



# **Feasibility of Reintroduction of Anadromous Fish Above or Within the Hells Canyon Complex**

James A. Chandler  
Editor

**Technical Report  
Appendix E.3.1-2**

Hells Canyon Complex  
FERC No. 1971

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# Habitat of the Snake River Plain

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## **Chapter 3**

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This chapter provides an overview of historic habitat conditions and of the flora and fauna associated with the Snake River basin upstream of Hells Canyon Dam. It also presents an overview of present day habitat conditions and factors that have influenced present day habitat quality. In the following two chapters (Chapter 4, Chandler and Chapman 2001; Chapter 5, Chandler et al. 2001), more detail is presented about the history of anadromous fish, present day habitat quality and present day limiting factors for each individual tributary basin and the mainstem Snake River, respectively.

## **1. SNAKE RIVER PLAIN**

### **1.1. Physiography**

#### **1.1.1. Formation of the Plain**

For the purposes of this chapter, the *Snake River Plain* includes the broad Snake River lowlands and the upland tributaries that lie upstream of Hells Canyon. The Snake River Valley, before the Miocene Epoch, was a broad valley about 4,000 feet (ft) lower in elevation than it is at present. The Snake River meandered through this valley to its confluence with the Columbia River. The Seven Devils Mountains did not exist. Since then, the valley has been filled by repeated lava flows from Oregon and the Snake River Plain, including sediments from highlands. Large quantities of sediments settled in ancient Lake Payette and Lake Idaho, both formed by lava flows in the Hells Canyon area.

The catastrophic Bonneville flood, which released the waters of Pleistocene Lake Bonneville, dramatically changed the Snake River basin. The mass of water, released 12,000 to 15,000 years ago (Malde 1968), covered the Snake River area to a depth of 392 meters (m) and flowed at speeds of over 7 meters per second (mps). This flood, together with periodic lava flows in the area, alluvial sediment deposits from mountain areas, and downcutting by the river, largely sculpted the river morphology that is visible today. Shoshone Falls, Upper Salmon Falls, and Lower Salmon Falls exemplify these combined effects. Eleven topographic basins (or coves) were formed, including Melon Valley, Hagerman Valley, Pasadena Valley, King Hill basin, Glens Ferry basin, Hammett basin, Indian Cove, Eagle Cove, Loveridge basin, Grand View basin, and Walters basin (Meatte 1990).

#### **1.1.2. Present Configuration**

In its more recent configuration, the Snake River Plain is a broad, shallow “downwarp” 60 to 100 miles (mi) wide that extends from the Idaho–Wyoming border to Weiser, Idaho, a total distance of about 400 mi. It is a broad, basaltic plateau. The western portion of the Snake River Plain, the area of concern in this report, covers about 98,000 square kilometers (km<sup>2</sup>) (Meatte 1990), although the U.S. Environmental Protection Agency (USEPA 1996) considered the area equal to only 41,000 km<sup>2</sup>.

Deeply dissected by streams and rivers, the forested northern Rocky Mountains—including the Boise, Smoky, and Sawtooth mountains—bound the northeastern portion of the Snake River Plain. That portion is interspersed with large, intermontaine valleys such as the Camas Prairie and Long Valley (Payette River). The Idaho batholith, a mass of Cretaceous-age bedrock, dominates the geology of the region and is critically important as a source of fine sediments in the Boise and Payette drainages because it breaks down readily to granitic sand when exposed to the atmosphere. The Weiser River lies outside of the Idaho batholith.

The headwaters of the northwest study area include the southern portion of the Blue and Wallowa mountains. Steep peaks are separated by broad, faulted valleys that have an undulating topography of rolling hills and isolated basalt buttes (Meatte 1990). Most of the modern topography is attributed to Pleistocene block-faulting and stream erosion. The bedrock of the region is less erosive than that in the Idaho batholith to the east.

The southwestern and western portions of the Snake River Plain consist of undulating rangeland called the Owyhee Uplands, a warped plateau of volcanic deposits that dips north into the plain (Meatte 1990). The dominant uplands are the Owyhee Mountains. Deep, terraced canyonlands occur on the northern and western flanks of the Owyhee Uplands and are cut by the Owyhee and Bruneau rivers.

The eastern and central portions of the Plain consist of a flat expanse of lava flows dotted with low cinder cones. The most prominent feature is the deeply incised Snake River canyon, with near-vertical walls of 150 to 180 m (Meatte 1990).

Snake River flows are controlled primarily by irrigation storage and water delivery. For example, the flow at Milner Dam is negligible when upstream reservoirs are filling or when diversions begin (USEPA 1996). Downstream of Milner Dam, ground water discharge increases flow substantially. A thick sequence of volcanic rocks that store and yield large volumes of water underlies the eastern Snake River Plain. Over 80% of the aquifer emerges as spring water in the Thousand Springs area. Over two-thirds of the flow passing King Hill (downstream) enters the Snake River from the aquifer between Milner Dam and King Hill. During the irrigation season, the springs contribute nearly all the flow.

## 1.2. Climate

Pacific and Arctic air masses determine the climate of the Snake River Plain. The former brings warm, moist air from the ocean; the latter carries cold, dry air from the north. In summer, Pacific air pushes dry air into the western basins. These unstable air masses have a thick, moist layer conducive to summer thunderstorms. In winter, Arctic air often spills over the Rockies into the western basins. Pacific air normally flushes this air out, but Arctic air can remain for long-lasting inversions. Rainfall averages 25 to 38 centimeters (cm) per year in most of the area, although it ranges from 17 cm in the Snake River canyon to about 100 cm in the Sawtooth Mountains. Summer temperatures range between 20 and 30 °C. Winter temperatures along the Snake River rarely drop to much below -10 °C, but at higher elevations surrounding smaller tributaries temperatures can remain at -20 ° to -30 °C for weeks at a time. These extremes are important influences on environmental conditions in tributary streams.

## 1.3. Terrestrial Vegetation and Aquatic Plants

### 1.3.1. Climax Condition

The Snake River Plain straddles two floristic provinces: the Cordilleran Forest and the Great Basin. The former province includes the mountain regions of the northwestern United States and supports tree species such as ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), Douglas-fir (*Pseudotsuga menziesii*), true firs (*Abies* sp.), western red cedar (*Thuja plicata*), western hemlock (*T. monophylla*), and western juniper (*Juniperus occidentalis*). The Great Basin Province includes arid regions of Utah, Nevada, southern Idaho, and southeastern Oregon. These areas are essentially high desert habitats with sagebrush (*Artemisia tridentata*), greasewood (*Sarcobatus* sp.), shadscale (*Atriplex confertifolia*), and pinyon pine (*P. monophylla*). Meatte (1990) notes that regional summaries document these provincial floras (Franklin and Dyrness 1973, Sharp and Sanders 1978).

Three types of vegetation occupy the Snake River Plain under climax conditions (Franklin and Dyrness 1973):

- **Salt-desert shrub** occurs on dry, saline soils with poor or interior drainage. Shadscale is a common shrub in this environment because it tolerates alkaline and saline soils.
- **Sagebrush-grass** covers most of the central and southern plain. Big sagebrush and perennial bunchgrass (*Agropyron* sp.) dominate. Meatte (1990) notes that “Within this habitat, streams and rivers typically support a rich riparian zone of Willows (*Salix*), Gooseberry (*Ribes*), Chokecherry (*Prunus virginia*), Hawthorn (*Crataegus*), and Giant Wildrye (*Elymus*). In higher riparian settings, Aspen (*Populus*), Cottonwoods (*Populus*), Wild Rose (*Rosa woodsii*) are abundant, as well as herbs and sedges.” Bottomlands and wet meadows support tubers including camas (*Camassia quamash*) and biscuitroot (*Lomatium* sp.).
- **Forest** vegetation occupies the higher elevations in the northern and northwestern areas, as well as pockets in the Owyhee and Jarbidge mountains. In these forested zones, the lower elevations are occupied by ponderosa pine, with Douglas-fir at higher elevations and on north-facing slopes. Lodgepole pine and western larch (*Larix occidentalis*) intermix with both species. True firs (*Abies* sp.) occupy wetter and higher sites. An extensive juniper woodland lies in the broken uplands of the Owyhee Mountains and the upper Malheur basin. These woodlands are generally at or above 1,500 m mean sea level (msl) and are characterized by an open, low, scrubby forest mixed with sage and grasses. Juniper is invading extensive areas at lower elevation.

Moseley (1998) identified or classified 34 riparian and wetland community types in lower-elevation, protected areas of southwestern Idaho. Fifteen of these community types were identified with “high classification certainty,” and 19 as “tentative community types.” The 15 with high classification certainty were the following:

- **Black cottonwood/Pacific willow**—occurs in low- to mid-elevation alluvial bars and the abandoned channels of major rivers and streams. This community type may also be found in narrow to broad, trough- or flat-shaped valley bottoms of low gradient (1–3%).
- **Black cottonwood/common snowberry**—occurs in mid-elevation, gentle terraces along major rivers and streams in the mountains of central Idaho and adjacent Oregon. Valley widths are usually broad (300–1,000 ft), but can be as narrow as 100 ft. In infrequently flooded areas, valleys are V-, flat-, or trough-shaped with moderate gradients (2–5%), often with steep sideslopes.
- **White alder/Syringa**—occurs in mountain areas dissected by Hells Canyon and its tributaries, from subalpine summits over 9,000 ft msl to canyon bottoms below 2,000 ft. Associated with poor stream stabilities, this community type is often flooded and subject to mud-rock flows.
- **Water birch/mesic forb**—occurs along terraces, seeps, and intermittent channels.
- **Water birch/Kentucky bluegrass**—occurs on stream terraces and occasionally in seeps in narrow valley bottoms. In rare instances, it may occur in moderately wide valley bottoms. Valley bottom gradients are low to moderate; elevations range between 3,200 and 7,800 ft msl.
- **Sandbar willow/barren**—occurs along active stream banks or nearby stream terraces, probably with annual flooding. Gradients are low to moderate, valleys are narrow to very wide, and elevations are mostly below 5,500 ft msl.
- **Sandbar willow/mesic graminoid**—occurs on stream terraces and in meadows associated with stream channels at 2,000 to 7,700 ft msl. Valley bottoms can be narrow to very wide and low to moderate in gradient.
- **Mountain alder/red-osier dogwood**—occurs adjacent to streams that are subject to seasonal fluvial scouring and deposition. Valley bottoms are narrow to moderately wide, and elevations range between 3,000 and 8,000 ft msl.
- **Basin big sagebrush/basin wildrye**—occurs in the transition zone between drier upland communities and the wetter riparian zone. This community type can be found on alluvial depositions such as floodplains, drainageways, and stream terraces, generally below 6,000 ft in Idaho and 8,000 ft in Nevada.
- **Red-osier dogwood**—occurs adjacent to stream and river channels. It may appear as a dense linear band on alluvial benches in narrow canyons or in broad thickets on islands and floodplains of major streams that have annual or near-annual flooding.
- **Greasewood/saltgrass**—occurs on broad, level, or gently sloping bottomlands, either along low-gradient creeks and rivers or as internally drained basins, generally below 5,000 ft in arid areas.

- **Bladder sedge**—occurs at moderate to high elevations in mountains, rarely in low-elevation valleys or volcanic plains. Valley bottom gradients are low, with meadows, seeps, stream terraces, and silted-in ponds and sloughs.
- **Hardstem bulrush**—occurs on the margins of ponds, lakes, and reservoirs; on stringers paralleling stream and river channels; or in broad swaths in backwater marshes and sloughs, at 2,000 to 6,600 ft msl. This community type often inhabits relatively deep water.
- **Common threesquare**—occurs along low-gradient, meandering, usually perennial streams and around the margins of ponds and marshes.
- **Cusick’s Camas seep**—occurs beneath basalt rims on colluvial inter-rim locations where seepage persists well into early summer. This community type may also occur on steep slopes with a southerly aspect at elevations of 3,000 to 6,000 ft msl.

With these and the additional 19 tentative community types, Moseley (1998) provides a description of the diversity and adaptability of riparian vegetation in southwestern Idaho. These 34 communities provide woody debris, support bank-building and stability, and in part dictate stream morphology under conditions of little or no cultural disturbance. Intensive livestock grazing, channelization, and flow regulation from water storage projects or irrigation withdrawals will alter and degrade the communities, with concomitant or resultant effects on stream morphology.

In the early 19th century, R. Stuart traversed the Snake River Plain, reaching the Burnt, Powder, Boise, Owyhee, Snake, and Bruneau rivers, and Salmon Falls Creek (Spaulding 1953). He repeatedly mentioned the abundant willows along stream courses other than the main Snake River. His descriptions in 1812 reflect the pristine character of riparian areas at that time. Grass was not abundant everywhere. Several other sources mention the scarcity of grass on Snake River uplands along the Oregon Trail (e.g., Clyman 1844). Overgrazing along the trail may have caused some of this scarcity, but the soil types and lack of moisture likely reduced grass biomass on the less-productive uplands.

### **1.3.2. Present Condition of Terrestrial Vegetation**

Agriculture (farming and ranching) is the predominant land use along the middle Snake River from Milner Dam to King Hill. The major crops are irrigated hay, grain, potatoes, beans, and sugar beets. Dryland agriculture produces wheat. Forest and urban areas make up less than 7% of total land use. Private lands make up 26% of total lands; federal lands, 70%; and state lands, 4%.

The middle Snake River area is not typical of the higher elevations of the basin upstream of the Hells Canyon Complex (HCC). The upper elevations of the Powder, Burnt, Malheur—and, to a greater extent, the Boise, Payette, and Weiser—river basins are heavily timbered. For example, over 9.3 billion board feet of standing mixed-conifer forest stock lies within the Payette National Forest. Much of this volume (66%) consists of overmature timber in which the annual net growth is 30.2 million board feet (MMBF), and “live cull” to disease and insects accounts for

717 MMBF. Because of the overmature status of the stands, they are growing at less than 25% of their potential 200 MMBF per year (USFS 1988).

Invader species continue to take advantage of the early seral conditions that accompany intensive grazing. Yensen (1982) notes:

The inevitable result of the intense competition for range resources was the alteration of the range vegetation. When sagebrush-grass vegetation types are intensively grazed, native perennial grasses are eliminated, and the shrubs, such as big sagebrush, tend to form dense monotypic stands.... [T]he replacement of the sagebrush-grass community by a sagebrush community resulted in a great loss of available forage. By 1890, the native perennial grasses, for all practical purposes, were no longer present on southern Idaho ranges.... The decimation of the native perennial grasses and forbs by the turn of the century left a void in the vegetation of the southwestern Idaho lowlands.... [S]oil erosion became a critical problem on Idaho rangelands.... Part, but not all, of the void was filled by ever denser stands of big sagebrush. With no easing of grazing pressure, rehabilitation of the native perennial grass and forb understory of the shrubs was not possible.... The stage was thus set for the invasion of exotic annuals.

The invader species included Russian thistle, cheatgrass, filaree, and exotic mustards. The deterioration of rangelands was ubiquitous throughout the basin upstream of the HCC. The common thread found in references is that abundant, lush stands of grasses were present before overgrazing began. However, this is not to say that all areas had good grass. From the very earliest historical period, a stretch along the Oregon Trail, between Twin Falls and the Boise River, had little water and poor forage for livestock.

Livestock grazing has been the greatest influence on riparian communities (Spence et al. 1996).<sup>1</sup> Climax riparian communities have suffered heavily from livestock damage since the latter half of the 1800s.

### **1.3.3. Aquatic Plants**

Vascular macrophytes cover up to 40% of the benthic habitat in some areas of the Snake River (USEPA 1996). The dominant species are *Ceratophyllum demersum* and *Potamogeton pectinatus*, species that are often associated with well-buffered, nutrient-rich water. Blooms of planktonic algae (*Microcystis*, *Cyclotella*, and *Ceratium*) and epiphytes (*Cladophora* and *Hydrodictyon*) occur continuously in spring and summer (USEPA 1996). Total epiphytic algae and vascular macrophyte biomass can exceed 2,000 grams/m<sup>2</sup> (dry weight). *Cladophora* can average 50% of the plant biomass in summer. River velocities greater than 1 to 2 mps limit vascular macrophytes.

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<sup>1</sup> Hydraulic giants, placering, and dredging were important causes of riparian alteration in localized areas. Road and railroad channel alteration were also major factors. However, over the entire basin, livestock did more, and continue to do more, to degrade riparian communities than any other agent of change.

Riparian vegetation bands are narrow. Sagebrush/grass desert and scrub wetlands are present, with some black cottonwood growth, especially on islands. The riparian zone is critical for waterfowl, upland game birds, and raptors because of the shortage of forests in the area.

## 1.4. Fauna

### 1.4.1. Prehistoric Use of Fauna by Native Americans

Mule deer (*Odocoileus hemionus*), whitetail deer (*O. virginianus*), Rocky Mountain elk (*Cervus canadensis*), bighorn sheep (*Ovis canadensis*), pronghorn antelope (*Antilocapra americana*), and some bison (*Bison bison*) used the Snake River Plain. Bison were present as far downstream as the Eagle Valley (Powder River) (Colton 1986). Small animals included various rodents, badger (*Taxidea taxus*), coyote (*Canis latrans*), and bobcat (*Lynx rufus*).

Humans have occupied the Snake River Plain since about 14,500 years before present (BP). For that time up through 200 years BP, Meate (1990) categorized three types of use: *broad-spectrum foraging* (to 4,200 years BP), having simple tools and exploiting a wide variety of food resources; *semisedentary foraging* (4,200–250 BP), having extended residential stays during winter and ability to store foods; and *equestrian foraging* (250–200 years BP), involving hunting for bison (this phase does not imply exclusive behavior, but rather combinations of the two non-equestrian foraging systems).

Native Americans extensively used the banks of the Snake River downstream of Shoshone Falls to Hells Canyon. Prehistoric use is documented in the archives of the Idaho Archaeological Society, Boise; Boise State University, Boise; and Idaho State University Museum, Pocatello. Presence of mussel shells, tools, and occasional mammal bones and fish vertebrae and bones are recorded in many sites.

The number of sites recorded in archives is nothing short of amazing. The incomplete information indicates very heavy prehistoric use of the main Snake River canyon. Population density and the location of winter encampments were tied to available natural resources. The area between Fort Hall and Shoshone Falls was very sparsely populated and few, if any, winter residents used the area. From Shoshone Falls downstream, winter villages lay on either side of the river where salmon could be cached for winter use (Butler 1978). Some “villages” were several miles from the main river. Each was little more than a collection of independent families that moved seasonally (Steward 1938). In winter, families lived on dried salmon, insects, and roots. The first anadromous fish to arrive in spring were steelhead (*Oncorhynchus mykiss*). Spring chinook salmon (*O. tshawytscha*) began ascending tributaries in August and September. Fall chinook salmon reached the mainstem of the Snake River in September and October. Most aboriginal sites away from the Snake River and Salmon Falls Creek may have been sparsely and infrequently used (Butler 1978). Winters in the higher-elevation lands away from the Snake River were harsh, and fish were not a major target of food-gathering by the seasonal occupants of these highlands (Barnes 1964).

Plew (1980) proposed a model for the aboriginals’ seasonal use of highlands and river valleys. He suggested that sites on Pole Creek and Camas Creek, tributaries to Deep Creek in the

Owyhee River basin, were used in spring, summer, and fall, but that in winter people occupied encampments in the Owyhee River canyon. Summer camps were often associated with the availability of camas. That pattern may have typified seasonal rounds in most of the Snake River basin upstream of Hells Canyon.

Fall chinook salmon used the main Snake River downstream of Shoshone Falls for spawning and early rearing before juveniles moved seaward. Adult salmon were very abundant seasonally (Gilbert and Evermann 1894). The Shoshone people of this area fished them extensively (Gilbert and Evermann 1894, Steward 1938). Spawning beds were located from Shoshone Falls downstream to at least Ontario (Evermann 1896). Fisheries occurred as far downstream as Huntington, Oregon. Various historic accounts of fisheries and fish presence mentioned silver salmon, dog salmon, silversides, salmon belly, chinook salmon, and quinnat salmon. Evermann (1896) stated that all these terms refer to chinook salmon.

Townsend (1834) mentioned camping on the Snake River near the mouth of the Malheur River on August 24, 1834. He described the river as “nearly a mile wide, but deep and clear.” He noted that Native Americans did not attempt to fish the “big river,” where it was wide and deep, but preferred the “slues, creeks.” He described the placement of a net of closely woven willows, stretched and placed vertically, extending from the river bottom to several feet above the surface. A number of Native Americans entered the water upstream a hundred yards and walked closely to drive the fish in a body against the wickerwork. Here the fish frequently became entangled and checked, so that they could be speared.

Anadromous fish remains have been found at excavated sites at Clover Creek, Three Island Crossing, Givens Hot Springs, Hahas Cave, Bliss, Deer Creek Cave, Pence Duerig Cave, and possibly Dry Creek Rockshelter. Chinook use can be dated to at least 4,200 years BP and probably to 7,000 years BP; steelhead, to at least 2,920 years BP (Meatte 1990). The scattered known sites do not permit an accurate determination of species use for all the many tributaries to the study area. Historical information must be used for that assessment.

Northern Shoshone and Northern Paiute fished for anadromous species in many areas upstream of Hells Canyon with harpoons and weirs (permitting easier spearing, dip netting, or hand capture). Basket traps were used in weir openings at some sites. Dip nets, seines, and jigging hooks and barbs were used. Meatte (1990) describes many aspects of cultural use in the prehistoric period.

In addition to on-site food acquisition, trade was well developed and may account for the discovery of anadromous bone fragments in locations outside sites that the fish frequented. The two most important sites were at Camas Prairie and near Weiser (Liljeblad 1957, Meatte 1990). At the Camas Prairie site, Nez Perce, Flathead, and Pend d’Oreilles brought coastal and interior products (Meatte 1990). Thus, for example, coho salmon (*O. kisutch*), whose bones were tentatively identified in two excavated sites (Billingsley Creek and near Hagerman) (Plew 1981), could have come from the Nez Perce fisheries on the Grande Ronde, or perhaps from the lower Clearwater River, or even from Celilo Falls. However, a more likely explanation is offered by Plew (1981):

It has been my experience and the experience of fish specialists I have worked with at the British Columbia Provincial Museum and the University of British Columbia, that salmonid vertebrae can not positively be identified to species.... Considering the size of the vertebrae recovered, most of the salmonid vertebrae probably represent either chinook salmon or steelhead trout. Although detailed, precise size estimates are not possible at the present time, most of the vertebrae should represent fish weighing approximately 10 pounds or more when they entered fresh water. This virtually eliminates sockeye and coho salmon from consideration.<sup>2</sup>

No record or literature offers evidence that coho salmon penetrated farther up the Snake River basin than the present site of Hells Canyon Dam.

Salmon captured by Native Americans in the upper Snake River, and perhaps more so in highland tributaries like headwaters of the Owyhee River, were lower in nutritional content than salmon taken earlier in the upstream migration (Plew 1983). Plew (1983) pointed out that native groups experienced food shortages during winter. He suggested that the causes for these shortages included 1) fluctuations in annual and semiannual fish populations, 2) duration or length of fish runs, 3) fishing and food storage technology, and 4) limited caloric content of fish close to spawning.

Walker (1993) estimated that the Weiser River–Boise Valley aboriginal fisheries contained 25 traditional weir and falls/cascades sites. He calculated that these sites produced an average catch of about 150,000 fish. He further estimated that the Hagerman-Shoshone Falls fisheries, with 15 weir or falls/cascades sites, could have produced 90,000 fish. He estimated the relative importance of various streams to Shoshone-Bannock fisheries, but did not distinguish between resident fish and anadromous fish importance.

Corless (1990) mentioned that the Weiser Shoshone and Northern Paiute peoples of eastern Oregon took salmon from the Boise, Weiser, Payette, and Snake rivers, “all major fish runs.” Steelhead were taken in spring, and chinook arrived in September. Sockeye salmon (*O. nerka*) “ran in vast numbers between August and late October and spawned in Big Payette Lake. The river outlet on Payette Lake was one of the favorite summer camps of the Weiser Shoshone and Nez Perce of the lower Salmon River. Other Sheepeater groups traveled over the mountains to join them at the lake for communal hunting and fishing” (Corless 1990).

Plew (1981) provided information on the fish species identified among fish remains in archaeological sites near Bliss. The large salmonid vertebrae found among the remains appeared to be from chinook salmon or large steelhead. Non-salmonid remains included northern squawfish, peamouth, suckers, and other unidentified cyprinids.

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<sup>2</sup> In fact, the presence of vertebrae from smaller anadromous adults, which one might interpret as suggestive of coho or sockeye, would be neither probative nor indicative. Many steelhead weigh considerably less than 10 pounds when they leave the sea. Furthermore, jacks (precocious males) formed a numerically important component of chinook salmon runs that entered the Snake River, if one uses historic data as a model. The size of jacks would be similar to that of coho and small steelhead.

Evidence from many archeological excavations (e.g., Gruhn 1961 and Mauser 1994) shows that aboriginal fishers used mussels extensively. Crayfish (*Pacifasticus* sp.) very likely were consumed, although their fragile exoskeletons did not persist in campsites that were later excavated.

### **1.4.2. Fish Distribution**

Anadromous fish species native to the area include chinook salmon, sockeye salmon, steelhead, Pacific lamprey (*Lampetra tridentata*), and to some degree white sturgeon (*Acipenser transmontanus*). Resident native species include redband trout (*O. mykiss gairdneri*), cutthroat trout (*O. clarki*), bull trout (*Salvelinus confluentus*), mountain whitefish (*Prosopium williamsoni*), redband shiner (*Richardsonius balteatus*), peamouth (*Mylocheilus caurinus*), chiselmouth (*Acrocheilus alutaceus*), speckled dace (*Rhinichthys osculus*), leopard dace (*R. falcatus*), longnose dace (*R. cataractae*), northern pikeminnow (*Ptychocheilus oregonensis*), mountain sucker (*Catostomus platyrhynchus*), largescale sucker (*C. macrocheilus*), and bridgelip sucker (*C. columbianus*). Several species of sculpins (*Cottus* sp.) are also native, including the endemic Shoshone sculpin (*Cottus greenei*) found in springs associated with the mainstem river in the Upper Salmon Falls and Lower Salmon Falls (Simpson and Wallace 1982).

Murray (1964) estimated that fall chinook habitat from Swan Falls to Shoshone Falls totaled about 140 stream miles. He felt that “tempered” or “buffered” water exiting the lava beds (downstream of Milner Dam) assured the development of fall chinook fingerlings and was the determining production factor for fall chinook upstream of the Swan Falls site.

While fall chinook used the main Snake River, steelhead and spring and summer chinook used the main river to gain access to and from tributaries. Spring and summer chinook used the Powder, Payette, Weiser, Bruneau, Burnt, Malheur, Owyhee, and Boise rivers. They probably entered the larger of several smaller tributaries, including the Wildhorse River and Pine, Rock, and Salmon Falls creeks. They may have used Sinkers, Castle, and Reynolds creeks, although the small size of these streams suggests use by steelhead rather than salmon. Sockeye salmon were only present in the Payette River system, associated primarily with Payette Lake near the headwaters of the basin.

Pacific lamprey migrated into the area to spawn (Groves and Bates 2001). Gilbert and Evermann (1894) found 40 dead lamprey on a sand bar below Lower Salmon Falls, noting that lamprey arrive at that point in the river sometime in July. Hallberg (1976) mentioned in an oral interview that his father “always had a barrel of salt eel...” at Caldwell, Idaho. It seems likely that the “eels” were Pacific lamprey. Lamprey were still fairly abundant in the mid-1950s in the Snake River, making up 47% of the nongame fishes captured in downstream-migrant barge traps in the river downstream of Brownlee Dam in 1959 (Bell 1960). Murray (1959) reported September catches in the adult trap at Oxbow in 1959, noting: “Lamprey eel moved into the Oxbow trap in large numbers in September. The largest run I have observed in the canyon.” In August 1960, Murray noted that “a fair run of eel” had arrived at Oxbow trap. Platts (1964) mentioned the capture of 33 lamprey in Wildhorse River trapping in 1958. Lamprey were present in the Boise River in the late 1800s (Eigenmann 1895).

Use of the lower ends of major river tributaries by fall chinook remains unverified. Creech (1979) mentioned that “dog salmon” of 35 to 50 pounds, with long, sharp teeth, were present as carcasses: “on the banks of the Snake River and the Boise River and the Payette River just lined with ’em. Hundreds and hundreds.” Unfortunately, the reference does not say where the carcasses were on the Boise and Payette rivers.

Fall chinook arrived in the Snake River upstream of Hells Canyon late August through late September. Williams (1845) wrote, after arriving at Fort Boise on September 1, 1841:

The first night we staid at Fort Bois, I lay on the bank of the river, where I could scarecely sleep for the Indians, who sung all night in a very curious manner. This is their practice when they are gambling. The poor things were almost naked. The salmon also kept a great noise, jumping and splashing about in the water.

Mr. Williams did not identify the stream on whose banks he slept, but the noise of salmon probably came from fall chinook that had arrived in quantity in the Snake River. Fort Boise was located on the main Snake River downstream of the main channel of the Boise River (Swinney and Wells 1962).

Observations of chinook salmon on September 1 near Fort Boise comport with Evermann (1896), who reported interviews noting large numbers of salmon well upstream of Fort Boise at Lower Salmon Falls from early September to early October.

Welsh et al. (1965) reported that chinook salmon spawning was completed by the end of August in streams commonly thought to support “spring chinook” and that spawning was largely complete by mid-September in stream segments thought to be used by “summer chinook.” Evermann (1896) mentioned the presence of live chinook salmon in the Weiser River above Council about mid-September. Local residents were reported as thinking most spawning occurred in late September, although Evermann (1896) thought the fish spawned “somewhat earlier.” He saw no fish on the Weiser River in a mile of examination upstream of Council Valley. One must recall that the heart of the chinook salmon runs, the portion that arrived in June in the lower Columbia River, was heavily overfished in the 1880s, quite possibly influencing the apparent timing of spawning by chinook salmon in the Snake River basin. This reference may support the presence of “summer” chinook, or it might refer to coho salmon caught in tributaries to the Grande Ronde and lower Clearwater rivers.

Introductions of exotic species began shortly after the turn of the century. Several species of exotic warmwater fish have been introduced into the Snake River. Exotic fish species in the main Snake River include brown trout (*Salmo trutta*), nonnative strains of rainbow trout (*Oncorhynchus mykiss*), largemouth bass (*Micropterus salmoides*), smallmouth bass, (*M. dolomieu*), black crappie (*Pomoxis nigromaculatus*), white crappie (*P. macrochirus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), warmouth (*L. gulosus*), yellow perch (*Perca flavescens*), bullhead catfish (*Ictalurus* sp.), channel catfish (*I. punctatus*), flathead catfish (*Pylodictus olivaris*), and common carp (*Cyprinus carpio*) (Reid 1974; C.J. Strike Reservoir, Lower Salmon Falls Reservoir, Richter and Chandler 2001). For a complete list of introduced species, see Richter and Chandler 2001.

Little is known on the distribution of endemic or introduced fish pathogens in the area (see Chapter 10, Chandler and Abbott 2001). Whirling disease, an introduced pathogen (*Myxobolus cerebralis*), is present in some of the basins upstream of the HCC. The presence of the pathogen does not automatically ensure that it negatively affects rainbow trout or other salmonids. Johnson (1998) noted that the pathogen was established and being transmitted to wild salmonids in Loving Creek and Silver Creek (Little Wood River), Big Wood River, and South Fork Boise River below Anderson Ranch Dam. In 1987, spores of the disease were found but not confirmed histologically in the Jarbidge River and in Salmon Falls Creek.

### 1.4.3. Invertebrates

Several invertebrate species in the main Snake River are protected under the Endangered Species Act. These include the Bliss Rapids snail (*Taylorconcha serponticola*), Utah valvata snail (*Valvata utahensis*), Snake River physid snail (*Physa natricina*, *Pyrgulopsis idahoensis*), Banbury Springs limpet (*Lanx* sp.), and candidate species California floater (*Anodonta californiensis*), giant Columbia River limpet (*Fisherola nuttalli*), and Columbia River Spire snail (*Fluminicola columbiana*) (USEPA 1996). The benthic community is dominated by a few taxa indicative of degraded conditions, including *Potamopyrgus*, Chironomidae, Oligochaeta, and Turbellaria. Crayfish (*Pacifastacus gambelii*) live in most streams in the area (Gilbert and Evermann 1894). While mussel remains have been found in many archaeological sites, no crayfish parts have been identified. That absence does not mean that crayfish were ignored in the subsistence rounds of prehistoric humans. Rather, it probably means that crayfish exoskeletons do not remain identifiable for long.

## 2. HISTORICAL CHANGES IN HABITAT

The first non-Native Americans to arrive in the Snake River Plain sought furs. Fur hunters discovered the Owyhee country<sup>3</sup> early in the 19th century, trapping as early as 1812 (ISHS 1964). Boise River basin gold discoveries in 1862 brought mining to the Owyhee region in 1863 and to other parts of the Snake River country at about the same time. The following sections vary in breadth and depth of content in accord with the literature.

This report will not extensively or fully describe all consequences to fish of habitat alteration. Other reports and reviews provide detailed information on this topic (e.g., Platts 1979, Chapman 1986, Spence et al. 1996, and Quigley and Arbelbide 1997).

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<sup>3</sup> Until 1879, when Cassia County was established, Owyhee County included all of Idaho south of the Snake River and as far east as the Raft River (ISHS 1964).

## 2.1. Mining

Settlement of Idaho began for its mineral productions, and “little attention was at first given to agriculture” (Bancroft 1890). Placer mining, with hydraulics and sluices, was common on the main Snake River downstream of Shoshone Falls, with 46 mining claims listed in the period 1878–1884 (Murphey et al. 1993). Chinese miners managed to extract gold (James 1995) after most white miners thought claims were “played-out.” In fact, Chinese were allowed to purchase only worked-out claims in mining districts largely deserted by Euro-Americans (Steeves 1984).

Mining operations undoubtedly contributed substantial quantities of fine sediments to the Snake River and its tributaries. The degree to which the quality of salmon spawning gravels was affected is completely unknown for the main Snake River. Steeves (1984) described the several methods of mining, including panning, ground sluicing, booming, rocker/cradling, using puddling boxes, using long-toms, sluicing, combining long-tom and sluice, using undercurrents, and hydraulicking. A detailed description of each method is unnecessary here. However, every mining method produced more or less fine sediment, which was delivered to stream courses. Several studies are available that report the damage caused by the various types of placer mining (e.g., Campbell 1954) and fine sediments (Chapman 1986).

Placer mining was common in tributaries where gold was discovered. Water diversions to supply mining endeavors were sometimes Herculean in scope. The Eldorado Ditch, in the Burnt River basin, offers an example. An abbreviated description of the ditch, from Stewart and Stewart (1956) follows:

Hundreds of Chinese, up to 1,000 at one time in the year 1870, worked with shovels to dig the Eldorado Ditch, more than 100 miles long, out of the dry earth of southern Baker County [Oregon].... [T]he main ditch was five feet wide at the bottom and seven feet wide at the top.... [T]he finished canal was 134 miles in length.... Waters of the Eldorado Ditch ran through an arid section of southern Baker County, tapping numerous tributaries of the Burnt River.... [B]efore the turn of the century miners had ceased to use the ditch.... [T]he Eastern Oregon Land Company started to employ the ditch for agricultural purposes in 1911, amid objections from Baker County farmers who protested losing the water to Malheur County.

The phrase “tapping numerous tributaries” suggests extensive interference with migratory routes of salmonid fishes. Ranchers of the growing livestock industry on the Burnt River wanted the Eldorado Ditch water for their hayfields. They expressed their resentment of the ditch-exported water by sabotaging the canal when they “felt especially surly” (Malheur Country Historical Society 1988). The ditch was later abandoned, even by the few ranchers who used it for irrigation.

It is reasonable to assume that ditches associated with mining and irrigation recruited extensive fine sediment to streams and disrupted fish migration pathways. ISHS (1980) described how streams around Placerville and Idaho City turned to mud during the placering season. The Eldorado Ditch was but one of many diversions for mining. Hiatt (1893) wrote:

The Auburn Canal Company completed the ditch to Pine Creek and also extended it southward to and beyond Auburn, built a large reservoir above the town and made distributing ditches to the various gulches.... [T]he canal is described as being thirty miles in length.... [S]ubsequently a ditch was constructed near the foot of the mountains to convey the waters of Pine Creek to Salmon Creek.... In 1868 a ditch was dug from Rock Creek to the mines tapping the creek at the point where the great landslide of 1862 filled the channel of the creek with debris.... [F]orty acres of placer mining ground on Boulder Creek [were] supplied with water by ditches four miles in length.... [T]wo men with a hydraulic t[ook] from three to four thousand dollars per year from the placer claim.... [T]he waters of Camp Creek had just been turned into the Burnt River ditch to be conveyed to the Eldorado diggings.

As noted earlier, the Eldorado Ditch carried water from the upper Burnt River, but also used all of the streams that it intercepted as feeder sources (Pro-Lysts 1978). This diversion would disrupt hydrologic patterns and, probably, fish migrations.

Irrigation flumes and ditches sometimes failed, carrying debris and sediment into salmon spawning areas. A description of irrigation-ditch construction in the King Hill Irrigation Project (Bliss 1976) follows:

A larger head of water was then turned on and the ditch ran half full. Too soon one of the earth fills across a lesser ravine gave way and necessitated the shut-down of the supply. By the time the ditch drained down to the break the entire fill was washed away. This convinced the engineers that the earth fills were not conducive for good ditch construction—so back to the building of more flumes....

...The break started at the lower end of the steep hil[l]side where the mile long ditch had been graded and the force of the escaping water had washed the entire grade into the river clear back to the river bridge siphon....

According to another source, “Shortly after 1870 the easily-worked basin stream gravels had yielded most of their gold, and miners shifted their attention to washing down higher bench placers with hydraulic giants” (ISHS 1992). Hydraulic giants used water delivered through extensive ditches at substantial head through a hose and nozzle. The high-velocity stream eroded whole hillsides to expose ore covered by overburden (ISHS 1980, Plew et al. 1984).

Still later, dredges worked stream bottoms, churning up the entire alluvial zone. Dredges operated in the Boise River basin and in the Burnt and Powder river basins. They left behind great piles of gravels and sand arranged in ways that drastically differed from original stream morphology and degraded riparian communities.

Farther up the Snake River, an early dam was built across the Bruneau River near the mouth. But the first attempt at dam construction in 1890 failed. This dam, completed in 1891, was washed out in February 1892. A replacement dam was constructed of timber to furnish water for placer mining. The Boston Company sold the canal system in 1904 to irrigators. In 1910, the dam failed again (Mullenix 1940). At the turn of the century, a new dam was built across the Bruneau River at the head of Grand View Canal (Gottsch 1985).

## 2.2. Livestock Grazing, Fire, and Vegetation Changes

Big sagebrush (*Artemisia tridentata*) now dominates the upland vegetation of the Snake River Plain at lower elevations. Plant communities dominated by Wyoming big sagebrush (*A. tridentata* ssp. *wyomingensis*) cover 29% of the Bureau of Land Management's (BLM) Owyhee Resource Area (ORA)<sup>4</sup>. Understory vegetation includes some grasses. Mountain big sagebrush (*A. tridentata* ssp. *vaseyana*) is dominant in plant communities on higher elevation lands with higher precipitation; this community covers 12% of ORA lands.

In the Owyhee Uplands, western juniper dominates on many areas, although less than 8% of the ORA is considered to have western juniper as the potential natural dominant. Before the arrival of Euro-Americans, fires that were either caused by lightning or deliberately set helped to keep sagebrush and junipers from taking over grasslands. In a 1976 interview, C. Love (Colton 1986) stated that "The Indians started the fires about the middle of the summer, when it was good and dry... [I]f it hadn't been for fires, when the white man crossed the Rocky Mountains into this country, he'd have had a mess. Sagebrush would have taken it. Fires kept it down." Burkhardt and Tisdale (1969) wrote that "juniper invasion is widespread throughout west-central Owyhee County[,] and from the age class distribution it is apparent that this process began in the 1860's. The rate of invasion was slow until about 1900, then increased to a maximum between 1930 and 1940. Since 1940 invasion has slowed, but is still occurring. At present, juniper has more than doubled the area occupied in 1860." Overgrazing contributed to the invasion (Burkhardt and Tisdale 1976).

Juniper invasion spreads largely downslope from old juniper stands on ridges or rimrocks. Most invading stands are continuous with climax stands (Burkhardt and Tisdale 1969). The invasion from climax stands, many over 150 years old, occurs in sites previously occupied by productive sagebrush-grass stands.

Upland areas of the Snake River Plain that have been subjected to cattle grazing are in generally poor condition. In the ORA, 58% of uplands are considered in poor condition, 32% in fair condition, and only about 9% in good or excellent condition. Uplands considered to be forested consist of juniper invasions, old-growth juniper (pre-invasion), and mostly second-growth Douglas-fir in associations with subalpine fir (*Abies lasiocarpa*). The latter species accounts for about 36,000 acres. Old-growth Douglas-fir was cut in the latter half of the 19th century. Forested lands within the ORA are in somewhat better condition than grazing lands, with 25% rated as excellent stands, 4% as good stands, 25% fair, and 50% poor.

Riparian vegetation that supported stream habitats for salmon and steelhead included willow (*Salix* sp.), aspen (*Populus tremuloides*), black cottonwood (*P. trichocarpa*), alder (*Alnus* sp.), dogwood (*Cornus stolonifera*), chokecherry (*Prunus virginiana*), black hawthorn (*Crataegus douglasii*), Wood's rose (*Rosa woodsii*), rushes (*Juncus* sp.), spike rushes (*Eleocharis* sp.),

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<sup>4</sup> The former Owyhee Resource Area is now encompassed by the BLM's Owyhee Field Office, which also manages a portion of the lands that were within the former Bruneau Resource Area.

sedges (*Carex* sp.), and bluegrass (*Poa* sp.) (BLM 1996a). These species are sensitive to overuse by livestock (Spence et al. 1996).

Thurrow (1988) examined human-caused habitat changes in the Wood River drainage. Although this area lies outside the zone of the Snake River Plain used by anadromous salmon and steelhead<sup>5</sup>, his descriptions of habitat change and human influence are typical of other streams in the anadromous zone:

Since the 1940s, man-induced activities have extensively altered trout habitat in the drainage. The most significant channel alterations have included: channel relocation, diking, channel clearance, and riprapping. Concurrent with channel alterations has been loss of riparian habitat. Most activities have been associated with attempts to control flooding, development of floodplain areas, and road construction. Studies conducted in 1967 and 1968 indicated 21 km of stream (22% of the area surveyed) had been altered on the main stem Big Wood River (Irizarry 1968). Simultaneously, as development proceeded, recreational opportunities in the Wood River Valley resulted in increased angling pressure. Between 1960 and 1980, Idaho's population increased by 41%. During the same period, the population of the upper Wood River Valley... has increased by 123%.<sup>6,7</sup>

Livestock grazing began on the Snake River Plain about 1700, when the Shoshone brought horses into the northern Great Basin (Yensen 1982). The first longhorn cattle from Texas arrived in the Bruneau River valley in 1869–1870 (Murphey et al. 1993), and in Owyhee County in 1868–1869 (ISHS 1964). Large ranches developed along the Snake River, exploiting high-country forage in summer and river bottoms during winter. Sheep herds of several thousand head had been trailed through the region since 1865 (Bancroft 1890). A vivid description of overgrazing problems in the Snake River watershed was offered by W. Hall (1982), of Baker City, Oregon, a U.S. Forest Service (USFS) employee on the Wallowa-Whitman National Forest:

By the 1920s the mountain and canyon rangeland of Wallowa county was in very poor shape due to overgrazing by sheep and cattle. Fifty thousand head of ewes and lambs wintered in the canyons and came up the Billy Meadows driveway each spring on the way to the high country. In 1919 there were 6,000 head of cattle under permit on the Chesnimnus allotment; this was a drought year and 600 head died because they were too weak to get out of the canyons. The allotment that year should have been 1,500 head with a short grazing season. By around 1930 the sheep allotments were reduced to 5,000 head since there was little available grass.

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<sup>5</sup> The area may not lie outside that used by Pacific lamprey. However, Close et al. (1995) and Simpson and Wallace (1978) note that *A. tridentata* distribution coincided with that of salmon.

<sup>6</sup> While human population growth has been less in some drainages, for example, in the Owyhee River and Salmon Falls Creek basins, it has been even greater in the Boise River basin and significant in other systems.

<sup>7</sup> Thurrow (1988) correlated  $\log_e$  rainbow trout density/100 m<sup>2</sup> with  $\log_e$  arcsin square root of percent cover (woody debris, undercut banks, vegetative overhang, etc.), finding  $R^2 = 0.90$  (highly significant).

The Owyhee country saw a rapid increase in livestock in the 1880s. One estimate placed the number of cattle in Owyhee County at about 30,000 in 1882, and over 100,000 by 1888–1889. Two severe winters and forage shortages decimated the herds; by 1899 an estimated 15,000 remained. However, sheep numbers had increased by the turn of the century to about 150,000 animals in Owyhee County (Anon. 1899). One important factor in the conversion from cattle to sheep was the latter's ability to fatten even on overgrazed lands where less-desirable seral and exotic plant species had replaced native climax vegetation.

In Baker County, Louise Dodson's uncle recalled riding from Anthony to Baker City when bunchgrass "as high as a horse's knee" covered all the hills, and she remembered "lots of willows and brush along all the waterways; this was killed out by agricultural spraying and weed control projects of the 1940s. Sheep overgrazing took out the grass and huckleberries in the mountains. The valley wetlands have been filled and drained" (Dodson 1976).

In an oral history (Gildemeister 1992), Charles Colton and Ned Foye mentioned that in the late 1800s, good stands of bunchgrass covered the hills from Medical Springs to the Snake River. In 1889, the Colton family moved to The Grove, east of Sparta, Oregon, where 10,000 head of sheep grazed the hills. Each year large bands came in from outside the area to compete for the grass. Within 15 to 25 years the range "was beat to death" (Gildemeister 1992).

Feral horses contributed to overgrazing, especially after internal combustion engines reduced the need for horses for transport and work: "Around the turn of the century feral horse bands ran all over the Snake River country. Dust could be seen a thousand feet in the air as the horses came down to the river at sundown. The stockmen came, killed off the horses, and ran many bands of sheep and great herds of cattle" (A. Huff in Gildemeister 1992). When market prices for domestic horses bottomed out, many of them were turned loose on the range.

One cause of increasingly hostile relationships between whites and Native Americans was the degradation of the environments on which the native peoples relied. Not only had buffalo been eradicated by the 1840s, but tall desert grasses that Native Americans used for food were destroyed by excessive grazing of emigrant livestock (Horton 1996).

Beginning about 1880, the Reynolds Creek watershed was grazed and trampled by flocks of sheep. The severe use drastically altered composition of the vegetation; many of the once well-grassed slopes became occupied by herbaceous species that were of little use for forage (Robins et al. 1965).

C. S. Tremewan (1964) was the first forest supervisor of the Humboldt National Forest. He reported in an interview that in 1900 his family moved from the foot of the Independence Mountains to the Bruneau River in Idaho at a location presently called "Mink Ranch." He noted:

We were running 400 cattle and never thought of feeding them during the winter. The grass was one and one-half feet high and waved in the wind all over the hills. That was real winter country.... At Gold Creek, Walt Martin used to cut his winter hay by mowing the ridges. The native grass was thick enough that all he had to do was find a smooth place.... All the smoother ridges were covered with bunch grass. There wasn't any sagebrush to speak of, just grass.... There was no sagebrush in them then [the creek

bottoms].... The Pole Creek area was another fine grazing country.... You could go out anywhere and mow hay, good hay.... [T]he sheep started to come into the country in large numbers. There were so many that the herders would run back and forth trying to beat one another to the better camp sites. This tromping and running around did more damage to the range than the feeding. The whole mountain range was tromped up. It was just a dust pit from Foreman Creek clear south to Taylor Canyon. By the first of September the country looked like a desert. There was nothing left.... In 1908, there were 560,000 sheep running on what is now the Independence, Gold Creek, and Jarbidge Ranger Districts.

Sheep numbers peaked on western ranges around the turn of the century, then dropped off as forest reserves developed and as resistance to overgrazing and free access increased. The numbers of sheep declined until the late 1920s, then increased sharply again in the early 1930s in response to favorable market conditions. Since then, sheep numbers have declined, while cattle numbers increased through 1992 (McIntosh et al. 1994, McIntosh et al. 2000). Total numbers of grazing animals have been relatively stable since 1970 (McIntosh et al. 2000).

The current estimated ecological status of uplands in the ORA, reasonably typical of the BLM uplands in the Snake River Plain, is 44% early seral, 43% mid-seral, 11% late seral, and less than 1% potential natural community (climax for the area). Heavy livestock use of the uplands and invasion of exotic plants keep vegetation in early to mid-seral condition.

Range degradation occurred early. The Secretary of Agriculture (1936) blamed excessive livestock use as the outstanding cause of range depletion. He estimated that in the western rangelands of the United States, 95% of the public domain and grazing districts had been degraded, and only 2% improved. He cited the disappearance of bluebunch wheatgrass, giant wildrye, ricegrass, dropseed, sacaton, and California oatgrass and their replacement by unpalatable sand sagebrush, greasewood, shadscale, and rabbitbrush. He also noted the invasions of star thistle (*Centaurea* spp.), Russian thistle (*Salsola* spp.), and cheatgrass (*Bromus tectorum*), as well as the increased flood frequency and severity because of depleted ranges. Unfortunately, the Secretary's estimate of the time required to rehabilitate western rangelands was too low. As noted elsewhere in this report (i.e., Chapter 4, Chandler and Chapman 2001) in discussions of specific subbasins, the public range is still overgrazed.

The 1936 report by the Secretary of Agriculture was not the first warning to Congress. The Public Lands Commission (1905) had stated thirty years earlier that "The general lack of control in the use of public grazing lands has resulted, naturally and inevitably, in overgrazing and the ruin of millions of acres of otherwise valuable grazing territory. Lands useful for grazing are losing their only capacity for productiveness, as, of course, they must when no legal control is exercised."

Range managers tend to evaluate range condition in terms of uplands rather than riparian zones. The Council for Agricultural Science and Technology (1974)<sup>8</sup>, in discussing the benefits and

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<sup>8</sup> The Council was composed of professors of range management, animal science, and agricultural economics, specialties with more than passing interest in maintaining continued grazing on federal lands in the West.

desirability of livestock grazing on federal lands in 11 western states, failed to mention effects of livestock damage in stream/riparian zones. The Council admitted that overgrazing had occurred on uplands between the 1860s and 1930s, but emphasized improvements in management and range condition since. But Platts and Nelson (1985) showed that “Estimates of forage use by cattle for a given pasture based on data from upland range sites did not provide an accurate indication of forage use on streambanks in our study areas.” Cattle prefer streamside areas and associated vegetation. Spence et al. (1996) summarized literature on the preference of cattle for riparian systems. Although riparian meadows usually make up 1 to 5% of the land area in grazing allotments, they account for most of the herbaceous biomass removed by livestock. Cattle and sheep select riparian zones because riparian areas offer water, shade, cooler temperatures, and vegetation more lush than that in upland zones.

It is useful here to describe habitat and riparian conditions in areas subjected to overgrazing.<sup>9</sup> BLM considers that 91% of the approximately 500 mi of stream habitat within the ORA are in “unsatisfactory condition” (BLM 1996a). Table 1 shows conditions for fish habitat and riparian zones in various streams that might be used by salmon or steelhead if anadromy were feasible. In the ORA managed by the BLM, 87% of the stream miles inventoried were found to be in unsatisfactory condition (BLM 1999a).

Clearly, allotment management plans that permit grazing on BLM holdings have not protected fish habitat and stream/riparian zones. The BLM (1996a, 1999a) states:

Current livestock grazing practices allow for too much use during the hot season (July–September). The rate and direction of riparian condition change is dependent to a large degree on the amount of vegetative regrowth occurring after livestock are removed from a pasture and the amount of physical damage (e.g., bank trampling and shearing) which occurs (BLM 1989).

With about 61% of the area streams having been inventoried, it is equally clear that excessive grazing cannot be blamed for all habitat degradation in the ORA. BLM (1999a) stated: “In the Snake River drainage, irrigation diversions, livestock grazing, road construction and historic mining have combined to reduce streamflows and alter stream channels and riparian communities on many streams in this area, resulting in impacts to fish habitat.” For example, in the Jordan Creek drainage, streams can reach a pH of 3.5, outside the survival range for aquatic life (BLM 1999a). However, BLM (1999a) also states that “Livestock overgrazing is the primary source of impacts to riparian areas.”

For streams in the Payette National Forest, monitoring for grazing effects was done as a follow-up to release of the 1988 forest plan. In Beaver, Lick, and Lost creeks, some evidence was found of sediment and organic enrichment. Samples taken within and outside an enclosure in Lost Creek showed that outside the fence, macroinvertebrate taxa present were tolerant of sediment and organic enrichment. Inside the enclosure, more clean-water species were found.

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<sup>9</sup> The term “overgrazing” here is used with respect to ecological health of stream/riparian zones.

Livestock degrade stream/riparian systems from climax conditions (including abundant shading, undercut banks, substrates of gravel/rubble, and low width-to-depth ratios) to conditions inimical to fish and riparian wildlife habitat (absence of shade, absence of undercut banks, substrate of silt/sand, and high width-to-depth ratios) (Platts 1979, Elmore and Beschta 1987). High water temperature in summer, poor insulation from cold winter temperatures, lack of diverse microhabitat for fish and macroinvertebrates, insufficient cover from predators, and lost spawning habitat are among the characteristics of such degraded habitat. The downstream boundary of suitable summer water temperatures moves toward the headwaters. Eroding streambanks recruit fine sediments to spawning gravels and interstices used by macroinvertebrates.

Hanson (1987) rated, in descending order of importance, the major factors that affected riparian zones in forested areas in eastern Oregon. His evaluation included the Malheur, Owyhee, and Powder rivers. The descending order of importance in 11 river basins was 1) livestock grazing, 2) timber harvest practices, 3) agricultural practices, 4) road construction, and 5) flood events.

### **2.3. Timber Harvest and Fire Control**

Areas adjacent to mining towns and mines were logged early and intensively to provide materials for mine structures, sluices, businesses, and houses. Higher elevations in the Owyhee Mountains offer examples, as do areas in the Boise River basin like Mores Creek. In the Reynolds Creek watershed, “The fair stands of timber then existing in the upper reaches of the watershed were clear cut for mine timbers; only scattered juniper, mountain mahogany, and patches of fir and aspen now remain” (Robins et al. 1965). “Several small sawmills were established in the booming mining districts in the John Day, Burnt River, and Powder River valleys in the 1860s to cut lumber for building materials and timbers for bridge, sluice, and mine construction” (Robbins and Wolf 1994).

High allowable cuts in USFS lands in the basin were the norm in the mid-1900s to the mid-1980s. The environmental movement that intensified with Earth Day 1969 has had important braking effects on timber management. The Payette National Forest provides an example. A series of rain-on-snow events along the South Fork Salmon River<sup>10</sup> caused mass wasting associated mostly with roads in the area. The South Fork area has a high proportion of lands in the Idaho batholith, a granitic mass with a shallow soil mantle that erodes easily when exposed (USFS 1988). The resultant bedload movement into streams, especially into the South Fork Salmon River itself, caused public outcry that, together with actions of management professionals, led to a moratorium on logging in the South Fork area. For all practical purposes, that moratorium remains in effect.

The closure of the eastern side of the Payette National Forest to logging resulted in very intensive logging in the western side of the forest, in areas that drain to the Weiser River. Volcanic parent materials strongly influence the western portion of the forest (about 27% of the

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<sup>10</sup> Outside the watershed upstream of the HCC, but useful as an example in the present context.

total Payette National Forest area). Those soils are less erodible than granitic soils, and they are more fine textured and productive.

Logging intensity was high in the mid-1900s in the Boise National Forest, as in other forests of the Snake River basin having marketable timber. Attempts to road and log roadless areas led to deadlock in Congress. The status of many unroaded areas remains in limbo, neither wilderness nor managed for timber harvest. Recently, the USFS placed a temporary moratorium on road building in western national forests. The Clinton administration declared the moratorium permanent in many areas (excluding, however, certain highly productive forest lands in northern California and Alaska). Allowable cuts<sup>11</sup> in national forests of the Snake River basin have declined sharply. Although the USFS (1988) stated a plan to harvest 81 MMBF per year for the next decade, harvests have been much lower because of litigation and Section 7 requirements of the Endangered Species Act. Harvest in the first five years averaged 65 MMBF, and only 41 MMBF in 1992 (USFS 1993).

Over the last 100 years, fire control throughout the Snake River basin has been diligent, even overly zealous. As a result, overstocked stands have developed that are of relatively lower vigor than would exist if wildfires of the prehistoric period and early 1800s had continued. Those fires resulted from lightning strikes and from intentional burning by Native Americans. The lower-vigor stands resulting from fire suppression are susceptible to insects and disease.

At least four fundamental causes underlay diligent fire suppression. The first was the desire to use forests for timber harvest. The second was a perceived need to protect private investment in structures dispersed in forest lands. The third was a perception that fires were wasteful. The fourth, perhaps grounded in the first three, was the “oversell” of Smokey the Bear, a symbol of vigilance and fire control. Regardless of which of the four factors governed, the net effect was a buildup of combustible fuels. The effects of zealous fire control became apparent as overmature timber died, increasing fuels, and as disease and insects killed timber tracts, leaving even more dead fuel. The Yellowstone National Park fire in the last decade provided a textbook example of the effects of fire after fuel buildup. When drought periods strike, those fuels become vulnerable to catastrophic fires like some of those in the last decade in the Payette and Boise National Forests.

In prehistory and in the first half of the 1980s, fires were endemic, burning sometimes in one basin, sometimes in another, and burning until fall rains extinguished them. The result was a mosaic of mature timber in climax forests and in early seral and mid-to-late seral communities. In mature ponderosa pine forests, for example, periodic fire kept underbrush from accumulating. Many areas that once supported those mature stands now consist of thick accumulations of overstocked true fir, lodgepole pine, and ponderosa pine. Fire burned with lower intensity than now occurs because fuel buildup was consumed in fire mosaics.

Excessive fuel buildup promotes hotter burns. Soils become more vulnerable to surface erosion and to rain-on-snow events that cause mass wasting. The net effect on streams is increased

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<sup>11</sup> Allowable cut was once based on the ability of forested lands to grow wood on a sustained-yield basis. It has come to mean a much lower timber removal consonant with other multiple uses, for example, recreation.

recruitment of fine sediments. The upper portion of the South Fork Payette River provides dozens of examples of mass wasting that followed intense fires in the last decade.

The USFS (1998) carefully described past actions that affected present condition of forested lands in the Payette National Forest:

Historically, the vegetation looked very different.... [B]efore Europeans came to this area, fire played an important role in shaping the species composition, ages, and patterns on the landscape. Fire was both natural and a tool used by Native Americans to influence vegetation and wildlife. Insects and diseases were also part of the natural processes...[,] although they were generally at low levels.

Fires were more frequent at the lower elevations and on south-facing slopes with perhaps a 5 to 20 year cycle. These...tended to be of low intensity, keeping the understory relatively free of vegetation, including young trees. These conditions gave rise to some stands with few trees per acre that tended to be older and larger.

In the low-lying area in the bottom (Paddy Flat), lodgepole pine was the dominant species. Able to withstand the colder temperatures, lodgepole survive where ponderosa pine and Douglas-fir cannot. On slight rises...there would be some relief from the cold, and pockets of ponderosa pine and Douglas-fir could become established. Englemann spruce could also be found in the bottoms of the draws.

On north slopes at the mid-elevations, denser stands of Douglas-fir and grand fir could be found.... Fires in this area and in the low-lying areas described above, tended to be spaced at longer intervals and were generally stand-replacing. Frequencies of 100 years in the lodgepole and 200 years on the north slopes were more normal.

The 1915 Land Classification status report...gives a description of...vegetation...at that time.... The area that supported commercial timber was covered by stands of mature lodgepole, relatively old and large. This would indicate a relative lack of fire.... [O]ther areas of the forest show vast areas burned, up to 25% of a Township (36 sq. mi.).... [The U.S. Forest Service started fire suppression about this time]....

In the early 1800s, the area must have looked different than it did in 1915. Many of the stands described as mature, even-aged lodgepole in 1915, must have been mostly seedlings or saplings in 1800. Large stand-replacing fires must have occurred....

By the 1950s, fire was largely kept out of lower-elevation, more accessible areas. But fire continued to burn with greater frequency in higher elevations. Fire suppression made grand fir a more important stand component.

The descriptions of fire effects on vegetation and long-term changes would be pertinent for other high-elevation forests like the Boise and Wallowa-Whitman National Forests.

Most studies of the effects of timber harvest on anadromous fish have examined environments west of the Cascades. However, Spence et al. (1996) note: "In eastside systems, canopy removal, loss of physical structure, and increases in sediment loading may have greater ecological impacts

on salmonids because different factors may limit production (e.g., summer temperatures, pool habitats).” Results reported in McIntosh et al. (1994 and 2000) support that opinion. McIntosh et al. (2000) concluded that management emphasis and human activities clearly influenced habitat conditions in pools in the interior Columbia River basin. They found that the persistent effects of human activities have simplified stream channels and reduced large- and deep-pool frequencies in watersheds outside of designated wilderness and roadless areas.

Radiation reaching the channel of an unshaded stream in eastern Oregon (John Day River tributary) was found to be six times higher than that in an adjacent well-shaded stream (Li et al. 1994). Trout biomass was negatively correlated with solar radiation. Li et al. (1994) reported that “In a study of cumulative effects of riparian disturbance by grazing on the trophic structure of high desert trout streams, watersheds with greater riparian canopy had higher standing crops of rainbow trout..., lower daily maximum temperatures, and perennial flow.”

## 2.4. Agriculture and Irrigation

Farming followed closely on the heels of mining. Bancroft (1980) notes that “Little was expected from farming by the pioneers; but land that in 1877 was a wilderness of artemisia (big sagebrush) was soon covered with fields of golden grain; and some of the finest orchards on the Pacific coast sprang up in Ada county. The agent which wrought this change was water.” The farming history of the Snake River basin connects inextricably with the development of irrigation, mostly with gravity canal systems that depended initially on diversions from tributary streams and springs. An example of this sometimes ingenious process was provided in W. Love’s description of his grandfather’s stream diversion sometime before 1900 in Colton (1986):

He had been thinking of building a reservoir to irrigate land on which the family had filed in the lower Powder Valley. In fact, he had picked out a probable site at the lower end of Pritchard Flat. He started by building a ditch to bring water from Lawrence Creek and Love Creek to the reservoir site. The ditch came around the hills on both sides to just above where the dam would be. The ground was plowed straight downhill from the end of the ditch to the dam, and a small dyke was built across the draw at the lower edge of the dam. The water was used to wash dirt downhill into the dam with a movable flume at the lower end to place the silt where it was needed.... A horse-drawn scraper borrowed from the county was used to build up the dyke as the dam progressed.... [I]t took two or three years to build the reservoir.... [W]hen it was finished the reservoir covered 120 acres.... [L]ater the dam was raised.... [T]oday the lake covers over 160 acres.

Later, dams provided the head needed to irrigate higher-elevation lands of the Snake River plain. Pumped-water irrigation came later. The storage and head-control irrigation dams radically changed the limnology of the Snake River. For example, Milner Dam, completed in the first decade of the 1900s, for many years passed only 10 cubic feet per second (cfs) through a leak in the structure during the irrigation season. River flow below the dam exceeded leakage only when Snake River inflow to Milner Reservoir exceeded storage capacity. More recently, flows in the peak irrigation season have been 200 to 300 cfs (USEPA 1996).

Irrigation has a 150-year history on the Snake River Plain. The first reported irrigation in the area was in 1843 adjacent to the Boise River (Goodell 1988). In the early 1900s, irrigated acreage expanded rapidly with provisions of the Carey Act of 1894 and the Reclamation Act of 1902. These regulations facilitated transfer of public lands to individuals and provided financing for large-scale reclamation projects.

The Twin Falls Project was developed under the Carey Act. Diverting water at Milner Dam, the project took the water about 40 mi to lands north and south of the river. Within 10 years, more than 300,000 acres were irrigated by the Twin Falls Project. The Boise and Minidoka projects, under the Reclamation Act, began in the first decade of the 1900s. By 1929, irrigated acreage stabilized at about 2.2 million acres. By 1945, irrigated area increased to about 2.5 million acres. The 1950s and early 1960s saw rapid groundwater development. At present, total irrigated area has stabilized at about 3 million acres. High-lift pumping from deeply entrenched reaches of the Snake River has increased. From 1965 to 1975, such pumped withdrawals increased about eightfold. By 1980, pumped water withdrawals accounted for about 90% of diversions from the Snake River downstream of Milner Dam. After the 1970s, higher power rates made water conservation important, and sprinkler system use expanded (Goodell 1988).

By 1900, the Boise Valley had 96,652 acres under irrigation, supplied from 568 mi of ditches that carried mostly Boise River water, with minor contributions from small tributaries in the lower valley (ISHS n.d.). Fish screens were nonexistent on irrigation ditches. Pearson (1921) noted that "There was considerable complaint from the vicinity of Cambridge (Weiser River) by the loss of fish through irrigation ditches and a visit was made there about June 1st. The fact that all of the ditches were involved and the loss in one ditch no greater than in any other, made the problem of screening too expensive and therefore nothing was done."

While the increased use of sprinkler irrigation has reduced water demand, sprinkler use has increased problems in canal systems. The systems were designed for gravity delivery and flood or furrow irrigation. When sprinkler pumps shut down, the smaller, lower laterals and ditches cannot handle the increased volume of water. Thus, sprinkler operators are usually asked to continue diverting at a constant rate (IWRB 1993). About 60 to 70% of northside tracts and only about 20% of southside tracts between Milner Dam and King Hill are sprinkler-irrigated.

As irrigation increased, so also did groundwater discharge from Milner Dam to King Hill, rising from 4,200 cfs in 1905 to 6,800 cfs in 1951. The increased spring flow was recharge from surface-water irrigation north and east of the springs. After 1950, groundwater recharge began declining in response to increased irrigation from groundwater. Also, more efficient distribution systems reduced water applied to fields, and conveyance losses declined. Between 1951 and 1980, spring flows to the Snake River between Milner Dam and King Hill decreased by about 600 cfs, or nearly 10% (Goodell 1988).

From 1965 to 1980, offstream water uses associated with food processing and aquaculture increased sharply. By 1980, nearly 2 million acre-feet of water, mostly from groundwater, were withdrawn for commercial and public fish farms. Idaho produces about 90% of processed rainbow trout in the United States, plus channel catfish, coho salmon, and cutthroat trout. Aquaculture consumptively uses only about 1,000 acre-feet of water because of evaporation. Nonindustrial public withdrawals in 1980 amounted to 22,000 acre-feet, rural domestic and

livestock withdrawals amounted to about 11,800 acre-feet, and the Idaho National Engineering and Environmental Laboratory consumed about 3,900 acre-feet.

Irrigation withdrawals centering around 1950 totaled about 15.4 million acre-feet. By 1980, withdrawals had increased to about 17.5 million acre-feet. Consumptive use in 1960 amounted to 5 million acre-feet, and by 1980 had increased to 6.3 million acre-feet. Other consumptive uses amounted to another 290,000 acre-feet (Goodell 1988). The net effect of increases after the mid-1950s was to decrease instream flow of the Snake River by roughly 1.5 million acre-feet.

As spring flows from the Snake River aquifer entered the river between Milner Dam and the mouth of Salmon Falls Creek, discharge of the Snake River again rose in the 1950s to about 7,000 cfs (Irving and Cuplin 1956). Between Salmon Falls Creek and Bliss Dam, the flow again increased to about 9,000 cfs. Between Bliss Dam and Walters Ferry, the flow again rose to about 10,000 cfs. The spring flows from the aquifer substantially derive from mountains to the north of the Snake River. The flows travel southward, and many sink into the substrate, to appear again as springs in coves along the main Snake River. Between the mouth of the Henrys Fork and the Malad River, a distance of 250 mi, no live streams flow across the surface of the Snake River plain on the north side of the Snake River.

The spring flows along the Snake River gave birth to the commercial trout hatcheries that abound there today. The first of many fish hatcheries began operations in 1885. Commercial fish production gained a strong foothold with a large rainbow trout hatchery at Clear Lakes.

The gradient of the Snake River between Salmon Falls Creek and Walters Ferry equals about 4.5 ft per mi, or 0.085%. Lava constrictions cause higher gradients in several locations, so that much of the river length has an even lower gradient (Irving and Cuplin 1956).

The use of irrigation expanded through the first half of the 1900s. The irrigated developments upstream of Oxbow Dam site increased from 2,278,000 acres in 1928 to 3,072,000 acres in 1960, and they were predicted to increase to 3,886,000 acres by 2010 (Water Management Subcommittee 1957). Most of the expansion between 1928 and 1960 occurred upstream of King Hill, with lesser acreage increases in the Payette and Owyhee river basins. By 1960, reservoir storage capacity had reached 5,154,000 acre-feet upstream of King Hill; 784,000 acre-feet in the Owyhee River; 1,192,000 acre-feet in the Boise River; 265,000 acre-feet in the Malheur River; 79,100 acre-feet in the Weiser River; and 25,200 and 17,400 acre-feet, respectively, in the Burnt and Powder rivers.

Agricultural withdrawal of Snake River and tributary flows has several ecological effects (USEPA 1996), including excessive algal and vascular macrophytic production, exceedance of water quality standards for phosphates and temperature, decreases in native aquatic species, and growth of pollution-tolerant and exotic aquatic species. The dense growth of plants indicates a system overly enriched with nutrients. As plants expand their biomass, water velocities decrease because of friction, and fines deposit among them, creating even better substrate for plant establishment.

Some exotic fishes have prospered in the nutrient-enriched middle Snake River, for example, carp (*Cyprinus carpio*). Channel catfish (*Ictalurus punctatus*) and tilapia (*Tilapia mozambica*),

*T. zillei*, and *T. nilotica*) occur infrequently. Nonnative invertebrates (*Potamopyrgus antipodarum* and *Corbicula fluminea*.) have invaded (USEPA 1996).

In the middle Snake River between Milner Dam and King Hill, 227,000 hectares (ha) is irrigated with water from the Snake River, and another 150,000 ha is irrigated with aquifer water. Nutrient-enriched water returns to the Snake River from 13 streams and over 50 surface drains. There are 140 private fish hatcheries and 4 state and federal ones in the area (USEPA 1996). Point sources of pollution include one municipal sewage treatment plant and 600 dairies and feedlots. The USEPA (1996) estimated that animal feeding operations between Milner Dam and King Hill deliver waste equivalent to that of a population of 5,000,000 humans.

Erosion is serious on many surface-irrigated lands in the Snake River basin. Gooding and Jerome counties each had more than 20,000 ha, with erosion rates that exceeded 1.8 metric tons per year (tons/yr). Twin Falls County had 2,000 to 20,000 ha, with erosion greater than the latter level, depending on the year. Perrine Coulee, a 35-mi<sup>2</sup> drain system that began as a natural drainage but was modified by canals and drains, provides an example of pollution by sediments and nutrients. The Perrine Coulee delivered 7,322 tons of sediment to the Snake River during the 1985 irrigation season. Inorganic nitrogen and total phosphorus exceeded recommended limits in the Perrine Coulee in summer. Fecal coliform bacteria exceeded limits (Clark 1987).

Surveys of the Snake River between Adrian, Oregon, and Weiser revealed that all of the streams evaluated (Owyhee, Malheur, and Boise rivers and mainstem Snake River) carried excessive loadings of sediments from irrigation return waters (OSSA and ISDH 1964). Algal blooms were extensive, implying income of agricultural fertilizers. Two grossly polluted areas were found: bacterial slimes blanketed the bottom in the Snake River on the Oregon side downstream of Ontario and in the Payette River downstream of Payette. Fish populations of the Malheur and Weiser rivers, and possibly the Owyhee River, were considered to be limited by high turbidities. However, all waters were considered to be capable of maintaining warmwater fishes.

## 2.5. Hydroelectric Dams

Five hydroelectric dams have been constructed on the main Snake River between Shoshone Falls and Brownlee Reservoir: Upper Salmon Falls (1932, RKM 936), Lower Salmon Falls (1949, replacing an earlier dam built in 1907, RKM 922), Bliss (1948, RKM 903), C.J. Strike (1952, RKM 792), and Swan Falls (constructed in 1901 at river kilometer [RKM] 737). “Firm power”<sup>12</sup> is produced at Upper Salmon Falls Power Plant. Load following<sup>13</sup> is practiced at Lower Salmon Falls, Bliss, and C.J. Strike dams. Swan Falls Dam re-regulates the river, reducing fluctuations in flows arriving at the pool.

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<sup>12</sup> Power generation that is constant, or dependable.

<sup>13</sup> Operation of a power plant that manipulates generation levels to meet changing daily customer demands for electricity.

All five hydroelectric dams between Brownlee Reservoir and Salmon Falls Creek present obstacles, in varying degrees, to upstream movement of migrating fish (Irving and Cuplin 1956). In the sense of reducing survival for potential downstream migrants, all the dams also constitute partial obstacles to juvenile fish, although Irving and Cuplin (1956) suggested that the dams “do not present much of an obstacle to the downstream movement of fish less than a foot long.” Irving and Cuplin (1956) stated that the only adult passage was at Swan Falls Dam, where a few steelhead managed to negotiate the fish ladder built in 1922 (Jones 1922). Irving and Cuplin (1956) blamed poor attraction flows at fishways for the failure of fish to find entrances of even relatively efficient fishways like those at Lower Salmon Falls. Flow at Swan Falls fishway is intermittent. No fishways were provided at Bliss or C.J. Strike dams.

The first dam constructed on the Snake River appears to have been a 19-ft high structure at Swan Falls, built by the Trade Dollar Consolidated Mining Company of Silver City. Van Dusen (1903) noted: “This dam acts as a complete stop to the salmon and affords a very good opportunity for work (egg takes) being carried on below it.” An experimental egg-taking station was in fact operated at the dam in 1902. The results were not very encouraging. About 544,000 eggs were taken, with 30,000 fry planted in the Snake River and 427,000 eggs shipped to a hatchery in Clackamas County, Oregon. In 1903, the egg-take was moved to Ontario, behind Morton Island, where two racks were installed about 1,500 ft apart. Salmon were passing before the racks were installed on August 25th. By spawning time, biologists had captured “between twelve and fifteen thousand salmon, all chinooks...[and] succeeded in taking 21,065,800 eggs.”

## 2.6. Pollution

Pollution has plagued the main Snake River from the latter quarter of the 19th century onward. The earliest serious pollution probably began with placer mining (Murphey et al. 1993). Casey (1959) documented over 30 sources of pollution that drained directly to the middle Snake River. Most of these were raw sewage and wastes from potato production and processing, dairies, and meat and other processing plants.

In addition, Casey (1959) listed 14 sewage or plant-waste sources in the area from Weiser to Grand View. Tributaries bore heavy pollution loads. Casey (1959) listed raw sewage delivery to the Weiser River from Council and Cambridge. He noted raw sewage delivery to the Payette River from McCall, Cascade, Emmett, New Plymouth, and Payette, as well as plant wastes and rotten produce from Emmett and plant wastes from two sources in Payette.

In the Boise River, Casey (1959) found many pollution outfalls, including milk wastes (1), plant wastes (13), sewage (9), herbicides (3), oil and grease (1), animal wastes and blood (5), sugar wastes (1), cannery wastes (1), and feed yard wastes (4). There is little doubt that Casey did not find all sources of pollution. For example, herbicides and oil and grease were undoubtedly delivered (and probably are still delivered) to the river sporadically by many parties. Nonpoint source delivery of fine sediments and nutrients in irrigation water returns were not noted.

Conway Gulch is a tributary to the Boise River at Notus. The results of a survey of pollution from Conway Gulch illustrate the agricultural loading that occurs in irrigation return waters (Clark and Bauer 1982). A total of 12,880 critical erosion acres were found in the drainage area

of the gulch. Baseline suspended sediments at the mouth of the gulch were 6,083 tons/yr over 6 years. The gulch annually delivered 9.8 tons of total phosphorus, of which 50% was attributed to agriculture; and 110 tons of inorganic nitrogen, of which 21% was directly attributed to agriculture.

Conway Gulch was reexamined in 1988–1989 to determine whether BMPs (best management practices) implemented since the report of Clark and Bauer (1982) had reduced pollution. Sediment delivery remained over 6,000 tons/yr (Ingham 1993). Bacterial density continued to exceed state water quality standards. Nutrient levels still exceed criteria for prevention of eutrophic conditions. Conway Gulch remained a major source of sediment, nutrients, metals, and bacteria to the lower Boise River, even with 35% of critical areas under some form of treatment.

Evaluations of other drains of the lower Boise River (Sand Hollow, Dixie, Ross East, and South Boise) revealed similar pollution loadings. Sand Hollow Drain annually delivered 11,040 tons; Dixie Drain, 11,900 tons; and South Boise Drain, 3,260 tons (Clark and Bauer 1983). Total phosphorus loads for the respective drains were 51, 85, 11, and 17 tons/yr, respectively. Water temperatures occasionally reached 22 °C, and the drains were considered to be “marginal” with respect to their ability to support coldwater biota.

Pollution was rampant along the Boise River in the first half of the 20th century: “Boise used to be awful polluted. In fact, all the sewers used to empty into the Boise River.... [B]eyond the Fairview bridge, there used to be a slaughterhouse down in there. They’d kill animals and butcher them. They’d pour the remains into the river down there” (Moser 1986). After Webb and Casey (1961) investigated water quality in the Boise River between Lucky Peak Dam and Parma, they classed the river as “polluted” from the Boise sewage treatment plant to Eagle, as well as from Caldwell to Parma, because of a combination of low winter flows and organic and inorganic wastes. Webb and Casey (1961) and Casey (1959) worked only in Idaho. The Owyhee, Malheur, and Powder rivers all had similar pollution problems that contributed to reduced water quality in the main Snake River.

Rock Creek near Twin Falls delivered raw sewage from Twin Falls; sugar wastes; animal refuse from packing companies (Casey 1959); and a heavy load of irrigation return water with fine sediment, plant nutrients, and probably pesticides. Cedar Draw Creek delivered sewage from Filer; Sewer Creek carried raw sewage from Buhl. Again, the undocumented pollution probably exceeds that noted by Casey (1959). Pollution sources upstream of Twin Falls were also many and varied. The result of sewage, plant waste, and nutrient income from multiple sources in the 1950s and later was a river with severe eutrophy and a dissolved oxygen sag in the early morning hours (Hill 1990a).

The USEPA (1996) evaluated the middle Snake River, including 22,326 km<sup>2</sup> downstream of Milner Dam, and identified three culturally augmented stressors: flow alteration, sediment loading, and nutrient loading. Effects of flow alteration include the following:

- Changed timing and quantity of freshwater inputs
- Reduced downstream flushing

- Siltation on gravel bars and riffles
- Erosion of the streambed and scouring in tailwaters of dams
- Increased deposition in areas of low water velocity, resulting in formation of vascular macrophyte beds and reduced fish spawning habitat
- Increased downstream temperatures
- Reduced downstream dissolved oxygen
- Altered velocities

The USEPA (1996) states that “the ecological integrity of the Mid-Snake River ecosystem is severely stressed by reductions in flow. This is a particularly acute problem in the spring and summer...” IDHW-DEQ (1989) listed the Snake River from C.J. Strike Reservoir to Swan Falls as not supporting salmonid spawning, but as supporting (though at risk) domestic and agricultural water supply, coldwater and warmwater biota, and primary and secondary contact recreation uses. The major pollutant in this stretch of river is sediment from irrigation return water. Whitefish kills have been common in the Swan Falls area in summer, apparently caused by high water temperatures.

Pollution can come from rangelands. Studies in Reynolds Creek watershed revealed that the occurrence of fecal coliforms was directly related to the presence of cattle on summer range and winter pastures. Fecal coliform counts in adjacent streams increased soon after cattle were turned in, and counts remained high for several months after cattle were removed (Stephenson and Street 1978). Rainstorm runoff increased total and fecal coliform concentrations in streams on summer range. However, streams do self-purify if recruitment of coliforms ceases at downstream points.

As noted earlier in this chapter, nutrient pollution in the middle Snake River has enhanced macrophyte beds there. Water in the beds has dissolved-oxygen levels that fluctuate between 1.0 and 12.0 milligrams per liter (Hill 1990a). Although rapids can reaerate oxygen-poor water in the reach, oxygen declines between rapids, especially at night. Adverse dissolved-oxygen levels limit salmonid fish habitat and populations in this reach of the Snake River. Fine sediments dominate in 70% of the channel in the middle Snake River (Platts 1990). The only action that would immediately alter this condition is increased river velocity. Reduction of sediment input from hatcheries and irrigation water returns would be required in the longer run. Platts (1990) recommended sediment-flushing flows in the normal spring high-water period, combined with cleansing flows in the summer biotic production period “to improve conditions in this badly-degraded stretch of the Snake River.” Current velocities in excess of 1 mps would be required in the summer growing season to reduce macrophytes (Hill 1990b).

The observations of Hill (1990a,b) and Platts (1990) were made during the 1986–1994 drought period in Idaho. Recent higher-flow years have dramatically reduced macrophytes (IPC, unpublished data).

## 2.7. Channelization

Irizarry (1968) documented stream alterations caused by riprap, channel clearance, road and railroad encroachment, and agriculture. Much of his documentation refers to the Boise and Payette river basins, but channel alteration is ubiquitous in every watershed upstream of the HCC. Irizarry (1968) found 7 times more catchable-size trout and over 60 times more whitefish in unaltered sections, as compared with altered reaches. Biomass of game fish was about 14 times greater in natural reaches.

Channelized stream sections along railroad and highway rights-of-way altered more than stream structure and riparian communities. Along Idaho Highway 55, one can find many areas where mass soil wasting has occurred because the soil mantle was cut at the rail or road grade. The wasting extends well uphill, exacerbated by overgrazing and livestock trailing on steep slopes. Until very recently, soil deposited on the rail or road grade at many (if not most) of these sites was side-cast into the active stream channel. Side-casting was a common practice on road and rail grades throughout the Snake River basin. It was simply the easiest way to dispose of soil and debris.

## 2.8. Water Temperature

The main Snake River from Brownlee Reservoir to C.J. Strike Dam supports a fishery for smallmouth bass, channel catfish, and white sturgeon (Moore 1986). Temperatures in summer make the reach unsuitable for rearing anadromous fish. Though Moore (1986) reports that from C.J. Strike Reservoir upstream, “Trout habitat in the main Snake River is good throughout most of the free-flowing reaches...[,]” his observation does not comport well with others of poor conditions for salmonids in the area of Kanaka Rapids. Here, irrigation return water brings high levels of nutrients and fine sediments to the river (Hill 1990a,b). However, salmonid rearing may be feasible from Banbury Springs to Bancroft, where spring flows enter the river.

Water temperature maxima recorded downstream of Swan Falls Dam in July ranged between 74 and 77.5 °F (23–25.3 °C) in the period 1954–1960. More recent spot maxima included 26 °C in 1977, a drought year (July 28); 28 °C in 1979 (July 20); 29 °C in 1992 (July 10). Maxima in 1997 did not exceed 24 °C. The maximum weekly average temperature (MWAT) at Swan Falls reached 23.3 °C in the first week of August 1997. High temperatures preclude use of the main Snake River by rearing salmonids in summer. Summer maximum water temperatures almost certainly were higher in the 1950s and remain higher today than they were in predevelopment times. Warming is a result of irrigation-reduced mainstem summer flows, warm irrigation water returned to the river (Dauble 1994), and tributaries warmed because of loss of riparian shading and reduced average water depth. As phosphates and nitrates reached the river in irrigation return water, aquatic plants flourished, creating dense mats in the free-flowing Snake River. An example of this effect can be seen near Kanaka Rapids above Bliss Dam (Hill 1990b). These plant mats absorb heat from the sun, contributing to temperature augmentation.

Evermann (1896) reported interviews in the mid-1890s that placed fall chinook spawning time in the first half of October near Upper Salmon Falls. Evermann’s notes on the condition of fish examined from seine catches suggest most spawning was complete by late October. Springs

downstream of Twin Falls moderated winter temperature of the main Snake River downstream of the springs to the point where large tributaries attenuated their influence.

Information on fall chinook carcasses found in the reach between Swan Falls Dam and Marsing for 1955 (IDFG 1955) suggests that spawning there ended in the second week of November. Live fish were still observed on November 16 in 1957 (Richards 1957). The onset of peak spawn times were not reported for those years; however, it appears that the onset was likely early to mid October. The spawn time would probably be similar today if fall chinook were to spawn in the main Snake River between Brownlee Reservoir and Swan Falls Dam. It would also be similar to present-day spawn time recently observed below Hells Canyon Dam (Groves 2001).

The lowest elevation that is suitable for stream rearing by salmonids has risen in tributaries to the Snake River. For example, Theurer et al. (1985) estimated that no spring chinook production could occur in the Tucannon River where mean daily water temperature for July exceeded 68 °F and the average maximum daily July water temperature exceeded 75 °F. They estimated that about 24 mi of the mainstem Tucannon River had been lost as usable habitat because of increased summer water temperatures and that the rising elevation of suitable temperatures had reduced adult productive capacity from 2,200 to about 900 fish.

Platts and Nelson (1989) hypothesized that deleterious effects of increased stream temperatures and temperature fluctuations limited trout in Great Basin streams and that increased primary productivity in open-canopy streams did not compensate for limiting effects of heat stress. Zoellick (1999) found densities and biomasses of redband trout were significantly greater in a well-shaded stream reach compared with those of trout in a reach having higher insulation and maximum stream temperatures. Trout density correlated negatively with maximum stream temperature in both streams.

One reason for the negative correlation of trout density with maximum stream temperature may involve the interaction of trout and fish species that tolerate warmer water. Reeves et al. (1987) reported that redband shiner and juvenile steelhead competed for habitat and that warmer water favored shiners. Production of trout decreased in warm water (19–22 °C) in the presence of shiners. Cyprinids and suckers that adapted to warm water increased in warmer, unshaded reaches of streams in the John Day River basin (Tait et al. 1994). Hillman (1991) found that redband shiners prospered better than chinook salmon as temperatures increased.

## **2.9. Summary of Habitat Changes as a Result of Development**

Murray (1964) succinctly summarized the effect of human activities on the Snake River system:

Total effect, or impact of present day civilization, or white man's activities on the Snake River drainage from Shoshone Falls downstream has been such as to alter the biological regime of the entire stream from tributary headwaters to the confluence of the Salmon River. Every drainage has been changed or influenced by domestic livestock, farming, timber cutting, fire and controlled burning, dam building and water diversion. Return flows from the several areas of human occupancy of land and multiple water uses

have contributed to the loading of streams with diluents of many types. The down grading of these drainages has been constant and cumulative for most of the present century. This has proceeded at an accelerated rate during the past 20 years as human occupancy has increased and the discharge of human and industrial wastes has multiplied.

Murray (1964) could have added mining to the litany of human activities, but his statement is certainly correct.

In 1894, McDonald (1894), in an overview of the state of salmon fisheries in the Columbia River basin, wrote: "The area of natural distribution has not as yet been very materially abridged. Certain streams, such as the Bruneau and the Boise, have been obstructed by dams near their mouths, but the vast extent of waters still accessible to salmon and affording suitable breeding and feeding grounds, indicates that we must look to other causes to explain any ascertained deterioration in the salmon fisheries of the Columbia."<sup>14</sup> The "other causes" referred to were fishing.

Development may have affected the various runs of anadromous fish with somewhat different consequences. Diversion dams and withdrawals for irrigation were more damaging to spring/summer chinook salmon than to steelhead. Steelhead adults migrated into tributaries to the Snake River mostly from February through June, before the irrigation season began. They could pass obstructions as freshets began and before diversion dams were heightened with boards. Also, they spawned late in the spring, before streamflows dropped sharply. Spring chinook began to appear in May, but moved mostly during the descending limb of the hydrograph, when irrigation was beginning. In some streams they moved into spawning sites in late July and early August. Therefore, they were more vulnerable to reduced streamflow, especially in low-flow years (Hauck 1961). Both species, but perhaps spring/summer chinook to a greater degree, were diverted as juveniles into irrigation ditches where they perished.<sup>15</sup> Fall chinook, while less affected by irrigation water withdrawals because of their mainstem spawning area in the Snake River, were more vulnerable to high water temperatures. Lamprey juveniles, which spend several years as ammocoetes in the stream substrate, and therefore were less mobile, may have suffered greater mortality from tributary dewatering than did salmonids.

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<sup>14</sup> While McDonald was correct in the larger view, habitat excision and degradation was certainly underway. For example, salmon and steelhead could very likely not use Mores Creek on the Boise River as a result of mining influences that began in 1863. The upper Burnt, Powder, and Malheur rivers were suffering from mining, and open ditches were sending juvenile chinook salmon and steelhead into fields to perish in alluvial valleys suited for irrigation or through hydraulic systems for sluicing hillsides. Many spawning grounds were already excised in the Snake River basin by irrigation diversion dams or degraded by fine sediments, in part from mining and in part from livestock and logging. The fish least affected by these activities were fall chinook, which spawned in big water less affected by development.

<sup>15</sup> Steelhead tend to penetrate farther upstream into higher gradients, and thus their progeny may be relatively less likely than chinook juveniles to encounter irrigation diversions when they move to rearing habitat. This may explain why steelhead persisted with greater numbers longer than chinook salmon in many streams (e.g., in Pine Creek, Oregon).

As a final comment on priorities, it is worthwhile to mention that an extensive literature exists on the development of minerals, mining, livestock ranches, irrigation, roads and rails, and hydropower. By contrast, the development and protection of fish and wildlife resources received little or no attention in the Snake River basin before the 1950s. For example, a history of the Malheur country (Malheur County Historical Society 1988) provides no information on salmon and steelhead runs and their disappearance. Similar historical treatments of other portions of the Snake River basin go to great length to describe economic development, especially from minerals, mining, grazing, and logging, but do not discuss fish and fisheries (Smith 1983). These disparities are understandable in light of the then-extant economic values and potentials of the various resources. Also, most fish runs were gone or all but extinct in most basins by the time authors got around to writing regional histories.

Anadromous fish, owned by no one and theoretically by everyone, a common-property resource, became victims of property ownership. Values in fish resources and fisheries were, in a broad sense, traded for private wealth in farms, ranches, mines, and hydropower. The first victims of development were Native Americans. Anadromous fish and fisheries followed. Fishing itself contributed to run depletion.

## 2.10. Fishing Effects on Fish Stocks

Authors as early as the late 1800s have commented on deleterious effects of fishing in the Columbia River.

We must look to the great commercial fisheries prosecuted in the lower (Columbia) river for an explanation of this decrease.... It is not a matter of wonder that, under existing conditions, there has been a serious deterioration in the value of these fisheries. It is, indeed, a matter of surprise that any salmon have been able to elude the labyrinth of nets which bar their course to the Upper Columbia. It is hardly an exaggeration to state that the entire volume of this great river is strained through the meshes of the innumerable nets which occupy and obstruct every passageway to the spawning grounds.... (McDonald 1894).

Rich (1941) stated:

The salmon of the Columbia River have supported an intensive fishery for over seventy years but are now showing unmistakable signs of depletion.... [T]he catch of chinooks has consistently declined during the past twenty years.... There are two main reasons for this depletion. First is the reduction in the area for spawning and rearing of the young fish that has come about through the advance of settlement and civilization along the tributaries.... But in addition to this, these fish have for many years been subjected to a very intensive fishery and without much protection....

Thompson (1951) clearly demonstrated the effects of overfishing on the productive late spring and summer segments of chinook salmon stocks in the Columbia River. The strong June–July catches of the mid-1870s had disappeared by 1919, a pattern distressingly similar to that of

declines in Karluk River sockeye salmon runs. In fact, the June–July catches declined well before 1919, leading to heavier fishing on early spring-run chinook salmon, coho, and steelhead.

Fishing emphasis did not shift to fall-run chinook salmon until after the turn of the century. In the 1870s, about three-quarters of the total catch consisted of the chinook salmon that entered the estuary in late spring and summer. By 1915–1919, about two-thirds of the total catch consisted of fall chinook salmon that arrived after August 1 (Chapman 1986). At the fishery peak, gear consisted of up to 1,200 gillnet boats, 45 fish wheels, 240 traps, and 40 beach seines. This list does not include fishing gear, chiefly dipnets, used by Native Americans at Cascade Locks and Celilo Falls, or gear employed by settlers and Native Americans in headwaters of the Columbia and Snake rivers. Early accounts mentioned fish taken by the wagonload. Fishing was prosecuted mostly with nets, but other methods, including dynamite, were used: “One blast of giant powder near the lower crossing (in Boise River) last week turned up over fifty pounds of fine salmon trout” (Idaho Statesman 1870, cited in Hart 1977). The newspaper printed in detail a guide for those who might want to try this “amusing pastime.”

One must bear in mind that the overfishing of the late 1800s possibly influenced observations of settlers, miners, and early biologists—and possibly affects the interpretation of data on fish timing and abundance obtained more recently. For example, summer-run chinook salmon, later extirpated by overfishing, may have been the fish observed by Townsend (1834) in the lower Boise River in mid-August. Those fish could have been holding in pools there, awaiting stimuli to move upstream onto spawning areas upstream of the present site of Boise. “Dog salmon” that spawned on riffles on the main Payette River near Montour may also have consisted of summer-run chinook salmon. There may, in fact, have been summer chinook in the mainstems of the Powder, Burnt, Malheur, Boise, Weiser, Payette, Owyhee, and Bruneau rivers. Both overfishing and, ultimately, habitat degradation would have eliminated the salmon by the early 1900s. Whether those fish were stream- or ocean-type chinook salmon remains unclear. It is likely that the fish graded from all stream-type in the high elevations to at least some ocean-type in the lower mainstems of tributaries in the predevelopment period.

The apparent disregard with which residents of the Snake River Plain viewed anadromous fish runs in the first 50 to 75 years of historical development may be explainable. Biological knowledge was limited, life was hard (especially before the advent of fossil fuels), and minerals and crops were obtained from the land with difficulty. Any connections made between what happened in the lower Columbia River and in headwaters regarding fishing and habitat were tenuous at best. To many early settlers, the fish runs must have seemed inexhaustible. Water for mines, then crops, and later for hydropower formed the real lifeblood of the territory. Delivery of water to the sites where it was needed in the high desert was of paramount importance. Thus, small dams, diversions, and water development were priorities. The gold standard governed monetary exchange, and therefore mining—though it was destructive to aquatic habitats—initiated settlement of much of the Snake River basin.

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Table 1. Condition of fish and riparian habitat that might be used by salmon or steelhead if anadromy were feasible within the Owyhee Resource Area. (BLM 1999b, adapted from Table RIPN-1, p. T-23)

Stream	Percentage of Fish Habitat Classified as “Unsatisfactory”	Percentage of Riparian Zones Classified as “Unsatisfactory”
	Differences in BLM (1999b) shown in parentheses	Differences in BLM (1999b) shown in parentheses
Big Boulder Creek	84	100
Cabin Creek	93	90
Castle Creek	73	100
Jordan Creek	100	100
Juniper Creek	89	85
Owyhee River	87 (75) <sup>2</sup>	nd
Middle Fork Owyhee River	100	100
North Fork Owyhee River	85 (51)	79 (62) <sup>1</sup>
South Fork Owyhee River	100 (nd)	nd
Pole Creek	100 (nd)	nd
Reynolds Creek	75	64
Salmon Creek	100	100
Squaw Creek	100	100 (98)

<sup>a</sup> The source of the difference between the 1996 draft and the 1999 version is unclear, but appears to result from allotment #05394. The 1999 version had 2.1 mi of stream with 2.1 mi in satisfactory condition, while the earlier draft had the same miles in unsatisfactory condition.

<sup>b</sup> The difference between the 1996 draft and the 1999 version (BLM 1999b) appears to be elimination from Table RIPN-1 of about 39 mi of habitat, most of it in unsatisfactory condition.

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