G. Carty, Ronald D. Jones, Lynn R. Kaeding, Daniel L. Mahony, and Tom Olliff. 1993. Annual Technical Report for 1992: Fishery and Aquatic Management Program in Yellowstone National Park. USDI FWS.

Bostrom, 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, Idaho Falls, Idaho.

Bowlby, J.N., and J.C. Roff. 1986. Trout biomass and habitat relationships in southern Ontario streams. Transactions of the American Fisheries Society 115:503-514.

Bowler, B. 1975. Factors influencing genetic control in lakeward migrations of cutthroat trout fry. Transactions of the American Fisheries Society 104:474-482.

Boyce, M.S. 1992. Population viability analysis. Annual Review of Ecology and Systematics 23:481-506.

Bozeman Daily Chronicle, Page 5, June 5, 1996.

Bozeman Daily Chronicle, Page 6, July 21, 1996.

Briggs, J.C. 1955. Behavior pattern in migratory fishes. Science 122:240.

Brown, C.J.D. 1971. Fishes of Montana. Big Sky Books, Montana State University, Bozeman, Montana.

Brown, R.R. 1974. The predation of cutthroat trout on redside shiners in Pelican Creek. In U.S. Fish and Wildlife Service, Division of planning and Assistance, Annual Project Report Yellowstone Fishery Investigations, Yellowstone National Park, Calendar Year 1973, June 10, 1974. Pp. 124-131.

Brown, R.S. and W.C. Mackay. 1995. Fall and winter movements of and habitat use by cutthroat trout in the Ram River, Alberta. Transactions of the American Fisheries Society 124:873-885.

Buchanan, D.V., J.L. Fryer, and J.L. Zinn. 1982. Relative susceptibility of four stocks of summer steelhead to infections of ceratomyxosis and bacterial diseases found in the Willamette River.

Bulkley, R.V. 1961. Fluctuations in age composition in growth rate of cutthroat trout in Yellowstone Lake. U.S. Fish and Wildlife Service Research Report 54.

Bulkley, R.V. 1963. Natural variation in spotting, hyoid teeth counts, and coloration of Yellowstone cutthroat trout, Salmo clarki lewisi. USDA FWS, Special Scientific Report – Fisheries 460.

Burr, J.M. 1993. Maturity of lake trout from eleven lakes in Alaska. Northwest Science 67:78-87.

Busak, C.A., and G.A.E. Gall. 1981. Introgressive hybridization in populations of Paiute cutthroat trout (Salmo clarki seleniris). Canadian Journal of Fisheries and Aquatic Sciences 38:939-951.

Busby, F.E. 1979. Riparian and stream ecosystems, livestock grazing, and multiple-use management. In O.B. Cope. Proceedings of the Forum – Grazing and riparian/stream ecosystems. Trout Unlimited, Denver, Colorado. Pp. 6-12.

Buth, D.G., R.W. Murphy, and L. Ulmer. 1987. Population differentiation and introgressive hybridization of the flannelmouth sucker and of hatchery and native stocks of the razorback sucker. Transactions of the American Fisheries Society 116:103-110.

Byorth, P.A. 1990. An evaluation of Yellowstone cutthroat trout production in three tributaries of the Yellowstone River, Montana. Master's Thesis, Montana State University, Bozeman.

Campton, D.E. 1987. Natural hybridization and introgression in fishes: Methods of detection and genetic interpretations. In N. Ryman and F. Utter (eds.). Population genetics and fishery management. Seattle: University of Washington Press. Pp. 161-192.

Campton, D.E., and F.M. Utter. 1985. Natural hybridization between steelhead trout (Salmo gairdneri) and coastal cutthroat trout (Salmo clarki) in two Pudget Sound streams. Canadian Journal of Fisheries and Aquatic Sciences 42:110-119.

Carlander, K.D. 1969. Handbook of freshwater fishery biology, Volume 1. 3rd edition. Ames: Iowa State University Press.

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

Caswell, H. 1989. Matrix population models. Sunderland, Massachusetts: Sinauer Associates.

Caughley, G. 1994. Directions in conservation biology. Journal of Animal Ecology 63:-215-244.

Chamberlain, T.W., R.D. Harr, and F.H. Everest. 1991. Timber harvesting, silviculture, and watershed processes. American Fisheries Society Special Publication 19:181-205.

Chaney, E., W. Elmore, and W.S. Platts. 1990. Livestock grazing on western riparian areas. EPA Report, 14-7, 26-7.

Chaney, E., W. Elmore, and W.S. Platts. 1993. Managing change: Livestock grazing on western riparian areas. U.S. Environmental Protection Agency, Denver, CO. 31 pp.

Chapman, D.W. 1988. Critical Review of Variables Used to Define Effects of Fines in Redds of Large Salmonids. Transactions of the American Fisheries Society 117, 1:1-21.

Chapman, D.W. and T.C. Bjornn. 1969. Distribution of salmonids in streams with special reference to food and feeding. Pages 153-176 in T.G. Northcote (ed.). Symposium on Salmon and Trout in Streams. H.R. Macmillan Lectures in Fisheries, University of British Columbia, Vancouver, Canada.

Claire, E., and M. Gray. 1993. Information survey data for U.S. Forest Service habitat conservation assessment inland cutthroat trout. Oregon Dept. of Fish and Wildlife.

Claire, E.W., and R.L. Storch. 1983. Streamside management and livestock grazing in the Blue Mountains of Oregon: A case study. In R.J. Behnke. Impact of livestock grazing on stream fisheries: Problems and solutions. In J.W. Menke (ed.). Proceeding of workshop of Livestock and Wildlife-fisheries relationships in the Great Basin. University of California Agricultural Sciences, Special Publication 3301, Berkeley.

Clancy, Christopher G. 1987. Inventory and survey of waters of the project area. Montana Department of Fish, Wildlife and Parks, Federal Aid in Fish Restoration, Project F-9-R-35, Job 1-C, Job Progress Report, Helena.

Clancy, Christopher G. 1987. Southwest Montana fisheries investigations. Montana Department of Fish, Wildlife and Park, Helena. Job Progress Report, Project F-9-R-35, Job 1-c.

Clancy, Christopher G. 1988. Effects of dewatering on spawning by Yellowstone cutthroat trout in tributaries to the Yellowstone River, Montana. American Fisheries Society Symposium 4:37-41.

Clark, T.W. A.H. Harvey, R.D. Dorn, D.L. Genter, C. Groves. 1989. Rare, sensitive, and threatened species of the Greater Yellowstone Ecosystem. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy, and Mountain West Environmental Services.

Clary, W.P., and Webster, B.F. 1989. Managing grazing of riparian areas in the Intermountain Region. USDA FS, Intermountain Research Station, General Technical Report INT-263. 11 pp.

Colorado Division of Wildlife, Southwestern Region. 1997. Rio Grande cutthroat trout management plan. Colorado Division of Wildlife, Montrose, Colorado.

Committee on Developing Strategies for Rangeland Management. 1984. Developing strategies for rangeland management. Committee on Developing Strategies for Rangeland Management, National Research Council/National Academy of Sciences. Westview Press, Boulder, CO.

Cope, O.B. 1957. The choice of spawning sites by cutthroat trout. Proceedings of the Utah Academy of Science, Arts, and Letters 34:73-79.

Cope, O.B. 1958. Incidence of external parasites on cutthroat trout in Yellowstone Lake. Proceedings of the Utah Academy of Science, Arts, and Letters 35:95-100.

Cope, O.B. 1979. Proceedings of the Forum – Grazing and riparian/stream ecosystems. Trout Unlimited, Denver, Colorado. 94 pp.

Corsi, C.E. 1988. The life history and status of the Yellowstone cutthroat trout (*Salmo clarki bouvieri*) in the Willow Creek drainage, Idaho. Master's Thesis, Idaho State University, Pocatello.

Courtnay, W.R., Jr., and J.R. Stuaffer, Jr. (eds.). 1984. Distribution, biology, and management of exotic fishes. Johns Hopkins University Press.

Crow, T.R. 1992. Landscape ecology: The big picture approach to resource management. in D.J. Decker et al. (eds.). Challenges in the conservation of biological resources: A practitioner's guide. Pp. 55-67. San Francisco, California: Westview Press.

Crumpacker, D.W. 1984. Regional riparian research and a multi-university approach to the special problem of livestock grazing in the Rocky Mountains and Great Plains. Pages 413-422 in R.E. Warner and K. Hendrix (eds.). California riparian systems: Ecology, conservation, and productive management. University of California Press, Berkeley, California.

Cunjak, R.A., and G. Power. 1987. Cover use by stream resident trout in winter: A field experiment. North American Journal of Fisheries Management 7:539-544.

Cunjak, R.A., and G. Power. 1987. The feeding and energetics of stream-resident trout in winter. Journal of Fish Biology 31:493-511.

Curtis, G.L. 1990. Recovery of an off-shore lake trout population in eastern Lake Superior, USA, and Canada. Journal of Great Lakes Restoration 16, 2:279-287.

Darling, Jim, Dave Genter, Lynn Kaeding, Robb Leary, Bruce May, Brad Shepard. 1993. Yellowstone cutthroat trout (Oncorhynchus clarki bouvieri): Management guide for the Yellowstone River drainage. Draft. Yellowstone Cutthroat Trout Working Group. Montana Department of Fish, Wildlife and Parks, Helena, and Wyoming Game and Fish Department, Cheyenne.

Darling, Jim, Dave Genter, Lynn Kaeding, Robb Leary, Bruce May, Brad Shepard, Mike Stone. 1992. Yellowstone cutthroat trout (Oncorhynchus clarki bouvieri): Management guide for the Yellowstone River drainage. Yellowstone Cutthroat Trout Working Group. Montana Department of Fish, Wildlife and Parks, Helena, and Wyoming Game and Fish Department, Cheyenne.

Darling, Jim, et al. 1994. Yellowstone cutthroat trout (Oncorhynchus clarki bouvieri): Management guide for the Yellowstone River drainage. Yellowstone Cutthroat Trout Working Group. Montana Department of Fish, Wildlife and Parks, Helena, and Wyoming Game and Fish Department, Cheyenne.

Davenport, M.B. 1974. Piscivorous avifauna on Yellowstone Lake, Yellowstone National Park. Yellowstone National Park, U.S. Fish and Wildlife Service internal report. 62 pp.

Dean, J.L. 1972. Fishery management investigations, Yellowstone National Park. U.S. Fish and Wildlife Service, Annual Project Report, Yellowstone National Park, Wyoming.

Dean, J.L. and J.D. Varley. 1974. Fishery management investigations, Yellowstone National Park. Bureau of Sport Fisheries and Wildlife, Technical Report for 1973, Yellowstone National Park, Wyoming.

Dean, J.L. and J.D. Varley. 1974. Yellowstone fishery investigations. U.S. Fish and Wildlife Service, Yellowstone National Park, Wyoming.

Delany, Daniel. 1997. Biological Evaluation of the effects of the proposed revised forest plan on Yellowstone cutthroat trout. USDA Forest Service, St. Anthony, ID.

Dennis, B., P.L. Munholland, and J.M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61:115-143.

Donald, D.B., and D.J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology 71, 2:238-247.

Doppelt, B., M. Scurlock, C. Frissell, and J. Karr. 1993. Entering the watershed: A new approach to save America's river ecosystems. The Pacific Rivers Council.

Dowling, T.E., and M.R. Childs. 1992. Impact of hybridization on a threatened trout of the southwestern United States. Conservation Biology 6:355-364.

Duff, D.A. 1983. Livestock grazing impacts on aquatic habitat in Big Creek, Utah. In J.W. Menke (ed.). Proceeding of workshop of Livestock and Wildlife-fisheries relationships in the Great Basin. University of California Agricultural Sciences, Special Publication 3301, Berkeley. Pp. 129-142.

Duff, D.A. 1995. Fish stocking in U.S. Federal Wilderness Areas: Challenges and opportunities. International Journal of Wildlife 1:17-19.

Duff, D.A. (tech. ed.). 1996. Conservation assessment for inland cutthroat trout: Distribution, status, and habitat management implications. USDA Forest Service, Intermountain Region, Ogden, UT.

Dwyer, W.P., and R.H. Kramer. 1975. The influence of temperature on scope for activity in cutthroat trout, *Salmo clarki*. Transactions of the American Fisheries Society 104:522-554.

Dwyer, W.P., and C.E. Smith. 1989. Metacercariae of Diplostomum spathaceum in the eyes of fishes from Yellowstone Lake, Wyoming. Journal of Wildlife Diseases 25:126-129.

Echelle, A.A. 1991. Conservation genetics and genic diversity in freshwater fishes of western North America. In M.L. Minckley and J.E. Deacon (eds.). Battle against extinction: Native fish management in the American West. University of Arizona Press, Tucson. Pp. 141-153.

Elle, S. 1997. Distribution of *Myxobolus cerebralis* in Idaho with data presented for trout populations in four of the positive drainages. Pages 27-30, In: Whirling disease symposium, expanding the database: 1996 research progress reports. Eccles Conference Center, Logan Utah, March 6,7,8, 1997. Compiled by the Whirling Disease Foundation, Bozeman, MT.

Elle, S., and C. Corsi. 1994. Regional fisheries management investigations, Project F-71-R-13, Job 6-c. Idaho Department of Fish and Game, Idaho Falls, Idaho.

Elle, S., and M. Gamblin. 1993. Region 6 (Idaho Falls) rivers and streams investigation. Idaho Department of Fish and Game, Boise. Job Progress Report, Project F-71-R-15, Job 6(IF)-c.

Erwin, T.L. 1991. An evolutionary basis for conservation strategies. Science 253:750-752.

Evermann, B.W. 1891. A reconnaissance of the streams and lakes of western Montana and northwestern Wyoming. Bulletin U.S. Fish Commission Vol. X, 3-60.

Evermann, B.W. and Ulysses Cox. 1894. A report upon the fishes of the Missouri River basin. Bull. U.S. Fish Comm. 20:325-429.

Ewing, R., J. Mohrman, and D. Carty. 1986. Sources and quantities of suspended sediment in the Yellowstone River and selected tributary watersheds between

Yellowstone Lake outlet, Yellowstone National Park, Wyoming, and Livingston, Montana: 1985 Annual Progress Report. U.S. Department of the Interior, Fish and Wildlife Service. Yellowstone Fisheries Assistance Office. Aquatic Ecology Studies: Technical Report No. 2. Yellowstone National Park, Wyoming.

Fabrizio, M.C., M.E. Holey, P.C. McKee, and M.L. Toneys. 1997. Survival rates of adult lake trout in northwestern Lake Michigan, 1983-1993. North American Journal of Fisheries Management 17:413-428.

Farag, Aida M. 1988. The effects of acid and aluminum on survival, whole body ion content, and weights of Yellowstone cutthroat trout (Salmo clarki bouvieri). M.S. Thesis, University of Wyoming.

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. 1989. Do gradient and temperature affect distributions of, and interactions between, brook charr (Salveinus fontinalis) and other resident salmonids in streams? Physiology and Ecology Japan, Special Volume 1:303-322.

Fausch, K.D., and T.G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences 49:682-693.

Fausch, K.D., and M.K. Young. 1995. Evolutionarily significant units and movement of resident stream fishes: A cautionary tale. In J.K. Nielsen and D. Powers (eds.). Evolution and the aquatic ecosystem: Defining unique units in population conservation. American Fisheries Society Symposium 17. American Fisheries Society, Bethesda, Maryland.

Ferguson, M.M., R.G. Danzmann, and F.W. Allendorf. 1985. Absence of developmental incompatibility in hybrids between rainbow trout and two subspecies of cutthroat trout. Biochemical Genetics 23:557-570.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8, 3:629-644.

Foley, P. 1994. Predicting extinction times from environmental stochasticity and carrying capacity. Conservation Biology (in press).

Forbes, S.H. and F.W. Allendorf. 1991. Mitochondrial genotypes have no detectable effects on meristic traits in cutthroat trout hybrid swarms. Evolution 45:1350-1359.

Foster, Lynn E. 1978. Food habits of the cutthroat trout in the Snake River, Wyoming. M.S. Thesis, University of Wyoming.

Fraley, J., and P. Graham. 1981. Flathead River fishery study-1981. Montana Department of Fish, Wildlife, and Parks, Helena.

Franklin, I.R. 1980. Evolutionary change in small populations. In M.E. Soulé and B.A. Wilcox (eds.). Conservation biology: An evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts. Pp. 135-149.

Frissell, C.A. 1993. A new strategy for watershed restoration and recovery of Pacific salmon in the Pacific Northwest. Eugene, Oregon: The Pacific Rivers Council.

Frissell, C.A., W.J. Liss, and D. Bales. 1993. An integrated biophysical strategy for ecological restoration of large watersheds. Pages 449-456 in D. Potts (ed.). Proceedings of the symposium on changing roles in water resources management and policy. American Water Resources Association, Seattle, Washington.

Fromm, R.J.. Circa 1941. An open history of fish and fish planting in Yellowstone National Park. National Park Service, Yellowstone National Park, Wyoming.

Gabriel, W., and R. Burger. 1992. Survival of small populations under demographic stochasticity. Theoretical Population Biology 41:44-71.

Garrett, P.A., and J.C. Knight. 1973. Limnology of the West Thumb of Yellowstone Lake, Yellowstone National Park. Montana State University, Final Report (Contract 2-101-0387), Bozeman.

Gilbert, C.H., and B.W. Evermann. 1894. A report upon investigations in the Columbia River basin, with descriptions of four new species of fishes. Bulletin U.S. Fish Commission. Pp. 165-205.

Gilpin, M.E. 1987. Spatial structure and population vulnerability. In M.E. Soulé (ed.). Viable populations for conservation. Cambridge: Cambridge University Press. Pp. 125-140.

Gilpin, M.E., and I. Hanski (eds.). 1991. Metapopulation dynamics. London: Academic Press

Gilpin, M.E., and M.E. Soulé. 1986. Minimum viable populations: Processes of species extinction. In M.E. Soulé and B.A. Wilcox (eds.). Conservation biology: An evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts. Pp. 19-34.

Goede, R. 1996. Known distribution of *Myxobolus cerebralis* in feral and hatchery fishes in Utah, Wyoming, and New Mexico. In E.P. Bergersen and B.A. Knopf (eds.). Proceedings: Whirling disease workshop: Where do we go from here? Colorado Cooperative Fish and Wildlife Research Unit, Fort Collins, Colorado. Pp. 37-39.

Goodman, D. 1987. The demography of chance extinction. In M.E. Soulé (ed.). Viable populations for conservation. Cambridge: Cambridge University Press.

Gregory, J. 1997. Upper Henrys Fork habitat assessment: Headwaters to Island Park Dam. Project Completion Report. Henrys Fork Foundation, Ashton, Idaho.

Gregory, J. In preparation. Upper Henrys Fork habitat assessment: Island Park Dam to Warm River. Project Completion Report. Henrys Fork Foundation, Ashton, Idaho.

Gregory, J.S., and Griffith, J.S. 1997. First-winter survival of wild and hatchery cutthroat trout caged in allopatry and sympatry with brook trout. Department of Biological Science, Idaho State University, Pocatello, Idaho.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. An ecosystem perspective of riparian zones. BioScience 41, 8:540-551.

Gresswell, R.E. 1980. Yellowstone Lake – a lesson in fishery management. In W. King (ed.). Wild trout II. Trout Unlimited and Federation of Fly Fisherman, Vienna, Virginia. Pp. 143-147.

Gresswell, R.E. 1985. Saving the dumb gene in Yellowstone: There is more to preservation than granola. Proceedings of the Annual Conference Western Association of Fish and Wildlife Agencies 65:218-223.

Gresswell, R.E. (ed.). 1988. Status and management of interior stocks of cutthroat trout. American Fisheries Symposium 4. 140 pp.

Gresswell, R.E. 1990. Special regulations as a fishery management tool in Yellowstone National Park. In G. Larson and M. Soukup (eds.). Fisheries and coastal wetlands. George Wright Society and U.S. National Park Service, Fort Collins, Colorado.

Gresswell, R.E. 1991. Use of antimycin for removal of brook trout from a tributary of Yellowstone Lake. North American Journal of Fisheries Management 11:83-90.

Gresswell, R.E. 1995. Yellowstone cutthroat trout. In M.K. Young (ed.). Conservation assessment for inland cutthroat trout. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical RM-GTR-256. Pp. 36-54.

Gresswell, R.E. In press. Response of Yellowstone Lake cutthroat trout to a 330-mm maximum size limit: 12 years of success. In R.A. Barnhart and T.D. Roelofs (eds.). Catch-and-release fishing: A decade of experience. Humbolt State University, Arcata, California.

Gresswell, R.E., B.A. Barton, and J.L. Kershner (eds.). 1989. Practical approaches to riparian resource management. U.S. Bureau of Land Management, Billings, Montana.

Gresswell, R.E., and W.J. Liss. 1995. Values associated with management of Yellowstone cutthroat trout in Yellowstone National Park. Conservation Biology 9, 1:159-165.

Gresswell, R.E., and W.J. Liss. In Press. Values associated with management of Yellowstone cutthroat trout in Yellowstone National Park. Conservation Biology.

Gresswell, R.E., W.J. Liss, and G.L. Larson. 1994. Life-history organization of Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) in Yellowstone Lake. Canadian Journal of Fisheries and Aquatic Science 51 (Suppl. 1):298-309.

Gresswell, R.E., and J.D. Varley. 1988. Effects of a century of human influence on the cutthroat trout of Yellowstone Lake. American Fisheries Society Symposium 4:45-52.

Gresswell, R.E., and J.D. Varley. 1989. Yellowstone cutthroat trout: *Oncorhynchus* (formerly *Salmo*) *clarki bouvieri*. In T.W. Clark, A.H. Harvey, R.D. Dorn, D.L. Genter, and C. Groves (eds.). Rare, sensitive, and threatened species of the Greater Yellowstone Ecosystem. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy, and Mountain West Environmental Services. Pp. 35-36.

Griffith, J.S. 1970. Interaction of brook trout and cutthroat trout in small streams. Doctoral dissertation, University of Idaho, Moscow.

Griffith, J.S. 1972. Comparative behavior and habitat utilization of brook trout (Salvelinus fontinalis) and cutthroat trout (Salmo clarki) in small streams in northern Idaho. Journal of the Fisheries Research Board of Canada 29:265-273.

Griffith, J.S. 1974. Utilization of invertebrate drift by brook trout (Salvelinus fontinalis) and cutthroat trout (Salmo clarki) in small streams in Idaho. Transactions of the American Fisheries Society 103:440-447.

Griffith, J.S. 1988. Review of competition between cutthroat trout and other salmonids. In Robert E. Gresswell (ed.). Status and management of interior stocks of cutthroat trout. American Fisheries Society Symposium 4:134-140.

Griffith, J.S. 1991. Overwinter survival of juvenile salmonid fishes as influenced by sediment and streambank habitat quality. 9 pp.

Griffith, J.S. 1993. Failure of submersed macrophytes to provide overwinter cover for juvenile rainbow trout in the Henrys Fork of the Snake River, Idaho – draft. 23 pp.

Griffith, J.S., and R.W. Smith. 1993. Use of winter concealment cover by juvenile cutthroat and brown trout in the South Fork of the Snake River. North American Journal of Fisheries Management 13:823-830.

Griffith, J.S., R. Smith, C.C. Brand. 1989. Evaluation of instream structures in the Henrys Fork of the Snake River. Targhee National Forest No. 40-02S2-9-0407. 9 pp.

Gunther, K.A. 1995. Grizzly bears and cutthroat trout: Potential impacts of the introduction of non-native lake trout to Yellowstone Lake. Bear Management Office, Yellowstone National Park, Information Paper No. BMO-8. 3 pp.

Gyllensten, U., R.F. Leary, F.W. Allendorf, and A.C. Wilson. 1985. Introgression between two cutthroat trout subspecies with substantial karyotypic, nuclear, and mitochondrial genomic divergence. Genetics 111:905-915.

Hadley, Kathleen, 1984. Status Report on the Yellowstone Cutthroat Trout. Montana Department of Fish, Wildlife and Parks. Helena, MT. 74 pp.

Hagenbuck, Warren W. 1970. A study of the age and growth of the cutthroat trout from the Snake River, Teton County, Wyoming. M.S. Thesis, University of Wyoming.

Hall, J.D., and C.O. Baker. 1982. Rehabilitating and enhancing stream habitat: 1. Review and evaluation. U.S. Forest Service General Technical Report PN-138.

Hall, M.C. 1930. Report on parasites of pelican and trout, investigations at Yellowstone Lake, 1930. Report to the U.S. National Park Service, Yellowstone National Park, Wyoming.

Hamley, J.M. 1975. Review of gillnet selectivity. Journal of Fisheries Research Board of Canada 32:1943-1967.

Hankin, D.G., J.W. Nicholas, and T.W. Downey. 1993. Evidence for inheritance of age of maturity in chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fishery and Aquatic Science 50:347-358.

Hanski, I. 1991. Single-species metapopulation dynamics: Concepts, models, and observations. Biological Journal of the Linnean Society 42:17-38.

Hanski, I., and M. Gilpin. 1991. Metapopulation dynamics: Brief history and conceptual domain. Biological Journal of the Linnean Society 42:3-16.

Hanson, D.L. 1977. Habitat selection and spatial interaction in allopatric and sympatic populations of cutthroat and steelhead trout. Ph.D. Dissertation, University of Idaho, Moscow.

Hanzel, D.A. 1959. The distribution of cutthroat trout (Salmo clarki) in Montana. Proceedings of the Montana Academy of Sciences 19:32-71.

Harig, A.L., and K.D. Fausch. 1996. Compilation of data on Colorado waters containing Rio Grande cutthroat trout. Technical Report No. 904-96, Colorado Division of Wildlife, Montrose, Colorado.

Harig, A.L., and K.D. Fausch. 1998. Evaluating risks of extinction from habitat fragmentation for native cutthroat trout in Colorado and Wyoming. Annual Report to the Colorado Division of Wildlife, U.S. Forest Service, and Trout Unlimited. Colorado State University, Ft. Collins. 62 pp.

Harrison, S. 1991. Local extinction in a metapopulation context: An empirical evaluation. Biological Journal of the Linnean Society 42:73-88.

Hauer, F.R., and C.O. Blum. 1991. The effect of timber management on stream water quality. Flathead Basin Forest Practices, Water Quality and Fisheries Cooperative Program. Flathead Basin Commission, Kalispell, Montana.

Hayden, Peter S. 1968. The reproductive behavior of Snake River cutthroat trout in three tributary streams in Wyoming. M.S. Thesis, University of Wyoming.

Healey, M.C. 1978. The dynamics of exploited lake trout populations and implications for management. Journal of Wildlife Management 42, 2:307-328.

Healey, M.C. 1986. Optimum size and age at maturity in Pacific salmon and effects of size-selective fisheries. In D.J. Meerburg (ed.). Salmonid age at maturity. Canadian Special Publication of Fishery and Aquatic Science 89:39-52.

Hearn, W.E. 1987. Interspecific competition and habitat segregation among stream-dwelling trout and salmon: A review. Fisheries (Bethesda) 12, 5:24-31.

Heckmann, R. 1971. Parasites of cutthroat trout from Yellowstone Lake, Wyoming. Progressive Fish Culturist 33:103-106.

Heckmann, R., and H.L. Ching. 1987. Parasites of the cutthroat trout, *Salmo clarki*, and longnose suckers, *Catostomus catostomus*, from Yellowstone Lake, Wyoming. Great Basin Naturalist 47:259-275.

Heggenes, J., T.G. Northcote, and A. Peter. 1991. Spatial stability of cutthroat trout (Oncorhynchus clarki) in a small, coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 48:757-762.

Hensler, M.E. 1987. A field evaluation of four strains of *Salmo* introduced into seven Montana waters. Master's Thesis, Montana State University, Bozeman.

Herger, L.G. et al. 1996. Comparison of habitat composition and cutthroat trout abundance at two flows in small mountain streams. North American Journal of Fisheries Management 16, 2:294.

Hickman, T., and R.F. Raleigh. 1982. Habitat suitability index models: Cutthroat trout. USDI FWS, Biological Services Program. 38 pp.

Hicks, B.J., J.D. Hall, P.A. Bisson, and J.R. Sedell. 1991. Responses of salmonids to habitat changes. In Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19, Bethesda, Maryland. Pp. 483-518.

Hoelscher, B., and T.C. Bjornn. 1989. Habitat, densities, and potential production of trout and char in Pend Oreille Lake tributaries. Idaho Department of Fish and Game, Boise. Project F-71-R-10.

Hoffman, G.L. 1967. Parasites of North American freshwater fishes. Berkeley: University of California Press.

Hoffman, G. 1970. Intercontinental and transcontinental dissemination and transformation of fish parasites with emphasis on whirling disease (Myxosoma cerebralis). American Fisheries Society, Special Publication 5:69-81.

Hoskins, W.P. 1975. Yellowstone Lake tributary survey project. U.S. Department of the Interior Interagency Grizzly Bear Study Team, Yellowstone National Park, unpublished report. 10pp.

Hubbs, C.L. 1955. Hybridization between fish species in nature. Systematic Zoology 4:1-20.

Hubert, W.A., R.W. Stonecypher, W.A. Gern, and J. Bobbit. 1994. Responses of cutthroat trout embryos to reduced incubation temperatures at different developmental stages. The Progressive Fish Culturist 56:185-187.

Hubert, W.A. et al. 1996. Angler survey contributes to socially acceptable modification of harvest regulations to preserve cutthroat trout fishery in Snake River, Wyoming. Environmental Management 20, 5:707.

Hunt, R.L. 1969. Overwinter survival of wild fingerling brook trout in Lawrence Creek, Wisconsin. Journal of Fisheries Research Board of Canada 26:1473-1483.

Hunt, R.L. 1976. A long-term evaluation of trout habitat development and its relation to improving management related research. Transactions of the American Fisheries Society 105:361-365.

Hunter, C.J. 1991. Better trout habitat. Island Press, Washington, D.C.

Huntington, C.W. 1995. Final Report: Fish habitat and salmonid abundance within managed and unroaded landscapes on the Clearwater National Forest, Idaho. Prepared for: Eastside Ecosystem Management Project, USDA Forest Service, Walla Walla, WA.

Ireland, S.C. 1993. Seasonal distribution and habitat use of westslope cutthroat trout in a sediment-rich basin in Montana. Master's thesis, Montana State University, Bozeman, MT.

Irving, J.S. 1979. The fish population in the Teton River prior to impoundment by Teton Dam with emphasis on cutthroat trout (*Salmo clarki* Richardson). Master's Thesis, University of Idaho, Moscow.

Irving, J.S., B. Shepard, T.C. Bjornn, N. Horner, and R.R. Ringe. 1983. Fish resources in the Gospel-Hump area of central Idaho, potential impacts of forest management activities. Idaho Cooperative Fishery Research Unit. College of Forestry, Wildlife and Range Science, University of Idaho, Moscow, Idaho.

Irving, J.S., and T.C. Bjornn. 1984. Effects of substrate size composition on survival of Kokanee salmon and cutthroat trout and rainbow trout embryos. Idaho Cooperative Fisheries Research Unit, College of Forestry, Wildlife, and Range Sciences. University of Idaho, Moscow. Technical Report 84-6. 21 pp.

Irving, R.B. 1955. Ecology of the cutthroat trout in Henry's Lake, Idaho. Transactions of the American Fisheries Society 84:275-296.

Jahn, L.A. 1969. Movements and homing of the cutthroat trout (*Salmo clarki*) from open-water areas of Yellowstone Lake. Journal of the Fisheries Research Board of Canada 26:1243-1261.

Johnson, J.E. 1987. Protected fisheries of the United States and Canada. American Fisheries Society, Bethesda, MD.

Johnson, T.H., and T.C. Bjornn. 1978. The St. Joe River and Kelly Creek cutthroat trout populations: An example of wild trout management in Idaho. In J.R. Moring (ed.). Proceedings of the wild trout-catchable trout symposium. Oregon Department of Fish and Wildlife, Corvallis.

Johnson, R.L. 1964. Stream channel alternation inventory – Shields River. Montana Department of Fish, Wildlife and Parks, Helena. Job Progress Report, Project F-9-R-12, Job 2.

Johnson, S.W., J. Heifetz, and K.V. Koski. 1986. Effects of logging on the abundance and seasonal distribution of juvenile steelhead in some southeastern Alaska streams. North American Journal of Fisheries Management 6:532-537.

Johnston, I.M., B.T. Coffey, and C. Howard-Williams. 1985. The role of recreational boat traffic in interlake dispersal of macrophytes: A New Zealand case study. Journal of Environmental Management 20:263-279.

Jones, R.D., R. Andrascik, D.G. Carty, R.E. Gresswell, D.L. Mahony, and S. Relya. 1990. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1989, Yellowstone National Park, Wyoming.

Jones, R.D., R. Andrascik, D.G.Carty, L.R. Kaeding, B.M. Kelly, D.L. Mahony, and T. Olliff. 1992. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1991, Yellowstone National Park, Wyoming.

Jones, R.D., P.E. Bigelow, R.E. Gresswell, L.D. Lentsch, and R.A. Valdez. 1983. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Yellowstone National Park, Wyoming.

Jones, R.D., P.E. Bigelow, R.E. Gresswell, and R.A. Valdez. 1982. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1981, Yellowstone National Park, Wyoming.

Jones, R.D., G. Boltz, D.G. Carty, L.R. Kaeding, D.L. Mahony, and T. Olliff. 1993. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Yellowstone National Park, Wyoming.

Jones, R.D., D.G. Carty, R.E. Gresswell, K.A. Gunther, L.D. Lentsch, and J. Mohrman. 1985. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1984, Yellowstone National Park, Wyoming.

Jones, R.D., D.G. Carty, R.E. Gresswell, C.J. Hudson, L.D. Lentsch, and D.J. Mahony. 1986. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1985, Yellowstone National Park, Wyoming.

Jones, R.D., D.G. Carty, R.E. Gresswell, C.J. Hudson, and D.L. Mahony. 1987. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1986, Yellowstone National Park, Wyoming.

Jones, R.D., R.E. Gresswell, K.A. Gunther, and L.D. Lentsch. 1984. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1983, Yellowstone National Park, Wyoming.

Jones, R.D., R.E. Gresswell, D.E. Jennings, S.M. Rubrecht, and J.D. Varley. 1980. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Yellowstone National Park, Wyoming.

Jones, R.D., R.E. Gresswell, S.M. Rubrecht, P.E. Bigelow, and D. Carty. 1981. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1980, Yellowstone National Park, Wyoming.

Jones, R.D., J.D. Varley, D.E. Jennings, S.M. Rubrecht, and R.E. Gresswell. 1977. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1976, Yellowstone National Park, Wyoming.

Jones, R.D., J.D. Varley, D.E. Jennings, S.M. Rubrecht, and R.E. Gresswell. 1979. Fishery and aquatic management program in Yellowstone National Park. U.S. Fish and Wildlife Service, Technical Report for 1978, Yellowstone National Park, Wyoming.

Jordan, D.S. 1891. A reconnaissance of the streams and lakes of the Yellowstone National Park, Wyoming, in the interest of the United States Fish Commission. Bulletin U.S. Fish Commission. Vol. 41-63.

Kaeding, Lynn R., Glenn D. Boltz, and Daniel G. Carty. 1995a. Lake trout discovered in Yellowstone Lake. In J.D. Varley and P. Schullery (eds.). The Yellowstone Lake Crisis: Confronting a lake trout invasion. Report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, Wyoming. Pp. 4-11.

Kaeding, Lynn R., and G.D. Boltz. 1997. Life history and population characteristics of lake trout recently discovered in Yellowstone Lake. U.S. Department of the Interior, Fish and Wildlife Service annual report to Yellowstone National Park. 22 pp.

Kaeding, Lynn R., Glenn D. Boltz, and Daniel G. Carty. 1996. Lake trout discovered in Yellowstone Lake threaten native cutthroat trout. Fisheries 21, 3 (March):16-20.

Kaeding, Lynn R., Daniel G. Carty, Daniel L. Mahony, Glenn Boltz, and Sonya Anderson. 1994. Fishery and Aquatic Management Program in Yellowstone National Park: 1993 Annual Report. USDI FWS, Fisheries and Federal Aid.

Kaeding, Lynn R., Daniel G. Carty, Daniel L. Mahony, Glenn Boltz, and Sonya Anderson. 1995b. Fishery and Aquatic Management Program in Yellowstone National Park: 1994 Annual Report. USDI FWS, Fisheries and Federal Aid.

Kaufman, L. 1992. Catastrophic change in species-rich freshwater ecosystems. BioScience 42:846-858.

Kaplinski, M.A. 1991. Geomorphology and geology of Yellowstone Lake, Yellowstone National Park, Wyoming. M.S. Thesis, Northern Arizona University, Flagstaff, AZ. 82 pp.

Keller, C.R., and K.P. Burnham. 1982. Riparian fencing, grazing, and trout habitat preference on Summit Creek, Idaho. North American Journal of Fisheries Management 2:53-59.

Kelly, B.M. 1993. Ecology of Yellowstone cutthroat trout and evaluation of potential effects of angler wading in the Yellowstone River. Master's Thesis, Montana State University, Bozeman.

Kendall, W.C. 1914. The fishes of the Yellowstone National Park. Report of the U.S. Commissioner of Fisheries. 4-28.

Kennedy, C.E. 1977. Wildlife conflicts in riparian management: Water. U.S. Department of Agriculture, Forest Service General Technical Report RM-42.

Kennedy, G.J.A., and C.D. Strange. 1982. The distribution of salmonid in upland streams in relation to depth and gradient. Journal of Fish Biology 20:579-591.

Kent, R. 1984. Fisheries management investigations in the Upper Shoshone River drainage, 1978-82. Wyoming Game and Fish, Fish Division Completion Report, Cheyenne.

Kent, M.L., D.J. Whitaker, and L. Margolis. 1993. Transmission of Myxobolus arcticus Pugachev and Khoklow, 1979, a myxosporean parasite of Pacific salmon, via a triactinomyzon from the aquatic oligochaete Stylodrilus heringianus (Lubriculidae). Canadian Journal of Zoology. 71:1207-1211.

Kiefling, John W. 1972. An analysis of stock densities and harvest of the cutthroat trout of the Snake River, Teton County, Wyoming. M.S. Thesis, University of Wyoming.

Kiefling, John W. 1978. Studies on the ecology of the Snake River cutthroat trout. Wyoming Game and Fish Department, Fisheries Technical Bulletin 3, Laramie.

Klamt, R.A. 1976. The effects of coarse granitic sediment on the distribution and abundance of salmonids in central Idaho Batholith. Master's thesis. University of Idaho, Moscow, Idaho.

Knight, J.C. 1975. 1975. The limnology of the West Thumb of Yellowstone Lake, Yellowstone National Park, Wyoming. Master's Thesis. Montana State University, Bozeman.

Koch, T. 1990. Effects of temperature and angling on brown and rainbow trout populations in the Firehole River, Yellowstone National Park. Master's Thesis, Idaho State University, Pocatello.

Kohler, C.C., and W.A. Hubert (eds.). 1993. Inland fisheries management in North America. American Fisheries Society, Bethesda, Maryland.

Kozel, S.J., and C. Reighn. 1993. Evaluation of livestock grazing effects on streambank stability, cover, and other habitat features in the Bear Valley watershed. USDA FS, Boise National Forest. 22 pp.

Krueger, C.C., and B. May. 1991. Ecological and genetic effects of salmonid introductions in North America. Canadian Journal of Fisheries and Aquatic Sciences 48 (Supplement 1):66-77.

Krueper, D.J. 1992. Effects of land use practices on western riparian ecosystems. USDA Forest Service, General Technical Report RM-229. Rocky Mountain Forest and Rangeland Experiment Station, Fort Collins, CO.

Kruse, Carter G. 1995. Genetic purity, habitat, and population characteristics of Yellowstone cutthroat trout in the Greybull River drainage, Wyoming. M.S. [Thesis?], University of Wyoming [?].

LaBar, B.W. 1971. Movement and homing of cutthroat trout (S*almo clarki*) in Clear and Bridge creeks, Yellowstone National Park. Transactions of the American Fisheries Society 100:41-49.

Lacey, R.C. 1987. Loss of genetic diversity from managed populations: Interacting effects of drift, mutation, selection and population subdivision. Conservation Biology 1:143-157.

LaFayette, R.A., and L.F. DeBano. 1990. Watershed condition and riparian health: Linkages. Watershed planning and analysis in action symposium proceedings of IR conference, Durango, CO, July 9-11, 1990. Pp. 473-484.

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

Lande, R., and S.H. Orzack. 1988. Extinction dynamics of age-structured populations in a fluctuating environment. Proceedings of the National Academy of Sciences, USA 85:7418-7421.

Langlois, D., J. Cameron, C.S. Hutchison, M. Japhet, D. Smith, and J. Castellano. 1994. Colorado River cutthroat trout conservation strategy for southwestern Colorado. Colorado Division of Wildlife.

Larson, G., and M. Soukup (eds.). 1990. Fisheries and coastal wetlands. George Wright Society and U.S. National Park Service, Fort Collins, Colorado.

Lawton, J.H. 1993. Range, population abundance and conservation. Trends in Ecology and Evolution 8:409-412.

Leary, R.F., F. Allendorf, and K. Knudsen. 1983. Genetic divergence among Yellowstone cutthroat trout in the Yellowstone River drainage, Montana: Update. Population Genetic Laboratory Report 89/2. Division of Biological Sciences, University of Montana, Missoula, Montana. 22 pp.

Leary, R.F., F. Allendorf, and K. Knudsen. 1985. Developmental instability as an indicator of reduced genetic variation in hatchery trout. Transactions of the American Fisheries Society 114:230-235.

Leary, R.F., F. Allendorf, and K. Knudsen. 1985. Inheritance of meristic variation and the evolution of developmental stability in rainbow trout. Evolution 39:308-314.

Leary, R.F., F. Allendorf, S.R. Phelps, and K.L. Knudsen. 1984. Introgression between westslope cutthroat and rainbow trout in the Clark Fork River drainage, Montana. Proceedings of the Montana Academy of Sciences 43:1-18.

Leary, R.F., F. Allendorf, S.R. Phelps, and K.L. Knudsen. 1985. Population genetic structure of westslope cutthroat trout: Genetic variation within and among populations. Proceedings of the Montana Academy of Sciences 45:37-45.

Leary, R.F., F. 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.

Lee, D., Sedell, J., Rieman, B., Williams J., Thurow, R.. 2/9/1996. Draft Aquatic and Riparian Staff Area Report for the Interior Columbia Basin Ecosystem Management Project.

Leigh, E.G., Jr. 1981. The average lifetime of a population in a varying environment. Journal of Theoretical Biology 90:213-239.

Leopold, A.S. 1975. Ecosystem deterioration under multiple use. In W. King (ed.). Wild trout management. Vienna, Virginia: Trout Unlimited. Pp. 96-98.

Lewinsky, V.A. 1986. Evaluation of special angling regulations in the Coeur d'Alene River trout fishery. Master's thesis, University of Idaho, Moscow.

Liknes, G.A., and P.J. Graham. 1988. Westslope cutthroat trout in Montana: Life history, status, and management. American Fisheries Society Symposium 4:53-60.

Linton, E. 1891. A contribution to the life history of Dibothrium cordiceps, a parasite infesting the trout of Yellowstone Lake. Bulletin of the United States Fish Commission 4:337-358.

Lodge, D.M. 1993. Biological invasions: Lessons for ecology. Trends in Ecology and Evolution 8:133-137.

Loomis, J.B., and D.S. White. 1996. Economic values of increasingly rare and endangered fish. Fisheries 21, 11:6-10.

Loudenslager, E.J., and G.A.E. Gall. 1981. Cutthroat trout a biochemical-genetic assessment of their status and systematics. University of California, Davis.

Lorz, H.V., Amandi, A., Banner, C.R. and J.S. Rohovec. 1989. Detection of Myxobolus (Myxosoma) cerebralis in salmonid fishes in Oregon. Journal of Aquatic Animal Health. 1:217-221.

Lusby, G.C., V.H. Reid, O.D. Knipe. 1971. Effects of grazing on the hydrology and biology of the Badger Wash Basin in western Colorado, 1953-1966. U.S. Geological Survey, Water-Supply Pager 1532-D.

MacConnell, B. 1996. Pathology associated with *M. cerebralis* infection in wild young-of-the-year rainbow trout in the Madison River. In E.P. Bergersen and B.A. Knopf (eds.). Proceedings: Whirling disease workshop: Where do we go from here? Colorado Cooperative Fish and Wildlife Research Unit, Fort Collins, Colorado. Pp. 160-162.

MacConnell, E., and J.E. Peterson. 1992. Proliferative kidney disease in feral cutthroat trout from a remote Montana reservoir: A first case. Journal of Aquatic Animal Health 4:182-187.

MacConnell, E., Molly Quinn, and Tammy Weiss. 1997. Susceptibility of grayling, rainbow and cutthroat trout to whirling disease by natural exposure to *Myxobolus cerebralis*. Pages 79-81, In: Whirling disease symposium, expanding the database: 1996 research progress reports. Eccles Conference Center, Logan Utah, March 6,7,8, 1997. Compiled by the Whirling Disease Foundation, Bozeman, MT.

MacConnell, E., and J.E. Peterson. 1992. Proliferative kidney disease in feral cutthroat trout from a remote Montana reservoir: A first case. Journal of Aquatic Animal Health 4:182-187.

MacIssac, H.J. 1996. Potential abiotic and biotic impacts of zebra mussels on the inland waters of North America. American Zoologist 36:287-299.

MacLean, J.A., and D.O. Evans. 1981. Assessing and managing man's impact on fish genetic resources. Canadian Journal of Fisheries and Aquatic Sciences 38:1889-1898.

MacPhee, C. 1966. Influence of differential angling mortality and stream gradient on fish abundance in trout-sculpin biotope. Transactions of the American Fisheries Society (Bethesda, MD) 95, 4:381-387.

Magee, J.P. et al. 1996. Spatial variation in spawning habitat of cutthroat trout in a sediment-rich stream basin. Transactions of the American Fisheries Society 125, 5:768.

Magnum, F.A. 1986. Aquatic ecosystem analysis for Soda Butte Creek 1984-1986. U.S. Department of Agriculture, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah.

Magnum, F.A. 1988. Aquatic ecosystem analysis for Soda Butte Creek 1987. U.S. Department of Agriculture, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah.

Magnum, F.A. 1990. Aquatic ecosystem analysis for selected streams of Yellowstone National Park, 1988-89. U.S. Department of Agriculture, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah.

Magnum, F.A. 1992. Aquatic ecosystem analysis for selected streams of Yellowstone National Park, 1990. U.S. Department of Agriculture, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah.

Magnum, F.A. 1992. Aquatic ecosystem analysis for selected streams of Yellowstone National Park, 1991. U.S. Department of Agriculture, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah.

Magnuson, J.J. 1976. Managing with exotics – a game of chance. Transactions of the American Fisheries Society 105:1-9.

Mahony, Daniel L., and James R. Ruzycki. n.d. Initial investigations towards the development of a lake trout removal program in Yellowstone Lake. U.S. Department of the Interior, National Park Service, Aquatic Resources Center, Yellowstone National Park.

Mangel, M., and C. Tier. 1994a. Dynamics of metapopulations with demographic stochasticity and environmental catastrophes. Theoretical Population Biology (in press).

Mangel, M., and C. Tier. 1994b. Four facts every conservation biologist should know about persistence. Ecology 75:607-614.

Marcus, M.D., M.K. Young, L.E. Noel, and B.A. Mullen. 1990. Salmonid-habitat relationships in the western United States: A review and indexed bibliography. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-188. 84 pp.

Marcuson, P.E. 1977. The effect of cattle grazing on brown trout in Rock Creek, Montana. Montana Department of Fish and Game, Special Report, Project F-20-R21, 11-A. Helena.

May, Bruce. 1996. Yellowstone cutthroat trout, *Oncorhynchus clarki bouvieri*. In Donald A. Duff (tech. ed.). Conservation assessment for inland cutthroat trout: Distribution, status and habitat. U.S. Department of Agriculture, Forest Service, Intermountain Region, Ogden, Utah.

May, Bruce. 1996. Status Assessment of the Yellowstone Cutthroat Trout. USDA, Forest Service, Bozeman, MT.

McAfee, W.R. 1966. Lake trout. In A. Calhoun (ed.). Inland fisheries management. California Department of Fish and Game. Pp. 260-271.

McCleave, J.D. 1967. Homing and orientation of cutthroat trout (*Salmo clarki*) in Yellowstone Lake, with special reference to olfaction and vision. Journal of the Fisheries Research Board of Canada 24:2011-2044.

McIntyre, John D. 1995. Review and assessment of possibilities for protecting the cutthroat trout of Yellowstone Lake from introduced lake trout: Proceedings of a workshop and information exchange held in Gardiner, Montana, February 15-17, 1995. In John D. Varley and Paul Schullery (eds.). The Yellowstone Lake crisis: Confronting a lake trout invasion. A report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, National Park Service. Pp. 28-33.

McIntyre, J.D., and B.E. Rieman. 1995. Westslope cutthroat trout. In: Young, M.K. (ed.). Conservation Assessment for Inland Cutthroat Trout. Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-256.

McMasters, M.J. 1970. The food habits of trout (Salmonidae) and sculpins (Cottidae) in two mountain streams. Master's Thesis, Idaho State University, Pocatello.

McMullin, Steve L., and Thurston Dotson. 1988. Use of McBride Lake strain Yellowstone cutthroat trout for lake and reservoir management in Montana. American Fisheries Society Symposium 4:42-44.

Mealey, S.P. 1980. The natural food habits of grizzly bears in Yellowstone National Park, 1973-1974. International Conference on Bear Research and Management 3:281-292.

Meehan, W.R. (ed.). 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Meehan, W.R., and W.S. Platts. 1978. Livestock grazing and the aquatic environmental. Journal of Soil and Water Conservation 33:274-278.

Meffe, G.K. 1986. Conservation genetics and the management of endangered fishes. Fisheries 11:14-23.

Meyers, L.H. 1989. Grazing and riparian management in southwestern Montana. In R.E. Gresswell, B.A. Barton, and J.L. Kershner (eds.). Practical approaches to riparian resource management. U.S. Bureau of Land Management, Billings, Montana. Pp. 117-120.

Miller, R.B. 1957. Permanence and size of home territory in stream-dwelling cutthroat trout. Journal of the Fisheries Research Board of Canada 14:687-691.

Miller, R.R., J.D. Williams, and J.E. Williams. 1989. Extinctions of North American fishes during the past century. Fisheries (Bethesda) 14, 6:22-38.

Miller, T.W., and E.R. Roby. 1957. A progress report: South Fork Snake River, upper Snake River. U.S. Fish and Wildlife Service, Portland, OR.

Mills, L.E. 1966. Environmental factors and egg mortality of cutthroat trout (Salmo clarki) in three tributaries of Yellowstone Lake. Master's Thesis. Colorado State University, Fort Collins, Colorado.

Mills, E.L., J.H. Leach, J.T. Carlton, and C.L. Secor. 1993. Exotic species in the Great Lakes: A history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19:1-54.

Mills, E.L., M.D. Schuerell, D.L. Strayer, and J.T. Carlton. 1996. Exotic species in the Hudson River Basin: A history of invasions and introductions. Estuaries 19:814-823.

Minckley, W.L., and James E. Deacon (eds.). 1991. Battle against extinction: Native fish management in the American West. University of Arizona Press, Tucson, Arizona.

Mode, C.J., and M.E. Jacobson. 1987. On estimating critical population size for an endangered species in the presence of environmental stochasticity. Mathematical Biosciences 85:185-209.

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

Mohrman, J., R. Ewing, and D. Carty. 1988. Sources and quantities of suspended sediment in the Yellowstone River and selected tributary watersheds between Yellowstone Lake outlet, Yellowstone National Park, Wyoming, and Livingston, Montana: 1986 annual progress report. U.S. Department of the Interior, Fish and Wildlife Service, Yellowstone Fisheries Office, Aquatic Ecology Studies Technical Report Number 4. Yellowstone National Park, Wyoming.

Montana Department of Fish, Wildlife and Parks [MDFWP]. 1975. Fish and game planning, upper Yellowstone and Shields River drainages. Montana Department of

Fish, Wildlife and Parks, Federal Aid to Fish, Wildlife Research Project FW-3-R:1-125.

Montana Department of Fish, Wildlife and Parks [MDFWP]. 1995. Annual Report.

Moore, K.M.S., and S. Gregory. 1988. Response of young-of-the-year cutthroat trout to manipulation of habitat structure in a small stream. Transactions of the American Fisheries Society 117:162-170.

Moore, V., and D. Schill. 1984. South Fork Snake River fisheries inventory. River and stream investigations. Idaho Department of Fish and Game, Boise. Job Completion Report, Project F-73-R-5.

Moring, J.R., G.C. Garman, and D.M. Mullen. 1985. The value of riparian zones for protecting aquatic systems: General concerns and recent studies in Maine. U.S. Forest Service General Technical Report RM-20:315-319.

Mosely, R., and C. Groves. 1990. Rare, threatened and endangered plants and animals of Idaho. Nongame and Endangered Wildlife Program, Natural Heritage Section, Idaho Department of Fish and Game, Boise.

Moyle, P.B., H.W. Li, and B.A. Barton. 1986. The Frankenstein effect: Impact of introduced fishes on native fishes in North America. In P. Stroud (ed.). Fish culture in fisheries management. American Fisheries Society. Bethesda, Maryland. Pp. 415-426.

Moyle, P.B., and R.M. Yoshiyama. 1994. Protection of aquatic biodiversity in California: A five-tiered approach. Fisheries (Bethesda) 19, 2:6-18.

Murphy, T.C. 1974. A study of Snake River cutthroat trout. Master's Thesis. Colorado State University, Ft. Collins, Colorado.

Murry, M.I. 1996. Natural processes: Wilderness management unrealized. Natural Areas Journal 16, 1:55-61.

Nehlsen, W., J.E. Williams, J.A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington.

Nehring, R.B. 1993. Biological, environmental, and epidemiological evidence implicating *Myxobolus cerebralis* (the protozoan parasite causing whirling disease) in the dramatic decline of the wild rainbow trout population in the Colorado River in Middle Park, Colorado. Colorado Division of Wildlife Report, Denver.

Nehring, R.B. 1996. Whirling disease in feral trout population in Colorado. In E.P. Bergersen and B.A. Knopf (eds.). Proceedings: Whirling disease workshop: Where do we go from here? Colorado Cooperative Fish and Wildlife Research Unit, Fort Collins, Colorado. Pp. 126-144.

Nehring, R. Barry, and David Nickum. n.d. Whirling disease and wild trout management.

Nehring, R.B., and P.G. Walker. 1996. Whirling disease in the wild: The new reality in the Intermountain West. Fisheries 21, 6:28-30.

Nelson, J.S. and M.J. Paetz. 1992. The Fishes of Alberta, 2nd edition. University of Alberta Press, University of Calgary Press.

Nelson, K., and M.E. Soulé. 1987. Genetical conservation of exploited fishes. In N. Ryman and F.M. Utter (eds.). Population genetics and fishery management. Washington Sea Grant Program, University of Washington Press, Seattle.

Nelson, R.L., M.L. McHenry, and W.S. Platts. 1991. Influences of forest and range management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19:425-451.

Nelson, R.L., W.S. Platts, and O. Casey. 1987. Evidence for variability in spawning behavior of interior cutthroat trout in response to environmental uncertainty. Great Basin Naturalist 47:480-487.

Nickum, David, Joseph McGurrin, and Donald Duff. 1994. Wild trout and Wallop-Breaux: Restocking or restoring fish? Presented at Wild trout V: Wild trout in the 21st century. Yellowstone National Park, Sept. 26-27, 1994.

Nilsson, N. 1963. Interactive segregation between fish species in S.D. Gerking (ed.). The biological basis of freshwater fish production. Blackwell Scientific Publication, Oxford, England.

Norris, L.A., H.W. Lorz, S.V. Gregory. 1991. Forest chemicals. American Fisheries Society Special Publication 19:207-296.

Noss, R.F. 1991. Landscape connectivity: Different functions at different scales. In W.E. Hudson (ed.). Landscape linkages and biodiversity, pp. 27-39. Washington, D.C.: Island Press.

Noss, R.F. 1992. The ecological effects of roads or The road to destruction. Preserve Appalachian Wilderness 2, 3:14-25.

Nunney, L., and K.A. Campbell. 1993. Assessing minimum viable population size: Demography meets population genetics. Trends in Ecology and Evolution 8:234-239.

O'Grodnick, J.J. 1979. Susceptibility of various salmonids to whirling disease (*Myxosoma cerebralis*). Transactions of the American Fisheries Society 108:187-190.

Olliff, Tom. 1995. A draft plan of action for controlling expansion of the lake trout population in Yellowstone Lake. In John D. Varley and Paul Schullery (eds.). The Yellowstone Lake crisis: Confronting a lake trout invasion. A report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, National Park Service. Pp. 34-36.

Olsen, T.M., D.M. Lodge, G.M. Capelli, and R.H. Houlihan. 1991. Mechanisms of impact of an introduced crayfish (Orconectes rusticus) on littoral congeners, snails, and macrophytes. Canadian Journal of Fisheries and Aquatic Sciences 48:1853-1861.

Oswald, R.A. 1982. A fisheries inventory of Bear Creek prior to proposed mineral mining at Jardine, Montana. Prepared for Homestake Mining Co., Golden, Colorado, by Montana Department of Fish, Wildlife and Parks, Bozeman.

Otto, T.N., and R.A. Heckmann. 1984. Host tissue response for trout infected with Diphyllobothrium cordiceps larvae. Great Basin Naturalist 44:125-132.

Overton, C.K., J.D. McIntyre, R. Armstrong, S.L. Whitwell, and K.A. Duncan. 1995. User's guide to fish habitat: Descriptions that represent natural conditions in the Salmon River basin, Idaho. General Technical Report INT-GTR-322, U.S. Department of Agriculture, Forest Service, Ogden, Utah.

Pacific Rivers Council. 1995. Northern Rockies Forests and Endangered Native Fish: The urgent need for watershed and native fish protection and restoration in Idaho, Montana and Northwest Wyoming. Briefing Book. Eugene, OR.

Paulrod, A., and A. Redin. 1996. An evaluation of population reduction fishing for the Canadian trout in Lake Annsjon. Report from the Swedish University of Agricultural Sciences.

Peters, D.J. 1988. Rock Creek Management Survey. Montana Department of Fish, Wildlife and Parks, Helena. Job Progress Report, Project F-12-R-29, Job II-a.

Philipp, David P., John M. Epifanio, and Martin J. Jennings. 1993. Conservation genetics and current stocking practices – Are they compatible? Fisheries 18, 12 (December):14-16.

Platts, W.S. 1983. Vegetation requirements for fisheries habitats. U.S. Forest Service General Technical Report INT-157:184-188.

Platts, W.S. 1989. Compatibility of livestock grazing strategies with fisheries. In R.E. Gresswell, B.A. Barton, and J.L. Kershner (eds.). Practical approaches to riparian resource management. U.S. Bureau of Land Management, Billings, Montana. Pp. 103-110.

Platts, W.S. 1991. Livestock grazing. In W.R. Meehan (ed.). Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19:389-423.

Platts, W., W. Megahan, and G. Minshall. 1983. Methods for evaluating stream riparian and biotic conditions. U.S. Forest Service General Technical Report INT-136.

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

Platts, W.S., and R.L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluations. North American Journal of Fisheries Management 8:333-345.

Platts, W.S., and R.F. Raleigh. 1984. Impacts of grazing on wetlands and riparian habitat. In Developing strategies for rangeland management. Committee on Developing Strategies for Rangeland Management, National Research Council/National Academy of Sciences. Westview Press, Boulder, CO.

Platts, W.S., and J.N. Rinne. 1985. Riparian and stream enhancement management and research in the Rocky Mountains. North American Journal of Fisheries Management 5:115-125.

Post, G. 1971. The Diphyllobothrium Cestode in Yellowstone Lake, Wyoming. Agriculture Experiment Station, University of Wyoming, Laramie. Research Journal 41.

Pringle, C.M., R.J. Naiman, G. Bretschko, J.R. Karr, M.W. Oswood, J.R. Webster, R.L. Welcomme, and M.J. Winterbourn. 1988. Patch dynamics in lotic systems: The stream as a mosaic. Journal of the North American Benthological Society 7:503-524.

Pulliam, H.R. 1988. Sources, sinks and population regulation. American Naturalist 132, 5:652-661.

Quinn, R.T., and M.J. Unwin. 1993. Variation in life history patterns among New Zealand chinook salmon (*Oncorhynchus tshawytscha*) populations. Canadian Journal of Fisheries and Aquatic Science 50:1414-1421.

Raleigh, R.F., and D.W. Chapman. 1971. Genetic control in lakeward migrations of cutthroat trout fry. Transactions of the American Fisheries Society 100:33-40.

Reese, Jerry B. 1997. Biological Evaluation for the Yellowstone Cutthroat Trout. Targhee National Forest. United States Department of Agriculture.

Reinhart, D.P. 1990. Grizzly bear habitat use on cutthroat trout spawning streams in tributaries of Yellowstone Lake. Master's Thesis, Montana State University, Bozeman.

Reinhart, D.P., and D.J. Mattson. 1990. Bear use of cutthroat trout spawning streams in Yellowstone National Park. International Conference on Bear Research and Management 8:343-350.

Reiser, D.W., and R.G. White. Effects of complete redd dewatering on salmonid egg-hatching success and development of juveniles. Transactions of the American Fisheries Society 112:532-540.

Ricciardi, Anthony. 1998. The exotic species problem and freshwater conservation. Wild Earth (Spring):44-49.

Rieman, B.E., and K.A. Apperson. 1989. Status and analysis of salmonid fisheries: Westslope cutthroat trout synopsis and analysis of fishery information. Idaho Department of Fish and Game, Boise. Job Performance Report, Project F-73-R-11, Subproject II, Job 1.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow. 1993. Consideration of extinction risks for salmonids. FHR Currents. USDA Forest Service, Fish Habitat Relationships Technical Bulletin 14. 12 pp.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. USDA Forest Service, General Technical Report INT-302.

Richmond, A.D., and K.D. Fausch. 1995. Characteristics and function of large woody debris in subalpine Rocky Mountain streams in Northern Colorado. Canadian Journal of Fisheries and Aquatic Sciences 52:1789-1802.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Roberts, B.C., and R.G. White. 1986. Potential influence of recreational use on Nelson Spring Creek. Montana Cooperative Fishery Research Unit, Montana State University, Bozeman.

Roberts, B.C., and R.G. White. 1992. Effects of angler wading on survival of trout eggs and pre-emergent fry. North American Journal of Fisheries Management 12:450-459.

Roberts, S. 1997. First detection of Myxobolus cerebralis in Washington state. Pages 39-42, In: Whirling disease symposium, expanding the database: 1996 research progress reports. Eccles Conference Center, Logan Utah, March 6,7,8, 1997. Compiled by the Whirling Disease Foundation, Bozeman, MT.

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

Ruggiero, L.F., R.S. Holthausen, B.G. Marcot, K.B. Aubry, J.W. Thomas, and E.C. Meslow. 1988. Ecological dependency: The concept and its implications for research and management. Transactions of the North American Wildlife and Natural Resources Conference 53:115-126.

Rollins, P.H. (ed.). 1935. The discovery of the Oregon Trails: Rober Stuart's narratives. New York: Schribner's.

Ruzycki, James R., and David A. Beauchamp. n.d. A bioenergetics modeling assessment of the lake trout impact in Yellowstone Lake.

Ryman, N. 1983. Patterns of distribution of biochemical genetic variation in salmonids: Differences between species. Aquaculture 33:1-21.

Ryman, N., and F.M Utter (eds.). 1987. Population genetics and fishery management. Washington Sea Grant Program, University of Washington Press, Seattle.

Sage, G.K., and R. Leary. 1990. Genetic analysis of trout populations in the Yellowstone, Gallatin, and Madison River drainages, Montana. Population Genetics Laboratory Report 90/1. Division of Biological Sciences, University of Montana. Missoula, Montana. 31 pp.

Sartz, R.S., D.N. Tolsted. 1974. Effect of grazing on runoff from two small watersheds in southwestern Wisconsin. Water Resources Research 10:354-356.

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.

Schmid, B.R., P.W. Birdsey, Jr., and B.R. Nielson. 1995. A conceptual management plan for cutthroat trout in Utah. Utah Division of Wildlife Resources, Salt Lake City. Publication 95-7.

Schmidt, Konrad. 1987. Endangered, Threatened, and Special Status Fishes of North America. Publication of the North American Native Fishes Association.

Scott, W.B., and F.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Schullery, Paul and John D. Varley. 1994. Fires and fish, the fate of Yellowstone waters since 1988. Trout 35, 2:16-23.

Schullery, Paul and John D. Varley. 1995. Cutthroat trout and the Yellowstone Lake ecosystem. In John D. Varley and Paul Schullery (eds.). The Yellowstone Lake crisis: Confronting a lake trout invasion. A report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, National Park Service. Pp. 12-21.

Scudder, G.G.E. 1989. The adaptive significance of marginal populations: A general perspective. In C.D. Levings, L.B. Holtby, and M.A. Henderson (eds.). Proceedings on the national workshop on effects of habitat alteration on salmonid stocks. Canadian Special Publication of Fisheries and Aquatic Sciences 105.

Sedell, J.R., F.H. Everest, and F.J. Swanson. Fish habitat and steamside management: Past and present. Pacific Northwest Forest and Range Experiment Station, USDA, Corvallis, Oregon. Pp. 244-255.

Sedell, J.R., G.H. Reeves, FR. Hauer, J.A. Standord, and C.P. Hawkins. 1990. Role of refugia in recovery from disturbances: Modern fragmented and disconnected river systems. Environmental Management 14:711-724.

Shaffer, M.L. 1987. Minimum viable populations: Coping with uncertainty. In M.E. Soulé (ed.). Viable populations for conservation. Cambridge: Cambridge University Press. Pp. 69-86.

Shepard, B.B. 1983. Evaluation of a combined methodology for estimating fish abundance and lotic habitat in mountain streams of Idaho. Master's thesis, University of Idaho, Moscow.

Shepard, B.B. 1992. Fisheries of the upper Yellowstone River including tributary recruitment: Report for years 1989, 1990 and 1991. Montana Department of Fish, Wildlife and Parks, Helena. Job Progress Report F-46-R-2, 3, and 4, Job I-f.

Shiozawa, Dennis K., and R. Paul Evans. 1993. An appraisal of cutthroat trout purity from Willow Creek and the Duchesne River in the Uinta National Forest. Final Report to the Heber District, Uinta National Forest, under Order Number 43-8462-2-4886.

Shiozawa, Dennis K., and R. Paul Evans. 1994a. Relationships between cutthroat trout populations from thirteen Utah streams in the Colorado River and Bonneville Drainages. Final Report to Utah Division of Wildlife Resources. Contract No. 93-2377.

Shiozawa, Dennis K., and R. Paul Evans. 1994b. The use of DNA to identify geographical isolation in trout stocks. In R. Barnhart, B. Shake, and R.H. Hamre (tech. eds.). Proceedings of Wild trout V: Wild trout in the 21st century. Trout Unlimited. Yellowstone National Park, Sept. 26-27, 1994. Pp. 125-131.

Shiozawa, Dennis K., and R. Paul Evans. 1995. Relationships between cutthroat trout populations from eight Utah streams in the Colorado River and Bonneville Drainages. Interim Report to Utah Division of Wildlife Resources. Contract No. 94-2377.

Shiozawa, Dennis K., and R. Paul Evans. 1997. Genetic relationships of nineteen cutthroat trout populations from Utah streams in the Colorado River and Bonneville Drainages. Final Report to Utah Division of Wildlife Resources. Contract No's 94-2377, 95-2377, and 96-2377 (in part).

Shiozawa, Dennis K., R. Paul Evans, and Richard N. Williams. 1993. Relationships between cutthroat trout populations from ten Utah streams in the Colorado River and Bonneville Drainages. Interim Report to Utah Division of Wildlife Resources. Contract No. 92-2377.

Shiozawa, D.K., and R.N. Williams. 1992. Geographic variation, isolation and evolution of cutthroat trout (Salmo clarki). National Geographic Society Final Report, Grant # 3653-87. 28 pp.

Sigler, W.F., and R.R. Miller. 1963. Fishes of Utah. Utah State Department of Fish and Game, Salt Lake City.

Simberloff, D., and P. Stiling. 1996. Risks of species introduced for biological control. Biological Conservation 78:185-192.

Simpson, J.C., and R.L. Wallace. 1978. Fishes of Idaho. The University Press of Idaho, Moscow.

Smith, R.H. 1984. Native trout of North America. Frank Amato Publications, Portland, OR.

Soulé, M.E. 1980. Thresholds for survival: Maintaining fitness and evolutionary potential. Pages 151-169 in M.E. Soulé and B.A. Wilcox (eds.). Conservation biology: An evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts.

Soulé, M.E. (ed.). 1986. Conservation biology: The science of scarcity and diversity. Sunderland, Massachusetts: Sinauer Associates.

Soulé, M.E. (ed.). 1987. Viable populations for conservation. Cambridge: Cambridge University Press.

Soulé, M.E. and B.A. Wilcox (eds.). 1980. Conservation biology: An evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts.

Spateholts, R., and V. Moore. 1985. Henrys Fork Fisheries Investigations, Project F-73-R-6, Subproject IV, Study III. Idaho Department of Fish and Game, Idaho Falls, Idaho.

Stacy, P.B., and M. Taper. 1992. Environmental variation and the persistence of small populations. Ecological Applications 2, 1:18-29.

Starnes, L.B. 1983. Effects of surface mining on aquatic resources in North America. Fisheries 8, 6:2-4.

Stolwell, R., A. Espinosa, T.C. Bjornn, W.S. Platts, D.C. Burns, J.S. Irving. 1983. Guide for predicting salmonid response to sediment yields in Idaho Batholith watersheds.

Stonecypher, R.W., W.A. Hubert, and W.A. Gern. 1994. Effect of reduced incubation temperatures on survival of trout embryos. The Progressive Fish Culturist 56:180-184.

Strebel, D.E. 1987. Environmental fluctuations and extinction – single species. Theoretical Population Biology 27:1-26.

Stuber, R.J., B.D. Rosenlund, and J.R. Bennet. 1988. Greenback cutthroat trout recovery program: Management overview. American Fisheries Society Symposium 4:71-74.

Swanson, R.D. 1981. Some aspects of the biology of the longnose sucker in Yellowstone Lake, Yellowstone National Park, Wyoming. Master's Thesis, University of Wyoming, Laramie.

Swenson, J.E. 1978. Prey and foraging behavior of ospreys on Yellowstone Lake, Wyoming. Journal of Wildlife Management 42, 1:87-90.

Swenson, J.E., K.L. Alt, and R.L. Eng. 1986. Ecology of bald eagles in the greater Yellowstone ecosystem. Wildlife Monograph No. 95. Pp. 1-46.

Tappel, P.D., and T. Bjornn. 1980. Effects of sediment composition on salmonid egg survival. Annual Report, Intermountain Forest and Range Experiment Station, U.S. Department of Agriculture, Forest Service, Idaho Cooperative Fishery Research Unit, College of Forestry, University of Idaho.

Tappel, P.D., and T.C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Taylor, E.B. 1991. A review of local adaptation in Salmonidae, with particular reference to Pacific and Atlantic salmon. Aquaculture 98:185-207.

Taylor, J.N., W.R. Courtnay, Jr., and J.A. McCann. 1984. Known impacts of exotic fishes in the continental United States. In W.R. Courtnay, Jr., and J.R. Stuaffer, Jr. (eds.). Distribution, biology, and management of exotic fishes. Johns Hopkins University Press. Pp. 322-373.

Templeton, A.R. 1986. Coadaptation and outbreeding depression. In M.E. Soulé (ed.). Conservation biology: The science of scarcity and diversity. Sunderland, Massachusetts: Sinauer Associates. Pp. 105-116.

Thomas, C.D. 1990. What do real population dynamics tell us about minimum population sizes? Conservation Biology 4:324-327.

Thompson, J.D. 1991. Phenotypic plasticity as a component of evolutionary change. Trends in Ecology and Evolution 6:246-249.

Thompson, P.D. 1995. Evaluating the effectiveness of electrofishing and man-made barriers for controlling brook trout populations in streams containing cutthroat trout. Master's Thesis, University of Wyoming, Laramie. 272 pp.

Thornberry, Rob. 1997. Cutts thriving in Teton River – Rainbows will be studied to track impacts of whirling disease. Hunting and Fishing.

Thornberry, Rob. 1997. The face of whirling disease – Biologists understand parasite's life cycle, but many questions remain unanswered. Hunting and Fishing.

Thurow, R.F. 1982. Blackfoot River fishery investigations. Idaho Department of Fish and Game, Boise. Job Completion Report, Project F-73-r-3.

Thurow, R.F. 1987. Evaluation of the South Fork Salmon river, steelhead trout fishery restoration program. Idaho Department of Fish and Game, Boise. Contract No. 14-16-0001-86505.

Thurow, Russell F., Charles E. Corsi, and Virgil 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, Russell F., and J.G. King. 1994. Attributes of Yellowstone cutthroat trout reds in a tributary of the Snake River, Idaho. Transactions of the American Fisheries Society 123:37-50.

Trippel, E.E. 1993. Growth rates of lake trout and lake conductivity. North American Journal of Fisheries Management 18:998-999.

Trojnar, J.R., and R.J. Behnke. 1974. Management implications of ecological segregation between two introduced populations of cutthroat trout in a small Colorado lake. Transactions of the American Fisheries Society 10:423-430.

Trotter, P. 1987. Cutthroat: Native trout of the west. Colorado Associated University Press, Boulder, Colorado. 219 pp.

Trotter, P.C. 1989. Preserve, protect, and perpetuate: The status of wild cutthroat trout stocks in the West. Paper presented at the Wild Trout IV conference, Mammoth, WY. September 18-19, 1989.

Trotter, P.C., and P.A. Bisson. 1988. History of the discovery of the cutthroat trout. American Fisheries Society Symposium 4:8-12.

Trout Unlimited. n.d. Technical support document for conserving salmonid biodiversity on federal lands: Trout Unlimited's policy on mining, grazing, and timber harvest. Arlington, Virginia: Trout Unlimited.

Tuljapurkar, S.D. 1990. Population dynamics in variable environments. Lecture Notes in Biomathemtics 85. New York: Springer-Verlag.

Turner, B.J. (ed.). 1984. The evolutionary genetics of fishes. New York: Plenum Press.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1997. Biological Evaluation of the effects of the proposed revised forest plan on Yellowstone cutthroat trout (Oncorhynchus clarki bouvieri). U.S. Department of Agriculture, Forest Service, Targhee National Forest.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1998. Forest Service roads: A synthesis of scientific information. U.S. Department of Agriculture, Forest Service.

U.S. Department of Agriculture, Forest Service [USDA FS n.d. a]. Existing condition of PWI Watershed 16 – Blackfoot River. U.S. Department of Agriculture, Forest Service, Caribou National Forest.

U.S. Department of Agriculture, Forest Service [USDA FS n.d. b]. Existing condition of PWI Watershed 17 – Upper Portneuf East. U.S. Department of Agriculture, Forest Service, Caribou National Forest.

U.S. Department of Agriculture, Forest Service [USDA FS n.d. c]. Existing condition of PWI Watershed 18 – Upper Portneuf West . U.S. Department of Agriculture, Forest Service, Caribou National Forest.

U.S. Department of Agriculture, Forest Service [USDA FS n.d. d]. Existing condition of PWI Watershed 20 – Lower Portneuf. U.S. Department of Agriculture, Forest Service, Caribou National Forest.

U.S. Department of the Interior, Fish and Wildlife Service [USDI FWS]. 1994. Endangered Species Act Section 7 Biological Opinion: Transportation and delivery of Central Arizona Project Water to the Gila River Basin (Hassayampa, Aguq Fria, Salt, Verde, San Pedro, Middle and Upper Gila Rivers and associated tributaries) in Arizona and New Mexico. April 15, 1994.

U.S. Department of the Interior, Fish and Wildlife Service [USDI FWS]. 1998. Greenback cutthroat trout recovery plan. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Denver, Colorado.

U.S. Department of the Interior, National Park Service [USDI NPS]. 1995. 1994 Fishery and Aquatic Management Program Annual Report: Yellowstone National Park. USDI National Park Service.

U.S. Department of the Interior, National Park Service [USDI NPS]. 1996. Research report on fisheries management. USDI NPS.

U.S. Department of the Interior, National Park Service [USDI NPS]. 1997 [1995]. Resource Management Plan: Yellowstone National Park. USDI National Park Service.

U.S. General Accounting Office. 1993. Fisheries management: Administration of the Sport Fish Restoration Program. GAO/RCED-94-4. Washington, D.C.

Van Den Avyle, M.J. 1993. Dynamics of exploited fish populations. In C.C. Kohler and W.A. Hubert (eds.). Inland fisheries management in North America. American Fisheries Society, Bethesda, Maryland. Pp. 105-135.

Van Kirk, R. 1996. A history of fisheries management on the Henrys Fork. Henrys Fork Foundation newsletter, Winter 1996. Henrys Fork Fountain, Island Park, Idaho.`

Van Kirk, Rob, Eric Bergman, Doug Hayes, Matt Jaeger, Vrian Krestian, Doug Morical, Wade Thorson, Jim Gregory, and Ted Kellogg. 1997. Status of Yellowstone cutthroat trout in the Upper Henrys Fork Watershed. Henrys Fork Foundation and USDA FS, Targhee National Forest.

Van Kirk, Rob, Dan Delany, Mark Gamblin, Jim Gregory, and Jack Griffith. n.d. Status of Yellowstone cutthroat trout in the Upper Henrys Fork Watershed, Idaho and Wyoming.

Varley, J.D. 1975. The Yellowstone fishery. In W. King (ed.). Wild trout management symposium. Trout Unlimited, Vienna, Virginia. Pp. 91-96.

Varley, J.D. 1979. Record of egg shipments from Yellowstone fishes, 1914-1955. U.S. National Park Service, Yellowstone National Park, Wyoming. Information Paper 36.

Varley, J.D. 1980. Catch-and-release fishing in Yellowstone Park. In W. King (ed.). Wild trout II. Trout Unlimited and Federation of Fly Fisherman, Vienna, Virginia. Pp.137-142.

Varley, J.D. 1981. A history of fish stocking activities in Yellowstone National Park between 1881 and 1980. National Park Service, Information Paper 35, Yellowstone National Park, Wyoming.

Varley, J.D. 1984. The use of restrictive regulations in managing wild salmonids in Yellowstone National Park, with particular reference to cutthroat trout, *Salmo clarki*. In J.M. Walton and D.B. Houston (eds.). Proceedings of the Olympic wild fish conference, March 23-25, 1983. Port Angeles, Washington. Pp. 145-156.

Varley, J.D. 1989. Wild fire and wild trout in 1988: Do you want to hear the bad news or the good news first? In F. Richarson and R.H. Hamre (eds.). Wild Trout IV. Trout Unlimited and Federation of Fly Fishers. Pp. 128-131.

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

Varley, J.D., and Paul Schullery. 1983. Freshwater wilderness: Yellowstone fishes and their world. Yellowstone Library and Museum Association, Yellowstone National Park.

Varley, John D. and Paul Schullery. 1995. Socioeconomic values associated with the Yellowstone Lake cutthroat trout. In John D. Varley and Paul Schullery (eds.). The Yellowstone Lake crisis: Confronting a lake trout invasion. A report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, National Park Service. Pp. 22-27.

Varley, John D. and Paul Schullery. 1995. The Lake Yellowstone trout crisis: Executive summary. In John D. Varley and Paul Schullery (eds.). The Yellowstone Lake crisis: Confronting a lake trout invasion. A report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, National Park Service. Pp. 2-3.

Varley, John D. and Paul Schullery. 1995. The Yellowstone Lake crisis: Confronting a lake trout invasion. A report to the Director of the National Park Service. Yellowstone Center for Resources, Yellowstone National Park, National Park Service.

Vincent, E.R. 1987. Effects of stocking catchable-seize hatchery rainbow trout on two wild trout species in the Madison River and O'Dell Creek, Montana. North American Journal of Fisheries Management 7:91-105.

Vincent, E.R. 1996. Whirling disease – the Montana experience, Madison River. In E.P. Bergersen and B.A. Knopf (eds.). Proceedings: Whirling disease workshop: Where do we go from here? Colorado Cooperative Fish and Wildlife Research Unit, Fort Collins, Colorado. P. 159.

Vincent, E.R. 1997. The susceptibility of five fish species and strains to whirling disease. Pages 77-78. In: Whirling disease symposium, expanding the database: 1996 research progress reports. Eccles Conference Center, Logan Utah, March 6,7,8, 1997.

Walker, P.G., and R.B. Henring. 1995. An investigation to determine the cause(s) of the disappearance of young wild rainbow trout in the upper Colorado River, in Middle Park, Colorado. Colorado Division of Wildlife Report, Denver.

Waples, R.S. 1991. Genetic interactions between hatchery and wild salmonids: Lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Science 48:124-133.

Ward, H.B. 1922. The pelicans of Yellowstone Lake. Report to the U.S. National Park Service, Yellowstone National Park, Wyoming.

Warren, M.L. and B.M. Burr. 1994. Status of freshwater fishes of the United States: Overview of an imperiled fauna. Fisheries 19, 1:6-18.

Weaver, T.M., and J. Fraley. 1991. Fisheries habitat and fish populations. Flathead Basin Forest Practices, Water Quality and Fisheries Cooperative Program. Flathead Basin Commission, Kalispell, MT.

Whirling Disease Foundation. 1997. Whirling disease symposium, expanding the database: 1996 research progress reports. Eccles Conference Center, Logan Utah, March 6,7,8, 1997. Bozeman, MT.

Whitmore, D.H. 1983. Introgressive hybridization of smallmouth bass (<u>Micopterus dolomieui</u>) and Guadalupe Bass (<u>M.</u> <u>treculi</u>). Copeia 1983:672-679.

Wilcove, D., M. Bean, P.C. Lee. 1992. Fisheries management and biological diversity: Problems and opportunities. Transactions of the 57th North American Wildlife and Natural Resources Conference.

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

Wiley, Robert W. 1993. Wyoming fish management, 1869-1993. Wyoming Game and Fish Department, Fish Division. Administrative Report.

Williams, J.E., J.E. Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M. Navarro-Mendoza, D.E. McAllister, and J.E. Deacon. 1989. Fishes of North America endangered, threatened or of special concern: 1989. Fisheries 14, 6:2-20.

Williams, R.N., D.K. Shiozawa, J.E. Carter, and R.F. Leary. 1996. Genetic detection of putative hybridization between native and introduced rainbow trout populations of the upper Snake River. Transactions of the American Fisheries Society 125:387-401.

Wilson, E.O. 1992. The diversity of life. Belnap Press of Harvard University Press, Cambridge, MA. 424 pp.

Wilzbach, M.A. 1985. Relative roles of food abundance and cover in determining the habitat distribution of stream-dwelling cutthroat trout (Salmo clarki). Canadian Journal of Fisheries and Aquatic Sciences 42:1668-1672.

Wilzbach, M.A., K.W. Cummins, and J.D. Hall. 1986. Influence of habitat manipulations on interactions between cutthroat trout and invertebrate drift. Ecology 67:898-911.

Wishard, L., W. Chistensen, and P. Aebersold. 1980. Biochemical genetic analysis of four cutthroat trout tributaries to the Idaho Blackfoot Reservoir system.. Idaho Department of Fish and Game, Boise. Final Report.

Wolf, K., and M.E. Markiw. 1984. Biology contravenes taxonomy in the Myxozoa: New discoveries show alternation of invertebrate and vertebrate hosts. Science 225:1449-1452.

Woodbury, L.A. 1934. Parasites and diseases of the trout of Yellowstone Lake: A biological account with special reference to the pathological aspects. Master's Thesis, University of Utah, Salt Lake City.

Wuerthner, George. 1998. A fish story. National Parks (May/June):24-27.

Yellowstone Center for Resources. 1996. Annual Report.

Young, Michael K. (tech. ed.). 1995a. A conservation assessment for inland cutthroat trout. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. General Technical Report RM-GTR-256. Pp. 16-23.

Young, Michael K. 1995b. Synthesis of management and research considerations. In. M.K. Young (tech. ed.). A conservation assessment for inland cutthroat trout. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. General Technical Report RM-GTR-256. Pp. 55-61.

Young, Michael K. 1996. Summer use and habitat movements by Colorado River cutthroat trout in small, montane streams. Canadian Journal of Fisheries and Aquatic Sciences 53, 6:1403.

Yule, D.L., and C. Luecke. 1993. Lake trout consumption and recent changes in the fish assemblage of Flaming Gorge Reservoir. Transactions of the American Fisheries Society 122:1058-1069.

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