Introduction — Section 1

Now as in the past, The Deschutes River binds the people of central Oregon together. As the river drops from mountain headwaters to the west, south and east, and through the high desert plateau in the middle and lower watershed, it collects the voices and stories of many people. These people share a love for the Deschutes, though they value the river in many different ways. Some, such as the people of the Warm Springs Reservation, value the river as part of their cultural heritage. For farmers and ranchers, people who make a living from the land and its natural resources, the river provides an important source of water needed for sustaining livestock, forage and cultivated crops. For loggers and mill and factory workers, forests in the basin supply the crop and raw material for income and employment. And for a growing number of people who reside in and outside the basin, the mountains, deserts, rivers of the Deschutes Subbasin provide valuable and diverse recreational opportunities.

The voices of many of people throughout the Deschutes subbasin were heard during the subbasin planning process, and this report reflects their thoughts and ideas. These people face a common challenge. This challenge is to restore and/or sustain healthy fish, wildlife and plant communities, water quality and instream flows in the Deschutes watershed while respecting cultural diversity, strengthening our communities, and providing economic stability for present and future generations.

This Introduction section identifies key participants in the planning process. It summarizes the key opportunities presented for stakeholder involvement and describes the process used to develop the plan with regards to organization and participation. It also identifies the process and schedule for revisiting and updating the subbasin plan after it is reviewed and adopted by the Northwest Power and Conservation Council.

1.1. Planning Entities and Participants

The foundation for this subbasin planning process is the belief that the responsibility for success of subbasin planning ultimately lies with the people of the Deschutes Subbasin. Developing a workable subbasin plan requires commitment and cooperation among various stakeholders: fish and wildlife managers, tribes, governmental agencies and citizens.

With this in mind, the Deschutes Coordinating Group (DCG) became the key coordinating entity in the subbasin planning process. The DCG formed in 2001 with the primary purpose of addressing issues from a subbasin-wide perspective. The group recognizes that fostering communication between people with varying interests in the watershed is key to this effort. The DCG includes representatives from subbasin organizations, watershed councils, cities, counties, irrigation districts, state agencies, and federal and resource management agencies. All meetings of the DCG are open to the public and participation of others interested in the subbasin planning effort is encouraged.

The overall purpose of the DCG's planning efforts goes beyond the requirements of the Northwest Power and Conservation Council's subbasin planning process. The DCG seeks to develop a watershed restoration plan that identifies and prioritizes actions needed to:

- Protect and enhance streamflows to meet water quality standards, instream water rights, fish and wildlife habitat objectives and existing water rights;
- Maintain the resource land base in the subbasin, consistent with acknowledged comprehensive land use plans, and the economic viability of the resource-based economy in the subbasin;
- Meet municipal and industrial water needs over the next 50 years; and
- Promote sustainability and conservation consistent with the custom, culture and quality of life in the subbasin.

The Deschutes Resource Conservancy (DRC) served as fiscal agent for the DCG during the subbasin planning process. The DRC managed the contract between the DCG and the NPCC, as well as other required contracts for services needed to prepare the plan. The DCG also contracted with Wy'East Resource Conservation and Development (Wy'East) to handle outreach and communication, including meetings of the DCG.

1.2. Stakeholder Involvement Process

The organizational structure of the DCG allowed coordination with all the groups actively working on watershed restoration in the Deschutes Subbasin. It is broadly representative of subbasin citizens and their varying interests in the Deschutes Subbasin.

The DCG held monthly meeting across the subbasin to discuss the plan. All those interested in watershed restoration in the subbasin were encouraged to attend and participate and comment. All DCG meetings were publicly notices and a website was set up specifically for the subbasin planning effort. DCG meetings held during the last six months of the subbasin planning process focused on the plan. Individuals serving on the DCG took responsibility to assure that their organizations received regular updates on the planning process so that as many people as possible could track developments as they occurred. DCG members also took a lead in reviewing various sections of the subbasin assessment and plan for accuracy, and in developing the vision, biological objectives, management strategies, and potential actions. The Outreach Coordinator also met with local elected officials, watershed councils and others to keep them informed about the subbasin planning process and receive comments.

The DCG held a series of open houses near the end of the planning process to introduce the plan and receive public comments and suggestions on how it could be improved to meet the needs of the residents in the subbasin. They also distributed 47,000 flyers in newspapers across the subbasin describing the importance of the planning activity and opportunities participate through the open houses and DCG meetings.

Technical teams with participants from ODFW, the Warm Springs Tribes, and other state and federal agencies and technical experts provided regular review and direction during the planning process. These technical experts and other interested individuals met for several work sessions around the subbasin. They provided key information to characterize fish, wildlife and habitat conditions in different Deschutes subbasin drainages. They also commented on draft material through personal communication with members of the subbasin planning team.

Many individuals provided key information, insight and suggestions during the planning process. Although it is impossible to name all of the individuals who contributed, some of the most active participants included Clair Kunkel, Steve Marx, Rod French, Brett Hodgson, Don Ratliff, Clay Penhollow, Chris Brun, Nancy Gilbert, Kyle Gorman, Bonnie Lamb, Roger Prowell, Jennifer Clark, Jason Dedrick, Mike Gauvin, Jeff Rola, Robert Marheine, Daniel Rife, Eric Schulz, Gustavo Bisbal, Rick Craiger, Merlin Berg, Michelle McSwain, Leslie Jones, Patrick Griffin, Ryan Huston, Ted Wise, Peter Lichwar, John Hurlocker, Steve Johnson, Jan Lee, Marc Thalacker, Jerry Cordova, Phil Roger, Jim Nartz, Jim Eisner, Randy Tweeten, Josh Moulton, Chris Rossel, Fara Currim, Marvin Davis, Bill McAllister, Jim Bussard, Dan VanVactor, Hal Lindell, Kolleen Yake, Ellen Hammond, Kimberley Priestley, Gene McMullen, Herb Blank, Jonathan La Marche, Clint Jacks, Bruce Aylward, Glen Ardt, Chris Carey, Russell Johnson, Nate Dachtler, Mike Weldon, Bob Spateholts, Tom Nelson, Amy Stuart, Larry Toll and Terry Luther.

1.3. Overall Planning Approach

Subbasin Assessment Units

To help expedite the subbasin planning process, the subbasin planning technical team broke the subbasin into eight smaller assessment units that generally had similar climatic, hydrologic, biologic and geologic characteristics. The DCG reviewed and approved the assessment units as appropriate areas for assessment and planning. The assessment units often support different salmonid populations and life history characteristics because of their differing environmental conditions. The eight assessment units and their unique characteristics include

- **Lower Westside Deschutes Assessment Unit:** Lower Deschutes River from RM 0 to RM 100, the Warm Springs River and Shitike Creek, and all small tributaries entering the lower Deschutes River, except for Buck Hollow, Bakeoven, and Trout creeks. The assessment unit provides important spawning and rearing habitat for fall and spring chinook, summer steelhead, redband trout, bull trout and Pacific lamprey.

- **White River Assessment Unit:** White River watershed above White River Falls (RM 2). The assessment unit supports production of unique redband trout populations that are genetically and morphologically different from lower Deschutes redband trout. White River Falls prevents anadromous fish access to the assessment unit and isolates populations of redband trout and other resident fish above the falls from those downstream.

- **Lower Eastside Deschutes Assessment Unit:** Major Deschutes River tributaries draining the lower eastern portion of the Deschutes Subbasin, including Buck Hollow, Bakeoven, Trout and Willow creeks. Three of these systems —Buck Hollow, Bakeoven and Trout creeks — provide important spawning and rearing habitat for summer steelhead in the Deschutes Subbasin. All the tributaries also support redband trout.

- **Lower Crooked River Assessment Unit:** Lower Crooked River drainage below Bowman and Ochoco dams, including lower Ochoco Creek and McKay Creek. The assessment unit supports several resident indigenous fish populations, including redband trout. The Pelton Round Butte Complex blocks all anadromous fish access to the drainage.

- **Upper Crooked River Assessment Unit:** Upper Crooked River drainage above Bowman and Ochoco dams, including upper Ochoco Creek, north and south forks of the Crooked River and Beaver Creek. Redband trout are the only native game fish left in the upper basin and reside primarily in the headwaters of smaller tributaries located on forestlands.

- **Middle Deschutes Assessment Unit:** The 32-mile reach of the Deschutes River from the Pelton Round Butte Complex (RM 100) to Big Falls (RM 132) and its two major tributaries, Metolius River and Squaw Creek. . The two major tributaries in the assessment unit once provided important salmonid spawning and rearing habitat, and continue to provide important habitats for bull trout and redband trout populations. The drainages will provide important habitat for reintroduced salmon and steelhead when fish passage is restored at the Pelton Round Butte Complex.

- **Upper Deschutes Assessment Unit:** The upper Deschutes River drainage from Big Falls (RM 132) to Wickiup Dam (RM 222), including Tumalo Creek, Spring River, the Little Deschutes River and Fall River. Big Falls was historically considered the upstream limit of anadromous fish passage. The assessment unit supports resident redband trout.

- **Cascade Highlands Assessment Unit:** The Deschutes River drainages above Wickiup Dam, including the Cascade Lakes. The assessment unit supports redband trout. In addition, the Odell Creek/Odell Lake complex, which is also part of this assessment unit, supports a remnant population of bull trout that is the only known resident, non-reservoir, adfluvial population remaining in Oregon.

Several assessment units used during the subbasin planning process overlap ESA-listed summer steelhead populations identified by the Interior Columbia Basin Technical Recovery Team (TRT). The TRT identified demographically independent summer steelhead populations and habitat areas, which included two populations in the lower subbasin and the historic habitat of an extirpated population in the upper subbasin (Interior Columbia Basin Technical Recovery Team, 2003). The TRT Deschutes River Westside Population occupies the southern end of the Lower Deschutes Westside Assessment Unit. The TRT Deschutes River Westside Population occupies the Deschutes River from the Trout Creek confluence to the Pelton Reregulating Dam and includes Shitike Creek and the Warm Springs River system. The TRT Deschutes River

Eastside Population occupies the Deschutes River and tributaries from the confluence with the Columbia River to the mouth of Trout Creek, except for Warm Springs River. The steelhead habitat the TRT identified above Pelton Dam includes the Metolius and Crooked River systems, as well as the Middle Deschutes River up to Big Falls and Squaw Creek. The subbasin plan breaks this historic steelhead habitat into three assessment units – the Middle Deschutes (Metolius River/ Squaw Creek/Middle Deschutes River), Lower Crooked River system (between Lake Billy Chinook and Ochoco and Bowman dams) and the Upper Crooked (upstream of Ochoco and Bowman dams).

Fish Assessments

Five of the thirty fish species in the Deschutes River Basin have been chosen as aquatic focal species for this subbasin plan: Chinook salmon (*Oncorhynchus tshawytscha*), steelhead/redband trout (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), sockeye salmon (*Oncorhynchus nerka*) and Pacific Lamprey (*Lampetra tridentata*). The five species were selected by the Fish Technical Team, a group of fish and natural resource experts brought together to provide technical advice during the subbasin planning process. The team selected the focal species based on their significance and ability to characterize the health of the ecosystem and the effectiveness of management actions. The list of focal species was then adopted by the Deschutes Coordinating Group for use in subbasin planning. Criteria used in selecting the focal species included a) designation as a federal threatened or endangered species, b) cultural significance, c) local significance, and d) ecological significance, or ability to serve as indicators of environmental health for other aquatic species.

During the subbasin planning process, the technical team used the Ecosystem Diagnosis and Treatment (EDT) and Qualitative Habitat Assessment (QHA) analyses to compare focal fish species needs during different life stages with the conditions existing in various stream reaches. These tools helped to bridge the gap between descriptions of the environment and population performance. The analyses integrate knowledge of the environmental attributes critical to fish with species-specific environmental requirements, reproductive potential and life history strategies to predict the performance of a population subject to current, historic or hypothetical environmental conditions.

The EDT and QHA tools were used to rate stream reaches throughout the assessment units with current or historic anadromous fish habitat for restoration and protection values. Ratings denoted which stream reaches were in the most need for habitat restoration, or simply habitat preservation or protection. The EDT Diagnostic Reports provided finer resolution by noting the presence and severity of habitat limiting factors by summer steelhead or Chinook salmon life stage. These data provided direction for planners to develop draft management objectives, strategies and actions to restore production of focal fish species in these assessment units.

Wildlife Assessment

Focal wildlife species were selected by a team of wildlife biologists considering listed species, and by considering species of concern. Focal species were chosen to represent a “guild” of species whenever possible, for example, the sharp-tailed grouse could represent grassland species, and the sage grouse could represent shrub-steppe species. Seven species were selected: American beaver, Columbia spotted frog, white-headed woodpecker, mule deer, greater sage grouse, Columbia sharp-tailed grouse and golden eagle.

A short list of focal habitats was also selected to represent environmental conditions in the subbasin for focal wildlife species. Focal habitats were selected from the complete list of habitats in the subbasin by examining current habitats compared to historic (1860) habitats at the subbasin level, and selecting those habitats that were reduced significantly from historic acreages.

The wildlife assessment presents information at three different levels of detail for the subbasin: (1) subbasin, (2) assessment unit, of which there are 8 in the subbasin, and (3) hydrogic unit code (HUC) 6th level subwatersheds, at the 1:24,000 scale. There are 341 HUC6 fields in the Deschutes Subbasin (O'Neil p.c.). Focal habitat information for the subbasin was also compared to focal habitat information for the Columbia Plateau Ecoprovince, a larger study area that is made up of 11 subbasins including the Deschutes subbasin. Information from the Northwest Habitat Institute Interactive Biological Information System (IBIS) was used as the primary source of wildlife information for this assessment.

1.4. Process and Schedule for Revising and Updating the Plan

The completed subbasin plan will be reviewed and adopted as part of the Council's Columbia River Basin fish and Wildlife Program, and will help direct Bonneville Power Administration funding of projects that protect, mitigate and enhance fish and wildlife that have been adversely impacted by the development and operation of the Columbia River hydropower system. The Council, Bonneville Power Administration, NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) intend to use the adopted subbasin plans to help meet requirements of the 2000 Federal Columbia River Power System Biological Opinion. The NOAA Fisheries and USFWS intend to use the subbasin plans as building blocks for recovery of threatened and endangered species.

Further, the Deschutes Subbasin Plan is a living document and plan development will be iterative. Information and direction in the subbasin plan will be revisited and updated through the Northwest Power and Conservation Council's Rolling Provincial Review Process once every three years.

Subbasin Overview
Section 2

The rich landscape and unique flow regime of the Deschutes River subbasin provide a wide variety of habitats for fish and wildlife. Stable flows and habitats in the lower Deschutes River produce healthy salmon, steelhead and resident fish populations. They also support the seasonal migration and rearing habitat for fish produced in connecting tributaries — which often exhibit very different climates, geology and vegetative conditions, and produce fish populations that reflect these differences. Wildlife habitat conditions also vary throughout the watershed. These habitats range from alpine to semi-arid desert areas and support a wide number of big game and furbearing species, including elk, deer, antelope, black bear, beaver, mink, otter, and bobcat, as well as more than 100 species of birds.

The unique landscape of the Deschutes subbasin also attracts large numbers of human residents and visitors to the area. It is highly valued for its quality of life — offering wide, open spaces, a distinct heritage and sense of community, and access to vast natural resources and recreational opportunities.

This overview section looks at the physical, natural and human landscapes of the Deschutes Subbasin. It summarizes how humans have influenced the subbasin's aquatic and terrestrial environments. It describes the subbasin's existing water resources, including its hydrologic regime, water quality and riparian conditions. Finally, it projects hydrologic and ecologic long-term trends that will shape the Deschutes River Subbasin over the next fifty years.

2.1. Physical, Natural and Human Landscape

2.1.1. Location and Size

The Deschutes Subbasin stretches over 10,700 square miles of land in central Oregon. Covering 11 percent of Oregon's land area, the Deschutes River subbasin is larger than other Oregon watersheds, except the Willamette. The subbasin extends west to the crest of the Cascade Mountains, south to lava plateaus, east into the Ochoco Mountains and to the plateau between the Deschutes and John Day Rivers, and north to its confluence with the Columbia River (Map 1). Its length reaches 170 air miles from peaks in the Cascade Mountains to where it joins the Columbia River, 205 miles from the Pacific Ocean. In width, it extends up to 125 miles from the eastern slopes of the Cascades to the western slopes of the Ochoco Mountains, and over the high desert landscape that covers much of the subbasin's interior.

All or portions of nine Oregon counties are situated in the Deschutes watershed. These counties include Crook, Deschutes, Harney, Hood River, Jefferson, Klamath, Lake, Sherman and Wasco. Five of these counties — Crook, Deschutes, Jefferson, Sherman and Wasco — comprise most of the watershed. Larger population centers in the subbasin include Bend, Redmond, Madras and Prineville.

2.1.2. Geology

The landscape of the Deschutes Subbasin — it's volcanoes, cinder cones, lava flows, sandy soils, spring-fed streams, and deep canyons — speaks of the turbulent natural events that shaped the subbasin. The sedimentary, igneous and metamorphic rocks that define its shape range from more than 250 million years old to as young as 1,300 years old (O'Connor et al. 2003). These past activities established the overall northern course of the Deschutes River about 12 million years ago, and carved the present canyon of the lower Deschutes 4 to 1 million years ago (O'Connor et al. 2003). Continuous geologic activity has refined the shape of the Deschutes hydrologic system many times. Periods of mountain building and river relocating volcanic activity across the landscape have been interspersed with periods of erosion and sedimentation associated with glacial activity and stream runoff. Evidence of geological events over millions of years can be traced in the lava fields of the upper Subbasin and in the deep gorge of the lower Deschutes River.

Today, a mosaic of geological footprints forms the Deschutes subbasin. To the west and south, the Cascade Range, an active volcanic arc, molds the high, rugged subbasin rim. Volcanic activity along the crest and volcanic centers along the eastern flanks create a topography of young volcanoes and lava flows. These porous volcanic soils and lava formations absorb most snow and rain that falls on the Cascade Basin and create the large underground aquifer that give the Deschutes and several tributaries naturally stable flows throughout the year.

The eastern rim of the watershed displays some of the Deschutes subbasin's oldest geological roots. These Mesozoic (250 to 65 million years old) and Paleozoic (more than 250 million years old) rocks lay within the headwaters of the Crooked River and Trout Creek drainages. Deposits from the John Day Formation cover most of the Crooked River watershed, including much of the Ochoco and Mutton Mountains. Areas in this ecological province are characterized by extensively geologically eroded, steeply dissected hills of thick, ancient sedimentary materials interspersed with buttes and basalt capped plateaus.

The Columbia River Basalt Group underlies much of the northern, central and eastern parts of the Deschutes watershed (O'Connor et al. 2003). This basalt group, which creates many of the major ridges in the subbasin, is between 1,000 and 2,000 feet thick. Sections of these basalts form the rim of the Deschutes River canyon. Deposits of loess, volcanic ash and pumice from more recent events often cover the basalt flows. This semiarid lava plateau defines much of the Deschutes subbasin landscape.

2.1.3. Climate and Weather

While the headwaters of the Deschutes River and most major tributaries receive large amounts of precipitation, much of the subbasin lies in the rain shadow of the Cascade Mountains and is sheltered from western Oregon's heavy rainfall. Average annual precipitation amounts to more than 100 inches on the eastern slopes of the Cascades, mostly as snow, but drops to only 40 inches in the Ochoco Mountains and 10 inches at lower central locations. Consequently, while the Metolius drainage receives up to 50 inches of precipitation annually, the Bakeoven drainage receives only 10-12 inches.

The climate in much of the subbasin is considered continental, with low precipitation and humidity, large daily temperature fluctuations throughout the year, and high evaporation rates. Cold winters and hot, dry summers are common. Temperatures in the Crooked River watershed, for example, can exceed 100°F in summer and drop below -30°F in winter. The City of The Dalles, located near the subbasin's mouth on the Columbia River, is often the warmest location in the state.

2.1.4. Land Cover

The geology and climate of the Deschutes Subbasin create a diverse landscape of mountain forests, juniper and sage rangelands, rugged outcroppings and deep river canyons. Wetlands and riparian areas account for only a small portion of the subbasin's total acreage. Higher elevations in the subbasin display ponderosa and lodgepole pine forests, wet meadows and savannah-like mountain grasslands. Peaks range from above 11,000 feet in elevation in the Cascades to about 6,500 feet in the Ochoco Mountains. At these highest elevations, where climatic conditions are often extreme, plant communities include hemlock, alpine and subalpine plants. Mid-elevation lands in the upper subbasin support mixed conifer and ponderosa pine forests. Along the upper river corridor, stands of old growth ponderosa pine and lodgepole are often mixed with lush wet marshes in the summer and large expanses of dry meadows.

Below Bend, the forest landscape merges with that of the high desert. Much of this semi-arid plateau is overlain with a blanket of pumice and volcanic ash, and covered by windblown sandy soils (BOR and OWRD 1997). Elevations across the central subbasin drop from 4,000 feet near Bend, to 2,300 feet near Madras, and 98 feet at the river's mouth. The central and lower subbasin is characterized by rolling sagebrush hills, juniper woodlands, scattered ranchlands, irrigated cropland and pastures, and urban and suburban communities. Native vegetation in the area includes sagebrush, bitterbrush, rabbitbrush, wheatgrass and bluegrass. Western yarrow, milk vetch, common woolly sunflower and lupine are common perennial forbs. Riparian communities consist of willow, alder, mock orange, juniper and sedges, with a wide variety of coniferous species at higher elevations. East and west side tributaries to the lower Deschutes often drain very different vegetation conditions, with tributaries on the west side of the subbasin draining lands with higher precipitation than those on the east.

Throughout the subbasin, noxious weeds are rapidly transforming vegetative communities. During the last 20 years, noxious weeds have become a problem along streamsides and on forest, agricultural and residential lands. These plants — including spotted and diffused knapweed; bull, Canada and Russian thistle; Dalmatian toadflax; and other unwelcome species — are quickly replacing native plant communities. The weeds contribute to higher soil erosion and runoff from agricultural and riparian lands.

2.1.5. Land Use and Population

The Deschutes Subbasin has long been a home to humans. American Indian groups — including ancestors to the Warm Springs and Wasco tribes — inhabited areas along the Columbia River and Cascade Mountains for at least 13,000 years before Europeans arrived. Evidence from Newberry Crater at the subbasin's south end indicates that humans inhabited that region at least 10,000 years ago, as did mastodons, camels and other now extinct species (USFS 1996). The middle watershed also supported humans, including the area where the Deschutes, Crooked and Metolius rivers converge. Archeological field inventories conducted for relicensing of the Pelton Round Butte Complex found the largest concentration of both prehistoric and historic sites and isolates near the confluence of these three rivers (CTWS 1999). These early residents probably also fished for salmon, steelhead, Pacific lamprey and other fish species at Sherars Falls.

Today, the Central Oregon region continues to be valued for its quality of life. The subbasin's picturesque landscape, productive natural resources, and outdoor recreational opportunities are essential to this quality of life.

Land Ownership

The Deschutes basin contains an estimated 6,850,700 acres, consisting of 6,797,300 acres of land and 53,400 acres of permanent water (NRCS 1997). The federal government owns about 50 percent of the subbasin, or about 3,380,900 acres. Most of this land, which includes three national forests, one national grassland and one Bureau of Land Management District, lies in the upper watershed. The U.S. Forest Service (31%) and Bureau of Land Management (18%) manage federal lands. State, county and city lands also cover a small percentage of the subbasin. (See Map 2.)

Lands of the Warm Springs Tribal Reservation extend over approximately 641,000 acres, or about 7 percent of the subbasin. Tribal lands lie mostly in the lower Deschutes River subbasin. Almost all land within the reservation boundaries is held in trust by the Bureau of Indian Affairs for the benefit of the Warm Springs Tribes or individual Tribal members. The reservation also includes a small amount of allotted land, which is mostly owned by individual Tribal members. In addition, the entire lower Deschutes River subbasin outside the reservation and most of the upper subbasin were ceded to the U.S. Government by the Tribes and Bands of Middle Oregon through the ratified treaty of 1855. This treaty reserves to the Indians exclusive rights of taking fish in streams running through and bordering the reservation.

Lands in private ownership comprise about 42 percent of the land area in the subbasin. Most of these lands support agricultural, forest and range uses.

Population: Past, Present and Future

The upper and middle Deschutes watershed is currently experiencing tremendous growth, and this trend is expected to continue. The growth rate in Deschutes County, particularly around the cities of Bend and Redmond, has been significantly higher than in most other rural areas. The county continues a 20-year trend of leading the state with the highest population growth. U.S. Census Bureau information indicates that the population of Deschutes County grew 53.9 percent between 1990 and 2000 (Table 2.1)(Hough 2002). This steady growth has continued for more than 30 years, with the county's population more than doubling in size between 1970 and 1990. In 1993, Portland State University's Center for Population Research and Census projected that Deschutes County's population would reach 128,868 people by the year 2010. However, by July 2002 the county had already reached 126,500 people (Hough 2002). The explosive growth in Deschutes County is also higher than most places in the United States. It was marked as the 74th fastest growing county in the nation between 2001 and 2002.

Crook and Jefferson counties have also experienced higher levels of growth than other areas in the state. U.S. Census Bureau statistics indicate that from 1990 to 2000 population growth was 39 percent in Jefferson County and 35.9 percent in Crook County (Hough 2002). Projections suggest these counties will continue to see above average growth for several years (COIC 2002).

Populations in the lower Deschutes watershed have also increased, but at much slower rates. According to U.S. Census information, Wasco County's population grew by 9.7 percent between 1990 and 2000, though less than half the people lived outside the City of The Dalles (Hough 2002). Sherman County remains the least populated county in the subbasin, with a population increase of only 0.8 percent since 1990 (Hough 2002).

Table 2.1. Population Changes for Counties in Deschutes River Subbasin: 1990 - 2000*.

Area	April 1990 Population	April 2000 Population	Population Change 1990-2000
State of Oregon	2,842,321	3,421,399	20.4 percent
Crook County	14,111	19,182	35.9 percent
Deschutes County	74,958	115,367	53.9 percent
Jefferson County	13,676	19,009	39.0 percent
Sherman County	1,918	1,934	0.8 percent
Wasco County	21,683	23,791	9.7 percent

* Census information produced by Population Research Center, Portland State University, 2002.

The influx of new residents has changed the character of some communities and rural areas. While agriculture, wood products, manufacturing, recreation and tourism continue to be primary land uses in the subbasin, some lands are being converted for new uses. Small agricultural towns and irrigation districts — particularly those around Bend — now have large residential development and hobby farms. There is also more demand for recreational areas, which has led to the development of at least seventeen 18-hole golf courses and/or destination resorts in Deschutes County alone.

2.1.6. Economy

The subbasin's economy has changed in pace with its population growth. While twenty years ago, the wood products industry was the leader in manufacturing jobs, many high-tech and cottage industries have appeared in recent years as the timber jobs declined. Today, manufacturing jobs continue to employ many residents, but jobs in construction, retail trade and social services employ a growing number of residents (Table 2.2). The agricultural and cattle industry continue to provide a significant number of jobs, particularly in Crook, Jefferson, Sherman and Wasco counties.

Information prepared by the Central Oregon Intergovernmental Council indicates that jobs in construction and mining led job growth in Central Oregon during the 1990s, with a 94.6 percent increase. This high growth rate reflected the region's expanding population, which led to fast growth in both residential and commercial construction. Jobs in the service industry and finance also grew, increasing 78 percent in Central Oregon from 1990 to 2000. Recent economic forecasts suggest that Central Oregon's economy will continue growing over the next six years, but will place greater emphasis on service-oriented businesses at the expense of manufacturing industries (COIC 2002).

Table 2.2. Percentage of Employment in Industries in 2000, by County (U.S. Census Bureau 2000).

Industry	Wasco	Sherman	Jefferson	Crook	Deschutes
Agriculture, forestry, fishing and hunting, and mining	6.6	19.8	10.3	10.3	2.5
Construction	6.4	6.9	5.4	8.3	11.7
Manufacturing	10.9	6.8	20.2	21.6	10.8
Wholesale trade	3.1	4.0	2.2	2.4	2.7
Retail trade	15.7	10.8	9.3	12.8	15.0
Transportation and warehousing, and utilities	5.6	9.1	3.0	4.0	3.7
Information	2.1	0.1	0.8	1.9	2.5
Finance, insurance, real estate, and rental and leasing	4.2	2.9	3.4	3.5	6.6
Professional, scientific, management, administrative, and waste management services	5.2	2.4	6.0	3.7	8.2
Educational, health and social services	20.6	17.5	16.5	17.6	17.4
Arts, entertainment, recreation, accommodation and food services	10.1	10.3	10.4	5.8	10.4
Other services (except public administration)	5.3	4.0	5.1	4.5	5.1
Public administration	4.3	5.4	7.5	3.6	3.4

2.1.7. Human Disturbances to Aquatic and Terrestrial Environments

Human influences on the hydrology and ecology of the Deschutes Basin extend back more than one hundred fifty years. Watershed conditions, particularly those in the lower Deschutes and Crooked River subbasins, began to change as trappers, ranchers, farmers and other settlers of European background moved into the area. The practices of these people differed from those of Native Americans who had lived in harmony with the watershed, and the water and fishery resources for thousands of years. Reports suggest that by the 1880s, the combination of beaver harvest, irrigation and cattle grazing had significantly affected streams and fish populations in the watershed, especially in the drier, east side tributaries and Crooked River (Lichatowich 1998). Oregon Fish Commissioners noted in their 1880 report to the governor that there were few salmon left in the Deschutes River, causing the Warm Springs Indians to travel to the Clackamas River to obtain their winter supply of fish (OSBFC 1888). Human activities throughout the 1900s continued to affect the river system.

Today, people are more aware of how different land and water management actions influence hydrology, habitat complexity and overall watershed health. As a result, many steps are being taken to correct watershed functions and improve land and water conditions in the watershed. These management changes and restoration measures are improving riparian areas, water quality and stream flows within the basin.

This section discusses past land and water management practices that have disturbed aquatic and terrestrial environments in the Deschutes Basin. It also describes some of the more recent practices that are having a positive influence on watershed conditions.

Beaver Trapping

Historically, beaver were plentiful throughout the Deschutes subbasin. Once scattered along the lengths of the tributary streams, beaver dams slowed high spring flows and recharged adjacent floodplains with water that was released slowly throughout the rest of the year. This natural storage helped produce good flows of high quality water and created habitat diversity, providing overhead and instream cover and a high quality and well distributed gravel substrate. These combined factors helped support salmonids throughout their life cycle, and were particularly important in arid river systems.

Beaver were targeted for their skins in the early 1800s and the Deschutes subbasin became well known for its beaver. Hudson Bay records comment on the large beaver in the Crooked River area, with hides that stretched five feet across instead of the usual three feet ( ). By 1839, the Hudson Bay's Company had harvested a significant number of beaver in the Columbia River Basin, including the Deschutes, and moved north. Loss of beaver greatly affected the ecosystem, particularly on the Crooked River and other eastside tributaries to the Deschutes. Without beaver, these systems became more susceptible to storm events, as well as the effects of livestock grazing and agricultural activities.

Today beaver populations are recognized for their great engineering abilities and contributions to watershed health. Their distribution in the subbasin is beginning to increase with the recovery of riparian vegetation along some stream reaches. Low fur prices during the last decade have also removed pressure on the animals and contributed to a rebounding population.

Livestock Grazing

Stockmen began driving cattle over the Cascades into the Deschutes country around 1857 (ODFW 1997) and continued into the early 1900s. By the late 1800s, grazing by high numbers of sheep, cows and horses was depleting grasslands in the subbasin. These native grasslands were replaced by encroaching sage and juniper communities, and more recently by noxious weeds, which contributed to higher soil erosion and runoff on uplands. The watershed's dry nature also caused livestock to concentrate near streams where they altered riparian vegetative communities. The interaction between high grazing pressure and variable climate (drought followed by intense summer and winter storms), as well as the loss of beaver and its associated habitat, caused streams to erode vertically and laterally, and contributed to the loss of riparian vegetation in the late 1800s to early 1900s (CRLAC 2003). Grazing pressure declined significantly after the early 1900s, but continued to contribute to stream corridor degradation. Stream channels generally continued to unravel, which resulted in a conversion of flow in some streams from perennial to intermittent or ephemeral, as natural water storage was reduced.

Today, livestock grazing in riparian zones of subbasin streams is less common than it was 100 years ago. Grazing practices are being revised to encourage early season use, better livestock distribution, and alter duration, timing, and intensity of use. Improved practices are allowing vegetation to reestablish and streambanks to stabilize. Trees and shrubs in these areas have re-colonized degraded streambanks.

Agricultural Practices

Farmers in the Deschutes Subbasin began converting valley bottoms and natural grasslands for agricultural use in the mid 1800s. This and other changes in land pattern accelerated runoff and natural erosion rates, and altered the timing and amount of water and sediment delivered to streams in some parts of the subbasin. Impacts from agricultural practices were particularly damaging to watershed conditions in some areas of the lower subbasin where soils are more susceptible to erosion — though the level of impact depended on soil type, location and management technique. For example, under some dry land farming methods, land has been left fallow every other year. This practice, though once believed to be state-of-the-art, reduced organic matter in the soil and vastly decreased infiltration rates. Erosion from these fallow fields has been severe, particularly during rain-on-snow events when the ground has been frozen. Natural Resource Conservation Service technicians have measured soil loss on steeper fields up to 300 tons per acre per year (Eddy 1996).

Today, agricultural practices in the Deschutes Subbasin are undergoing important changes. Farming and conservation practices on dry land grain fields have improved. Erosion has also been reduced through the Conservation Reserve Program and other efforts.

Forest Practices

Most forested lands in the subbasin have sustained some level of harvest and roading during the past 70 years. During the early 1900s, many stream systems (and their aquatic and terrestrial resources) in upper subbasin forests were seriously damaged by timber harvest and the transport of logs downstream. Harvesting of trees in sensitive areas, including riparian areas, was a common practice until the early 1990s when forest practice laws were implemented. Merchantable timber was repeatedly removed from streams bottom forests in the Cascade and Ochoco mountains. Woody debris in and near the stream channel was commonly removed.

Such practices affected aquatic and terrestrial species in several ways. Riparian harvest reduced stream shade and led to higher water temperatures. Riparian harvest also depleted future large woody debris that would enhance the stream. Loss of large woody debris led to loss of pools, channel complexity, and channel alteration. Timber harvest also increased sedimentation due to soil disturbance, and altered the timing and quantity of peak flow events (USDA 1989b). Road building associated with timber harvest caused further habitat degradation and sedimentation by increasing the “hydrologic net” of a watershed, increasing peak runoff and sedimentation. In addition, impassable culverts placed at stream and river crossing delayed or prevented upstream fish movement. Soil compaction from timber harvest and roading also contributed to reduced infiltration and the problems mentioned above.

In addition, years of aggressive fire suppression on forestland has produced an unnatural accumulation of explosive fuels and the invasion of fire intolerant tree species. There have been several subbasin examples of the catastrophic impacts of wild fire in recent years. These fires can burn with enough heat to sterilize the remaining soil and substantially increase the time required for watershed recovery, while increasing the risk of soil erosion and stream habitat degradation. Some parallel conditions are also found on historic grassland habitat that has been converted to sagebrush/juniper communities because of land management and fire suppression. Some of these stand replacement fires have also consumed portions of communities and subdivisions during the past two decades.

Positive steps taken in recent years on public and some private forestlands are helping reverse the impacts of timber harvest on fish and wildlife habitat. Efforts are allowing stream recovery and providing shade, streambank stability, and future large woody debris. Inadequate road culverts for fish passage are also being replaced with bridges or open arch culverts where possible, and reconstructed to pass 50-year flood events.

Recreational Use

Concentrated recreational use, commonly associated with campgrounds or day use sites has resulted in the loss or some reduction in riparian vegetation and stream bank stability. Dispersed camping and recreation in localized areas also has contributed to loss of riparian vegetation and trampling and compaction of streamside soils.

Residential and Municipal Development

A recent land use activity affecting aquatic and terrestrial habitats has been the subdividing of land and construction of homes, golf courses and resorts on private lands. This land use began to expand tremendously in the late 1970's and continues today. Since the 1980s, more farmlands have been subdivided to smaller acreages, or converted into hobby farms. Development has also occurred near rivers and stream courses. Results of this growth have been loss and fragmentation of wildlife habitats, loss of riparian structure and habitat vegetation, loss of instream structure from construction of retaining walls and boat docks (such as along the upper Deschutes River), and degradation of water quality from fertilizers, pesticides, and failed septic systems.

Today, efforts are being made to reduce residential and municipal impacts on the environment. For example, while experiencing heavy growth, the City of Bend has become a leader in water conservation and stewardship. Through an aggressive program of water metering, conservation incentives and partnerships, and public education, the city maintained the same peak summer demand in 2003 as compared to 2002 despite 1,000 new service connections (Prowell 2004). Other municipalities in the subbasin are also adopting water conservation programs to use available water supplies more efficiently.

Transportation Network

Transportation corridor development in the lower Deschutes River subbasin began in earnest in the 1850's, efforts began to develop a railroad line into Central Oregon to reach and harvest the basin’s vast ponderosa pine forests. Subsequent railroad construction from 1906 to 1911 along the Deschutes River from the mouth to Warm Springs affected riparian and aquatic habitat. Blasting basalt outcroppings, slope excavation, and side casting excavated material eliminated areas of riparian vegetation and filled sections of river. In addition, culverts installed at tributary stream crossings eventually formed barriers that now preclude upstream fish migration.

Development of a road transportation network in the basin also had some negative impacts on the watershed and water quality. Road construction commonly occurred in stream bottoms and frequently resulted in the loss of riparian vegetation, changes in the channel configuration, filling of the stream channel, and constriction of flow at bridge sites. Road corridors frequently are a source of erosion that culminates in turbidity and sedimentation in adjacent streams. This can be a significant problem when the road is located in close proximity to the stream. Road surfaces have also reduced natural infiltration of water into the soil, which is important for ground water and spring recharge. Roads have acted to divert and concentrate surface water flow, which can exacerbate erosion and stream sedimentation problems.

Irrigation

Settlement of the lower White River country began in the 1850's and orchards were planted in the Tygh Valley area by 1858 (Clark and Lamson, 2003). Water in the Deschutes subbasin was first diverted in 1866 when settlers took water from the South Fork Crooked River (BOR 1980). Water diversions from Squaw Creek began in 1871. In the early 1900s several ditch companies, irrigation districts and municipal improvement districts formed to supply water to farms via storage reservoirs and canals. Soon water rights on several streams were over-appropriated. By 1914, filings for water rights to the Deschutes River above the City of Bend amounted to 40 times the river's flow (Nehlsen 1995). The need for summer irrigation water prompted the construction of irrigation storage reservoirs in the White River drainage, beginning in 1928, to supplement the natural stream flow.

Today, irrigation water is supplied by three large reservoirs in the upper Deschutes subbasin and two large reservoirs in the Crooked River drainage. Water management operations have replaced the stable natural flows in the upper Deschutes River with very low flows during the winter when the reservoirs are being filled, and very high flows during the summer irrigation season, when water is being released from the reservoirs. Below Bend, where most of the water is diverted to meet irrigation needs, summer flows in the middle Deschutes River drop to about 60 cfs. On the Crooked River, Bowman and Ochoco dams also altered natural flow cycles, reversing the size and timing of peak flows.

Smaller storage reservoirs and irrigation diversions also exist on many tributary streams. The White River drainage, for example, contains four reservoirs, including Clear and Badger lakes and Rock Creek and Pine Hollow reservoirs that supply much of the irrigation water to irrigated cropland. Diversion of water for irrigation and storage in Rock Creek and Pine Hollow reservoirs converted the lower reaches of Gate, Rock and Threemile creeks from perennial to intermittent streams for much of the year.

Many early irrigation diversions were unscreened or equipped with inefficient louvers that allowed juvenile fish to become stranded in the canals — particularly before the 1930s when federal screening programs were initiated. In addition, some irrigation structures lacked proper upstream fish passage facilities, which limited adult salmonid access to spawning areas. This contributed to the extirpation of bull trout in the upper subbasin. Fish passage was also restricted in some streams by the annual construction of temporary gravel dams to divert water into irrigation canals or ditches. Water could filter through these gravel dams, but there was no overflow to permit either upstream or downstream fish passage.

Irrigation withdrawals affect anadromous salmonids in several ways. Low summer flows and high water temperatures in diverted stream reaches limit habitat for rearing juveniles. They also restrict fish passage to other areas and connectivity between fish populations. The effects of reduced streamflows are particularly damaging to salmonid populations in degraded stream reaches, which may be wider than they were historically and lack deep pools and other structure that could provide refuge for fish during low flow periods.

The altering of the natural stream flow cycles also affect riparian communities, leaving streambanks and channels unstable, reducing aquatic vegetation and habitat, and seasonally displacing or eliminating some vertebrates and invertebrates. Flow restrictions also contribute to stream channel constriction and simplification. In addition, storage projects interrupt some gravel and large woody material recruitment to lower stream reaches. Inundation of lands for reservoir development affects terrestrial populations.

Today, irrigation districts and other water users in the Deschutes River Subbasin are allocating significant energy and funds toward water conservation and efficiency. With help from organizations such as the Deschutes Resource Conservancy, subbasin irrigation districts are implementing water conservation projects that are putting water back into streams where summer flows have been severely depleted for many years. Recent projects include canal lining and piping, source switches, instream transfers, instream deliveries and water leasing. Such projects are already improving instream flows in the Deschutes River below Bend, where summer flows have increased from as low as 30 cfs during the irrigation season to 60 cfs. In Squaw Creek, water conservation through piping, water leasing, source switching and other projects is expected to provide a permanent flow of 7 cfs in the creek near the town of Sisters, which has largely been dry during summer months since the late 1800s.

Hydroelectric Development

Dams were also constructed on Deschutes Subbasin streams to generate power. Early hydroelectric dams include the Cline Falls Power Company and Cove Power Plant, which were operating by 1901 and 1910, respectively. These early dams did not provide fish passage.

Construction of the largest dam complex in the Deschutes Subbasin began in the late 1950s. The Pelton Round Butte Complex, built on the Deschutes River near RM 100, had a significant effect on fish production in the basin. The complex was constructed with fish passage facilities, but attempts to pass juvenile anadromous fish through the project failed. Consequently, the dam complex blocked anadromous fish from part of their historic spawning and rearing habitat, particularly in the Squaw Creek, Metolius River and Crooked River systems. The dam complex also reduced peak flows in the lower Deschutes River and interrupted some gravel and large woody material recruitment.

The project also altered terrestrial habitats. Much of the upland area inundated by Lake Billy Chinook served as winter range for migratory mule deer. Filling of the reservoirs also inundated a small amount of wetland vegetation. The loss of riparian vegetation reduced cover, breeding and foraging habitat and undoubtedly affected some wildlife species.

Efforts are underway to reestablish anadromous fish passage at the Pelton Round Butte Complex as part of the hydro relicensing process. If successful, these efforts will restore salmon and steelhead to habitats in the Deschutes River between Round Butte Dam and Big Falls, and to available habitats in the lower Crooked River, Metolius River, and Squaw Creek drainages. In addition, project operators are reducing flow fluctuations by keeping the reservoir near full pool. Generally, the reservoir level only fluctuates 6 inches to 1 foot per day from late spring to early fall.

2.2. Water Resources

2.2.1. Watershed Hydrography

In a natural state, the Deschutes River displays a unique flow regime that sets it apart from other eastern Oregon rivers. The U.S. Reclamation Service recognized the river's unique character in 1914 and reported

> *"The flow of the river is one of the most uniform of all streams in the United States, not only from month to month, but also from year to year."*

Historic flows in the Deschutes River were especially uniform in the reach between Benham Falls (RM 180.9) and the mouth of the Crooked River (RM 113.7) (USGS 1914).

The steady flows through the length of the Deschutes River were primarily due to the volcanic geology of the upper subbasin and substantial groundwater storage. Porous volcanic soils and lava formations absorb much of the snow and rain that falls on the Cascade Basin, creating a large underground aquifer. Most of this groundwater discharges into streams in three areas: the southern part of the subbasin in and near the margin of the Cascade Range, the Metolius Basin adjacent to the Cascade Range, and the area surrounding the confluence of the Deschutes, Metolius and Crooked rivers extending downstream to about Pelton Dam (Gannett et al. 2001). Other parts of the subbasin receive lesser amounts of groundwater discharge. Subbasin-wide, the average annual rate of groundwater recharge from precipitation is about 3,800 cfs, with recharge in the low-elevation areas of the central and lower subbasin contributing little to this amount (USGS 2001).

While natural flows in the mainstem are fairly stable, those in tributaries are often more variable. Annual, and sometimes daily, stream flows are particularly changeable in eastside tributaries draining semiarid lands in the Cascade rain shadow that do not receive abundant groundwater discharges. Stream flows in westside tributaries, that drain the wetter, cooler slopes of the Cascades and benefit from groundwater and surface water are generally less variable. For example, flows in the Crooked River are highly variable, while those in the Metolius River fluctuate little. Further, while the Crooked River drains 40 percent of the Deschutes Subbasin, it contributes only 27 percent of the total flow to Lake Billy Chinook and the Metolius River, which only drains 3 percent of the Deschutes Subbasin, contributes 26 percent of the total flow to Lake Billy Chinook (O'Connor et al. 1999).

The Deschutes River near its confluence with the Columbia River has a mean monthly flow ranging from 4,388 cfs in August to 7,511 cfs in February (Deschutes River at Moody). The highest monthly flows usually occur in early spring as a result of snowmelt in the Cascade Range. The lowest flows typically occur in late summer during July, August and September. The average annual discharge for the Deschutes River Subbasin is 4.2 million-acre feet, with the lower watershed contributing about 1.2 million-acre feet to this runoff (O'Connor et al. 2003).

2.2.2. Current Hydrologic Regime

Regulation of the Deschutes River by upstream reservoirs and irrigation diversion systems alters the river's stable natural flow pattern. Two main water projects on the upper Deschutes River, Crane Prairie (1922) and Wickiup Dam (1945) regulate flows in the upper and middle Deschutes River. Water storage and releases create very low flows in the upper Deschutes River above the City of Bend during the winter, when reservoirs are being filled, and very high flows during the summer irrigation season, when water is being released from the reservoirs (Figure 2.1). Flow fluctuations in this upper reach are most significant between Wickiup Dam and the mouth of Fall River, and lessen as tributaries and springs augment flows of the mainstem between Fall River and Sunriver. Water storage and releases in the Little Deschutes River system also alter flow patterns —though the change is less significant than in the Deschutes River. Flow storage in the Little Deschutes system at Crescent Lake and drawdowns for irrigation create an artificial flow cycle in the four-mile reach of the Little Deschutes River below the Crescent Creek confluence, with low flows during winter months and high flows during spring and summer months.

Six irrigation diversion canals remove water from the Deschutes River near Bend (Table 2.3). Consequently, natural flows in the middle Deschutes River below Bend are altered by water storage in upper river projects and by withdrawals for irrigation. Reservoir storage reduces flows during winter months and irrigation withdrawals reduce flows during summer months (Figure 2.2). The median ratio of summer to winter flows from 1961 through 1999 below Bend is roughly 30/600 cfs (OWRD 2001). Irrigators currently release approximately 60 cfs below Bend during the irrigation season, but there is no legally established minimum flow for instream use in the Deschutes River below North Canal Dam. Other irrigation diversions remove water from Deschutes River tributaries, including the Crooked River, Tumalo Creek and Squaw Creek. These diversions also alter natural flow regimes.

Low summer flows between Bend and Lake Billy Chinook are slowly supplemented by flows from Tumalo Creek, Squaw Creek, and natural springs. By the time the river reaches the Pelton Round Butte Complex average summer flows in the Deschutes River increase from 30 cfs to 550 cfs (ODFW 1996).

Natural flows in the Crooked River are altered through water storage and releases at Bowman and Ochoco Dams, and other smaller reservoirs. While natural flows in the Crooked River follow a cycle of spring runoff, with flows peaking in March and April, operations at Bowman and Ochoco dams have altered the flow regime in the streams below the dams. These reservoirs are designed to control flooding and have successfully reduced damaging floods through Prineville for more than 40 years. One exceptional flood in May 1998 occurred outside of the flood control season on Ochoco Dam and did cause substantial damage through Prineville, but this was a highly unusual event and could not have been prevented. The reservoirs provide irrigation water during the summer and as a consequence, the flows below Ochoco Reservoir and, more significantly, below Bowman Dam have benefited by having exceptionally cool water flow at levels near optimum throughout the hot summer months until diversions substantially reduce the flow near Prineville.

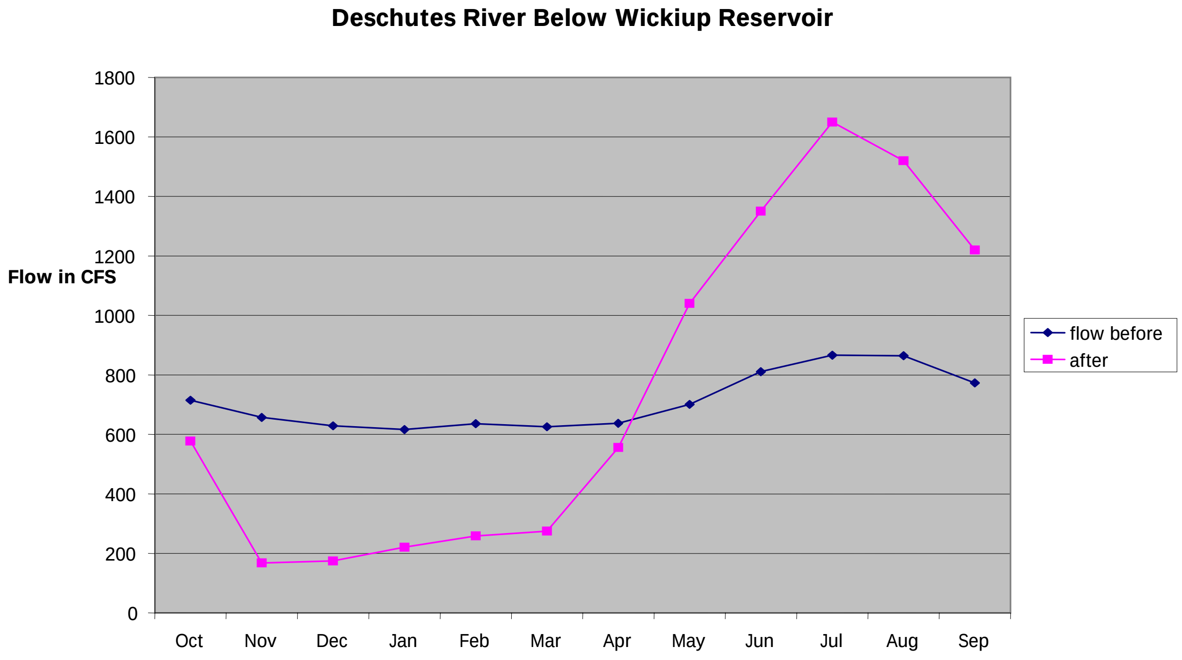

Figure 2.1. Comparison of average monthly flow in the Deschutes River below Wickiup Reservoir before and after construction of Wickiup Dam.

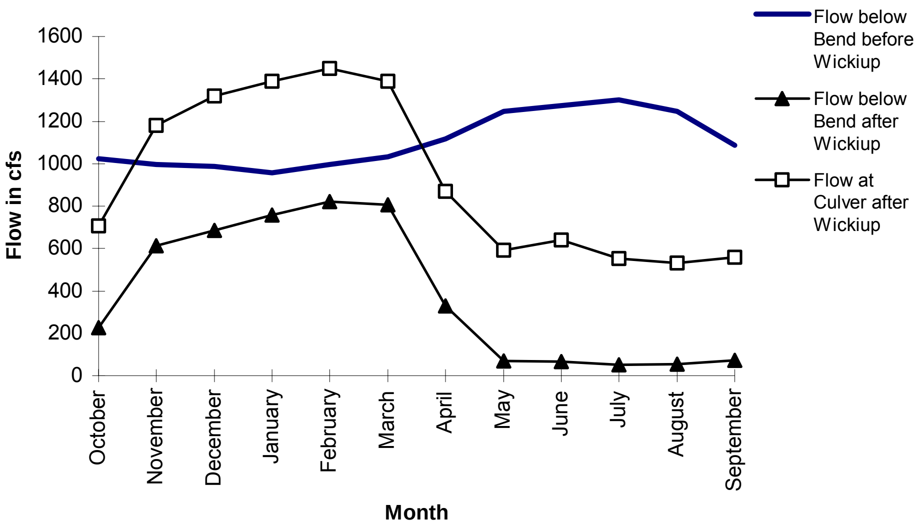

Figure 2.2. Comparison of average monthly flow in the Deschutes River below North Canal Dam in Bend and above Lake Billy Chinook (Culver) before and after construction of Wickiup Dam (Pre-Wickiup Dam data is not available for the Lake Billy Chinook site).

Together, water storage projects in the upper Deschutes and Crooked River systems provide a total of 532,100 acre-feet of storage capacity. The stored water is primarily used for irrigation.

Table 2.3. Storage and Diversion Facilities in the Upper Deschutes River Subbasin.

Name	River mile	Maximum storage/diversion	Irrigation District
Crane Prairie Reservoir	239.0	55,000 acre feet of storage	Lone Pine, Arnold, and Central Oregon Irrigation District (COID)
Wickiup Reservoir	227.0	200,000 acre feet storage	North Unit Irrigation District
Crescent Lake	*	86,050 acre feet storage	Tumalo Irrigation District
Arnold Canal	174.6	135 cfs	Arnold Irrigation District
Central Oregon Canal	171.0	650 cfs	COID
PP&L Hydroelectric (Bend)	166.2	1,325 cfs	
Bend Feed Canal	165.8	150 cfs	Tumalo Irrigation District
North Unit Main Canal	164.8	1,100 cfs	North Unit Irrigation District
North Canal	164.8	600 cfs	COID and Lone Pine Irrigation Districts
Swalley Canal	164.8	120 cfs,	Swalley Irrigation District
PP&L Hydroelectric (Cline Falls)	145.0	90 cfs	
Tumalo Creek (City of Bend)	n/a	21 cfs	
Tumalo Creek (Tumalo Feed Canal)	n/a	180 cfs	Tumalo Irrigation District
Squaw Creek Canal	n/a	150 cfs	Squaw Creek Irrigation District

* Located at head of Crescent Creek

Several smaller reservoirs also store and release water for irrigation. The White River drainage contains four reservoirs, including Clear and Badger lakes and Rock Creek and Pine Hollow reservoirs that supply much of the irrigation water to the 8,640 acres of irrigated cropland. There are up to eighteen irrigation diversions that supply irrigation canals or ditches that in turn convey the water from streams in the drainage to the specific points of use. Most of these diversion structures lack provisions for fish passage or protective screening (ODFW 1985).

Diversion of water for irrigation and storage in Rock Creek and Pine Hollow reservoirs converted the lower reaches of Gate, Rock and Threemile creeks from perennial to intermittent streams for much of the year. The lower reaches of other streams, including Badger, Tygh, and Boulder creeks, have also seen substantial reductions in summer flow because of upstream irrigation water withdrawals. The irrigation water delivery system that carries water to storage impoundments and individual landowners in the Juniper Flat and Wamic areas is comprised of many miles of open, earthen ditches and canals. These ditches and canals are believed to be relatively inefficient due to the potential for significant water loss through leakage and evaporation between the source and the eventual destination (ODFW 1997).

Flows improve substantially in the Deschutes River below the Pelton Round Butte Complex. The total average annual flow past the USGS gage below Round Butte Dam is 3,279,000 acre-feet, or 4,519 cfs. Much of the flow can be attributed to large amounts of groundwater entering the system through springs within the Metolius drainage, and into the Deschutes and Crooked canyons shortly above the Pelton Round Butte

Complex. Because of groundwater releases and surface flows from tributaries, flows in the lower Deschutes River are more stable than those above the dam. Flows in the lower Deschutes River have exceeded 3,200 cfs 99 percent of the time, but have only exceeded 9,040 cfs 1 percent of the time since 1965 (Huntington 1985, O'Connor et al. 2003a).

Since the early 1980s, most fish bearing streams in the Deschutes River Basin have received instream water rights. Table 2.4 shows some of these instream flow water rights. Because instream water rights generally have more recent filing or priority dates, they tend to be the most junior water right on a particular stream. For instream water rights that are most junior in priority date, there are no junior users to be regulated in order to achieve target instream flows. There are, however, two instream water rights in the lower Deschutes River Subbasin that are the result of conversion of minimum perennial stream flows. These instream water rights have older priority dates and water rights with junior dates could be regulates in times of shortage.

2.2.3. Water Quality

Water quality in the Deschutes Subbasin varies from pristine to degraded. Some changes in water quality occur naturally because of differences in geography, climate and vegetation. For example, because of their different environmental attributes, water temperatures in most streams on the lower eastside of the subbasin rise naturally to higher levels than those on the west side of the subbasin. In addition, sediment levels in the White River, which drains glaciers on Mt. Hood, are naturally much higher than in other nearby rivers.

Water quality in several parts of the subbasin, however, is affected by human practices. A number of stream segments in the Deschutes Subbasin have been declared water quality limited by the Oregon Department of Environmental Quality under Section 303(d) of the Clean Water Act (Map 3). Water quality standards are violated on some streams for temperature, sedimentation, pH, dissolved oxygen, flow modification and habitat modification. Of these, temperature, flow and pH are primarily summer concerns. Dissolved oxygen is primarily a summer/fall concern. Exceeding these standards indicates potential problems for fish populations. Water quality concerns in the different assessment units and in different stream reaches within the subbasin are discussed in Section 4, Environmental Conditions and in Appendix II of this document.

Table 2.4. Selected Instream Flow Water Rights in the Deschutes Subbasin (Gorman 2004).

Stream	Priority Date	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Deschutes R., Pelton Dam to Mouth	10/2/1989	3000	3000	3500	3500	3500	3500	3000	3000	3000	3000	300	3000
Deschutes R. Pelton Dam to Mouth	1/16/1991	4500	4500	4500/ 4000	4000	4000	4000	4000/ 3500	3500	3500/ 3800	3800	3800	3800/ 4500
Deschutes R., Wickiup to Little Deschutes	11/3/1983	300	300	300	300	300	300	300	300	300	300	300	300
Deschutes R., L. Deschutes to Spring R.	11/3/1983	400	400	400	400	400	400	400	400	400	400	400	400
Deschutes R., Spring R. to North Canal D.	9/24/1990	660	660	660	660	660	660	660	660	660	660	660	660
Deschutes R., North Canal D. to LBC	3/21/1990	250	250	250	250	250	250	250	250	250	250	250	250
Trout Cr., Antelope C. to Mouth	5/9/1990	25	67/73	73	73	73	33.5	6.19	1.94	1.94	2.83	9.67	25
Trout Cr., Clover C. to Antelope C.	10/11/1990	25	67/ 72.9	73	73	54.5	16.4	2.98	0.93	0.93	1.3	4.09	15.8
Tumalo Cr.	10/11/1990	47	47	68.7	76.6	82	47	32	32	32/47	65.3	47	47
Squaw Cr., Indian Ford Cr. To Mouth	10/11/1990	33	33	50	50	50	33	33	33	33	33	33	33
Squaw Cr., SF Squaw Cr. To IFC	10/11/1990	30	20	20	20	20	20	10	20	20/30	50	30	30
L. Deschutes R., Crescent Cr. To Mouth	10/11/1990	200	200	236	240	240	200	126	74.5	92.2	116	164	196
L. Deschutes R., RM 72 to Crescent Cr.	10/11/1990	52.7	60	61.6	75	75	60	40	37.4	34.6	35.1	36.8	39.9
L. Deschutes R., Headwaters to RM 72	10/11/1990	34	34	44.8	62.1	68	34	34	34	32.8	33.3	35.3	37.8
Ochoco Cr., Ochoco Dam to Mouth	8/30/1990	23	23/35	45	45	45	35	14.7	6.27	6.5	6.89	8.62	23
Crooked R., NF Crooked to Prineville Res.	5/11/1990	50	50/75	113	113	113	75	50	47.8	50	50	50	50
Crooked R., Prineville Res to mouth	5/11/1990	75	75/ 150	255	255	255	150	75	75	75	75	75	75
Metolius R., Canyion Cr. To LBC	9/19/1990	200	200	335	335	335	200	200	0/335	335	335	335	335
Metolius R., springs to Canyon Cr.	9/19/1990	110	110	185	185	185	110	110	0/185	185	185	185	185
White R.	10/2/1989	60	100	145	145	145	100	60	60	60	60	60	60

2.3. Hydrologic and Ecologic Trends

2.3.1. Macro-climate and Influence on Hydrology and Ecology

Over the last century, the region has seen natural multi-decade swings in climate. Generally, the region experienced warming from the 1920s to 1940s, cooling in the 1950s and 60s, and more warming from the 1970s through 1990s. These changes affected temperature ranges and snow accumulations that influenced hydrology and ecology throughout the Northwest, including the Deschutes Subbasin. Such natural multi-decadal cycles will continue to influence hydrologic and ecologic trends in coming years.

Some scientific studies indicate that natural climatic trends will be further affected by human-induced actions, including global warming (Mote et al. 2003). For example, studies by climatologist Phil Mote (2003) indicate that snowpack levels have dropped considerably throughout the west in response to a 0.8°C warming since the 1950s. They also reveal that if moderate regional warming predictions for the next fifty years come true, western snowpacks will be reduced by up to 60 percent in some areas, including in Oregon's Cascade Mountains. This would in turn reduce summer stream flows in some areas by 20 to 50 percent (Mote et al. 2003). Other climatologists, however, believe future trends will be less severe. According to George Taylor, state of Oregon climatologist, the effects of human induced global warming will be small compared to effects from multi-decadal cycles.

In the Deschutes Subbasin, impacts from possible climatic changes will likely be mixed. Warmer temperatures will mean precipitation falls more as rain instead of snow, particularly at lower elevations. This will have little influence on flows in the Deschutes River and other streams that receive large contributions from groundwater. However, it may alter flow cycles in systems that respond primarily to surface runoff. Less snow will mean earlier and lower spring runoff, with possible increases in winter flooding, and less water available for summer use. Streams with warmer temperatures and reduced summer flow will affect focal fish production, water quality and water availability for different water users.

Temperature changes may also reduce the amount of water stored naturally in upland areas for later use. Warmer temperatures could increase that rate at which plants use water and some plants would be weakened by drought conditions (Mote et al. 2003).

2.3.2. Human Influence on Hydrologic and Ecologic Trends

In recent years, people across the subbasin have initiated strong actions to improve flows and watershed health in the Deschutes ecosystem. Together, these actions will have a significant impact on future hydrologic and ecologic conditions in the Deschutes watershed.

Recent studies show that water use in the subbasin is already changing. Because of the conversion of traditional farmland to hobby farms or uses that are less water-intensive, and because of added improvements in water conservation and conveyance, water demand in most irrigation districts has decreased over time. Over the last 36 years, diversions for irrigation on the Deschutes River and Tumalo, Squaw, Crescent and Ochoco creeks have declined from about 870,000 acre-feet to about 640,000 acre-feet, a reduction of 230,000 acre-feet. They have averaged 640,000 over the last five years (Gorman 2004). These water savings, however, have not been seen instream. Water rights in many streams are over-allocated and saved water goes to junior water uses. Water saved from out-of-stream use often only stays instream when protected through Transfers or the Conserved Water Statute.

Steps are also being taken to restore watershed health, and these efforts are expected to increase in the future. Soil and water conservation districts, watershed councils and others are working with landowners to improve farming and conservation practices on upland watersheds. Restoration efforts include terracing fields and/or constructing water and sediment control basins to reduce erosion and the amount of sediment that enters the water. Erosion has also been reduced through placement of lands in the Conservation Reserve Program. Along the riparian corridors, restoration takes the form of planting native vegetation to increase habitat, or fencing streams to exclude livestock. At home, subbasin residents are beginning to reduce water use by watering their lawns efficiently, planting vegetation that require smaller amounts of water, buying water and energy smart appliances, and generally using water wisely.

With implementation of these and other steps to improve water use and restore watershed lands, many streams and rivers of the Deschutes Subbasin will take on a new look in fifty years. Fortunately, the river environment is very resilient. For example, riparian fencing in the Trout Creek and Warm Springs River systems and along the lower Deschutes River has allowed vegetation to reestablish and stabilize stream banks. Alders are now common along sections of the lower Deschutes River where few stood before riparian exclosure fencing. Instream habitat projects on the Warm Springs River and Trout Creek have increased both quantity and quality of fish habitat.

Control of flows and sediment from the uplands and improvements in riparian areas will allow stream systems to regain natural functions. Drainages will release rain and snowmelt to streams more slowly, improving summer stream flows and keeping water temperatures from reaching levels that are lethal to fish populations. Well-developed riparian areas will also act to reduce the extremes of flow. Well-developed stream channels and associated higher water tables will hold more water during the wet season and release water slowly during the dry season allowing streams to flow year-round. However, these increased flows not be available to improve habitat conditions for fish and wildlife if diverted out-of-stream by junior water uses.

Improvement of conditions within riparian corridors will also increase the amount of large woody debris within streams where the cover is now lacking. Generally, the more instream habitat diversity created by large woody material, the greater the rearing potential for fish.

If current efforts are successful to provide anadromous fish passage around the Pelton Round Butte Complex, salmon and steelhead will regain habitat in the upper Deschutes River Subbasin. The productivity of these returning anadromous fish will depend greatly on the amount and quality of habitat they find in tributary habitats. While conditions in the Metolius River remain good, conditions in Squaw Creek, the Crooked River and many other tributaries beg for improvement.

In addition, with projected growth in the Bend/Redmond area, meeting this demand will require that new water rights issued from groundwater mitigate their use. Projections suggest that there is ample water to meet current and future demands. However, to meet present and future water needs in the subbasin, residents need to accelerate actions to modify inefficient water policies and water delivery. To meet increasing future water demands — while at the same time protecting water quality and restoring critical fish and wildlife habitat — steps must be taken to re-allocate water to increase stream flows in critical areas. At the same time, new approaches must be created for developing or transferring groundwater and surface water to places where it is needed. The Oregon Department of Water Resources had enacted the Deschutes Basin Groundwater Mitigation Program, which requires any new water right issued in the basin within the USGS Groundwater Study Area to mitigate the consumptive use of the new water right (Gorman 2004). To meet the mitigation requirements, an applicant will have to provide an equal amount of water instream whether by a temporary instream lease or permanent transfer. Already, this mitigation water is being provided in Squaw Creek and the Middle Deschutes River (Gorman 2004).

Further, some irrigation water storage will be lost over the next 50 years as reservoir capacity declines. There are efforts underway to provide increased minimum flow releases below the reservoirs in the Upper Deschutes Subbasin, including the Crooked River drainage. The U.S. Bureau of Reclamation has a target of 75 cfs outflow from Prineville Reservoir in the winter when water is available, which is above 10 cfs (Gorman 2004). The local Watermaster’s office has implemented the ramping rates for the outflow from Wickiup Reservoir as outlined in the Upper Deschutes River Wild and Scenic River Management Plan (USFS 1996). In addition, the Tumalo Irrigation District has voluntarily released a minimum of 5 cfs from Crescent Lake to protect instream flow values. There is no minimum from this impoundment (Gorman 2004).

2.4. Regional Context

2.4.1. Relation to the Columbia River Basin

The Deschutes Subbasin is a major subbasin of the Columbia River and the second largest river drainage system in Oregon. The annual average subbasin runoff to the Columbia River is 4.2 million acre feet. There are only five other, within-Oregon, watersheds that have greater annual runoff (Aney 1967).

Historically the subbasin was an important Columbia River contributor of spring, summer and fall Chinook salmon, sockeye salmon, summer steelhead and Pacific lamprey. In addition, the historic Deschutes meta bull trout population had cohorts that intermingled in the Columbia River with bull trout from other meta populations.

Today, The Deschutes Subbasin, which lies above two Columbia mainstem dams, continues to be an important contributor to salmon and steelhead runs in the Columbia River Basin. In addition, the cool water plume at the mouth of the Deschutes River provides temporary refuge for salmon and steelhead migrating to upriver tributaries.

2.4.2. Relation to the Ecological Province

The subbasin is part of the Columbia Plateau Province. This province, or eco-region, is one of eleven eco-regions that make up the Columbia River Basin. The provinces are groups of adjoining subbasins with similar climates and geology. The Columbia Plateau Province covers approximately 45,275 square miles and extends over much of north central and northeast Oregon, southeast and south-central Washington, and a small part of western Idaho.

2.4.3. NMFS Evolutionary Significant Units (ESUs)

Deschutes River summer steelhead are included in the Mid-Columbia ESU. This ESU includes the portion of the Columbia River Basin from the Wind and Hood rivers on the west, and extends up to and includes the Yakima River in Washington. Summer steelhead within this ESU were federally listed as threatened on March 25, 1999 (NMFS 1999).

2.4.4. USFWS Designated Bull Trout Planning Units

The U.S. Fish and Wildlife Service issued a final rule listing the Columbia River population of bull trout, including the Deschutes subbasin populations, as a threatened species under the Endangered Species Act on June 10, 1998 (63 FR 31647) (USFWS 2002). Bull trout are currently listed on the Oregon Sensitive Species List (OAR 635-100-040) as Critical.

The Deschutes subbasin contains two designated Bull Trout Planning Units, the Deschutes Recovery Unit and the Odell Lake Recovery Unit. Bull trout are distributed among five or more local populations in the Deschutes Recovery Unit, with five or more local populations in the lower Deschutes Core Area. In the Odell Lake Recovery Unit, bull trout are distributed among one or more local populations, depending on whether fish are found to exhibit homing fidelity to individual streams.

2.4.5. National Wild and Scenic Rivers and Oregon State Scenic Waterways

Several sections of the Deschutes River and its tributaries have also received special protection through designation as national wild and scenic rivers and/or state scenic waterways (tables 2.5 and 2.6). (See Map 4.)

The Wild and Scenic Rivers Act of 1968 provides for the protection and enhancement of Outstandingly Remarkable Values of free-flowing and other natural river sections. Under the Act, rivers are designated as recreational, scenic or wild. Recreational rivers are defined as *“Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.”* Scenic rives are defined as *“Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.”* Wild rivers are defined as *“Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.”*

The Oregon Scenic Waterways Act, adopted in 1970 and amended in 1988 under the Oregon Rivers Initiative, provides further protection for Deschutes subbasin rivers. The program are designed to protect and enhance the scenic, aesthetic, natural, recreation, and fish and wildlife values along selected rivers.

Table 2.5. National Wild and Scenic Rivers in the Deschutes Subbasin.

Section	Description	Designation
Deschutes R.	Mouth to Pelton Rereg. Dam (RM 0-100)	Recreation
Deschutes R.	Lake Billy Chinook to Odin Falls (120-140)	
Deschutes R.	Bend UGB to Lava Island Camp (172-175)	Recreational
Deschutes R.	Lava Island Camp to Sunriver (RM 175-186.2)	Scenic
Deschutes R.	Sunriver to Wickiup Dam (RM186.2 to 226.7)	Recreational
White R.	Mouth to forest boundary	Scenic: 24.3 miles Recreational: 22.5
Metolius R.	Lake Billy Chinook to Bridge 99 (RM 12-29.1)	Scenic
Metolius R.	Bridge 99 to Metolius Springs (RM 29.1-41)	Recreational
Squaw Cr.	Gauging station to wilderness boundary (8.8 m)	Scenic
Squaw Cr.	Wilderness boundary to source (6.6 miles)	Wild
Crooked R.	National Grasslands boundary to Dry Creek	Recreational
NF Crooked R.	One mile above mouth to source (RM 1-33.3)	Wild: 11.1 miles Scenic: 9.5 miles Recreational: 11.7
L. Deschutes R.	Hemlock Cr. To headwaters (RM 84-97)	
Crescent Cr.	County Rd. to Crescent Lake Dam (RM 18.5-30)	Recreational
Marsh Cr.	Mouth to headwaters (RM 0-15)	Recreational

Table 2.6. Deschutes Subbasin Scenic Waterways.

DESCHUTES SUBBASIN SCENIC WATERWAYS		
Section	**Description**	**Data/Method of Designation**
Lower Deschutes	Pelton Rereg-dam to mouth, except City of Maupin	1970 initiative
Below Bend	Sawyer Park to Tumalo Park, Deschutes Market Road to Lake Billy Chinook	1988 initiative 1987 legislation and 1988 initiative
Below Harper Bridge	Harper Bridge to Bend Urban Growth Boundary (RM 171)	1987 legislation and 1988 initiative
Below Wickiup Dam	Gage to General Patch Bridge	1987 legislature
Below Lava Lake	Lava Lake to Crane Prairie Res.	1988 initiative
Metolius River	Headwaters to Candle Creek	1988 initiative

Focal Species Characterization
Section 3

This section summarizes key characteristics of focal fish and wildlife species selected to evaluate the health of the Deschutes Subbasin ecosystem and the effectiveness of management actions in the subbasin. Each focal species is described in terms of its special ecological, cultural and/or legal value, abundance and distribution, key life history strategies and habitats, genetic integrity, and population trends. More detailed discussions of the focal species can be found in Appendices I and III.

3.1. Focal Species Selection

Five aquatic species and seven terrestrial species in the Deschutes River Subbasin have been chosen as the focal species for this subbasin plan. The five aquatic focal species include: Chinook salmon (*Oncorhynchus tshawytscha*), steelhead/redband trout (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), sockeye salmon (*Oncorhynchus nerka*) and Pacific Lamprey (*Lampetra tridentata*). The seven terrestrial focal species include: American beaver, Columbia spotted frog, white-headed woodpecker, mule deer, Greater sage grouse, Columbian sharp-tailed grouse, and golden eagle. These five aquatic species and seven terrestrial species are all indigenous to the Deschutes Subbasin.

Focal species were selected based on their significance and ability to characterize the health of the ecosystem and the effectiveness of management actions. Criteria used in selecting the focal species included a) designation as a federal threatened or endangered species, b) cultural significance, c) local significance, and d) ecological significance, or ability to serve as indicators of environmental health for other aquatic or terrestrial species.

The focal species are characterized below. Section 3.2 summaries characteristics of the aquatic focal species. These characteristics are discussed in more detail in Appendix I. Section 3.3 summarizes characteristics of the terrestrial focal species in the Deschutes Subbasin. These characteristics are further described in Appendix III. In addition to the focal species, the Deschutes River Subbasin supports more than thirty species of indigenous and introduced fish (Appendix I) and numerous amphibians, reptiles, birds and mammals (Appendix III).

3.2. Aquatic Focal Species

3.2.1. Chinook Salmon

Historically Chinook salmon returned to the Deschutes Subbasin from spring until fall. Spring Chinook, usually the smallest of the Chinook, returned to the subbasin first and spawned primarily in the headwaters of major tributaries, including the Metolius and Crooked rivers. The larger fall Chinook spawned in the lower Deschutes River mainstem. A summer Chinook run is thought to have also once returned to the Deschutes. However, this run is believed to have been lost after construction of the Pelton Round Butte Project. Today, research suggests that only two indigenous races of Chinook salmon — spring Chinook and summer/fall Chinook — spawn and rear in the Deschutes Subbasin. During the past 30 years, fish managers have not found any temporal or spatial separation during spawning in the lower Deschutes River that could verify distinct populations of summer and fall Chinook salmon within the subbasin. Both segments of the run appear to spawn in the same areas during the same time period and interbreeding between the two has been suspected for many years, suggesting that only one run exists. For simplicity, this plan will consider this protracted Chinook salmon run as the Deschutes River fall Chinook salmon population.

Importance

Chinook salmon are an indigenous anadromous species in the Deschutes Subbasin with strong ecological and cultural value (Table 3.1).

Table 3.1. Rationale for Selection of Chinook as a Focal Species.

Species Designation	Species Recognition	Special Ecological Importance	Tribal Recognition
Spring Chinook salmon are not an ESA-listed species in the Deschutes River subbasin or the Mid-Columbia ESU. The Mid-Columbia ESU fall Chinook populations, including the Deschutes River population, were proposed for ESA listing, but it was determined that a listing was not warranted.	Deschutes River Chinook have provided an important food source for Native Americans over hundreds, if not thousands of years. Once harvested at many sites within the subbasin, including Sherars Falls on the lower Deschutes River. Fall Chinook were generally preferred for drying since their flesh contained less oil than the spring Chinook. Today Chinook continue to provide important recreational and traditional fisheries, also near Sherars Falls.	An important food source for a variety of wildlife. Chinook die shortly after spawning and their carcasses provide marine derived nutrients that have wide-reaching benefits to the biota of the subbasin, including aquatic insects, aquatic and semi-aquatic plants and, indirectly, terrestrial plants. Chinook also till the gravel substrate during spawning. This helps prevent cementing or embeddedness and benefits production of macro invertebrates and other aquatic species.	Strong cultural, religious and subsistence values for Native Americans throughout the Pacific Northwest, including the Warm Springs Tribes. Salmon are considered part of the spiritual and cultural identity of the Indian people. They also have commercial value, and historically were the center of an important trade economy between various tribes. Fishing is still the preferred livelihood of some tribal members.

Characteristics that define spring and fall Chinook salmon populations in the Deschutes Subbasin are summarized in the following section. The runs are described in more detail in Appendix I.

Spring Chinook

Population Abundance

Historically, the Deschutes River system may have supported four times as many spring Chinook salmon as it does today. A robust meta population once spawned and reared in the mainstem Deschutes River below Big Falls and in several tributaries including

Shitike and Squaw creeks, and the Warm Springs, Crooked and Metolius river systems (Map 5). Population abundance dropped after the early 1800s — particularly in the Crooked River and Squaw Creek systems — due to watershed alterations and water withdrawals. The spring Chinook population faced further declines in the early and mid-1900s. The Cove Power Plant, built around 1910 on the lower Crooked River, barred upstream spring Chinook spawners at low flows and Ochoco Dam, built 10 miles above the mouth of Ochoco Creek in 1922, further blocked fish passage (Nehlsen 1995). All spring Chinook production in tributaries and mainstem reaches of the Deschutes River above RM 100 was lost in the late 1960s when anadromous fish passage failed at Pelton and Round Butte dams. The Pelton Round Butte hydro project operator and fishery managers at the time estimated the average pre-dam spring Chinook run past the dam sites at approximately 1,200 adults. This number reflected fish counts made before and during construction of the project.

Today, both wild and hatchery spring Chinook return to the Deschutes Subbasin. The wild spring Chinook run averages 1,780 adults and returns to spawning grounds in the Warm Springs River and Shitike Creek drainages on the Warm Springs Reservation. Fish managers have no evidence that wild spring Chinook spawn in the mainstem lower Deschutes River or other tributaries. Run size varies considerably from year to year, with annual wild spring Chinook numbers since 1977 ranging from 241 to 3,460 fish (French and Pribyl 2004). These numbers could increase in the near future if passage past the Pelton Round Butte Project is restored.

Currently, the Warm Springs system produces most wild spring Chinook in the Deschutes River Subbasin. The natural smolt production capacity of the Warm Springs River system is estimated to be 132,000 smolts (ODFW 1977). The number of juvenile spring Chinook migrants averaged 78,736 for brood years 1978 through 1998. The total number of fall and spring migrants (age-0 and age-1+ spring Chinook) from the Warm Springs River ranged from 3,784 fish to 155,225 fish for the 1975 through 1998 broods (CTWS unpublished data). Tribal spring Chinook redd counts in the Warm Springs system since 1982 show an average of 341 redds counted per year, with a range from 62 in 1995 to 752 redds in 2001. A smaller wild spring Chinook run returns to Shitike Creek. Spawning ground counts show that an average of 49 adult spring Chinook escaped annually to Shitike Creek between 1982 and 1995 (ODFW 1997). This population is believed to be composed entirely of wild spring Chinook. All 17 spring Chinook carcasses sampled in Shitike Creek from 1986 through 1995 were wild fish (CTWS, unpublished data).

The subbasin also supports a run of hatchery spring Chinook. From 1993 to 2002, an average of 4,778 hatchery spring Chinook (4,103 adults and 675 jacks) returned to the Deschutes Subbasin. Spring Chinook salmon smolts are reared and released from two hatcheries in the subbasin: Round Butte Hatchery, operated by ODFW since 1973, and Warm Springs Hatchery, operated by USFWS since 1980 (ODFW 1997). Round Butte Hatchery raises about 300,000 spring Chinook yearling smolts annually for release into the Deschutes River. Annual releases from this hatchery include 230,000 yearling spring Chinook smolts immediately below Pelton Reregulating Dam to meet adult mitigation requirements, and 65,000 to 70,000 yearling smolts at the same site as part of a study to evaluate innovative fish rearing cells in the Pelton Fish Ladder (ODFW 1997). Warm Springs Hatchery currently raises up to 750,000 juvenile spring Chinook for release in the Warm Springs River. Approximately 10% of the juvenile Chinook produced annually at Warm Springs Hatchery voluntarily migrate from the hatchery in the fall as age-0 fish. The remaining juveniles are released as age-1 smolts the following spring. Since 2000, adult hatchery spring Chinook have also been outplanted in Shitike Creek below Peters Pasture (RM 23). These releases included 159 fish in 2000, 200 fish in 2001 and 80 fish in 2002. The program is scheduled to continue when there are adequate numbers of hatchery adults available at Warm Springs Hatchery (Gauvin 2003).

Key Life History Strategies

Wild spring Chinook adults return to the Deschutes River from March through June. Generally, the first spring Chinook reach Sherars Falls in early to mid-April and the run peaks at Sherars Falls in early to mid-May. Most spring Chinook pass above Sherars Falls by mid-June. About 80% of the spring Chinook run returns to the Deschutes after two years in the ocean (age-4 at spawning). Roughly 5% of the run returns as 3-year old jacks and 15% returns as age-5 adults (PGE 1999).

For several months before spawning, adult fish seek secure holding areas with good water quality in the mid-reaches of Shitike Creek and the Warm Springs River. They move upstream to spawning areas shortly before spawning during August and September. Spawning generally occurs in smaller headwater stream reaches with abundant clean gravel substrate and good instream and overhead cover. Fry emerge from the gravel in February and March. Fry and juvenile Chinook prefer to remain in or close to areas with lower water velocity near good escape and hiding cover, which is usually associated with emergent and aquatic plants and riparian vegetation along the stream margins. Juvenile spring Chinook rear in freshwater for a year and smolt as age 1+ fish.

Juvenile spring Chinook leave the Warm Springs River in two peaks, a fall migration from September through December and a spring migration from February through May (Lindsay et al. 1989). Fall migrants are age-0, ranging in size from 3.1 inches to 4.3 inches fork length, and do not have a smolt appearance. They likely rear over winter in the Deschutes or Columbia rivers before entering the ocean the following spring at age-1+. Most spring migrants are age-1+ fish, ranging from 3.5 inches to 5.1 inches fork length, and have the bright silver coloration characteristic of smolts (ODFW 1997). Spring Chinook in Shitike Creek are believed to follow a similar life history pattern.

Life history patterns for spring Chinook salmon have probably not changed in the last one hundred years. Former production areas located upstream of the Pelton Round Butte Project were lost, but it is likely that Deschutes spring Chinook have always migrated as 1+ smolts. It is possible that past ocean harvest of Chinook salmon may have accounted for the low percentage of five-year old spawners in this population, but there has not been a marked increase in the numbers of five-year old spawners since the U.S./Canada Salmon Treaty was implemented.

Genetic Integrity

Oregon's Wild Fish Population List recognizes natural production of spring Chinook from two separate Deschutes Subbasin populations, one in the Warm Springs River and one in Shitike Creek. Currently information is insufficient to determine if the two groups have enough genetic differences to qualify as separate populations.

Effects of hatchery releases: ODFW, USFWS and the Warm Springs Tribes have worked conscientiously to maintain the wild characteristics of spring Chinook produced at Warm Springs and Round Butte hatcheries. The 2003 Warm Springs Hatchery and Genetic Management Plan directs that all hatchery brood stock be collected from spring Chinook indigenous to the Warm Springs River. To maintain genetic diversity in the hatchery stock, a minimum of 10% wild brood stock is incorporated into each hatchery brood if wild fish returns are sufficient to meet escapement goals above Warm Springs Hatchery (passage of 1,000 wild spring Chinook above the hatchery to spawn). A maximum of 630 adult salmon are collected for brood stock annually, though actual production varies with brood stock availability (USFWS 2003). Brood fish are collected throughout the run in proportion to their time of return.

Round Butte Hatchery has only used spring Chinook originating from the hatchery (verified from coded wire tags) as brood stock since 1995 (French 2003). Brood stock is collected throughout the run, proportional to their abundance, to maintain diversity in the time of return. Before 1995, most brood stock was collected from fish returning to the Pelton Fish Trap, though some wild fish were also used. From 1985 to 1994, unmarked spring Chinook made up 5.1% to 39.4% of the spring Chinook brood stock at Round Butte Hatchery. Wild spring Chinook passing Sherars Falls were also used as brood stock during the low hatchery run years of 1977 through 1980.

Hatchery spring Chinook releases in the subbasin are generally timed to coincide with smolting so the fish migrate quickly out of the Deschutes River and into the ocean. This rapid migration minimizes interactions with naturally produced salmon. The exception is the small volitional release of fall migrants from Warm Springs Hatchery. Most of these fish over-winter in the Deschutes or Columbia Rivers where they may compete with some naturally produced spring Chinook juveniles. Possible effects from outplanting adult hatchery produced spring Chinook in Shitike Creek have not yet been determined.

Effects of harvest: Spring Chinook harvest data at Sherars Falls from 1977 through 1993 shows that harvest of hatchery and wild spring Chinook averaged 1,002 and 737 fish, respectively. Harvest rates of wild and hatchery spring Chinook salmon were similar, averaging 32% for the wild stock and 36% for the hatchery stock (ODFW 1997). Since the 1980s, recreational and tribal fisheries for spring Chinook have been closed or restricted in some years to help insure adequate wild spring Chinook spawner escapement. Harvest rates on wild Deschutes River spring Chinook in Columbia River and ocean fisheries have also dropped. Coded wire tags recovered from tagged wild spring Chinook juveniles from the 1977-79 brood years (the only lower Deschutes River wild spring Chinook to be coded wire tagged) showed that 33% of total harvest for those brood years was in the ocean, 24% in the Columbia River, and 43% in the lower Deschutes River (ODFW 1997). Today's out-of-subbasin harvest rates on Deschutes spring Chinook are likely significantly lower because of stock protection received under international harvest agreements and from the Endangered Species Act (French 2004, personal communication).

Relationship with Other Key and/or Sensitive Species

Since spring Chinook spawn in small headwater streams, they are reproductively isolated from fall Chinook but often share spawning and early rearing habitat with redband, summer steelhead and/or bull trout. Adult and sub-adult bull trout likely prey on rearing or migrating juvenile spring Chinook, particularly in areas where hiding and escape cover have been degraded. There is probably little interaction between spring Chinook and redband trout juveniles since redband spawn in late spring/early summer, though redband juveniles may compete with spring Chinook for food and space.

Population Trend and Risk Assessment

The Deschutes spring Chinook populations are small and, as such, are at greater risk from a number of factors, including environmental catastrophe, loss of genetic variability, environmental change, poor migration and ocean-rearing conditions and over-harvest. In addition, the population's freshwater spawning and rearing habitat is concentrated in several small geographic areas. The two populations have had a number of brood years that were too small to withstand in-subbasin tribal and/or recreational harvest and still meet spawner escapement goals. In most years, the number of wild spring Chinook returning to the Deschutes River has exceeded 1,300 adults, the replacement level suggested by the stock-recruitment model to maintain the stock. However, poor returns were observed from the 1989 through 1995 brood years, except in 1992. Returns in 1989 and 1990 exceeded 1,300 adults (ODFW 1997). Spring Chinook returns in 2000 and 2001 exceeded 2,000 adults, indicating that the stock is fairly healthy and productive (French and Pribyl 2003).

Fall Chinook

Population Abundance

Little is known about historic fall Chinook production in the Deschutes Subbasin. While Big Falls on the Deschutes River historically blocked all upstream migration of anadromous salmonids, it is unclear whether fall Chinook distribution extended past Steelhead Falls, or even much above the present site of the Pelton Round Butte Project. The large Chinook may have been able to pass above Sherars Falls before development of the large irrigation systems in Central Oregon, but low flows after the irrigation systems were in place may have impeded fish passage above the falls until 1940 when a fishway was built. Fall Chinook distribution to possible historic spawning grounds was blocked in the 1960s by construction of Pelton Dam (Map 6).

Historically, the subbasin probably also supported a summer Chinook run. Galbreath (1966) reported several instances where Chinook tagged at Bonneville Dam during the summer Chinook migration were recovered later in the Deschutes Subbasin — including recovery of three tags in the Metolius River before anadromous runs were blocked by dams on the Deschutes River. Further, data collected before construction of Pelton and Round Butte dams shows a number of Chinook captures at the Pelton Fish Trap before September 1, excluding spring Chinook (Jonasson and Lindsay 1988). Two peaks in the Chinook run also occurred at Sherars Falls, a July peak and a September peak. Based on the timing of Chinook passing Sherars Falls and those trapped at the Pelton, Jonasson and Lindsay (1988) concluded that the summer run probably spawned above the dam site at a higher rate than those that migrated in the fall (Nehlsen 1995).
Today, all production of fall Chinook salmon in the subbasin is from wild stock. Fall Chinook spawn and rear in the lower 100 miles of the Deschutes River mainstem. ODFW and the Warm Springs Tribes have recorded fall Chinook salmon redds from RM 1 upstream of Moody Rapids to the area of the Pelton Fish Trap at RM 99.8. Following completion of the Pelton Round Butte Project, most spawning occurred in the six miles of the lower Deschutes River from Dry Creek to Pelton Reregulating Dam (Jonasson and

Lindsay 1988; Huntington 1985). However, most fall Chinook have spawned downstream from Sherars Falls since the 1980s. Fall Chinook spawning has not been documented in any Deschutes River tributaries.

The size of the fall Chinook run varies considerably from year to year, but is now substantially larger than in the past. This rise is primarily due to increased fall Chinook escapement to spawning areas in the Lower Deschutes below Sherars Falls, as fish escapement above Sherars Falls has stayed relatively constant. Annual estimated escapement of fall Chinook spawners averaged 7,146 fish from 1977 to 2003, and ranged from a low of 2,205 fish in 1984 to a high of 20,678 in 1997. Annual escapement of adult fall Chinook upstream from Sherars Falls averaged 2,438 fish for the period 1977 through 2003 and 2,597 fish from 1993 through 2003. Annual spawning escapement of adult fall Chinook from the mouth of the Deschutes River up to Sherars Falls averaged 3,708 fish for the period 1977 through 2003, and 7,237 fish for the period 1993 through 2003 (French and Pribyl 2004).

Key Life History Strategies

Fall Chinook spawners return to the Deschutes River from July through November. They hold in deep pools and runs before spawning in the Deschutes mainstem. Spawning begins in late September, peaks in November, and is completed in December. Fall Chinook incubation and growth occurs much faster than for spring-run Chinook because they spend their freshwater life in the warmer mainstem river instead of cool, westside tributary streams (CTWS 1999a). Emergence of fall Chinook fry from the gravel begins in January or February and is completed in April or May. The juveniles begin their ocean migration the same spring, from May to July, at age-0. The downstream migration through the Columbia River occurs from April to August, with the median passage in June and July. A small percentage of the juvenile fall Chinook remains in the lower Deschutes River over winter and emigrates in spring at age-1.

Genetic Integrity

It is uncertain if one or two fall Chinook populations currently return to the lower Deschutes River — though the adult run timing of this population(s) overlaps the accepted summer and fall Chinook run timing in the Columbia River. Speculation also remains about whether one population spawns throughout the lower 100 miles of the Deschutes River or if there are two populations; one spawning above Sherars Falls and one spawning below Sherars Falls. Existing evidence supports both the one population concept and the two populations concept (ODFW 1997).

Effects of hatchery releases: Interactions between wild Deschutes fall Chinook and other stray, hatchery origin summer or fall Chinook appear to have increased substantially within the lower reaches of the Deschutes River during the last few years. Recent radio telemetry data and an ongoing Tribal fall Chinook study support this conclusion. Few stray, out-of-subbasin fall Chinook were observed in the Deschutes River before this, though it was difficult to identify stray fish since they often lacked external markings. A Columbia Basin adult fall Chinook radio telemetry study provides some insight into the straying of fish into the Deschutes River. During the 2001 through 2003 brood years, approximately 42%, 30% and 54% (respectively) of the adult fall Chinook tagged at Bonneville Dam that then entered the Deschutes River did not remain to spawn in the Deschutes River. This suggests that upriver bright fall Chinook use the Deschutes for temporary holding during migration to spawning areas in the upper

Columbia and Snake systems (Brun 2004). Further, during 2001 and 2002 tribal biologists recovering fall Chinook spawner carcasses estimated that only about 1% of the carcasses examined were fin-marked, out-of-subbasin stray salmon. Most coded wire tags recovered from these fin-clipped carcasses were from Klickitat River and Lyons Ferry fish hatcheries (Brun 2003). Nevertheless, it will be impossible to accurately estimate the number of stray hatchery salmon spawning in the river, or estimate their effect on the Deschutes River population, until all Columbia Basin hatchery-origin fall Chinook are distinctively marked.

Effects of harvest: Harvest of fall Chinook salmon in the lower Deschutes River occurs primarily in a three-mile section from Sherars Falls downstream to the first railroad trestle (RM 41–44). Recreational harvest averaged 320 adult fall Chinook and tribal harvest averaged 1,297 adult fall Chinook from 1977 to 1990, years when season length and harvest restrictions were not in place (ODFW 1997). In recent years, recreational and tribal harvests have been restricted to increase fall Chinook production in the subbasin. Recreational harvest averaged 168 adult fall Chinook and tribal harvest averaged 438 adult fall Chinook from 1998 through 2003, years when season lengths and harvest restrictions were in place (French 2004).

Relationship with Other Key and/or Sensitive Species

Juvenile fall Chinook rear in the lower Deschutes River for four to six months before migrating. Their rearing along the river's margin may overlap that of spring Chinook juveniles and redband/steelhead fry for a short period, but the effects are unknown. Adult Chinook may share holding waters with adult steelhead for several months prior to spawning. The small bull trout population rearing in the lower Deschutes River likely preys upon Chinook juveniles when the opportunity arises.

Population Trend and Risk Assessment

The fall Chinook population has experienced some of its largest runs to the Deschutes River in the past ten years. This increase coincides with years of good ocean productivity and may be directly associated with reduced ocean harvest following implementation of the U.S./Canada Salmon Treaty.

Risks to this population range from water quality to environmental catastrophe. Elevated river temperatures before the smolt migration could produce appreciable losses from *Ceratomyxosis.* Lower Deschutes River fall Chinook are susceptible to *Ceratomyxosis*, the disease caused by the myxosporidian parasite Ceratomyxa shasta (*C. shasta*). Most juvenile fall Chinook salmon may avoid contracting *Ceratomyxosis* by migrating to the ocean before July when high numbers of infective units of *C. shasta* are present in the river. An ongoing juvenile fall Chinook tagging project shows many fall Chinook juveniles are present in the river upstream of Sherars Falls during July (Brun 2002). The cooler water temperatures above Sherars Falls may delay juvenile outmigration, forcing these late migrants to migrate through the warmer water below Sherars Falls during June and July. In contrast, juveniles rearing in the river downstream from Sherars Falls appear to leave the river by early June when water temperatures begin to rise (Brun 2002). Fall Chinook are also susceptible to environmental catastrophe. An accidental derailment and spill of hazardous material along the rail line that closely borders the lower 86 miles of the Deschutes River could devastate all aquatic life from that point downstream, though the population's complex life history patterns allow some built-in population protection from such a catastrophic scenario.

3.2.2. Redband Trout

Redband trout are a hardy race of rainbow trout generally found in more arid regions east of the Cascade Mountains. Two distinct life forms of redband trout, resident redband trout and anadromous summer steelhead, are native to the Deschutes River subbasin.

Importance

Large numbers of anadromous and resident redband trout once spawned and reared throughout the Deschutes Subbasin. Today, redband trout remain a valued ecological and cultural resource in the Deschutes Subbasin and attract anglers from around the world (Table 3.2). Summer steelhead in the subbasin are listed as threatened.

Table 3.2. Rationale for Selection of Redband Trout as a Focal Species.

Species Designation	Species Recognition	Special Ecological Importance	Tribal Recognition
Two demographically independent Summer steelhead populations and one unoccupied habitat were identified by the TRT as part of the Mid-Columbia ESU, which extends from the Wind and Hood rivers on the west, and up to and including the Yakima River. Summer steelhead within this ESU were federally listed as threatened in March 1999. Later in 1999, NOAA Fisheries removed the Deschutes River hatchery steelhead stock from the ESU as it was not essential for the recovery of the wild steelhead population. The resident redband trout were proposed for ESA listing throughout its range, but a listing was determined not warranted at that time.	Redband trout, especially summer steelhead, have provided an important food source for Native Americans over thousands of years. They have also provided an important recreational fishery for other non-tribal fishers. The fishery is now generally confined to the more robust populations. The lower Deschutes subbasin supports at least three distinct populations of resident redband trout. Some populations in the White River system may represent remnants of an ancestral population and an evolutionary line originating from a primitive race of redband trout.	Redband trout serve as an important food source for a variety of wildlife and contribute nutrients that have wide-reaching benefits to the biota of the subbasin. Steelhead and redband trout spawners till portions of the gravel substrate, in different areas than Chinook. This benefits macroinvertebrates and other aquatic species. Historically, steelhead may have had one of the widest distributions of any of the anadromous fish species found within the subbasin, possibly exceeded only by the Pacific lamprey.	Native Americans throughout the Pacific Northwest, including the Confederated Tribes of the Warm Springs, maintain strong cultural and religious values for summer steelhead and Chinook salmon. These fish have long had important tribal subsistence, ceremonial and commercial value.

The following discussions briefly describe the summer steelhead and resident redband trout populations in the Deschutes Subbasin. More information on these species is provided in Appendix I.

Summer Steelhead

Population Abundance

Historically, the Deschutes summer steelhead population was robust and widely distributed. Summer steelhead occurred throughout the mainstem lower Deschutes River below Steelhead Falls and in many of the larger tributaries, including the Crooked River and Squaw Creek systems (Nehlsen 1995). Borovicka (1953) observed steelhead passing Steelhead Falls in the 1950's, though there was no known passage over Big Falls (OSGC 1953). Seven adult steelhead were captured in a trap at the ladder on Steelhead Falls. Borovicka also observed that it was possible for steelhead to go over the falls and bypass the ladder under period of high flow. After construction of the Steelhead Falls fish ladder in 1922, fish could move upstream, regardless of flow conditions, to access some excellent gravel areas and cool spring-fed flows between Steelhead and Big falls (Nehlsen 1995). Steelhead natural distribution was restricted in the Crooked River system by construction of Ochoco Dam (Ochoco Creek, RM 10) and Bowman Dam (Crooked River, RM 70) in 1921 and 1961, respectively. Borovicka (1956) reported *"a concentration of steelhead in undetermined numbers was found below the dam of the Ochoco Lumber Co. on Ochoco Creek in the town of Prineville* (OSGC 1956). Borovicka (1956) also reported *that "steelhead were observed jumping at the Stearns Dam above Prineville on the mainstem of Crooked River". "Steelhead are able to pass the Stearns Dam during flood stages of the Crooked River"* (OSGC 1956). Access to habitat above RM 100 on the Deschutes River was blocked by Pelton and Round Butte dams (Map 7).

Today, wild summer steelhead spawn in the lower Deschutes River, Warm Springs River system, White River, Shitike Creek, Wapinitia Creek, Eagle Creek, Nena Creek, the Trout Creek system, the Bakeoven Creek system, the Buck Hollow Creek system and other small tributaries with adequate flow and a lack of barriers to fish migration. Only about 5-10% of the steelhead/redband spawning in the Deschutes occurs below the confluence of White River. Most of the spawning below Sherars Falls is likely associated with the tributaries. Juvenile rearing also occurs in the mainstem below Sherars Falls and may be more important because of the general upward trend in the condition of the riparian community.

The Interior Columbia Basin Technical Recovery Team (TRT) identified two demographically independent steelhead populations, and one extirpated population in the Deschutes Subbasin. The Deschutes River Eastside Tributaries (DREST) population encompasses the mainstem Deschutes River from its mouth to the confluence of Trout Creek, and the tributaries entering the Deschutes from the east: Buck Hollow, Bakeoven, and Trout Creeks. The Deschutes River Westside Tributaries (DRWST) population are mainstem spawners from the mouth of Trout Creek upstream to Pelton Reregulating Dam (current upstream barrier to anadromous fish), and in the Warm Springs River and Shitike Creek. The Deschutes River above Pelton Dam historically supported a third population that was extirpated by the Pelton Round Butte dam complex. The population structure of steelhead in the area now blocked by Pelton Dam is ambiguous. The population may have included multiple life histories, including spring-run fish (Nehlsen 1995). Historically, steelhead were found in the Deschutes River upstream to Big Falls (RM 132), in Squaw Creek and the Crooked River, and possibly in the Metolius River, with Squaw Creek and the Crooked River being particularly productive (TRT 2003).

Estimates of wild summer steelhead migrants over Sherars Falls have ranged from a low of 482 fish in the 1994/95 run year to a high of 9,624 in the 1985/86 run year, averaging 5,005 fish annually for the period of record (1977/78 – 2002/03). However, actual wild steelhead escapement in 1985/86 may have been lower, as the escapement estimate likely included unmarked stray hatchery-origin fish that were indistinguishable from wild fish (French and Pribyl 2003).

In recent years, wild adult steelhead returns to the Deschutes Subbasin have exceeded the NOAA Fisheries interim spawner escapement objective for the subbasin of 6,300 wild steelhead. The run, however, remains below the ODFW goal for the Deschutes, which calls for a spawning escapement of 6,575 wild steelhead upstream from Sherars Falls to sustain maximum natural production potential during years of good juvenile and adult survival conditions. During years of outstanding fresh water and ocean rearing conditions and high smolt-to-adult survival, spawning escapement could be considerably larger (ODFW 1997). Steelhead production in the subbasin may expand in the near future if passage is restored past the Pelton Round Butte Project.

The subbasin also supports a run of hatchery-produced steelhead from Round Butte Hatchery. The hatchery was completed in 1973 and is the only hatchery releasing summer steelhead in the Deschutes River subbasin. As mitigation for effects of the Pelton Round Butte Project, the project operator is required to return 1,800 Deschutes stock summer steelhead adults annually to the Pelton Fish Trap from hatchery smolt releases.

Life History Strategies and Habitats

Counts of adult steelhead at Pelton Dam from 1957 through 1965 show adults migrating throughout of the year, with peaks in July, late fall, and early spring (Nehlsen 1995; King 1966). Steelhead passing the Pelton site appeared to form three size groups: a group in late spring averaging 8-12 pounds, a group in the summer averaging 3-5 pounds, and a group in the fall weighing 8-12 pounds (Gunsolus and Eichler 1962). This data suggests that the steelhead run comprised multiple life histories (Nehlsen 1995).

Adult summer steelhead generally return to the Deschutes River from June through October and pass Sherars Falls from June through March, with peak movement in September or early October. Wild female steelhead consistently outnumber males in a run year. The relative proportion of mainstem and tributary spawning is unknown. Based on limited spawning ground counts in the mainstem and tributaries, managers believe that mainstem spawning accounts for 30 to 60% of the natural production (ODFW 1997). The Warm Springs River system, the main spring Chinook producer, does not appear to produce large numbers of wild summer steelhead. Shitike Creek is a major producer of steelhead and spring Chinook.

Steelhead spawning in eastside tributaries occurs earlier than in the mainstem and westside tributaries. Steelhead usually spawn in Bakeoven, Buck Hollow and Trout creeks from January through mid-April. Some opportunistic steelhead move into small tributaries during short periods of high water to spawn in late January or February. Spawning in eastside tributaries may have evolved to an earlier time than westside tributaries or the mainstem Deschutes River because stream flow tends to decrease earlier in the more arid eastside watersheds (Olsen et al. 1991). Spawning in the lower Deschutes River and westside tributaries usually begins in March and continues through

May (Zimmerman and Reeves, 1999). Steelhead begin their spawning migration into the Warm Springs River in mid-February.

Steelhead fry emerge in spring or early summer depending on time of spawning and water temperature during egg incubation. Zimmerman and Reeves (1999) documented Deschutes River summer steelhead emergence in late May through June. Juvenile summer steelhead emigrate from the tributaries in spring from age-0 to age-3. Steelhead fry from small or intermittent tributary streams experience greater growth than those in the mainstem Deschutes River, and may have a competitive advantage as they move from tributary environments to the river (Zimmerman and Reeves, 1999). Many juvenile migrants continue to rear in the mainstem lower Deschutes River before smolting. Scale patterns from wild adult steelhead indicate that smolts enter the ocean at age-1 to age-4 (Olsen et al. 1991). Specific information on time of emigration through the Columbia River is not available, but researchers believe that smolts leave the Deschutes River from March through June.

Lower Deschutes River origin wild summer steelhead typically return to the Deschutes after one or two years in the Pacific Ocean (termed 1-salt or 2-salt steelhead). Typical of other summer steelhead stocks located east of the Cascade Mountains, very few steelhead return to spawn a second time in the lower Deschutes River. Egg-to-smolt and smolt-to-adult survival rates are not known for wild summer steelhead in the lower Deschutes River.

Genetic Integrity

Effects of hatchery releases: Hatchery releases, especially from out-of-subbasin hatcheries, pose a significant threat to wild summer steelhead populations in the Deschutes Subbasin. If numbers of hatchery origin summer steelhead captured at the Pelton Fish Trap and Warm Springs Hatchery trap and estimated in angler harvest upstream from Sherars Falls are subtracted from the estimated number of hatchery summer steelhead passing Sherars Falls, many hatchery fish remain unaccounted for. Steelhead spawning surveys on Buckhollow and Bakeoven creeks indicate that many of these fish remain in the wild each year, potentially spawning with wild steelhead. From 1984 to 1991, estimated hatchery origin summer steelhead adults migrating upstream from Sherars Falls exceeded estimated numbers of wild summer steelhead adults six of those ten years. From 1992 to 2002, the estimated number of hatchery origin summer steelhead adults escaping upstream from Sherars Falls exceeded the number of wild steelhead every year. In the 1997/98 run year, stray hatchery origin steelhead were nearly 10 times as abundant as wild steelhead (French 2004).

These out-of-subbasin strays may be contributing significant amounts of maladapted genetic material to the wild summer steelhead population in the lower Deschutes River subbasin. Round Butte Hatchery summer steelhead contribute to this problem, but their impact is small, numerically and genetically, compared to the impact of large numbers of out-of-subbasin stray hatchery steelhead that are also present in the spawning population. Round Butte Hatchery does not release any non-indigenous summer steelhead stocks in the subbasin. The cumulative effect of this genetic introgression from hatchery fish may contribute to lowered productive capacity of the wild population as evidenced by low run strength of wild summer steelhead through time.

The component of the Deschutes steelhead population spawning in the Warm Springs River system upstream of Warm Springs Hatchery may be at less genetic risk. The Warm Springs system is of particular value as a refuge for wild summer steelhead since hatchery marked or suspected hatchery origin summer steelhead are not allowed to pass the barrier dam at the hatchery (WSNFH Operational Plan 1992-1996). This effectively excludes all non-Deschutes River origin summer steelhead except stray wild summer steelhead or stray, unmarked, hatchery origin fish.

Effects of harvest: Since 1979, recreational angling regulations have stipulated that all wild fish be released unharmed. Tribal harvest of wild steelhead since 1998 has also been restricted at Sherars Falls, where most tribal summer steelhead harvest occurs. From 1993 to 2003, the annual harvest of wild steelhead in this subsistence fishery averaged 34 fish, with a range from 0 to 135 per year (French and Pribyl 2004). Significant tribal harvest of steelhead continues to occur in the mainstem Columbia, however the number of Deschutes origin fish harvested in this fishery is unknown (French 2004).

Relationship with Other Key and/or Sensitive Species

Summer steelhead and resident redband trout are reproductively isolated in the Deschutes River by a combination of spatial and temporal mechanisms (Zimmerman and Reeves 1999). Steelhead usually spawn as much as 10 weeks before redband spawn, and they also select spawning sites in deeper water with larger substrate than those selected by redband trout.

Population Trend and Risk Assessment

The TRT has identified two demographically independent summer steelhead populations in the subbasin, which are included in the Mid-Columbia ESU and have been designated as a threatened species under the federal Endangered Species Act. Rationale for this listing included the genetic risks posed to the wild population by thousands of stray, upper Columbia River Basin, hatchery-origin, steelhead. The incorporation of genetic material from large numbers of stray steelhead could have a long term effect on the subbasin steelhead production through reduced resilience to environmental extremes and diverse survival strategies. Out-of-subbasin strays also pose a threat to steelhead population health. About 5% of the hatchery stray steelhead have tested positive for whirling disease (Engleking 2002).

Resident Redband Trout

Redband trout are a large group of inland native rainbow trout endemic to basins of the Pacific Northwest east of the Cascade Mountains. They are often called the desert trout because they show a greater tolerance for high water temperatures, low dissolved oxygen levels, and extremes in stream flows that frequently occur in desert climates.

Population Abundance

The lower Deschutes River drainage is capable of producing large populations of wild redband trout. In fact, the lower mainstem Deschutes River has the strongest population of resident redband trout in Oregon (Kostow 1995). ODFW currently recognizes 46 wild populations of resident/fluvial redband trout in the Deschutes Subbasin up to Big Falls, with the strongest populations located in the lower mainstem. Wild redband trout are present throughout the lower Deschutes River, though are more abundant above Sherars Fall and most abundant in the 50-mile stretch between the Reregulating Dam and Maupin (ODFW 1997). Densities of redband trout greater than 8 inches in the 1980's averaged 1,630 fish/mile in the North Junction area (river mile 69.8 to 72.8) and 1,830 fish/mile in the Nena Creek area (river mile 56.5 to 59.5) of the lower Deschutes River. Redband trout may be less abundant below Sherars Falls because of high water temperatures, increased competition for food and habitat, and lack of high quality spawning gravel below the confluence of White River. Glacial sediments from White River may also decrease egg to fry survival and decrease aquatic insect production in the lower Deschutes (ODFW 1997). Several lower river tributaries also support redband trout populations. However, trout production capacity in many lower subbasin streams, such as White River and Trout, Bakeoven and Buck Hollow creeks, is depressed by degraded habitat, predation and competition.

Principal redband trout production areas above Lake Billy Chinook include the mainstem Deschutes up to Big Falls, Squaw Creek, the Metolius River, and the Deschutes River above Crane Prairie Reservoir, Crooked River below Bowman Dam, and the North Fork Crooked River and tributaries. During snorkeling and raft electrofishing surveys conducted from 1989 to 1991, biologists counted 1,261 redband trout in 0.42 miles surveyed between Big Falls and Lake Billy Chinook. In comparison, they counted only 68 redband trout in 0.88 miles surveyed between Big Falls and Bend. Low summer stream flow and elevated water temperature are believed to be a primary cause for the decline in fish production in this section of river (ODFW 1996). Redband trout production in the Deschutes River between Bend and Crane Prairie Reservoir varies by reach and is directly associated with winter flow conditions and available spawning and rearing habitat. Brown trout are the dominant species between Benham Falls and Wickiup Reservoir.

The Crooked River system once supported large numbers of redband trout, but production potential is currently limited by habitat degradation. Historically the system is believed to have contained two contiguous redband trout populations that were separated by a geologic barrier in the North Fork Crooked River. Today most redband populations in the Crooked River system are fragmented and isolated due to physical and water temperature barriers. As a result, the drainage contains as many as 28 isolated redband trout populations (Stuart and Thiesfeld 1994). Many of these isolated populations are thought to be depressed. Redband trout populations in the Crooked River watershed are generally healthy in streams with year around flow, instream cover, suitable water temperatures, clean spawning gravel and an intact riparian zone.

Key Life History Strategies and Habitats

Redband trout spawn in the lower Deschutes River drainage during spring and early summer, with most spawning occurring from April to June. Colder water temperatures may delay spawning in some streams. Zimmerman and Reeves (1999) observed redband spawning in the lower Deschutes River from mid-March through August. Most suitable trout spawning gravel in the lower Deschutes River is in the area from White River to Pelton Reregulating Dam (Huntington 1985).

Studies indicate that most redband trout migration is associated with spawning activity (Schroeder and Smith 1989). During studies by ODFW in the lower Deschutes River, about 75% of the tagged trout greater than 8 inches in length that were caught one to five years after tagging and were recaptured within the same 3-mile study area. Median distance of upstream and downstream migration for tagged fish that did leave the tagging area was about 9 miles and 6 miles, respectively (ODFW 1997).

Redband trout spawn in the Crooked River system from late April through early June. Fry emergence has been observed in early July to mid August. Redband trout in most streams reach about 3 inches at age one, 4.5 inches at age two, and 5-6 inches at age three. Very few redband trout exceed 10 inches. Redband trout in the Crooked River below Bowman Dam, benefiting from cold water reservoir releases, have considerably faster growth rates. Maturing Crooked River redband trout migrate up their respective spawning tributary, probably during March, April, or May, while others spawn in the same general area where they rear and little or no migration is associated with spawning.

Above the Pelton Round Butte Project, redband trout spawn in rivers and streams with cool, clean, well-oxygenated water from March through May. Redband in the Metolius spawn from November through May. Above Crane Prairie spawning occurs from January through May (Marx,2004). Fry emerge from the gravel in June and July and generally live near where they were spawned. They mature at age-3, and size varies with productivity of individual waters. Few redband trout in the upper subbasin exceed 10 inches in length (ODFW 1996).

Genetic Integrity

Redband trout isolated in the White River system above White River Falls are more similar to isolated populations of redband trout in the Fort Rock Basin of south-central Oregon — both genetically and morphologically — than they are to lower Deschutes River redband trout (Currens et al. 1990). A possible explanation is that the Deschutes River drained the Fort Rock Basin until lava flows separated the drainages in the late Pleistocene epoch (Allison 1979). Ancestral redband trout probably invaded White River and the Fort Rock Basin when they were connected to the Deschutes River. Subsequent isolation of White River and Fort Rock subbasins prevented these populations from acquiring genetic traits that evolved in the Deschutes River population during the last glacial period. Thus, some populations in the White River system may represent remnants of the ancestral population and an evolutionary line originating from a primitive race of redband trout.

Effects of hatchery releases: Differences between populations in the White and lower Deschutes rivers are probably not attributable to the influence of past hatchery rainbow trout releases in the White River system. However, evidence suggests that genetic introgression between indigenous redband trout and hatchery populations may have occurred in the lower White River, lower Tygh Creek, Jordan Creek, and Rock Creek (Currens et al. 1990). Redband trout in Deep Creek (North Fork Crooked River tributary) also exhibited a moderate level of hatchery introgression from legal rainbow trout released from 1963 to 1990 (ODFW 1995). Some populations in the Ochoco Creek system and lower Crooked River areas show low to moderate levels of hatchery introgression, probably due to a combination of high levels of past hatchery stocking and chemical treatment projects.

Effects of harvest: The lower Deschutes River supports a popular redband trout fishery. The character of this fishery has changed over the years as angling regulations have become more restrictive and the stocking of hatchery rainbow trout has been discontinued. Angling regulations and management strategies have changed to protect juvenile steelhead and to potentially increase certain size groups of wild redband trout (ODFW 1997). Current trout bag limit and tackle restrictions encourage catch and release angling. Similar angling regulation restrictions have limited redband trout harvest on the Crooked and Metolius rivers and promoted catch and release angling. Angling on the Metolius is restricted to catch and release only.

Relationship with Other Key and/or Sensitive Species

Redband appear to be reproductively isolated from steelhead. There is likely some overlap in juvenile rearing habitat between redband, Chinook salmon and steelhead.

Population Trends and Risk Assessment

The redband trout populations in the lower Deschutes River and White River are robust. The biggest risk to these populations is a catastrophic environmental incident. The lower Deschutes population may be vulnerable to the effects of a hazardous substance spill that could result from a train derailment on the rail line closely bordering the lower river. The White River population could be particularly vulnerable to catastrophic flooding associated with volcanic activity on Mount Hood. Habitat deficiencies in some small tributaries — including low flow, temperature extremes and lack of cover — put trout populations at risk.

Natural mortality of trout in the lower Deschutes River, particularly associated with spawning, is high (45% to 69%) for fish about 12 inches or more in length. This high natural mortality, and not harvest, is likely the limiting factor controlling recruitment of trout into size ranges over about 16 inches (Schroeder and Smith 1989).

Lower Deschutes River redband trout are resistant to *Ceratomyxosis*, a parasitic infection in the intestinal tract that spreads to other tissues and ultimately resulting in mortality. This disease was first detected in the lower Deschutes River immediately below the Pelton Reregulating Dam in 1965. Its presence has been detected every time tests have been conducted since 1965 (ODFW 1997). Studies done by ODFW in 1984 indicate that redband trout in the White River system are susceptible to infection by *C. shasta*.

In the Crooked River drainage, small fragmented and isolated redband trout populations reside in tributary streams, while in the mainstem of Crooked River vast reaches — with the exception of the 19 km reach below Bowman Dam — have severely reduced redband trout abundance. Only 7% of the Crooked River drainage supports strong populations of redband trout. Fragmentation and isolation of populations may eliminate life history forms and reduce survival, growth and resilience. Populations with extremely low abundance, in streams with marginal habitats, and with little or no exchange of genetic material, have a high risk of extinction (Rieman and McIntyre 1993).

Redband populations in the upper Deschutes subbasin are smaller than those in the lower subbasin and often fragmented. These populations may have been genetically impacted by past stocking of hatchery rainbow trout or are at genetic risk because of the small remaining population size. Environmental conditions associated with diminishing stream flows, degraded stream habitat, and passage barriers have placed a number of populations at risk. Upper subbasin redband populations are also at risk from disease. Metolius redband trout, for example, are much more susceptible to *C. shasta* than redband trout from the Deschutes River, which have genetic resistance to the lethal disease. Data indicates that genetic introgression with non-native hatchery rainbow trout has made the Metolius River redband more susceptible to *Ceratomyxosis* when conditions for infection occur (Currens, et al. 1997).

Introduced brown trout have proven to be a formidable competitor for redband trout in the subbasin upstream of Lake Billy Chinook, however this is mostly related to habitat modification. Brown trout are more tolerant of warm water temperatures that occur between Bend and Lake Billy Chinook in the summer and low water conditions below Wickiup in the winter. When flows below Wickiup drop in the winter (during irrigation storage months) much of the riffle habitat utilized by redband trout for feedng and rearing is lost. Brown trout tend to occupy the limited pool habitat that remains (Marx 2004). Brook trout have also become well established in a number of headwater streams and may aggressively compete with or displace redband trout.

Depressed redband trout populations are capable of rapid recovery if habitat conditions are favorable and other limiting factors are not oppressive. Redband trout production is increasing in some areas because of changes in fish management and habitat enhancement. Redband trout populations in the Metolius River have shown indications from annual redd counts that this population is on the increase due to management changes that resulted in elimination of stocking of hatchery trout and habitat protection and enhancement measures. Record high redd numbers were observed in the Metolius River in 2001-2002. ODFW biologists have also documented rebounds in the redband population below Wickiup Reservoir following several years of good winter flows. Redband populations were very depressed during the low water years in the early 1990's and increased dramatically in the late 1990's when higher flows were maintained below Wickiup Reservoir due to a series of good water years. Numbers of redband have dropped again in recent years due to poor water conditions.

3.2.3. Bull Trout

Bull Trout in the Deschutes Subbasin are part of the Deschutes Recovery Unit, which encompasses the Deschutes River and its tributaries and contains two core bull trout habitat areas. The lower Deschutes Core Area and upper Deschutes Core Area are separated by Big Falls on the mainstem Deschutes River at RM 132. In addition, the Odell Lake Core Area supports a small remnant bull trout population in a portion of the extreme southern end of the subbasin that was cut-off from the Upper Deschutes River system by a lava flow. The lower Deschutes Core Area is generally described as the mainstem Deschutes River and its tributaries from Big Falls downstream to the Columbia River. The upper Deschutes core habitat is generally described as the upper Deschutes River, Little Deschutes River, and other tributaries upstream from Big Falls at about River Kilometer 212 (River Mile 132). Current subbasin bull trout distribution is limited to the lower Deschutes Core Area, which includes the five local populations in Shitike Creek, the Warm Springs River, and the three Metolius River population complexes and the Odell Lake population (USFWS 2002). The upper Deschutes core habitat does not currently support bull trout populations, but had bull trout historically (Map 8).

Importance

Bull trout were selected as a focal species based on an evaluation of the legal, cultural and ecological status (Table 3.3).

Table 3.3. Rationale for Selection of Bull Trout as a Focal Species.

Species Designation	Species Recognition	Special Ecological Importance	Tribal Recognition
The U.S. Fish and Wildlife Service issued a final rule listing the Columbia River population of bull trout, including the Deschutes subbasin populations, as a threatened species under the Endangered Species Act in June 1998. Bull trout are also currently listed on the Oregon Sensitive Species List as Critical.	Until about 1960, bull trout were not highly regarded by tribal or non-tribal fishers or fishery managers. Instead they were trapped and removed [killed] from the Metolius and Warm Springs rivers because of perceived predation on spring Chinook eggs and juveniles	Historically bull trout were an important component of the subbasin's aggregate fish population. The fish were an important predator that co-existed with other fish species and helped to keep the ecosystem in balance. Today bull trout are recognized as indicators of high quality fish habitat and cold water. Their presence is associated with an intact aquatic ecosystem.	Historically, the tribes utilized bull trout as food fish. Bull trout were generally perceived to be a predatory fish that harmed more desirable fish species. This tribal image of the fish was fostered by the negative image given by ODFW and the USFWS. Today, the tribes view bull trout as being an important part of healthy, functioning ecosystems, which is consistent with their traditional beliefs.

Characteristics that define bull trout populations in the Deschutes Subbasin are summarized in the following section. Appendix I describes the populations in more detail.

Population Abundance

Historically the Deschutes Subbasin supported a number of bull trout populations that included the lower Deschutes River population in the mainstem and tributaries upstream to Big Falls, the upper Deschutes River population above Big Falls and tributaries, and the Odell Lake – Davis Lake population. Anecdotal information suggests that bull trout in the lower Deschutes River subbasin were more abundant historically than at present. Workers at a Pelton Reregulating Dam fish trap, in place before 1968, recalled annually passing up to several hundred large bull trout upstream for a number of years, indicating that bull trout were much more abundant historically (Ratliff et al. 1996). Today, Deschutes River bull trout populations are listed as threatened under the Endangered Species Act.

The Metolius River system supports the largest complex of bull trout populations in the Deschutes Subbasin and contains both resident and adfluvial bull trout. Bull trout currently inhabit most riverine habitats of the Metolius drainage (USFWS 2002). The drainage also supports a migratory bull trout population that uses the Metolius River and Lake Billy Chinook as seasonal foraging habitat and as a migratory corridor (Buchanan et al. 1997). The local population has exhibited a positive trend in spawning numbers, possibly in response to angling restrictions. The number of redds observed increased from 27 in 1987 to 330 in 1994 (Ratliff et al. 1996), and more recently to a high of 760 redds in 2001 and 643 in 2002 (Wise 2003). The 2002 count was a decrease of 15.4% from 2001, but still the second highest count on record. Based on an estimate of 2.3 adult fish per redd, 1,479 bull trout moved into Metolius Basin streams to spawn during the 2002 year (Wise 2003).

Bull trout in the lower Deschutes subbasin reside in the mainstem above Sherars Falls, Shitike Creek and the Warm Springs River (USFWS 2002). The draft bull trout recovery plan estimates there are 1,500 to 3,000 adult bull trout in the recovery unit, which are distributed in the lower Deschutes Core Area (USFWS 2002). In 2001, Brun (2001) estimated there were approximately 260 and 470 bull trout spawners in the Warm Springs River and Shitike Creek, respectively. The Shitike Creek population may be comparable to the Metolius River populations in juvenile bull trout densities, but the Warm Springs River population is much smaller. In a 1997 study, ODFW estimated that the lower Deschutes River reach near North Junction (RM 68.5 to 71.5) contained an estimated 7 fish per mile over 25 cm in length (Newton and Nelson 1997).

The Odell Lake subpopulation contains the last extant native lake migratory (adfluvial) bull trout in Oregon (Ratliff and Howell 1992; Buchanan et al. 1997). Bull trout redd numbers in Trapper Creek, the only known spawning area in the Odell/Davis complex, have ranged from 12 to 24 redds in recent years. Juvenile bull trout were documented in Odell Creek by USFS personnel in 2003, the first observations of bull trout in Odell Creek since the early 1970's (Marx 2004).

Key Life History Strategies

The Warm Springs River and Shitike Creek bull trout populations are thought to be fluvial, but contain a resident component as well. These systems provide the only known suitable bull trout spawning areas in the lower Deschutes Subbasin. The fluvial life history pattern is dominant in the lower Deschutes River, with bull trout migrating from their smaller natal streams to a larger river (the Deschutes) to rear, and then back to their natal stream to spawn. Adults return from the Deschutes River to headwater spawning areas in the Warm Springs River and Shitike Creek from April to June (Brun and Dodson 2000). Fish generally reach spawning habitat by September and complete spawning by the end of October. Spawning in Shitike Creek has been observed from August 20 through early November when water temperature averaged 6.2°C (43°F) between RM 18 to 27; this was the mean 7-day average from thermographs. In the Warm Springs River, temperatures averaged 6.6°C (44°F) between RM 31 to 35 during the late-August to early November spawning period (Brun 1999).

At age-2 and age-3, some juvenile bull trout from the Warm Springs River and Shitike Creek migrate to the mainstem lower Deschutes River to rear. Brun (1999) found that juvenile bull trout migrants from Shitike Creek averaged 131mm and 183.9mm in the spring and fall, respectively. At age-5, fluvial and adfluvial fish migrate back to their natal tributary to spawn (USFWS 2002). Bull trout are very piscivorous allowing them to reach up to 20 lbs in size depending on food availability.

The Metolius River complex populations have a life history similar to the Shitike Creek and Warm Springs River populations. However, the Metolius populations contain an adfluvial component that spends a portion of its life rearing in Lake Billy Chinook. Most bull trout in the Metolius system spawn from August 15 to October 1, though spawning has been observed as early as July 13 and as late as mid-October (Ratliff et al. 1996).

Genetic Integrity

Research conducted on the genetics of bull trout in Oregon established the genetic baseline for bull trout and confirmed Oregon Department of Fish and Wildlife's designation of Deschutes bull trout as a separate gene conservation group (Spruell and Allendorf 1997). Fluvial subpopulations in Shitike Creek and the Warm Springs River contribute bull trout into the lower Deschutes River. The Metolius River system populations were historically a component of the lower Deschutes populations. The Pelton/Round Butte Project isolated some of these populations. The Odell Lake population has been isolated from other subbasin populations for approximately 6,000 years.

Effects of hatchery releases: Bull trout have not been artificially produced in the subbasin and there are no records of artificially produced bull trout being released anywhere in the subbasin. In addition, there are no documented instances of bull trout from other subbasins straying into the Deschutes subbasin.

Releases of other hatchery-reared salmonids within the subbasin may mimic or potentially be more harmful than the potential effects of straying. Hybridization with brook trout is a concern for the Warm Springs River and Shitike Creek populations. A low level of hybridization has been documented in the lower Deschutes River subbasin. Brook trout are present in high lakes and the upper reaches of Shitike Creek and the Warm Springs River. Competition between juvenile brook trout and bull trout for available resources may exist where both are present (Brun and Dodson 2000). Introduced brook and brown trout may also be limiting some bull trout populations in the Metolius River basin due to their potential for interaction. Brown trout in Suttle Lake may have been partially responsible for the demise of that bull trout population.

Effects of harvest: In the past 20 years, size and bag limit regulations on the lower Deschutes River have likely precluded a target bull trout fishery and limited exploitation rates to very low levels. The taking of bull trout was banned by rule in the lower Deschutes River starting in 1994 (ODFW 1997). Today, the only legal harvest of bull trout within the Deschutes Subbasin is a very restrictive fishery within Lake Billy Chinook. Protective bull trout angling regulations in the Metolius River have been implemented since 1980, which culminated in the closure of the tributaries below Lake Creek to angling in 1994 (USFWS 2002). Overharvest of bull trout may be a factor in a mixed fishery with brown trout because of angler confusion about species identification (Ratliff et al*.* 1996).

The Warm Springs River and Shitike Creek are closed to tribal angling to protect spring Chinook salmon, except for the occasional opening of the Warm Springs River from the mouth to the hatchery for spring Chinook when the salmon are abundant. Tribal angling is generally very light during these special seasons. A small tribal harvest of bull trout may occur from the lower Deschutes River bordering the reservation (Brun 2003).

Relationship with Other Key and/or Sensitive Species

Bull trout share spawning and early rearing habitat with spring Chinook and redband trout. They may prey on spring and fall Chinook juveniles in the Deschutes River.

Population Trends and Risk Assessment

Bull trout core areas with fewer than five local populations are at increased risk, core areas with between five and ten local populations are at intermediate risk, and core areas with more than ten interconnected local populations are at diminished risk. In the lower Deschutes Core Area, there are currently five known local populations. Based on the above guidance, bull trout in the Deschutes Recovery Unit is at an intermediate threat category (USFWS 2002). Bull trout in the Odell Lake – Davis Lake population are at an increased risk of extinction.

The bull trout populations in the Metolius River system appear to have rebounded from extremely low levels as recently as the 1980s (Fies et al. 1996). The recent trend in Metolius River system bull trout redd counts also appears to indicate an upward population trend. Bull trout spawning surveys in Shitike Creek and the Warm Springs River indicate that the annual spawner numbers are stable in the Warm Springs River system and on an upward trend in Shitike Creek.

Small bull trout populations risk extinction through excessive rates of inbreeding and chronic or catastrophic natural processes. It is unknown if lower Deschutes River subbasin bull trout populations are large enough to escape these risks (ODFW 1997). The limited quantitative measures of bull trout numbers in the lower Deschutes suggest several small populations exist. Tribal fishery managers have been closely monitoring bull trout populations in recent years at the weirs in Shitike Creek and the Warm Springs River, so any unusually population characteristics should be promptly noted.

3.2.4. Pacific Lamprey

Importance

The Pacific Lamprey is an indigenous, anadromous species in the Deschutes Subbasin. It was selected as a focal species based on its cultural significance (Table 3.4).

Table 3.4. Rationale for Selection of Pacific Lamprey as a Focal Species.

Species Designation	Species Recognition	Special Ecological Importance	Tribal recognition
Pacific lamprey were listed as a state sensitive species in 1993. In 1997 they were given further legal protected status by the state. They are not listed as a federally threatened or endangered species. Conservation groups in several western states petitioned to give lamprey federal protection under the Endangered Species Act in January 2003. Budget limitations forced the USFWS to defer formal consideration of the petition.	Historically lampreys provided an important local tribal fishery for subsistence, ceremonial and medicinal purposes. However, people have commonly viewed lampreys as a threat even where they are native and live in harmony with their ecosystem. Some people seem to find their parasitic behavior repulsive, a view that is perhaps also sustained by their sliminess and snake-like appearance (Kostow 2002).	Historically this species likely had the widest distribution of any of the anadromous species in the subbasin. Lamprey can often negotiate barriers that effectively interrupted migration of other fish. Historically pristine conditions in the subbasin likely supported lampreys. Most adult lampreys die shortly after spawning, feeding various scavenger species and contributing rich nutrients throughout their freshwater habitat (Kostow 2002).	The species is culturally significant for Native Americans, including the Warm Springs Tribes. They have religious and ceremonial importance. They are also important in the annual tribal subsistence fishery in the Deschutes River at Sherars Falls. Fatty and highly nutritious, they are a traditional food for some Native Americans (Kostow 2002). They have also been used for medicinal purposes, including as hair oil and to cure tuberculosis.

Characteristics that define Pacific lamprey populations in the Deschutes Subbasin are summarized in the following section. The populations are described in more detail in Appendix I.

Population Abundance

Historically, Pacific lamprey were widely distributed throughout the Deschutes Subbasin. Pacific lamprey distribution in the Deschutes subbasin is currently confined to the Deschutes River and select tributaries downstream of the Pelton Round Butte Project. Most, if not all, spawning is believed to occur within the boundaries of the Warm Springs Reservation, likely only in the Shitike Creek and Warm Springs River systems. ODFW personnel have conducted numerous steelhead surveys on the tributaries entering the lower Deschutes River from the east. No adult or juvenile lampreys have been observed during these surveys. Tribal biologists are currently mapping the known larval distribution of lamprey within reservation waters (BPA Project 200201600) (Brun 2003).

Historic lamprey counts at Bonneville and The Dalles dams suggest that lamprey production swung between tens of thousands and hundreds of thousands in just a few years (Kostow 2002). In recent years, pacific lamprey abundance throughout the Columbia River Basin has decreased significantly (ODFW 1997). Pacific lamprey abundance in the Deschutes Subbasin has not been estimated, but appears to be low. The current carrying capacity for pacific lamprey in the Deschutes Subbasin is unknown, however, because of their high fecundity rate, lamprey populations may be able to quickly rebound if freshwater and ocean survival conditions are favorable.

Key Life History Strategies

Life history information for the Deschutes River subbasin lamprey population is generally lacking. The following description of the Pacific lamprey life cycle is generally based on observations and data from other Columbia River Basin or Pacific Northwest lamprey populations.

Pacific lampreys are an anadromous species that is parasitic during their life in the ocean. Adult lampreys return to the Deschutes River during the summer months. It is assumed that they over-winter in subbasin streams before spawning the following spring or early summer. Willamette River subbasin lampreys spawn from February through May (Kostow 2002). Colder water temperatures in the westside Deschutes River tributaries may result in a slightly later spawning time in the Deschutes River subbasin.

Spawning generally occurs just upstream of stream riffles and often near silty pools and banks. Lampreys' fecundity is thought to be highly variable, possibly ranging from 15,500 to 240,000 eggs/female (Kostow 2002). This may suggest a variety of life history patterns or age classes in a single spawning population. Lampreys spawn in low gradient stream sections and construct gravel nests at the tail-outs of pools or in riffles. Most authorities believe that all lampreys die after spawning. However, there have been several reported observations of robust lamprey kelts migrating downstream and an indication of repeat spawning in one Olympic Peninsula population (Kostow 2002).

Lamprey eggs hatch within 2-3 weeks, depending upon water temperature. The juveniles emerge from the spawning gravel at approximately 1 cm in length. The ammocoetes burrow into the soft substrate downstream from the nest and may spend up to six or seven years in the substrate. They are filter feeders that feed on algae and diatoms. The ammocoetes will move gradually downstream, often at night, seeking coarser sand/silt substrates and deeper water as they grow. They appear to concentrate in the lower parts of basins before undergoing their metamorphism, or body transformation. After completing their metamorphism from the juvenile to adult stage, they migrate to the ocean from

November through June (Kostow 2002). In the Umatilla River this out-migration was observed to occur in the winter to early spring (Kostow 2002).

Pacific lampreys enter saltwater and become parasitic. They feed on a wide variety of fishes and whales. They appear to move quickly offshore into waters up to 70 meters deep. Some individuals have been caught in high seas fisheries. The length of their ocean stay is unknown, but some have speculated that it could range from 6 to 40 months (Kostow 2002).

Genetic Integrity

Little is known about straying of lamprey in the Deschutes River subbasin, including the straying of lamprey from other subbasins into the Deschutes. Studies of sea lamprey (*Petromyzon marinus*) in the Great Lakes indicate that some lampreys have essentially no homing behavior. Instead, the adults may be attracted to streams with concentrations of ammocoetes, which were detected by some chemical stimuli (Kostow 2002). If these observations apply to Pacific lampreys, straying may be common if the chemical stimuli are an indiscriminate attractant for all lampreys.

Effects of hatchery releases: There have been no artificial lamprey production programs anywhere within the subbasin.

Effects of harvest: All lamprey harvest in the subbasin is associated with the Tribal salmonid subsistence fishery located at Sherars Falls. Tribal harvest of adult lampreys in recent years has been low, but there are no estimates of the numbers of lampreys harvested. The first sampling program designed to monitor tribal harvest of adult lamprey from the Deschutes River is scheduled to begin in 2003 at Sherars Falls (run 2003).

Relationship with Other Key and/or Sensitive Species

Lampreys are not parasitic while in fresh water. There is an overlap of fresh water habitat with other subbasin focal fish species, but since the lampreys are filter feeders there is little opportunity for competition. Juveniles are likely a food source for other fish.

Population Trends and Risk Assessment

Risks to lamprey populations include stream habitat degradation (including erratic or intermittent flow, decreased flows, increased water temperatures and poor riparian areas), predation in all life stages, artificial barriers and the lack of appropriate screening for lampreys. They are particularly vulnerable to pollution and erratic stream flows during their juvenile or ammocoete life stage because of the length of time they reside in the stream substrate. Migrating ammocoetes are especially vulnerable to predation during their in-river and ocean migration. While most movement appears to occur at night, their size (up to 10 cm) and the number of predators — especially in the Columbia River and impoundments — pose a serious risk.

3.2.5. Sockeye Salmon

This assessment considers both anadromous sockeye salmon, which were extirpated from the subbasin about 1940, and the landlocked sockeye or kokanee salmon, which is an important subbasin fish species today. Appendix I provides a more detailed discussion of the populations.

Importance

Sockeye were an indigenous, anadromous species found in the Deschutes Subbasin and were selected as a focal species because of their historic ecological value, tribal significance and potential for re-introduction if remedial fish passage issues at the Pelton Round Butte Project are successful (Table 3.5).

Table 3.5. Rationale for Selection of Sockeye as a Focal Species.

Species Designation	Species Recognition	Special Ecological Importance	Tribal recognition
Sockeye/kokanee salmon within the Mid-Columbia ESU are not listed on the state or federal sensitive species lists.	Since sockeye salmon were indigenous to Suttle Lake and Link Creek, it is reasonable to believe a residual sockeye (kokanee) population existed as well. The 1940 lake survey of Suttle Lake (Newcomb 1941) reported that land-locked Blueback salmon were abundant. It is unknown if the indigenous form of kokanee are still present in Suttle Lake (Fies et al. 1996).	Sockeye salmon were once an important anadromous species in the subbasin, with habitat in the Deschutes River and the Metolius River and tributaries. Sockeye die shortly after spawning. Their carcasses were utilized by various scavenger species and contributed rich nutrients throughout their freshwater and associated riparian habitat. Large spawning populations of kokanee salmon are now making similar contributions to the ecosystems in the upper portion of the subbasin.	Sockeye are highly regarded by members of the Confederated Tribes of the Warm Springs Reservation. The adult sockeye salmon were a high quality fish that was an important Tribal food source. They were captured as adults on the Deschutes River at Sherars Falls and in the Metolius River system on their spawning grounds.

Population Abundance

Sockeye salmon in Suttle Lake were an indigenous species (Fies and Robart 1988; Fulton 1970; NOAA No. 618) that used Link Creek for spawning and Suttle Lake for rearing. The historic sockeye run was suppressed by the 1930's and apparently extirpated by 1940, due to passage problems on Lake Creek near the outlet of Suttle Lake (Fies et al. 1996). Recent estimates of spawning adult kokanee in the Metolius River basin range from 83,471 adults in 1996 to 569,201 adults in 2000 (Thiede et al. 2002). Modeling of potential sockeye production was completed by Oosterhout (1999) using the Passage Risk Assessment Simulation (PasRAS) for Lake Billy Chinook and tributaries based on downstream passage efficiencies and incorporates simulated life-cycle survival. Oosterhout notes that the PasRAS model is primarily intended for assessing passage options. Oosterhout (1999) ran four scenarios using collection efficiencies between 60% and 100%. Predicted spawner populations ranged from 17,472 spawners with a starting population of 1-3,000 adults and supplementation to 209,476 spawners with collection efficiencies of 100% and full seeding with supplementation.

Kokanee, the resident form of the species, provide a valuable fishery in ten subbasin lakes and reservoirs, including the former sockeye habitat in the Metolius/Suttle Lake complex. The composite subbasin kokanee carrying capacity has not been estimated.

Key Life History Strategies

Sockeye salmon populations often exhibit a number of different life history patterns from each brood year's production. Most sockeye juveniles smolt and migrate to the ocean after 12 to 15 months rearing in a freshwater lake environment. A small percentage smolt and migrate after two years of lake rearing. Adult sockeye return to spawn after 1 to 3 years of ocean life (Wydoski and Whitney 1979).

Kokanee generally reach sexual maturity at age-3, and then die in the fall after spawning (Fies et al. 1998). Kokanee migrate from Lake Billy Chinook each fall to spawn in the Deschutes River above Lake Billy Chinook and in the first two miles of Squaw Creek (Fies et al. 1998). Kokanee from Lake Billy Chinook also spawn in the Metolius River and tributaries. A similar migration of Wickiup Reservoir Kokanee occurs annually in the short segment of the Deschutes River below Crane Prairie Dam.

Genetic Integrity

Out-of-basin sockeye stray into the Deschutes River and are captured in the Pelton Fish Trap each year. These fish have reached a dead-end and have no biological impact on the subbasin since the native sockeye salmon population was extirpated. There is no evidence that the small numbers of kokanee out-migrants leaving the subbasin are straying into other subbasins.

Effects of hatchery releases: Hatchery-reared kokanee salmon are released annually within the subbasin in several lakes and reservoirs, including East and Paulina lakes and Crane Prairie Reservoir. Other kokanee populations associated with subbasin lakes and reservoirs are self-sustaining. Hatchery releases of kokanee into subbasin waters have originated from a number of in-subbasin and out-of-subbasin sources. Current kokanee released into East and Paulina lakes are reared at the Wizard Falls Fish Hatchery from eggs collected annually at the outlet of Paulina Lake (Fies et al. 1998).

Effects of harvest: The only sockeye salmon harvest occurring within the basin is minor incidental harvest of a few individuals annually in the subsistence tribal fishery at Sherars Falls. Kokanee provide a valuable fishery in ten subbasin lakes and reservoirs, including the former sockeye habitat in the Metolius/Suttle Lake complex.

Relationship with Other Key and/or Sensitive Species

Historically sockeye spawning and juvenile rearing occurred in the same habitat utilized by bull trout. Juvenile sockeye or kokanee could provide an important food source for sub-adult and adult bull trout. Sockeye likely interact with other species during downstream migration in the mainstem Deschutes.

Population Trends and Risk Assessment

The indigenous Deschutes River subbasin sockeye salmon population was extirpated by 1940. Currently, the only adult sockeye salmon found in the subbasin are the few fish observed at the Pelton Reregulating Dam fish trap each year. These fish are assumed to be out-of-basin strays or adults returning from kokanee that successfully migrated downstream through the Pelton Round Butte Project.

3.3. Terrestrial Focal Species

Focal species were selected by considering listed species, and by considering species of concern by local biologists. Wildlife recognized by local biologists as rare or significant to local areas in the subbasin are shown on Table 3.6. Other considerations during the focal species selection process are identified below.

Table 3.6. Wildlife Species Recognized as Rare or Significant to a Local Area.

Wildlife Species Recognized as Rare or Significant		
Species	**Significance**	**Assessment Unit(s) Locations of Local Areas**
Mule deer (white-tailed deer and black-tailed deer are also present in the subbasin)	Ungulate winter range degradation (George, p.c.)	Lower Deschutes, Metolius/Squaw Creek.
Bighorn sheep (reintroduced population)	Ungulate winter range degradation (Kunkel, p.c.)	Lower Deschutes, Eastside.
Mountain goat (former population)	ungulate winter range degradation (ODFW 2003b)	White River, Lower Deschutes, Metolius/Squaw Cr
Sharp-tailed grouse (former population) habitat	Habitat loss, grasslands (Kunkel p.c.)	East Side, Upper Crooked, Lower Crooked
Greater sage grouse	Habitat degradation, shrub-steppe (Hanf, p.c.)	Lower Crooked River, Upper Crooked River
Golden eagle habitat	Threat of habitat degradation, rimrock and cliff nesting sites (Gilbert p.c.)	All except Cascade Highlands

Managed Wildlife Species. Currently, 68 wildlife species are harvested during hunting seasons in the subbasin (Appendix III).

HEP Wildlife Species. Species used in loss assessments for hydrosystem development. Twenty-four wildlife species used in the HEP process occur in the subbasin (Appendix III).

Partners in Flight. High priority bird species used for monitoring. A total of 111 species occurring in the subbasin were listed by the Partners in Flight organization (Appendix III).

Critical Functionally Linked Species. A list of critical functionally linked species thought to occur historically in the subbasin (Appendix III).

Species of Special Cultural Significance. Members of the Confederated Tribes of the Warm Springs Indian Reservation consider all forms of wildlife to be culturally important. While some species are important primarily for one purpose, such as food, often a single species is important for several reasons. For example, mule deer are important as food, but non-food parts of each animal could be valuable for clothing, regalia, medicine, and other uses. The presence of frogs in a small spring might indicate that the water is safe to drink. The complex relationship between tribal members and wildlife of all species in the subbasin is a fundamental part of tribal culture (Calvin 2004).

Based on these considerations, seven terrestrial focal species were selected (Table 3.7). These focal species were chosen to represent a “guild” of species whenever possible, for example, the sharp-tailed grouse could represent grassland species, and the sage grouse could represent shrub-steppe species.

Table 3.7. Wildlife Focal Species in the Deschutes Subbasin.

Wildlife focal species selected and rationale for selection, and associated habitats.

Focal Species	**Rationale for Selection***	**Associated Habitats**
American beaver	Riparian habitat species, modifies habitat. On list 5.	Riparian, herbaceous wetlands.
Columbia spotted frog	Riparian habitat and herbaceous wetlands habitat species. List 1.	Riparian, herbaceous wetlands
White-headed woodpecker	Large ponderosa pine tree habitat species. List1.	Ponderosa pine forest and woodlands.
Mule deer	Ungulate winter range habitat species. Lists 2 and, 4.	Ungulate winter range.
Greater sage grouse	Shrub-steppe habitat species. Lists: 1,2,3,4,5.	Shrub-steppe.
Columbian sharp-tailed grouse	Grassland species. List 3.	Eastside interior grasslands.
Golden eagle	Cliff and rimrock habitat, grassland, shrub-steppe habitat species. List 2.	Cliff and rimrock habitats, grassland, shrub-steppe.

* 1=threatened, endangered, and state sensitive species, 2=species recognized as rare or significant to a local area, 3=Partners in Flight species, 4=HEP species, 5=game species, 6=critically functionally-linked species.

Species accounts for each terrestrial focal species are presented in Appendix III. These accounts present biological, populations and trends data if available. A summary of status for each focal wildlife species in the subbasin is presented in Table 3.8. Of the focal species selected, only the sharp-tailed grouse has been extirpated from the subbasin (Csuti et.al 2001). Local biologists believe the American beaver has been extirpated from many former habitat areas in the subbasin, as are Columbia spotted frogs. No introduced species were chosen as focal species.

Current and Historical Habitat types are shown on Maps 9-12 for the Deschutes Subbasin and larger Columbia Plateau Province.

Table 3.8. Terrestrial Focal Species Distribution, Populations and Trends.

Species	Terrestrial Focal Species Distribution in Assessment Units	Population and trends
American beaver	All	Historically depleted, but now recovered. Currently harvested during hunting and trapping season, population tracked by ODFW
Columbia spotted frog	Upper Crooked River	Remnant population. Declining.
White-headed woodpecker	All	Status unknown.
Mule deer	All	Game animal. Population tracked by ODFW. Declining in some areas due to development on winter ranges.
Greater sage grouse	Upper Crooked River, Lower Crooked River.	Game bird. Population tracked by ODFW. Declining.
Columbian sharp-tailed grouse	Extirpated.	Extirpated.
Golden eagle	All.	57 active nest territories counted in 2000 (Clowers 2004.) Population trend unknown in Oregon (Ibid, Marshall 2003.) Some indications of decline in the general region of northern Great Basin (Marshall 2003 p. 162.)

3.3.1. American Beaver

Importance

The American beaver was chosen as a focal species because of its unique habitat-altering role in riparian habitats. This unique species alters the riparian habitat by constructing dams across streams to form still-water ponds, building stick lodges in the ponds, felling large trees into the water, and transporting smaller woody material into the aquatic environment.

Population Abundance and Distribution

The beaver occurs throughout most of the U.S. and Canada and into northern Mexico, except for the Arctic northern fringe, southern Florida and California, and the southern half of Nevada (Burt 1976). The beaver occurs throughout the State of Oregon. The subspecies *Castor Canadensis leucodontus*, a large chestnut-brown colored variation, occurs in the northern two-thirds of Oregon east of the Cascade Range, including the Deschutes Subbasin (Ibid).

No estimates of beaver populations are available for Oregon and, in the absence of systematic population estimates, harvest and damage complaint levels are considered indicative of the population levels in local areas and statewide (Ibid). From 1981 to 1991, over 5,000 complaints of beaver damage were received by the Oregon

Department of Fish and Wildlife (Ibid). During the 1930s, many beaver were transplanted in Oregon from areas of damage to areas of suitable habitat with no beaver (Ibid). The range of reported annual beaver harvests for the counties within the Deschutes Subbasin for the years 1990-95 are shown in Table 3.9. Clatsop County's harvest range is shown for comparison. Special beaver harvest regulations were in place within the subbasin for July 1, 2002 through June 30, 2004 (ODFW 2002).

Table 3.9. Range of Annual Beaver Harvest for the Years 1990-95 for counties in the Deschutes Subbasin. Clatsop County harvest range is shown for comparison.

County	Range of Numbers of Beaver Harvested Annually, 1990-95.
Clatsop	212-821
Deschutes	31-63
Crook	13-50
Hood River	18-40
Jefferson	4-31
Sherman	No numbers shown (previous 5 years: 0-8)
Wasco	24-86

All wetland cover types (e.g., herbaceous wetland and deciduous forested wetland) must have a permanent source of surface water with little or no fluctuation in order to provide suitable beaver habitat (Slough and Sadleir 1977). Water provides cover for the feeding and reproductive activities of the beaver. Lakes and reservoirs that have extreme annual or seasonal fluctuations in the water level will be unsuitable habitat for beaver. Similarly, intermittent streams, or streams that have major fluctuations in discharge (e.g., high spring runoff) or a stream channel gradient of 15 percent or more, will have little year-round value as beaver habitat.

Beavers can usually control water depth and stability on small streams, ponds, and lakes; however, larger rivers and lakes where water depth and/or fluctuation cannot be controlled are often partially or wholly unsuitable for the species (Murray 1961; Slough and Sadleir 1977). Rivers or streams that are dry during some parts of the year are also assumed unsuitable beaver habitat (Ashley and Stovall 2004). In riverine habitats, stream gradient is the major determinant of stream morphology and the most significant factor in determining the suitability of habitat for beavers (Slough and Sadleir 1977). Stream channel gradients of 6 percent or less have optimum value as beaver habitat (Ashley and Stovall 2004).

An adequate and accessible supply of food must be present for the establishment of a beaver colony. The actual biomass of herbaceous vegetation will probably not limit the potential of an area to support a beaver colony (Boyce 1981). However, total biomass of winter food cache plants (woody plants) may be limiting. Low marshy areas and streams flowing in and out of lakes allow the channelization and damming of water, allowing access to, and transportation of, food materials (Ashley and Stovall 2004).

Key Life History Strategies

The basic composition of a beaver colony is the extended family, comprised of a monogamous pair of adults, subadults (young of the previous year), and young of the year (Svendsen 1980). Female beavers are sexually mature at 2.5 years old. Females normally produce litters of three to four young with most kits being born during May and

June. Gestation is approximately 107 days (Linzey 1998). Kits are born with all of their fur, their eyes open, and their incisor teeth erupted (Ashley and Stovall 2004).

Subadults disperse during the late winter or early spring of their second year, with increased runoff from snowmelt or spring rains. Subadult beavers have been reported to disperse as far as 236 stream km (147 mi) (Hibbard 1958), although average emigration distances range from 8 to 16 stream km (5 to 10 mi) (Hodgdon and Hunt 1953; Townsend 1953; Hibbard 1958; Leege 1968). The daily movement patterns of the beaver centers around the lodge or burrow and pond (Rutherford 1964; Ashley and Stovall 2004).

3.3.2. Columbia Spotted Frog

Importance

The Columbia spotted frog was chosen as a focal species since it represents species that require a permanent-water habitat. The species occupies habitats in the Crooked River drainage. The Oregon spotted frog, while not a focal species, shares many of the same habitat requirements. Important habitat for this spotted frog lies in the upper Deschutes subbasin. Immediate opportunities exist for spotted frog habitat restoration.

Population Abundance and Distribution

The adult Columbia spotted frog (*Rana luteiventris*) is about 4 inches long, not including the legs. The adult frogs are green to greenish-brown, with large black spots on the back. Eggs are deposited in a soft, orange-sized egg masses, sometimes several egg masses on top of one another, and the egg masses may separate and float on the top of the water in a frothy mass before hatching. Tadpoles are small, from 0.25 in. to 1.5 in. long.

This frog occurs from British Columbia south into Eastern Oregon and Northern Nevada and Utah in small isolated populations (Csuti et al. 2001). In the Deschutes Subbasin, it occupies small areas in the upper and lower Crooked River drainage (Carey 2004).

The Columbia spotted frog is relatively aquatic and is rarely found far from water. It occupies a variety of still water habitats, and can be found in streams and creeks (Hallock and McAllister 2002). They are closely associated with clear, slow-moving or ponded surface waters, with little shade (Reaser 1997). The Columbia spotted frog occupies aquatic sites with a variety of vegetation types, from grasslands to forests (Csuti 1997). A deep silt or muck substrate may be required for hibernation and torpor. In colder portions of their range, they use areas where water does not freeze, such as springheads and undercut streambanks with overhanging vegetation (IDFG et al. 1995). They may disperse into forest, grassland, and brushland during wet weather, and will use streamside small mammal burrows as shelter. Adults are opportunistic feeders and feed primarily on invertebrates. Larval frogs feed on aquatic algae and vascular plants, and scavenged plant and animal materials (Morris and Tanner 1969).

Key Life History Strategies

Columbia spotted frog populations reproduce in habitats characterized by springs, floating vegetation, and larger bodies of pooled water (e.g., oxbows, lakes, stock ponds, beaver-created ponds, seeps in wet meadows, backwaters) (IDFG et al. 1995; Reaser 1997). Breeding habitat is the temporarily flooded margins of wetlands, ponds, and lakes (Hallock and McAllister 2002). Breeding habitats include a variety of relatively exposed, shallow-water (<60 cm), emergent wetlands such as sedge fens, riverine over-bank pools, beaver ponds, and the wetland fringes of ponds and small lakes. Vegetation in the breeding pools generally is dominated by herbaceous species such as grasses, sedges and rushes.

Though movements exceeding 1 km (0.62 mi) and up 5 km (3.11 mi) have been recorded, these frogs generally stay in wetlands and along streams within 0.6 km (0.37 mi) of their breeding pond (Bull and Hayes 2001). Frogs in isolated ponds may not leave those sites.

3.3.3. White-headed Woodpecker

Importance

The white-headed woodpecker was chosen as a focal species due to the unique large ponderosa pine tree habitat required by this species, which was of some special concern in the subbasin, and its role as a primary excavator of tree cavities that are used by other species.

Population Abundance and Distribution

The white-headed woodpecker (*Picoides albolarvatus*) is a robin-sized black woodpecker with white wing patches which are visible in flight, and is the only woodpecker in Oregon with a white head, although the acorn woodpecker is somewhat similar with some white on the head (Robbins 1966).

This woodpecker is found from interior British Columbia south to Nevada and southern California. In Oregon, it is found in the Ochoco, Blue, and Wallowa mountains in Eastern Oregon, and also in some areas in the Siskiyou Mountains and on the “north part of the east slope of the Cascades” (Marshall et al. 2003). Marshall et al. (2003) states that this bird occurs in “…open ponderosa pine or mixed-conifer forest dominated by ponderosa pine.” It may occur in areas dominated by large-diameter ponderosa pine even if the stand has undergone silvicultural treatments such as thinning (Ibid.). The range in Oregon appears not to have changed from 1940, but “…seems to have become more patchy because of habitat deterioration (Ibid.). White-headed woodpecker density found in 1997 on five study areas in the Deschutes National Forest were calculated to be 0.03-1.54 birds per 100 acres. Still, the population may be declining on the forest, despite the fact that the Deschutes and Winema National Forests may provide some of the best remaining white-headed woodpecker habitat in Oregon (ibid.).

Key Life History Strategies

White-headed woodpeckers excavate nests in large-diameter snags, stumps, leaning logs, and dead tops of live trees. Mean dbh of nest trees in the Deschutes National Forest was found to be 25.6 in. or 65 cm for 43 nests observed (Ibid). Nesting activities occur in May and June, and young birds fledge in June and July.

This woodpecker is non-migratory. Some seasonal wandering outside the nesting territory occurs.

3.3.4. Mule Deer

The Rocky Mountain Mule Deer (*Odocoileus hemionus hemionus*) is a native species to Oregon, and occurs generally east of the crest of the Cascade Mountains, including the entire Deschutes Subbasin (ODFW 2003). It was chosen as a focal species because it serves as an example of species that use aspen groves, oak groves, and ungulate winter ranges.

Population Abundance and Distribution

Mule deer occupy all terrestrial habitats in the subbasin (IBIS 2004). Oregon Department of Fish and Wildlife biologists survey mule deer in Oregon each year to estimate the populations in each of the wildlife management units that make up the Eastern Oregon mule deer range. The population objective for the nine wildlife management units that exist in the Deschutes Subbasin is total of 71,500 deer (Table 3.10). This total could be considered an estimate of the current deer population in the Deschutes Subbasin.

Table 3.10. Population management objectives for mule deer for 9 wildlife management units that approximately make up the Deschutes Subbasin, Oregon; mule deer population estimate for Warm Springs Reservation; and hunting tags issued, hunter-days expended, and deer harvest estimates for 1996 for the 9 wildlife management units and the Warm Springs Reservation (ODFW 2003).

Wildlife management unit	1996 Hunting Tags	1996 Hunter-days used	1996 Hunting Harvest	Population management objective (1990)
Ochoco	6324	34,959	1199	20,500
Grizzly	2843	15,823	810	8,500
Maury	1035	4,804	273	5,200
Maupin	355	1,167	198	3,000
White River	2920	12,977	826	9,000
Hood	641	2,923	118	400
Metolius	2307	11,420	581	6,200
Paulina	3425	20,088	705	16,500
Upper Deschutes	4425	26,971	679	2,200
Warm Springs Reservation	1300	--	455	7,100*
Total	25,575	131,132	5844	71,500

*Population estimate calculated by biologists in spring 1998 (CTWSRO 1999).

Key Life History Strategies

Mule deer generally summer at higher elevations, then move to lower elevations for the winter. These lower elevation areas are referred to as winter ranges (Map 13).

Mule deer are adapted to the cycle of food availability during the year, so that they are able to maintain functions during cold winters when food is scarce, and then are able to take advantage of food abundance in the summer for reproduction and for storing fat reserves for winter. During winter, mule deer utilize snow as a source of water, but require free water during other times of the year, especially nursing females and fawns.

Supplemental winter feeding may or may not be effective in saving deer that are starving, depending on when the feeding is started and what feed is provided to the deer.

Mule deer feed on a wide variety of grasses, small weedy plants, and leaves and twigs in a selective manner, choosing the best pieces of forage based on smell, taste, appearance, and touch, and the physical form of their long nose and teeth are well suited to this selective feeding (Wallmo 1981). During critical winter months, new growth on the ends of twigs on shrubs and trees serve as food for mule deer. Sagebrush, bitterbrush, rabbitbrush, juniper and mountain mahogany are also eaten during winter. Deer also eat acorns, legume seeds, and fleshy fruits, and mushrooms and other fungi, all of which are highly digestible for the deer digestive system (Wallmo 1981).

Breeding occurs in the fall and winter from October through early January, and one to three fawns are born by each doe the following May through July. A buck deer will seek out and mate with many females, and there is no pair fidelity. The female cares for the fawn.

3.3.5. Greater Sage Grouse

Importance

Greater sage grouse was chosen as a focal species due to the unique aspects of habitat requirements of the bird within the steppe habitats, and special concerns for components of the areas the bird inhabits. The sage grouse requires a very specific plant species, big sage, within the shrub steppe habitat, and the concern for steppe habitat management involving fire and plant succession and plant species composition changes is an issue in the subbasin as well as throughout the West.

Population Abundance and Distribution

The greater sage grouse is a pheasant-sized bird. The male has black markings on the belly and throat and neck, while the female appears uniformly gray (Robbins et al. 1966). Of the three subspecies of sage grouse, the subspecies occupying areas in the Deschutes Subbasin is *Centrocercus urophasianus urophasianus* (Marshall et al. 2003).

Once found across most of the Western U.S. and into Canada, the sage grouse "…now has a local reduced population in the central part of western North America." "…from Eastern Washington to North Dakota." (Csuti et al, 2001). Marshall (2003) states that sage grouse had contracted in range in Oregon by 50 percent from previous population levels by the 1940's, and that populations were lost in the Blue Mountains and Columbia Plateau ecoregions of Oregon by that time. In the Deschutes Subbasin, sage grouse are currently found in eastern Crook and Deschutes counties (Ibid,) within the Upper Crooked and Lower Crooked assessment units.

Key Life History Strategies

No regular migration occurs, but sage grouse may move several miles between feeding and brooding areas to find suitable forage, and will move several miles to areas where sage is not covered by snow to obtain forage in the winter (Marshall et al. 2003). Sage grouse primarily eat the leaves of sagebrush throughout the year, but small weedy plants and insects are important during the nesting and brood seasons. They do not eat grasses.

Male sage grouse gather on display areas, or leks, in late February, and strut early in the mornings, beginning before dawn, to attract females. Females are attracted from surrounding habitat by the males displaying, and may choose a single male in a certain area of the lek as the primary breeding male. Leks are usually areas of sparse vegetation within sagebrush habitat. New leks have been established on recently burned sites. Nests are established as shallow depressions lined with grass, usually under sagebrush, and usually in taller sagebrush habitat. Eggs are laid in May, and hatch in late May to mid-June. Nest success from an area near Prineville was 31 percent, with most unsuccessful nests the victims of predators. Hens may return to the lek and then renest after losing the first nest. Nest success in Oregon is lower than that reported from other areas states (Marshall et al. 2003).

3.3.6. Columbian Sharp-Tailed Grouse

Importance

The Columbia sharp-tailed grouse was chosen as a focal species due to the unique aspects of its habitat requirements. The sharp-tailed grouse requires a mix of riparian and grassland habitat types within the steppe habitat, and riparian habitat issues have been identified as the first priority in the subbasin.

Population Abundance and Distribution

Sharp-tailed grouse were called prairie chickens by early Oregon residents, and these birds were abundant in grasslands and foothills in Eastern Oregon “prior to the late 1800s” (Marshall et al. 2003). Although sharp-tailed grouse have not been found in Eastern Oregon or the Deschutes Subbasin since the 1970s, it is thought by local biologists to be a good candidate for future re-introduction in the subbasin. An unsuccessful re-introduction of the plains sharp-tailed grouse subspecies *Tympanuchus phasianellus jamesi* was conducted in Jefferson and Wasco counties in 1963 (Marshall et al. 2003). Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus* are being re-introduced in an ongoing effort near Enterprise in Wallowa County, Oregon that was started in 1991, and some success seems to have occurred. The Oregon Department of Fish and Wildlife was reported to be considering areas for restoration of sharp-tailed grouse populations west of the Blue Mountains prior to 2003.

The sharp-tailed grouse is a pheasant-sized bird with an overall light gray-brown coloration. Sexes are similar in appearance. When in flight, the narrow pointed tail is edged in white, distinguishing the sharp-tail from pheasants (Robbins et al. 1966). Of six subspecies, only the Columbian sharp-tailed grouse was found in Oregon (Marshall et al. 2003).

Key Life History Strategies

Sharp-tailed grouse inhabit grasslands or grass-shrublands and utilize deciduous shrubs and trees for wintering (Marshall et al. 2003). Adult birds feed extensively on small weedy plants, and chicks require insects for feed. In the winter when snow covers ground plants, birds feed on the buds of quaking aspen, chokecherry, black hawthorn, and willow. In Wallowa County, Oregon where Columbian sharp-tailed grouse are being released to establish new populations, birds can be seen in the winter perched in shrubs and small trees, presumably feeding on buds. Marshall (2003) reports that birds moved as far as four miles to deciduous shrub patches after a heavy snowfall. In Wallowa County, Oregon released birds used Conservation Reserve Program agricultural fields that were planted to perennial grasses and small weedy plants for lek sites and for late summer and fall feeding.

Male birds display on special openings in the grasslands or grass-shrubland called leks from early March through early June, attracting females for breeding. Nesting occurs in May and June. Two nests found near the mouth of the Deschutes in 1935 consisted of slight hollows in the ground of an agricultural grainfield lined with grasses, grains, stems, and feathers (Gabrielson and Jewett 1970).

Columbian sharp-tailed grouse are non-migratory, but may move several miles away from the lek during the year (Csuti et al. 2001). The grouse form flocks during the winter.

3.3.7. Golden Eagle

Importance

Golden eagles are a native species to the subbasin and are protected by the Bald Eagle Protection Act. It is unlawful to possess any part of any eagle except by federal permit. Four counties in the Deschutes subbasin have adopted ordinances designed to protect golden eagle nest sites by regulating development within a 0.25-mile zone around the nest: Deschutes, Jefferson, Crook, and Wasco counties (Marshall et al. 2003). The golden eagle serves as an example of species that require cliffs and rimrocks for habitat.

Population Abundance and Distribution

The golden eagle (*Aquila Chrysaetos*) is one of two eagles occurring in Oregon, the other being the bald eagle. The golden and bald eagle are the largest raptors currently occurring in Oregon, formerly being exceeded in size only by the condor. Adult golden eagles are colored a rich brown with lighter golden nape feathers, and the sexes are similarly colored. Adult and juvenile golden eagles are easily confused with immature bald eagles, all three birds being generally dark colored at a distance (Robbins 1966).

The golden eagle occurs worldwide. In North America, it occurs in Alaska and Canada, and in western North American south to Mexico (Csuti et al. 2001). Golden eagles occur most commonly east of the Cascades in Oregon, and have been noted from all Eastern Oregon counties, including all counties in the Deschutes Subbasin (Marshall et al. 2003).

Numbers of golden eagles in Oregon were estimated to number 1,000-1,500 in 1982 (Marshall et al 2003). Numbers of golden eagles observed during mid-winter bald eagle surveys in Oregon during 1992-2001 have averaged 97 (Ibid). Fifty-seven active golden eagle nesting territories were identified in the Deschutes Subbasin in 2000 (Clowers 2004). Taking into account areas not inventoried by past surveys, biologists estimate that about 60 nesting territories currently exist in the subbasin (Carey 2004). The population trend of golden eagles in Oregon, or the Deschutes subbasin is unknown (Marshall et al. 2003; Clowers 2004).

Key Life History Strategies

Generally, golden eagles in Oregon are considered resident birds, but out-of-state migrant golden eagles from northern regions have been recorded passing through the State (Marshall et al 2003).

Unlike the bald eagle, golden eagles are aggressive hunters. The black-tailed jackrabbit was historically a basic food item for golden eagles, but other animals such as marmots, ground squirrels, birds such as sage grouse and sharp-tailed grouse, and other species are taken. Golden eagles kill deer and pronghorn fawns, wild and domestic lambs, and will eat fresh carrion and steal prey from other raptors.

Nests are established most frequently in cliffs (65 percent of 506 occupied nests in Oregon in 1982), but nests are also built in large trees greater than 30 inches dbh, and occasionally on electric towers. Egg-laying occurs from late February to mid-April and young are fledged between Late June and early August. Breeding territories range in size between 10-40 sq. mi., and may include several habitat types. Alternate nest sites, consisting of partially built or complete nests, within the same nesting territory may be maintained. Tolerance to human disturbance at nest sites varies widely among individual nesting pairs; some are very tolerant, others will abandon the nest if disturbed.

Environmental Conditions — Section 4

The unique geology, hydrology and climates of the Deschutes River Subbasin create a diverse mix of habitat conditions for fish and wildlife. These populations are linked to the ecosystems in which they live and their health, individual characteristics and abundance reflect the diversity — and quality — of their environments.

This section describes the often diverse environmental conditions that define the Deschutes River watershed. It builds on the more general review provided in the Overview by discussing conditions within the eight assessment units (Map 14):

- **Lower Westside Deschutes Assessment Unit:** Lower Deschutes River from RM 0 to RM 100, the Warm Springs River and Shitike Creek, and all small tributaries entering the lower Deschutes River.

- **White River Assessment Unit:** White River watershed above White River Falls (RM 2).

- **Lower Eastside Deschutes Assessment Unit:** Major Deschutes River tributaries draining the lower eastern portion of the Deschutes Subbasin, including Buck Hollow, Bakeoven, Trout and Willow creeks.

- **Lower Crooked River Assessment Unit:** Lower Crooked River drainage below Bowman and Ochoco dams, including lower Ochoco Creek and McKay Creek.

- **Upper Crooked River Assessment Unit:** Upper Crooked River drainage above Bowman and Ochoco dams, including upper Ochoco Creek, north and south forks of the Crooked River and Beaver Creek.

- **Middle Deschutes Assessment Unit:** The 32-mile reach of the Deschutes River from the Pelton Round Butte Complex (RM 100) to Big Falls (RM 132) and its two major tributaries, Metolius River and Squaw Creek.

- **Upper Deschutes Assessment Unit:** The upper Deschutes River drainage from Big Falls to Wickiup Dam (RM 222), including Tumalo Creek, Spring River, the Little Deschutes River and Fall River.

- **Cascade Highlands Assessment Unit:** The Deschutes River drainages above Wickiup Dam, including the Cascade Lakes.

The section looks briefly at historical conditions within each assessment unit — those conditions believed to exist at the time of European settlement in the early and mid 1800s. It summarizes unique environmental conditions in each assessment unit that exist today. In addition, it identifies desired future conditions for the assessment units, and examines what future conditions might exist with no additional actions. Appendix II provides more detailed information on environmental conditions in the Deschutes Subbasin.

4.1. Lower Westside Deschutes Assessment Unit

The lower 100 miles of the Deschutes River flow through a low gradient channel with scattered rapids set in a deep, narrow, arid valley. Stream width of the lower river averages 236 feet and varies from 30 to 560 feet, excluding islands. The reach provides important spawning and rearing habitat for fall chinook, summer steelhead and redband trout, and rearing habitat for spring chinook and bull trout. Salmonids also use the reach as they move to and from tributary spawning and rearing grounds.

Principal westside tributaries of the lower Deschutes River are the Warm Springs River and Shitike Creek. Both watersheds lie within the Warm Springs Reservation. The Warm Springs watershed covers 526 square miles, reaching from 3,775 feet in elevation in the Cascade Mountains to 1,230 feet at its confluence with the Deschutes River (RM 84). The river flows 53 miles and provides 41 miles of anadromous fish habitat. Two major tributaries, Mill Creek and Beaver Creek, also support anadromous fish. Shitike Creek drains 76 square miles, with elevations ranging from 5,280 to 1,476 feet. It extends 30 miles, providing 25.7 miles of anadromous fish habitat, and joins the Deschutes River at RM 97. Minor westside tributaries include Fall, Ferry Canyon, Oak Brook, Wapinitia, Nena, Eagle and Skookum creeks. Minor eastside tributaries include Macks Canyon, Jones Canyon and Stag Canyon creeks. These are generally short, steep streams with small watersheds. The assessment unit also includes the lower two miles of White River below White River Falls, which provides spawning and rearing habitat for resident redband trout and summer steelhead.

Cliffs and rimrocks are present along many of the stream and river canyons, and are valuable habitat for species such as the golden eagle. Ungulate winter ranges are present on many low elevation hillsides and valleys.

4.1.1. Historical Conditions

Before 1855, lower Deschutes River channel characteristics and configurations resembled those seen today. The river flowed within a constrained channel flanked by deep canyon walls with few side channels. Streamflow was quite uniform throughout the year, due to a high contribution of spring fed waters from upstream springs. Periodic high flow events and associated bedload redistribution occurred, but were infrequent (Hosman et al. 2003). Flows from runoff-dominated tributaries were moderated by well vegetated floodplains, which stored and released water throughout the drier summer months. This stable flow pattern supported healthy riparian communities. Alder, willow, birch and some cottonwood trees dominated riparian vegetation with shrubs, grasses, sedges, rushes, and other forbs skirting the water’s edge. Water temperatures in the mainstem and many tributaries were also more stable year-round, due to the moderating effect of upstream springs.

The Warm Springs River and Shitike Creek displayed complex and very favorable riparian and instream channel conditions for salmonid production (CTWS 1999a). Variable habitat characteristics within constrained and unconstrained stream reaches provided single and multiple channel areas. Beaver created off-channel habitat and wet meadows along unconstrained reaches. Riparian corridors were well developed with deciduous and coniferous trees, shrubs and grasses. Groundwater recharge from wet meadows and beaver complexes stabilized summer flows and moderated water temperatures. Summer water temperatures were optimal for salmonid growth and survival, while cold winter flows were moderated by springs and groundwater discharge from well developed riparian areas. Abundant supplies of large woody debris and logjams provided high quality fish hiding and rearing habitat, and sorted and collected gravel suitable for fish spawning. Stable watershed conditions produced smaller fine sediment loads in the Warm Springs River and Shitike Creek (CTWS 1999a).

Eagle, Nena, Wapinitia, Oak Brook, Jones Canyon, Macks Canyon, Stag Canyon and Ferry Canyon creeks drained smaller watersheds, but frequently contained good spawning gravel for summer steelhead and redband trout. Diverse riparian corridors with functional floodplains provided good instream habitat complexity. Some juvenile salmonids left these streams to rear in the Deschutes as flows receded in late spring.

Historic habitat maps indicate that nearly 100,000 acres of wild grassland habitat were once present in the assessment unit (IBIS 2003). The grasslands mostly covered three large areas in the center and north end of the assessment unit. Shrub-steppe habitat and ponderosa pine forests dominated remaining areas at mid- and lower elevations, with mixed conifer forests in the higher elevations in the Cascades.

4.1.2. Current Conditions

Uplands

The lower Deschutes subbasin displays steppe, shrub-steppe and juniper savanna habitats in the canyon and plateau areas, and coniferous forests in the Cascade mountains. The Warm Springs River and Shitike Creek begin in mountain forests and drop into semi-arid environments. Lands are in public, Tribal and private ownership and generally managed for agriculture, range, timber harvest and recreational uses. Comparison of historic and current habitat maps indicates that 37 percent of historic ponderosa pine forest shave been replaced by mixed conifer forests (IBIS 2003).

Degradation of many upland areas has occurred through livestock use, forest and agricultural practices, and invasion by western juniper and noxious exotic vegetation. Native grasslands in the assessment unit have been completely replaced by agricultural crops, shrub-steppe and juniper woodlands. Many oak groves once present on benches above the streams and rivers are also now gone. The loss of grasslands, oak and cottonwood groves, and conversion of habitat to other uses has degraded ungulate winter ranges. In some areas, development for homesites and other uses have reduced use of cliff and rimrock habitat that supports many wildlife species, including golden eagle and bighorn sheep.

Many upland areas show reduced ability to capture and slowly release precipitation. Still, watershed stability in the Warm Springs River and Shitike Creek drainages is usually good to very good, with higher stability in upper watersheds. Several drainages, including Warm Springs tributaries Quartz and Coyote creeks, have highly erosive soils and watershed stability is poor to fair (CTWS 1999b). Uplands in the smaller Deschutes River tributaries are often more prone to erosion, primarily due to conversion of native grasslands to grazed range and tilled fields.

Riparian Areas

The lower mainstem is confined in a deep, narrow valley with interspersed basalt canyon walls and shows many aspects of a spring-controlled system. Many reaches are lined with a narrow fringe of trees and other riparian vegetation. The channel is remarkably stable and has not shifted more than 200 feet in the last 90 years, despite two exceptionally large floods (O'Connor et al. 2003, Curran and O'Connor 2003). In some areas, land use activities have degraded vegetation and reduced habitat complexity along stream margins of the lower Deschutes. However, camping and vehicle use restrictions, and grazing management have initiated riparian recovery in some reaches. Riparian condition along some reaches of the lower Deschutes has improved dramatically over the last 20 years because of restoration efforts.

The Warm Springs and Shitike Creek drainages show a slight to moderate loss of riparian vegetation or vegetative species diversity and of proper floodplain function. Many stream reaches remain in good to excellent condition, with overall conditions improving as land management practices improve. Complex riparian vegetative corridors with good species diversity armor these stream reaches. One of the largest remaining stands of old growth cottonwood in the area frames the lower six miles of Shitike Creek. The greatest losses of habitat quality have occurred along lower stream reaches, although timber harvest and livestock grazing have degraded localized areas in the upper watershed. In the Warm Springs system, stream channels have been incised along the Warm Springs River (Ka-Nee-Ta Resort area), Beaver Creek (below Quartz Creek) and in the Quartz and Coyote Creek systems. Channel alterations and stream bank armoring along the lower Warm Springs River in the Ka-Nee-Ta Resort area degrade two to three miles of riparian and floodplain lands. Parts of lower Shitike Creek below RM 4 are also degraded. Smaller Deschutes River tributaries have lost riparian vegetative species diversity due to land use practices. The three smaller eastside stream drainages have been ravaged by wild fires in the last ten years.

Instream Habitat

A complex aquatic habitat — including large boulders, bedrock irregularities, rooted aquatic macrophytes, overhanging vegetation, and varying water turbulence and depth — provides diverse cover for focal species in the lower 50 miles of the Deschutes River. The stream and island margins provide important rearing habitat and escape cover for 0-age fish. In 1995, about 68 percent of all steelhead spawning from the Reregulating Dam to the mouth of Trout Creek occurred in side channels between islands and channel margins, despite the fact that such side channels comprise less than 10 percent of the channel length within the reach (Zimmerman and Ratliff 2003; Zimmerman 2000). Large boulders and cobble also provide good instream structure. Wood from riparian areas, mainly dead white alders, accumulates between high flows and enhances instream habitat.

Some reaches are deficient in instream structural habitat diversity. The substrate of the lower 46.5 miles of the Deschutes River contains high levels of glacial sand and silt that originate from White River. The lower river also receives heavy silt loads from other tributaries during high intensity storms. As a result, lower mainstem spawning areas often contain high amounts of glacial sand and silt and are frequently embedded (Huntington 1995). Fine sediments also impact larger gravels used by fall Chinook salmon, though these larger fish move and clean the substrate during spawning (Huntington 1995).

Warm Springs River and Shitike Creek channels have boulder/cobble substrate floors that create good spawning and rearing habitat. Spawning gravel abundance, however, has likely declined below historic levels because of a drop in large wood supply due to land use practices (Weldon 2004). Fine sediment content in spawning gravels is also a concern. Instream channel structure, cover and complexity has been lost due to flashier flow regimes, channel simplification, and land use practices, particularly along lower reaches of the Warm Springs River and Shitike Creek.

Flashy flow regimes have accelerated floodplain scouring and loss of instream habitat structure in the small westside Deschutes River tributaries. The few remaining pools, which contain little or no cover or cool spring water inflow, provide limited salmonid habitat. Many small eastside tributary reaches also lack instream habitat complexity. Lack of instream cover makes fish more susceptible to harassment and predation. Fish passage obstacles at road crossings of Jones Canyon and Stag Canyon creeks hinder upstream movement.

Flows

The lower river experiences only small seasonal variations in discharge because of the large groundwater contributions from the upper Deschutes River, Metolius River and lower Crooked River (Gannett et al. 2003). Groundwater contributions boost flow further in this stretch of the Deschutes, as the river gains 400 cfs from groundwater inflow between Round Butte Dam and Dry Creek at RM 91.8 (Gannett et al. 2001). The river level is also controlled by long-term weather patterns and by Pelton Round Butte Complex operations. Mean annual flow near the confluence with the Columbia River (Moody gage) averages 5,739 cfs and ranges from 4,290 to 7,380 cfs. Maximum flows occur from January through March and minimum flows from July to October. Water withdrawals from the lower reach for irrigation or other uses are minimal. Flows from lower westside tributaries contribute significantly to peak flows in the mainstem Deschutes. More than 70 percent of the peak discharges of both the December 1964 and February 1996 flood flows in the lower Deschutes entered the river below the Pelton Round Butte Complex (O'Connor et al. 2003).

Snowmelt dominates runoff in the Warm Springs River and Shitike Creek, causing flows to peak in spring, taper off throughout summer, and drop to base flows in August or September. The Warm Springs River maintains a mean annual flow of 425 cfs and recorded flows range from 149 to 24,800 cfs. Shitike Creek contributes a mean annual flow of 93.3 cfs to the Deschutes River and recorded flows range from 17 to 4,500 cfs. Flows in smaller westside Deschutes tributaries are also dominated by snowmelt and peak in the spring. High flows in these drainages taper off through summer and drop to base flow or, in some cases, dry channels. Occasionally, warm winter storms cause rain-on-snow events with extremely high flows in the affected drainages. Small eastside Deschutes River tributaries have extended reaches with intermittent flow or dry channel during the summer and fall months.

Water Quality

The lower Deschutes River and several westside tributary reaches are included on the 2002 ODEQ 303(d) list of water quality limited streams (Appendix II, Table x). The lower Deschutes exceeded temperature criteria for spawning below White River, and for bull trout (50°F) and salmonid rearing (55°F) from White River to the Reregulating Dam. The reach above White River also exceeded the dissolve oxygen criteria for salmonid spawning from September 1 to June 30. In addition, the lower Deschutes exceeded the State's pH standard 23 percent of the time at the river mouth and 11 percent of the time at RM 96 (ODEQ 2002). White River flushes large amounts of glacial sand and silt into the lower Deschutes River that occasionally cause significant turbidity (ODFW 1997).

Water temperatures in lower reaches of the Warm Springs River and Shitike Creek can exceed 70 °F from mid to late summer. Excessive sediment loads also occur occasionally in the Warm Spring River, primarily due to runoff from lower tributaries, including Coyote and Quartz creeks in the Beaver Creek drainage. Turbidity from intermittent tributaries also reduces water quality in Shitike Creek during high intensity storms. Municipal waste spill/discharge can degrade water quality in Shitike Creek.

4.2. White River Assessment Unit

White River begins on the White River Glacier on Mount Hood and flows southeast to join the Deschutes River just upstream of Sherar's Falls at RM 47.5. The watershed covers 419 square miles, with elevations ranging from 11,291 feet on Mount Hood to 789 feet at the river mouth. Major tributaries to White River include Clear, Boulder, Threemile and Tygh creeks.

This assessment unit includes the drainage above White River Falls, a series of three drops totaling 180 feet, which lies two miles above the river's mouth and prevents anadromous fish access to the rest of the watershed. The falls also isolates populations of redband trout and other resident fish above the falls from those downstream. Redband trout in the upper White River system above White River Falls are more similar to isolated populations of redband trout in the Fort Rock Basin of south-central Oregon, both genetically and morphologically, than they are to lower Deschutes redband trout (Currens et al. 1990).

4.2.1. Historic Environment

White River and tributaries were generally shaped by a confined narrow, V-shaped canyon in some areas and by unconfined broad, flat-bottomed U-shaped valleys in other areas. The river transported large volumes of fine glacial sand and silt from its source on Mount Hood. This made the mainstem channel unstable, with high glacial sediment and sand loading. Tributary channels not affected by glacial activity were more stable.

Historic habitat maps show that uplands were predominately covered with ponderosa pine forests, with mosaics of oak groves interspersed at mid-elevations in the Cascades. Higher elevations in the Cascades were characterized by mixed conifer forests. Lower elevations, such as Tygh Valley, were characterized by shrub-steppe habitat (IBIS 2003).

Flows in the White River system, which are influenced primarily by surface runoff, showed normal season variation, with late spring high flows and fall low flows. Conditions supported development of complex riparian vegetation along stream margins, with good species diversity. Functional floodplains and frequent beaver activity along tributaries added to habitat diversity and complexity. Water temperature variations were slight to moderate because of prolonged snow and/or glacial melt. Other water quality variables, such as dissolved oxygen and pH, were also good, except for turbidity caused by glacial runoff.

4.2.2. Current Environment

Uplands

The watershed is heavily forested in the upper drainage, but becomes more arid at lower elevations. It supports timber, grazing and farm uses. Forest lands cover 188,000 acres in the watershed and rangelands 90,000 acres. Agricultural lands cover 47,500 acres, with 38,500 acres non-irrigated as the watershed receives less than 20 inches of precipitation annually (Lamson and Clark 2003). Approximately 4,490 acres are included in the Conservation Reserve Program or have been converted to pasture grasses (Clark 2004). The watershed contains one of only two Oregon White Oak plant communities east of the Cascades.

Many ponderosa pine forest areas and interspersed oak groves and shrub steppe areas have been replaced by encroachment by mixed conifer forest, agricultural uses, by development for homesites, and other uses. Comparisons of historic and current wildlife habitat maps indicate that ponderosa pine forests and interspersed white oak groves have been reduced by 57 percent from historic levels. Shrub-steppe habitat has been reduced by 36 percent from historic levels (IBIS 2003).

Riparian Areas

Overall riparian condition in the upper White River watershed is good with diverse vegetation, though some areas have been degraded through land use practices. Some reaches have wide floodplains and others support wetlands and meadow. Riparian vegetative condition declines in the middle watershed, primarily because of past forest fire and, in some cases forest and agricultural practices and overgrazing. Loss of riparian vegetation has reduced beaver numbers and distribution. Riparian conditions in the Tygh and Threemile systems generally show degradation from agricultural, range and forest practices. Riparian conditions in the lower watershed remain good, except in isolated canyon areas where steep walls and flashy flows limit vegetative growth. A band of mature cottonwood borders the river above White River Falls.

Instream Habitat

White River carries considerable glacial silts and sands. The river cuts through old mudflows and glacial deposits and is often unstable, particularly in the upper reaches. More than 20 miles of braided channel flow out of the White River Glacier (Lamson and Clark 2003). The fine sand and sediments from the glacier are deposited in slack water areas and affect spawning gravels down to the river mouth. Lack of habitat complexity and large wood limit instream habitat condition in some areas. The subbasin also contains many barriers to fish movement including natural waterfalls, road culverts, dewatered stream reaches, diversion structures, and impassable dams at large storage impoundments. Most water diversions in the system are unscreened.

Flows

Flows in White River are heavily influenced by snowmelt and glacial runoff. They peak during periods of runoff in winter and spring, and diminish as the summer progresses.

The mean low and mean high river discharge into the Deschutes River are approximately 100 cfs and 1,500 cfs, respectively (Heller et al. 1983). Naturally low flows in the system are further reduced by spring-fall irrigation diversions and winter-spring reservoir storage. The lowest flow recorded at White River Falls was 66 cfs in January 1979, followed by 68 cfs in September 1977 (Lamson and Clark 2003).

Water Quality

Water temperatures in lower White River and several tributaries often exceed the 64.4°F standard for salmonid rearing during summer months. Stream reaches on the 2002 ODEQ 303(d) list for exceeding water quality criteria for stream temperature included Clear Creek (mouth to RM 15.1), Gate Creek (mouth to RM 14.3), Rock Creek (mouth to RM 8.1 and RM 8.8 to 14.1), Threemile Creek (mouth to RM 11.3) and White River (mouth to RM 12). Turbidity associated with glacial silt and rock flour also reduces water quality in the White River system. Stream reaches on the 2002 ODEQ 303(d) list for sediment concerns included Gate Creek (mouth to RM 14.3) and Rock Creek (mouth to RM 15.9).

4.3. Lower Eastside Deschutes Assessment Unit

Four stream systems are included in this assessment unit — Buck Hollow, Bakeoven, Trout and Willow creeks. Three of these systems —Buck Hollow, Bakeoven and Trout creeks — provide the primary spawning and rearing habitat for summer steelhead in the Deschutes Subbasin. The tributaries also support redband trout, though steelhead appear to use the tributaries more than resident trout (Zimmerman and Reeves 2002). Trout Creek may have also supported chinook salmon production at one time. Willow Creek currently supports a small redband trout population.

Streams in the assessment unit drain the lower eastside of the Deschutes watershed. Buck Hollow Creek drains 198 square miles, with elevations from 680 to 3,325 feet. It extends 36.3 miles from its confluence with tributary Thorn Hollow Creek to where it enters the Deschutes River just below Sherars Falls (RM 43). Bakeoven Creek drains 146 square miles, with elevations ranging from 3,487 feet at Bakeoven Summit to 870 feet where it meets the Deschutes River at Maupin (RM 51). Trout Creek drains 697 square miles, with elevations from 5,940 feet to 1,280 feet. It extends 51 miles in length from its headwaters in the Ochoco Mountains to its confluence with the lower Deschutes River at RM 87, six miles west of the community of Willowdale. The drainage includes 115.5 miles of perennial streams and 41.2 miles of intermittent streams, with 113 miles currently supporting summer steelhead production. Willow Creek drains 180 square miles and extends 34 miles from the Ochoco Mountains to Lake Simtustus, part of the Pelton Round Butte Complex (RM 105), where it joins the Deschutes River.

4.3.1. Historic Conditions

The lower eastside tributaries once displayed highly favorable conditions for redband trout and summer steelhead production (CTWS 1999a). Lush bunch grass plant communities covered much of the area and were interspersed with well-vegetated stream corridors. Variable habitat characteristics existed within constrained and unconstrained stream reaches, providing a mix of single channel and multiple channel areas. In lower gradient reaches, stream channels were sinuous and bordered by thick deciduous vegetation and grasses. Beaver complexes and off-channel habitat were common along the unconstrained reaches. Relatively good supplies of in-channel large wood and debris dams provided adult and juvenile cover and rearing habitat (CTWS 1999a).

Still, the lower eastside of the Deschutes Subbasin exhibit some of the highest average slope and drainage densities in the entire Deschutes subbasin (O'Connor et al. 2003), and these stream systems likely showed more response to climatic changes than other subbasin areas — although the magnitude of the climatic affects was moderated by healthy watersheds. As today, occasionally severe thunderstorms caused sudden and high flows, promoting more dynamic stream channel behavior and characteristics than typically found in other tributary streams within the Deschutes Subbasin. In streams where natural flows often dropped to low levels during summer months, late summer water temperatures became elevated, particularly during low precipitation years. Large floodplains with diverse vegetative communities helped stabilize flows and water temperatures. Beaver complexes and wet meadows also promoted sustained groundwater recharge (CTWS 1999a). Deep pools and recharge areas provided refuge for salmonids when flows were low and water temperatures high.

4.3.2. Current Conditions

Uplands

The lower eastside Deschutes watershed generally displays steppe, shrub-steppe and juniper savannas in the canyon and plateau areas, and mixed conifer forests in the headwaters of Trout Creek. Comparisons of historic and current wildlife habitat maps indicate that more than 370,000 acres of wild grassland habitat existing historically on upper bench lands in the eastern part of the assessment unit have been completely lost (IBIS 2003).

Private lands cover much of the area and are used as rangeland and cropland. The Bakeoven Creek drainage contains about 83 percent rangeland and 15 percent cropland, with 8,512 acres of cropland currently enrolled in the Conservation Reserve Program. (Wasco SWCD 1994; Clark 2004). The watershed is sharply dissected by deeply entrenched drainage systems and contains no urban areas. The Buck Hollow Creek drainage contains about 52 percent rangelands, with remaining lands used as cropland (19 percent), Conservation Reserve Program (26 percent), and roads and urban (3 percent) (CTWS 1999a). The Trout Creek drainage is about 86 percent rangeland, and most remaining lands are headwater forests (12 percent) in the Ochoco Mountain Range. Agricultural (1.5 percent) and residential/urban uses also cover small amounts of land in the Trout Creek drainage, with Antelope and Ashwood the main population centers. The Willow Creek drainage is about 75 percent rangeland and 25 percent cropland, with 70 percent of the cropland irrigated (MDLAC 2001). Willow Creek runs through the Crooked River National Grasslands and City of Madras.

Uplands in the assessment unit are generally degraded with reduced ability to collect and store runoff, and maintain soil stability. Soils in the assessment unit are often highly susceptible to erosion, and the loss of watershed retention capabilities due to human activities has reduced the watersheds' ability to buffer high runoff events. Consequently, the watersheds' respond quickly to snowmelt and precipitation, and are vulnerable to flash flooding. Upland conditions are improving in parts of these watersheds due to restoration efforts over the last 15 years.

Riparian Areas

Riparian areas in the Buck Hollow, Bakeoven, Trout and Willow creek watersheds have generally been degraded by overgrazing, periodic wild fires and catastrophic flooding over the last century. Today, Buck Hollow Creek is incised in the valley floor in some areas and has scoured laterally in other areas to form broad, shallow channels with little or no bank structure or stability and very little shade. Few riparian trees exist along the creek. Similar conditions exist in the Bakeoven drainage. Riparian habitat conditions are considered poor along 59 percent of Bakeoven Creek, 49.4 percent of Deep Creek, and 92.3 percent of Robin Creek (Wasco County SWCD 1994). Wide, shallow stream channels with sparse riparian cover in both the Buck Hollow and Bakeoven systems are prone to icing and corresponding fish loss during occasional periods of prolonged cold temperatures. Degraded riparian conditions also exist along middle and upper Willow Creek, though conditions improve below the City of Madras where the creek flows through a narrow basalt canyon with numerous springs before entering the Deschutes River.

Many streambanks and most riparian areas in the Trout Creek drainage are also in low ecological condition (MDLAC 2001). Currently, only 31 percent of the riparian areas are in satisfactory condition (Runyon et al. 2002). Increased runoff peaks have overloaded and exceeded the capacity of the natural floodplains in some places. Flood control berms, constructed after flooding in 1964, added to riparian and stream channel degradation by destroying natural channel meander, backwaters, and oxbow sloughs. Riparian vegetation, such as willow and alder, now occupy less than 25 percent of the stream margin along lower Trout Creek (Runyon et al. 2002). In other areas, riparian condition is constrained by livestock grazing, agricultural practices and other uses. The Mud Springs Creek drainage appears to have the lowest portion (10 percent) of riparian areas in satisfactory condition in the Trout Creek watershed (Runyon et al. 1998), while the upper Trout Creek watershed has the largest proportion of riparian stands in satisfactory condition.

Efforts continue to improve riparian condition in these watersheds through livestock management, berm removal and other restoration activities. Trout Creek, for instance, has been part of an intensive fish habitat restoration program for the last 15 years. Restoration strategies appear to be effective in enhancing riparian conditions along some stream reaches.

Instream Habitat

Loss of riparian vegetation, channel alterations and flood scouring have contributed to a general lack of instream habitat complexity and pool habitat in most stream reaches. Buck Hollow and Bakeoven creeks contain wide, shallow or braided reaches that move laterally across the valley during high flow events. They also lack instream cover and structure, including large woody debris, and have limited supplies of cobble and boulder. Fine sediment deposits are more of a problem in Bakeoven Creek than in Buck Hollow, which is a gravel-rich system. Intense runoff events in the Bakeoven system have scoured out long reaches of the creek, removing large woody debris, and causing erosion and siltation of pools (CTWS 1999a). The lack of pool habitat is a primary factor limiting salmonid production in the drainages. The streams contain only small numbers of scattered pools that provide limited holding and summer low flow rearing habitat. The remaining deep pools provide the best over summer habitat for adult and juvenile fish. Fish are often concentrated in these pools with little overhanging vegetation, or instream vegetation or woody structure for hiding, which exposes them to serious predation. Instream habitat complexity is also limited in much of the Willow Creek drainage, though it improves in the lower basalt canyon.

In the Trout Creek watershed, most high quality fish habitat lies in the upper drainage. Instream and overhead cover are lacking in most of the watershed, and infrequent shallow pools and woody cover provide much of the fish habitat. A lack of pools and cover leaves fish in many areas vulnerable to predation at low or intermittent flows. The stream substrate generally displays large gravel, cobble and boulders, with many spawning and incubating habitats degraded by elevated fine sediment inputs. Physical barriers, such as irrigation dams and road culverts also restrict fish from volitional movement and use of connective habitats during critical periods of their life history (CTWS 1999a).

The lack of channel continuity and complexity in Trout Creek increased following the large flood of 1964 with the diking of several central and lower stream reaches. Some channels were also straightened and/or isolated from their floodplains and side channels. This channel work altered velocities, sediment movement and deposition, and bed morphology. It generally reduced diversity of aquatic habitat in much of lower and central Trout Creek (WPN 2002a). Long reaches of several major tributaries — including Antelope, Mud Springs, and Hay creeks — have also been channelized, relocated or blocked and are no longer accessible to steelhead.

Flows

Watershed and stream corridor degradation have resulted in an altered flow regime with higher peak flows and lower or intermittent flows in many stream reaches. Flows peak in winter and early spring, and during severe summer thunderstorms. Streamflows drop to low levels during extended cold winter periods and from mid-summer to late fall. Fluctuations in flow are now larger in the assessment unit than they were historically. The Natural Resource Conservation Service, for example, estimates that current peak flows in some segments of the Trout Creek system are two to three times greater than under pre-settlement conditions (Jefferson County SWCD 1996). Loss of vegetative cover, decrease in number and size of beaver dams, channel down cutting and channelization, loss of wet meadows and other wetlands appear to be factors responsible for changes in flow patterns, and for moving some reaches of Trout Creek from a perennial to an intermittent flow condition (WPN 2002a).

In Buck Hollow Creek, average discharge ranges from 95 cfs in April to 2 cfs from July through October. Tributary flows are frequently intermittent during summer and fall months. One surface water right exists in the Buck Hollow Creek watershed, diverting up to 0.57 cfs for irrigation of 34 acres (LDLAC 2002).

In the Bakeoven Creek drainage, stream flow is generally perennial in Deep Creek and upper Bakeoven Creek and intermittent in lower Bakeoven Creek. Most tributaries are currently intermittent (Wasco County SWCD 1994). No active surface water irrigation withdrawals remove water from this stream system, though several large irrigation wells exist within the watershed. Flow in Willow Creek in and above the City of Madras is generally lacking or intermittent for much of the year (Ratliff 2004).

In the Trout Creek watershed, consumptive use of water for irrigation exceeds the estimated volume of natural stream flow during the summer months in all drainages (WPN 2002a). These withdrawals contribute to an inability to meet instream water rights in the areas where they have been established. Flows in Trout Creek below diversions in the Ashwood and Willowdale areas frequently become intermittent from mid-summer to late fall. Streamflows in Trout Creek below Amity Creek average less than 1 cfs during the hot months of August and September, and have also fallen below 1 cfs during dry years from May through December (WPN 2002a).

Water Quality

High water temperatures in the Buck Hollow, Bakeoven, Trout and Willow Creek systems limit fish production. Water temperatures in the systems typically exceed State water quality criteria for salmonid rearing during summer months. In Trout Creek, water temperatures usually surpass recommended levels by late May and can remain high through October. In Buck Hollow Creek, summer water temperatures often pass 75°F, except in areas of cool water refugia where seeps and springs enter the channel, or where widely scattered deep pools are recharged with cool subsurface flow. Summer temperatures in Willow Creek upstream from Lake Simtustus also range into the middle and upper 70’s. Bakeoven Creek experiences high water temperatures and other water quality problems, including turbidity, low dissolved oxygen, and nutrients. The entire length of Trout Creek and a number of tributaries (Auger, Big Log, Bull Cartwright, Dick, Dutchman and Potlid creeks) are listed as water quality limited because of temperature and sediment concerns (ODEQ 2002).

4.4. Lower Crooked River Assessment Unit

The assessment unit includes areas in the Crooked River watershed below two major impoundments: Bowman Dam on the Crooked River (completed in 1960) and Ochoco Dam on Ochoco Creek (completed in 1921). Dam operations alter flow patterns and restrict fish production in the lower 68.2 miles of Crooked River and lower 10 miles of Ochoco Creek. In addition, the dams lack fish passage facilities and isolate fish populations in lower stream reaches from spawning and rearing habitat in upper watershed areas. The Pelton Round Butte Complex blocks all anadromous fish access to the drainage.

Before construction of dams and water diversions, the Crooked River supported spring Chinook, summer steelhead, redband trout, bull trout, mountain whitefish, and non-game fish species. Today, watershed supports several resident indigenous fish populations, including redband trout. A major tributary McKay Creek joins the lower Crooked River at RM 45.2 and provides more than 50 miles of fish habitat.

4.4.1. Historical Conditions

Early explorers and military expeditions described the Crooked River drainage as rich in abundant riparian vegetation and adequate supplies of grass, water and firewood. Forested uplands in the lower drainage were described as open, park-like stands of ponderosa pine and western larch maintained by frequent ground fires. Lower and middle elevation lands were often covered by abundant bunch grasses. According to one early rancher, *"This was, certainly, as fine a country then as a stock man could wish to see. The hills were clothed with a mat of bunch grass that seemed inexhaustible. It appeared a veritable paradise for stock* (George Barnes, Prineville rancher, 1887)."

Riparian and floodplain areas in the watershed had significantly more woody vegetation than now (CRLAC 2003). Floodplains were dominated by bunchgrass and wild rye grass, with little invasion of juniper and sage communities. The Crooked River had a large floodplain that was described by early settlers as having waist high grasses. Willows were a primary component of riparian species (Ochoco means 'willow' in Paiute) but cottonwoods, aspen, alder, and shrub species such as chokecherry, hawthorn, or dogwood were also common. In some areas, the dense vegetation along the Crooked River had to be cut away to facilitate travel (Buckley 1992). Journals of early explorers comment on the abundant grasses and willows.

These healthy upland and riparian conditions modified streamflow fluctuations in the Crooked River drainage. Groundwater was regularly recharged during the wet season and streamflow was augmented during the dry part of the year. More springs and watercourses existed in the basin because of higher water tables. Beaver dams were plentiful and instrumental in maintaining a high water table under most stream valleys. As a result, many streams that are now intermittent were perennial (Whitman 2002). Seasonal flow fluctuations occurred, but were smaller than seen today where natural headwater water storage has been reduced. One expedition described Crooked River tributaries in late June, 1859 as, *"all the principal streams and their tributaries are pebbly bottomed and skirted with willows, some of them from four to six inches in diameter, affording good fuel, and the waters are generally sweet and icy cold"* (U.S. Congress 1860; Stuart et al. 2002).

4.4.2. Current Conditions

Uplands

Livestock production and livestock forage dominate land use in the lower Crooked River watershed. Forest lands, as in the upper McKay drainage, also support timber production. Irrigated agriculture occurs in the Prineville area and along narrow stream valleys.

Comparisons of historic and current habitat maps indicate that 34,000 acres of native grassland and 84,000 acres of lodgepole pine forests that existed historically in the assessment unit are now gone (IBIS 2003). Upland watershed health remains high where perennial grasses are present, but has been lost or diminished though most of the area (CRLAC 2003). As in most other lower eastside drainages, soils are generally finely textured and highly susceptible to precipitation-driven erosion (Whitman 2002). Degradation of uplands through land use practices, and invasion of western juniper and noxious exotic vegetation, has reduced their ability to collect and store runoff and maintain soil stability. Sections of the Crooked River and Ochoco Creek also run through the City of Prineville urban growth boundary and support residential, industrial and commercial uses.

Riparian Areas

Degraded riparian condition is a common problem in the lower Crooked River drainage. Stream channelization and over use has caused downcutting along many stream reaches, leaving streams disconnected from their floodplains (CRLAC 2003). On-going restoration efforts have improve riparian conditions along some stream reaches, but recovery of riparian communities is slow (Whitman 2002). Riparian areas along the Crooked River corridor between RM 57 and Highway 97, and along lower Ochoco Creek and McKay Creek (Walter 2000) are generally degraded. The Crooked River below Highway 97 displays the best riparian condition, with a relatively undisturbed character. Riparian conditions also remain fair to good along the Crooked River from Bowman Dam to RM 57.

Instream Habitat

Stream channel alteration has reduced instream habitat complexity in many parts of the assessment unit. Instream habitat complexity is limited in much of McKay and lower Ochoco creeks, with surveys in McKay Creek showing that pools average less than 10 percent of the channel (Walter 2000). The reach of the Crooked River from the City of Prineville to RM 34 also lacks instream habitat complexity and the substrate contains a high percentage of fine sediment. Lack of large wood also reduces instream condition. In addition, the lower drainage contains several artificial passage barriers that limit fish production and connectivity. Some irrigation diversions lack fish screens (Marx 2004).

Instream habitat condition generally remains good in the Crooked River from Bowman Dam to the city of Prineville, and from RM 34 to the mouth. Channel conditions below Bowman Dam are stable, though spawning habitat is limited. The coarse substrate in this reach provides instream habitat complexity as large wood is lacking. Instream conditions improve in the Crooked River from RM 57 to the City of Prineville, displaying good riffle/pool ratio and spawning gravel. The canyon reach from RM 34 to Highway 97 displays a mix of boulder-strewn riffles and long glides with a low gradient. The reach from Highway 97 to the mouth displays very good instream condition and complexity, and contains a mix of high gradient boulder reaches and long slow glides.

Flows

Flows below Bowman Dam are regulated by the Bureau of Reclamation and managed by the Ochoco Irrigation District. Flows below Bowman Dam typically range from 200-250 cfs during summer irrigation and 30-75 cfs during winter storage.

Summer flows in the Crooked River drop significantly at RM 57, where 160 to 180 cfs is diverted during the irrigation season. Several other diversions remove additional flow below RM 57. Together, these diversions remove most remaining flow and leave the Crooked River below Prineville with very low summer flow. River flows range from 10 cfs, the minimum flow required by the project, to 3,100 cfs, the legal maximum. Some irrigation return water from Ochoco and McKay creeks augments flow in the lower Crooked River, though additional irrigation diversions downstream continue to withdraw water. IFIM studies suggest that higher flows would be required to obtain optimal production of adult and spawning redband trout (ODFW 1996c). Natural spring releases augment flows in the Crooked River below Highway 97. The volume of spring flow increases as the river flows north, with Opal Springs discharging up to 240 cfs. The river averages over 1,550 cfs when it joins the Deschutes at Lake Billy Chinook.

Flows in lower Ochoco Creek also respond to water storage and releases. Ochoco Dam operations reverse the natural seasonal flow pattern in the lower stream reach. High flows occur during irrigation (April to mid-October) and low flows occur while water is stored for the next irrigation season.

Watershed and stream corridor degradation, and irrigation withdrawals in the McKay Creek system contribute to flashier flows and produce low or intermittent flows in many stream reaches. Flows in McKay Creek are frequently intermittent or dry from the Allen Creek confluence to the mouth during the irrigation season.

Water Quality

Cold-water reservoir releases strongly influence water temperatures in the Crooked River below Bowman Dam. Summer water temperatures average 47° F to 50° F, with a high of 54° F; and winter temperatures average 37° F to 40° F, with a low of 32° F. Water discharged from the reservoir rarely exceeds 54° F. Sediments suspended in the reservoir water, however, create turbid flow in the Crooked River from the dam to near Highway 97 where spring inflow contributes to good water clarity and cooler temperatures (ODFW 1996c). Variable discharges cause nitrogen super saturation when water is spilled over Bowman Dam or high volumes are released through the outlet structure (ODFW 1996c).

Summer water temperatures increase in the Crooked River as flow is diverted for irrigation, and water temperatures near Prineville can exceed 80° F. The reach from Prineville to Highway 97 also suffers from high pH (summer and winter), high bacteria (summer), high BOD, and low dissolved oxygen. Water quality improves below Highway 97 with additional flow from natural springs. The Crooked River below Baldwin Dam (RM 0-51) exceeds State water quality criteria for summer temperatures and bacteria, and pH (ODEQ 2002).

Water quality in McKay, Marks, Mill and Ochoco creeks also surpasses State water temperature criteria for salmonid spawning and rearing (ODEQ 2002). Summer water temperatures typically reach 75° F in Little McKay Creek, and reach 80° F in lower McKay and Allen creeks.

4.5. Upper Crooked River Assessment Unit

The upper Crooked River drainage above Bowman and Ochoco dams includes the upper mainstem Crooked River, the North Fork Crooked River drainage, Camp Creek, the South Fork Crooked River drainage, Beaver Creek, and the upper Ochoco Creek drainage. Redband trout are the only native game fish left in the upper basin and reside primarily in the headwaters of smaller tributaries located on USFS lands. Spring chinook and summer steelhead runs returned to the area historically.

4.5.1. Historical Conditions

Diverse and abundant vegetation in the upper drainage historically created good fish and wildlife habitat and provided for general watershed health. Large trees were primarily fire resistant ponderosa pine at lower elevations, Douglas fir and western larch at middle elevations and true firs at higher elevations (Whitman 2002). Frequent fires maintained an open park-like structure at lower elevations, but were less frequent on cooler and higher elevations. When fires did occur at higher elevations, they burned a high percentage of trees (Whitman 2002). Historic maps indicate that much of assessment unit was covered with juniper woodland and over one million acres of shrub-steppe habitat (IBIS 2003). An estimated 61,000 acres of natural grasslands covered the middle drainage (IBIS 2003), protecting the area's highly erodible soils during periods of runoff. Well developed floodplains and riparian areas also reduced erosion. Still, periodic natural events caused areas with fine-grained soils to erode. A study of Camp Creek in the upper Crooked River basin, for example, identified several periods of prehistoric incision followed by aggradation that may have corresponded to subtle climatic shifts (O'Connor et al. 2003).

Typical of drainages in the semiarid climate, stream flows rose following winter storms and dropped during dry summer months. There were also more springs and watercourses in the basin. Beaver dams were plentiful and instrumental in maintaining a high water table under most stream valleys. Ogden's' journals of his expeditions up the Crooked River in 1826 described the excellent quality of beaver habitat and noted specifically that all of the tributaries and the mainstem he observed were lined with willows and aspen, and grass as tall as 7 feet (Ogden 1950). Ogden also noted the presence of an Indian fish weir below the junctions of the North and South forks that was apparently used for capturing anadromous fish (ODFW 1996c). Other journals mention good trout and salmon populations in Ochoco and Beaver creek watersheds.

4.5.2. Current Conditions

Uplands

Generally, lands in the assessment unit are split equally into federal and private ownership. Public forest lands cover much of the headwaters and contain wet meadows and forested areas. Uplands in the middle and lower drainage generally support sagebrush and juniper communities, with irrigated meadows and hay fields along the stream bottoms. The South Fork Crooked River drains a high desert and plateau landscape, and more than a third of this drainage does not contribute runoff in most years. Camp Creek and several small tributaries drain the arid Maury Mountains.

Comparisons of historic and current habitat maps indicate that 93 percent of the native grasslands, 38 percent of the shrub-steppe, and 35 percent of the ponderosa pine forests in the assessment unit have been lost (IBIS 2003). The former shrub-steppe and ponderosa pine areas have been taken over by juniper woodland and mixed conifer forests, respectively, which have increased by over 200 percent and over 600 percent. Approximately 39,000 acres have also been replaced by agricultural uses (IBIS 2003).

Soils in much of the drainage are vulnerable to erosion due to steep slopes, high clay content and poor vegetative cover. Loss of forest structure and native grasslands, and expansion of western juniper and noxious weeds, has affected watershed hydrology and increased erosion and soil disturbance (Whitman 2002).

Riparian Areas

Most riparian corridors in the upper Crooked River drainage are degraded with open canopies that provide little to no shade (ODFW 1996c). Habitat surveys conducted by

USFS (1998) in the Bear, Camp, and Deep creek drainages and in the North Fork and middle Crooked rivers found that the loss of riparian tree and shrub species had reduced vertical habitat complexity and reduced water storage capacity of riparian areas. Surveyors noted density of riparian vegetation had improved since the1960s with land management changes, but the low gradient stream systems had not returned to historic condition (Whitman 2002). Surveys by ODFW have also found poor riparian conditions in the Beaver Creek and South Fork drainages (ODFW 1996c). Riparian condition along Camp Creek remains below historic level, though riparian density has improved significantly in some reaches due to restoration activities.

Riparian assessments conducted in 2000 in the Mill, Marks and Ochoco creek drainages using OWEB methodology showed that riparian recruitment was generally inadequate along Mill Creek, West Fork Mill Creek, Marks Creek and Ochoco Creek (Whitman 2002). USFS and ODFW surveys for the upper Ochoco Creek drainage in 1979, and for Marks and Mill creeks in 1977, showed that stream reaches with the best riparian conditions were upper reaches of Canyon and Ochoco creeks (ODFW 1996c). Some riparian areas along upper Mill Creek are still recovering from the Hash Rock forest fire.

Instream Habitat

The upper mainstem Crooked River and many of its tributaries, including Beaver Creek and the South Fork Crooked River, display low gradients with high pool:riffle ratios characterized by long slow moving shallow pools and long glides. Substrates often contain high levels of fine sediments in pools and glides, with occasional riffles of cobbles and boulders. Spawning gravel is limited. Many reaches of the upper mainstem Crooked River have been disconnected from adjacent floodplains and/or channelized. Many reaches of Camp, Bear and Sanford creeks have incised into the fine valley soils, with a corresponding drop of former floodplain water table. Streams generally lack large woody debris, instream habitat complexity, or perennial stream flow.

In the upper Ochoco Creek drainage, recent assessments indicate that channel sensitivity to erosion is high for 84 percent of the Ochoco Creek, and that riparian recruitment is inadequate for roughly two-thirds of stream reaches. Channel sensitivity for Marks and Mill creeks was rated as high for the entire channels (Walters 2000). Lack of instream habitat complexity and large wood contribute to reduced fish production in many reaches. Fish populations have also been fragmented by dams built for irrigation diversion and by the creation of small impoundments built without passage facilities or protection screens (Marx 2004).

Flows

Low summer flows, primarily created as a result of irrigation water withdrawals, reduce flows needed for aquatic production in much of the upper Crooked River drainage. Surface water rights are over-allocated for the entire Crooked River watershed. Summer flows in the upper Crooked River reach 1 to 7 cfs with temporary irrigation dams diverting much of the flow throughout private lands. In the North Fork Crooked River drainage, streams commonly carry late summer flows of less than 2 cfs, although Deep Creek, a major tributary below Big Summit Prairie, and the North Fork Crooked River below the confluence of Deep Creek, generally have flows of 5 to 10 cfs. Summer flows typically range from 2 to 9 cfs in the South Fork and from 0 to 5 cfs in the Beaver Creek drainage. Low summer flows are also a problem in Camp Creek and other Maury Mountain drainages. Most flow in Ochoco, Marks and Mill creeks below the Ochoco

National Forest is also diverted for irrigation, and Ochoco and Mill creeks are frequently dry above the reservoir in July, August and September.

Further, flood intensity, such as during the 1964 flood, has increased in much of the upper drainage because of the loss of natural water storage. The Post/Paulina area is particularly threatened by floods due to landscape condition. Rapid snowmelt, or a rain on snow event, sends water rushing from degraded headwater tributary streams to lower Beaver Creek and the upper Crooked River where the faster runoff can cause flooding (Whitman 2002).

Water Quality

High summer water temperatures, particularly as a result of low instream flow, affect fish production and restrict fish movement in much of the upper Crooked River drainage. The Upper Crooked River, North Fork, South Fork, Beaver Creek, Bear Creek, and many tributaries are included on the 2002 ODEQ 303(d) list for exceeding summer rearing temperatures. Summer water temperatures commonly reach the mid-70s and, in some areas, the mid-80s. Sedimentation also causes water quality problems in the drainage. Erosion from the mainstem Crooked River and tributaries, including Camp, Eagle, Lost and Conant creeks, contributes to turbidity and sediment loads in Prineville Reservoir. In addition, inactive mercury (cinnabar) mines located at the headwaters of Johnson Creek in the North Fork drainage may adversely impact water quality.

4.6. Middle Deschutes River Assessment Unit

This assessment unit includes the 32-mile reach of the Deschutes River from the lower end of the Pelton Round Butte Complex (RM 100) to Big Falls (RM 132). The reach historically supported anadromous fish production, with Big Falls blocking anadromous fish passage to upriver areas (Nehlsen 1995). Today, anadromous fish passage is blocked at the lower end of the Pelton Round Butte Complex.

Two tributaries to this reach of the Deschutes, the Metolius River and Squaw Creek, fall within the assessment unit. The Metolius River drainage covers 315 square miles and contains 110 miles of perennial streams, 324 miles of intermittent streams, 42 lakes and 121 ponds. The river flows 29 miles and joins the Deschutes at Lake Billy Chinook. The Squaw Creek drainage covers 230 square miles. The creek flows 35 miles to enter the Deschutes River at RM 123.1, a few miles above Lake Billy Chinook. These two major tributaries once provided important salmonid spawning and rearing habitat, and continue to provide important habitats for bull trout and redband trout populations. The drainages will provide important habitat for reintroduced salmon and steelhead when fish passage is restored at the Pelton Round Butte Complex.

4.6.1 Historical Conditions

The tightly confined canyon of the Deschutes River between Big Falls and Lake Billy Chinook exhibited many conditions seen today. Deciduous vegetation consisting of alders and willows dominated riparian areas along benches and islands. Juniper, scattered pine and various grasses and forb species armored the stable riverbanks created by a uniform flow regime. Large springs in the lower reaches maintained relatively cool and stable year-round temperatures that provided ideal conditions for salmonid growth and survival.

Upland areas in the assessment unit displayed a wide diversity in vegetation. Historic maps show that ponderosa pine forests were the predominant forest type, at an estimated 300,000 acres. Smaller acreages of shrub-steppe, juniper woodland, and mixed conifers forests were also present. Relatively small areas of wild grassland (15,000 acres) covered what is now called Plainview between Squaw Creek and the Deschutes River. Cottonwood and aspen groves were once abundant in the Squaw Creek and Metolius watersheds (IBIS 2003).

Tall stands of ponderosa pine armored streams in the spring-fed Metolius watershed, along with a well-developed growth of deciduous vegetation. The stream channel was very stable and constrained over most of its length, except a few locations where braiding occurred. Water quality was excellent, with low contributions of fine sediment and cool summer streamflows (CTWS 1999a). There was also more large wood in the streams, which slowly developed into floating island habitat.

Higher quality habitat conditions also existed in Squaw Creek before the late 1800s when flow allocations for irrigation began. High quality spawning gravel was well distributed throughout the system. Higher natural flows created an abundance of off-channel habitats in Squaw Creek and Indian Ford Creek, and more frequent use of side channels and floodplains. The higher summer flows also provided deeper pools for fish use during summer months. Diverse riparian vegetation grew along the streambanks and provided shade for off-channel and pool habitat. Pools formed by large wood may have been more frequent in lower Squaw Creek. Water temperatures were probably more suitable for salmonid spawning and rearing. Houslet (1998) found that if average summer flows were not diverted, the average maximum water temperature for August would be near 66.5°F above Alder Springs (RM 2).

4.6.2. Current Conditions

Uplands

The Deschutes River from Big Falls to Lake Billy Chinook flows within a narrow deep canyon surrounded by a desert landscape. Major land uses include livestock grazing, agriculture and recreation. Vegetative communities are dominated by juniper and sparse ponderosa pine communities.

The Metolius River and Squaw Creek drain the forested eastern slopes of the Cascade Range, and drop into sagebrush steppe and farm and ranch lands in the lower watersheds before reaching the Deschutes River. Public forestland managed by the Deschutes National Forest cover 60 percent of the Metolius River drainage and remaining lands are in private or Tribal ownership. Primarily land uses in this drainage include recreation, timber, farming and residential. The middle and lower Squaw Creek watershed contains farming and range lands, with more than half of the land along Squaw Creek is in private management (UDLAC 2002). The creek also runs through the City of Sisters.

All wild grasslands in the assessment unit are now gone, converted to other uses or encroached by juniper woodland and shrub-steppe vegetation. Comparisons of historic and current habitat maps indicate that ponderosa pine forests and western juniper woodlands have declined 47 percent and 80 percent, respectively, to be replaced by mixed conifer forests (IBIS 2003). Aspen and cottonwood groves are reduced or have been eliminated in much of their former areas.

Riparian Areas

From Big Falls to Lake Billy Chinook, the Deschutes River canyon gradually deepens to 700 feet and becomes narrower. The narrow riparian area is dominated by woody species, such as alder, red-osier dogwood, willow, chokecherry, rose and as well as sedge, rush and various grasses. Riparian vegetation is thicker in areas where springs emerge from the canyon walls, and along river benches and islands.

Stable flows within the Metolius River promote a healthy riparian corridor along the stream and undercut banks. Good riparian growth also exists along most of the river's tributaries. Riparian conditions along several reaches, however, have been damaged by dispersed recreational use, timber harvest, grazing, and recent wild fires.

Riparian condition along upper Squaw Creek is generally good, though some areas show damage from timber harvest and recreation use. The most severe riparian condition extends from just above the City of Sisters downstream 11 miles. This reach has been damaged by past grazing, channel alterations, and development. Many sections of lower Squaw Creek have a broad riparian area comprised of floodplains, willow stands, and cottonwood bottom lands. Riparian vegetation along Indian Ford Creek has also been degraded by past grazing.

Instream Habitat

Instream habitat remains in good conditions in the Deschutes River from Big Falls to Lake Billy Chinook. Spawning gravel recruitment is naturally limited and is lacking below Steelhead Falls, but good gravel exists in the Foley waters area above Steelhead Falls. Large boulders provide most structural diversity in this reach of the Deschutes as large wood is lacking.

Stream channels in the Metolius drainage are generally stable with functional floodplains and habitats created by beaver activity, including ponds and wetlands. The river also contains high quality spawning gravel suitable for redband trout, particularly in the reach above Gorge Campground. Instream habitat complexity in the Metolius River and some tributaries, however, is limited by the lack of large woody debris. Several cool, spring-fed tributaries to the lower Metolius River contain abundant spawning gravel, undercut banks, side channels and wood that form high quality bull trout rearing habitat (Ratliff et al. 1996).

In the Squaw Creek drainage, channel alterations and streambank erosion have reduced habitat quality for the native redband and bull trout populations. In particular, channel simplification has reduced channel complexity and stability from RM 24.7 to the National Grassland Boundary (RM 5), resulting in a loss of sinuosity and stream length. Lower Squaw Creek also displays a high percentage of fine sediment associated with unstable streambanks and livestock grazing. Large wood volume is low or absent from the channel below RM 25. Most irrigation diversions from Squaw Creek lack fish passage and protection facilities.

Flows

The Deschutes River gains a substantial amount of flow from groundwater releases in this reach. However, flows from upstream are substantially reduced during the irrigation season and flows remain low in parts of this reach. Summer flows in the Deschutes River near Lower Bridge (RM 134) drop to as low as 30 cfs in hot summer months (although flows to 1 cfs have been recorded). Approximately 400 cfs from groundwater flow is discharged into the river before it enters Lake Billy Chinook (Gannett et al. 2001). The 20-mile reach of the Deschutes from the top of Lake Billy Chinook to the Reregulating Dam is constrained by a series of reservoirs and dams that are managed by Portland General Electric and the Warm Springs Tribes for hydroelectric production.

Flow regimes in the Metolius River and Squaw Creek differ significantly. Constant flow from spring releases keeps the Metolius running bankfull at all times. Average flows at the river's mouth range from 1,653 cfs in June to 1,360 cfs in October. The river is swift flowing with a relatively uniform gradient. In comparison, streamflow in Squaw Creek is notoriously "flashy", fluctuating from extremely high flow to low flows that at times go subsurface. The creek is also heavily used for irrigation and stream flows are over allocated. The natural flow pattern in Squaw Creek remains generally undisturbed from the headwaters to RM 23.5, where a series of diversions remove most of the water for irrigation during summer months. Flows gradually improve between the City of Sisters and Camp Polk Road RM 17 with the discharge from a series of springs and irrigation return flow. Springs near Camp Polk Road contribute 7 cfs to flows in Squaw Creek. Indian Ford Creek, which joins Squaw Creek at RM 20, becomes dry due to irrigation diversions, though water lost in this tributary may later resurface as springs. Alder Springs (RM 2) contributes 74.5 cfs to the stream. A minimum of nearly 100 cfs discharges to the Deschutes River because of groundwater springs (UDLAC 2003).

Water Quality

The Deschutes River from Steelhead Falls to Big Falls was included on the 2002 ODEQ 303(d) list for exceeding temperature criteria for salmonid fish spawning between September 1 and June 30. Part of this reach, from Steelhead Falls to Bend, was also listed in 2002 for exceeding ODEQ criteria for pH and for salmonid rearing temperatures (Yake 2003).

Water quality is generally excellent in the Metolius system due to spring sources in the tributaries and the mainstem. Water testing has shown low dissolved solids, low alkalinity, and low conductivity. Phosphorus levels have measured higher than the recommended DEQ maximum. Water temperatures in the Metolius are generally cold because of cold water springs, and usually do not exceed 50°F (measured at Bridge 99) during the summer. The cool flows are preferred by bull trout, but limit growth of redband trout, which prefer temperatures of 55-65°F. Water temperatures in the lower Metolius can exceed the temperature criteria for bull trout (50°F) during certain seasons of the year, making those stream reaches candidates for inclusion on the ODEQ 303d list. In addition, water temperatures in one Metolius River tributary, Lake Creek, exceed State water temperature criteria for salmonid spawning and rearing (ODEQ 2002).

Squaw Creek is included on the 2002 ODEQ 303(d) list for exceeding water temperature criterion for salmonid spawning during summer months. High water temperatures particularly limit fish production in the diversion-impacted reach (RM 2 to 25). Below water diversions near the City of Sisters, water temperatures in Squaw Creek can rise to over 70°F. The warmer water temperatures result in lower dissolved oxygen as the stream flows through the dry canyon section (ODFW 1996a). Water quality in Squaw Creek is also reduced by turbidity, nutrients, streambank erosion, decreased stream flow, and insufficient stream structure.

4.7. Upper Deschutes River Assessment Unit

The largest of the assessment units, this drainage includes the reach of the Deschutes River that is primarily influenced by flow storage, releases and withdrawals. It also includes the upper watershed tributaries Tumalo Creek and Fall, Spring and the Little Deschutes Rivers.

Tumalo Creek extend about 20 miles fromits headwaters in the Cascade Range to where it enters the Deschutes River below Bend at RM 160.4. Several tributaries contribute an additional 20 stream miles to the system. Spring River originates from a spring source and is approximately one mile long, joining the Deschutes River at RM 191. The Little Deschutes River begins near Mule Peak in Klamath County and drains approximately 1,020 square miles, flowing 97 miles to its confluence with the Deschutes River at RM 192.5. Fall River originates from a spring and flows 8.15 miles to meet the Deschutes River at RM 204.5.

4.7.1. Historic Conditions

The upper Deschutes watershed displayed a diverse landscape extending from conifer forests, to extensive lodgepole pine forests and pumice plains, to grasslands of the arid high desert. Historic habitat maps show large areas of both ponderosa pine and lodgepole pine forests across the southern two-thirds of the assessment unit. Map analysis suggests that 479,000 acres of ponderosa pine forest and 359,000 acres of lodgepole pine forest existed historically (IBIS 2003). Historic forest conditions, shaped by frequent fire activity, were generally open in appearance. Journal notes by the Williamson—Abbott railroad survey crew in 1853 state *"We found yellow pine still abundant, forming by far the most constant feature in the vegetation of our route from Pit River to the Columbia. ….The volcanic soil, as light and dry as ashes, into which the feet of our horses sank to the fetlock, produces almost nothing but an apparent unending succession of large trees of P. Ponderosa* (Yake 2003; USFS 1998d*)."*

Below Bend, the river corridor transitioned from forest to desert canyon reflecting a more arid, high desert. Vegetative communities in the desert landscape were dominated by native grasses and widely scattered juniper trees. Historic habitat maps show 100,000 acres of juniper woodland in the area between what is now Bend and Redmond, as well as 37,000 acres of wild grassland in the Tumalo area (IBIS 2003).

The river's stable flows supported lush riparian zones. Springs and seeps frequently occurred along the stream banks between the present sites of Wickiup Dam and the city of Bend. Wet meadows and forested wetlands were associated with the high groundwater table and low stream gradient upstream from Benham Falls. Below Bend, the narrow basalt canyon exhibited many conditions seen today. Deciduous vegetation consisting of alders and willows dominated riparian areas along benches and islands.

4.7.2. Current Conditions

Uplands

Public forest lands cover much of the upper Deschutes River drainage above Bend and are managed by the U.S. Forest Service for recreation and timber harvest. Private lands are also scattered throughout the upper watershed above Bend and include lands around the La Pine area that are used as grazed timberland and for subirrigated agriculture. Many private lands in the Sunriver-La Pine area support rural or recreational home sites, including most of the land adjacent to the Deschutes and Little Deschutes rivers. Lands in the drainage below Bend are 61 percent private, 34 percent federal, 3 percent state and 2 percent county and support farming, ranching, rural residential development, municipal and recreational uses. The area also includes the communities of Bend, Redmond, LaPIne and Gilchrist.

All native grasslands in the Tumalo area have been replaced by other uses or vegetation types (Hostick 2004). Comparisons of historic and current habitat maps show that ponderosa pine and lodgepole pine forests have been fragmented, and 50 percent of the lodgepole pine forests have been lost to other uses or different vegetation types, including mixed conifer forest, which has increased over 110 percent (IBIS 2003).

Riparian Areas

Riparian areas below Wickiup Dam, especially in the reach above Benham Falls, show the signs of an altered flow regime. A 1978 streambank erosion survey estimated that bank erosion in the reach generally ranged from zero to two inches per year, but jumped to eight inches per year at many locations (Yake 2003). This erosion appears to have started after development of Wickiup Dam and subsequent changes in the timing of high and low river stages. Riparian vegetation degradation has been accelerated by freezing and thawing of exposed river bed and banks, followed by up to a 700 percent spring flow increase to supply irrigation water downstream. A comparison of 1943 and 1991 photographs reveals that the Deschutes River between Wickiup Dam and Benham Falls widened an average of 20 percent in the 48-year period (ODFW 1996a; USFS 1994).

Riparian condition improves below Benham Falls. From Benham Falls to Bend, lava flows, boulders, and rubble armor much of the streambed and banks from the erosive action of high irrigation flows. Vegetation stretching along the west side of the Deschutes shows signs of disturbance from recreational use, especially from Benham Falls to Lava Island Falls (Yake 2003). The Deschutes River canyon below Bend supports a narrow riparian area dominated by woody species, such as alder, dogwood, willow, chokecherry and rose, as well as sedge, rush and various grasses.

Tributaries to this reach of the Deschutes River drain mountain forests and are often in good condition, including Fall River, the upper Little Deschutes River, and much of Tumalo Creek. Some areas along Tumalo Creek show damage from past forest fires and salvage operations. Degraded riparian areas are common along the first 38 miles of the Little Deschutes and in many areas between RM 44.6 to RM 63 (ODFW 1995).

Instream Habitat

The Deschutes River displays a low gradient, averaging less than 1 percent, between Wickiup Dam and Benham Falls, except for Pringle Falls at RM 217. Sloughs and oxbows are found throughout the reach; and the river substrate is generally silt, sand, and pumice with an underlayer of clay and siltstone. Alluvial gravel is found mixed with these substrates. There is little instream habitat complexity, and large wood and boulders are scarce or lacking. ODFW, USFS and volunteers have conducted a number of projects to add large wood or spawning gravel at a number of sites. The Little Deschutes River also lacks instream habitat complexity and structure, particularly in the lower river where degraded riparian habitat, impacted by grazing and development, has contributed to some channel instability problems with increased fine sediments in the substrate.

Streambanks in this reach show signs of "frost heave", with soils loosened during low flows washing downstream when flows increase in the river during the beginning of irrigation season. At a flow of 30 cfs, half the stream channel is exposed to frost action cycles (USFS 1994). When the river is at the minimum flow of 20 cfs below Wickiup Dam, even more of the channel is exposed. Freezing in the river channel eliminates habitat for fish and aquatic invertebrates.

Fish habitat improves progressively in the Deschutes River below Fall River — though there is still icing and lack of channel complexity in the reach above Sunriver. Spawning gravels are also limited. Fall and Spring rivers provide some habitat in this reach, but lack abundant spawning gravel, instream wood structure, and pool habitat. Below Sunriver, lava formations in the mainstem create pools that support larger fish during low flows and provide rubble, cobble and boulder substrate that are important winter habitat for juvenile trout. The high gradient channel below Benham Falls and increased flow provides more fish and aquatic habitat than the upper reach. Both reaches, however, contain limited spawning gravel and large woody structure. From Bend to Big Falls, channel stability and habitat diversity in the Deschutes River are good, though instream wood material is often lacking or absent and good spawning habitat is also not abundant.

Many reaches of Tumalo Creek contain good instream habitat, including high quality spawning gravel. Habitat condition is reduced in lower Tumalo Creek below RM 2.5 where summer flows are diverted for irrigation. Pool habitat is also lacking in this reach, and in several upper reaches where forest fires reduced riparian and instream condition. Several artificial and natural barriers in lower and upper stream reaches also restrict fish movement.

Flows

Wickiup and Crane Prairie reservoirs store water for spring and summer irrigation. The altered flow pattern replaces the stable natural flows in the Deschutes River above Benham Falls with flows as low as 20 cfs in winter to under 1,600 cfs during high irrigation demand in summer months (Gorman 2004). Flows increase downstream with contributions from Fall, Spring and the Little Deschutes rivers.

Nearly all the water (90 percent) in the Deschutes is diverted near RM 164 during the high withdrawal months of June through September (Yake 2003). Flows between Bend and Lower Bridge reach as low as 30 cfs in hot summer months during the irrigation season (although historical short-term flows to 1 cfs have been recorded). Instream transfers and conservation work have recently brought the minimum up to 35 cfs (UDLAC 2003).

Flows in the Little Deschutes River are regulated for storage and release of water from Crescent Lake, which serves as an irrigation reservoir. Unlike in the upper Deschutes, however, stored water releases from Crescent Lake actually benefit summer flows in the Little Deschutes River in that minimum flows have increased (UDLAC 2003). Flow regulation has little effect on average winter flows in the Little Deschutes River.

Flow in lower Tumalo Creek (below RM 2.5) is substantially reduced by withdrawals for irrigation use. The lower two miles of the stream have become intermittent during the irrigation season in the past. In recent years, however, a live flow of 5.8 cfs has been maintained in the lower creek. The water savings has been largely due to conservation efforts by the Tumalo Irrigation District.

Water Quality

While most smaller streams and tributaries in the upper Deschutes watershed are in good condition, reaches of the Deschutes River and several tributaries experience seasonal temperature extremes (i.e. high summer temperatures and winter icing), high erosion rates, low dissolved oxygen and other problems. The mainstem Deschutes River from Steelhead Falls to Sunriver exceeds the temperature criterion for salmonid fish spawning between September 1 and June 30. Part of the reach, from Steelhead Falls to near Bend, also exceeds temperature criteria for salmonid rearing and pH levels. State dissolved oxygen levels for spawning are exceeded in the mainstem Deschutes River upstream of Bend (RM 168.2) to just below Wickiup Dam (RM 222.2). The river is also listed for exceeding cold water dissolved oxygen levels from Bend (RM 168.2) to below Sunriver (RM 189.4). Four segments of the Little Deschutes River are also listed as water quality limited streams on the 2002 ODEQ 303(d) list, all for temperature. In addition, sedimentation and turbidity reduce water quality in the upper Deschutes. Water clarity deteriorates rapidly below Wickiup Dam when turbidity levels increase as much as 30 times after spring water releases for irrigation (Yake 2003).

4.8. Cascade Highlands Assessment Unit

The eight-mile reach of the Deschutes River above Crane Prairie is the only reach of a total 252 miles where the flow regime remains unaltered by dams. The Odell Creek/Odell Lake complex, which is also part of this assessment unit, supports a remnant population of bull trout that is the only known resident, non-reservoir, adfluvial population remaining in Oregon.

4.8.1. Historic Conditions

The Deschutes River Highlands Assessment Unit lies in the high Cascade Mountains above 4,300 feet in elevation and was historically heavily forested. Historic habitat maps indicate that forests were almonst evenly divided between mixed conifer types (120,000 acres) and ponderosa pine and lodgepole pine forests (124,000 acres)(IBIS 2003).

Frequent seeps and springs in the highlands created a number of natural wetlands, including Crane Prairie a natural meadow where the Deschutes River, Cultus River, Quinn River, Rock Creek, Cold Creek, Deer Creek and Cultus Creek converged. The upper segment of the Deschutes River and most tributaries had fairly stable flows associated with natural spring sources, though flows fluctuated from year to year depending upon precipitation and climatic cycles. Deer and Cultus creeks depended primarily on snow melt and were frequently intermittent by late summer or fall. Streams generally had good riparian and instream cover, including large woody debris. Spawning gravel quality was limited by the general stable stream flows, a lack of flushing type flows and the naturally high levels of fine sediments in the stream substrate.

Odell and Davis lakes, received inflow from part of the high Cascades south of present day Wickiup and Crane Prairie reservoirs. They were isolated from the Deschutes River by a lava flow 5,500 years ago that impounded Odell Creek and formed Davis Lake (USFS 1994).

4.8.2. Current Conditions

Uplands

The headwaters of the upper Deschutes River collect flow from public forestlands managed by the U.S. Forest Service for recreation and timber harvest. Comparisons of historic and current maps indicate that many former areas of lodgepole pine and ponderosa pine forests have been replaced by mixed conifer forests. Pine forests have been reduced by 80 percent compared to historic estimates, while mixed conifer forests have increased a similar 80 percent (IBIS 2003).

The Deschutes River originates approximately 8.4 river miles north of Crane Prairie in Little Lava Lake, a spring-fed body of water. Timber harvest and grazing in the area has been limited. The area surrounding Odell Lake is also forested. Plant communities upslope of Odell Lake are primarily mountain hemlock or mountain hemlock/lodgepole pine. The watershed includes several recreation sites. with an extensive road network providing access to most streams, lakes and associated recreation sites.

Riparian Areas

Except for past grazing, recreation sites and transportation impacts — the upper section of the Deschutes remains relatively natural (ODFW 1996a). Healthy corridors border stream channels with lodgepole pine forests, riparian meadows, and grasses. Lupine, false hellebore and a variety of rushes and sedges are also present (USFS 1989). Mountain alder and spruce are found along with lodgepole pine (ODFW 1996a).

The riparian condition around the Odell Lake watershed is generally excellent, except for localized recreation sites where human influences have altered the form and function of riparian and floodplain areas (USFS and BLM 1999).

Instream Habitat

Much of the historic spawning gravel occurred in the area now inundated by Wickiup Dam and the reservoirs. The best remaining spawning and rearing habitat for redband trout lies in the Deschutes River between Crane Prairie and Little Lava Lake. Of the approximately 13.5 total miles of tributary habitat available in the Cultus and Deer Creeks and Cultus, Quinn, and Deschutes rivers, over three quarters of it is in the Deschutes River (ODFW 1996a). Other tributaries to Crane Prairie Reservoir provide varying amounts of trout spawning and rearing habitat for both reservoir and resident fish populations. According to 1989 Forest Service stream surveys, much available spawning gravel in these tributaries is embedded with naturally occurring fine sediments.

Trapper Creek is the only tributary to Odell Lake with a known spawning population of bull trout. Juvenile bull trout rear in Trapper Creek, Hemlock Creek, and Odell Creek, and likely use a number of other tributary streams intermittently. Habitat in Trapper Creek occurs in the lower 0.8 miles between the mouth and a 7.5-foot waterfall (USFWS 2002b). A 1996 USFS habitat survey found 35 percent of the total habitat units in Trapper Creek had bull trout-size spawning gravels; however, spawning habitat was limited by other factors, including water depth and velocity (USFWS 2002b). Low gravel and large wood levels also limit bull trout production in Trapper Creek. The 1996 survey found only five side channels for rearing, constituting only 5 percent of the total habitat area in the 0.8-mile reach of Trapper Creek (USFWS 2002b). High fine sediment levels in tributaries may limit salmonid spawning potential.

Flows

The Deschutes River originates at Little Lava Lake and flows south for approximately 8.4 miles before entering Crane Prairie Reservoir. In low water years, "Blue Lagoon" or "Blue Hole" — a massive spring located at RM 251 — appears to be the head of the Deschutes, although there are subterranean water flows moving south in the basin upstream from this spring area (ODFW 1996a). The result is a very stable hydrologic regime in which daily, monthly, and even annual fluctuations in water flows and temperatures are minimal compared to rivers dominated by surface runoff (Mathisen 1990). Unlike most streams in Oregon, flow is lowest in the winter and peaks in August to early September (ODFW 1996a).

Odell Lake is a natural lake in the Cascade Mountains. The lake covers 3,600 acres and has an average depth of 40 meters. Trapper Creek is the only tributary of Odell Lake that responds to runoff events (USFWS 2002b). Most of the basin exhibits fixed drainage patterns fed by spring releases. Davis Lake, a shallower natural lake (20 feet maximum depth), has no surface outlet; however, many seeps in the lava flow allow water into Wickiup reservoir (USFWS 2002b).

Water Quality

Water quality in the spring-fed Deschutes River above Crane Prairie remains good to excellent, though problems exist in some tributaries and lakes. High summer water temperatures associated with surface reservoir releases reduce water quality in reach between Crane Prairie Dam and Wickiup Reservoir. In addition, water temperatures in Lava Lake exceed cool water dissolved oxygen criterion. Cold water temperatures may also limit trout rearing potential in the Cultus River, Snow Creek and other tributaries and some lakes.

In 2002, ODEQ listed Odell Lake and parts of Odell Creek as water quality limited for pH and of concern for chlorophyll *a*. Odell Creek was also listed for exceeding water temperature criteria for spawning and rearing. Summer water temperatures in Odell Creek generally exceed 70°F as a result of the discharge of warm surface water from Odell Lake (USFWS 2002b).

Out-of-Subbasin Effects
Section 5

Environmental factors outside the Deschutes Basin also have a significant effect on each focal species. It also establishes assumptions for each external effect that will be used to calculate the effects of external conditions on the productivity and sustainability of fish and wildlife within the Deschutes Basin.

This section identifies factors outside the Deschutes Basin that have a significant effect on the focal species, with particular attention to bottlenecks.

5.1. Effects on Aquatic Species

Subbasin planning, by definition, is focused on the major tributaries to the mainstem Columbia and Snake rivers. However, many focal species migrate, spending varying amounts of time and traveling sometimes extensively outside of the subbasins. Salmon populations typically spend most of their lives outside the subbasin. Unhindered, sturgeon will spend short periods in the ocean. Lamprey typically spend most of their life as juveniles in freshwater, but gain most of their growth in the ocean. Planning for such focal species requires accounting for conditions during the time these populations exist away from their natal subbasin. Out-of-subbasin effects (OOSE) encompass all mortality factors from the time a population leaves a subbasin to the time it returns to the subbasin. These effects can vary greatly from year to year, especially for wide ranging species such as salmon. Out-of-subbasin factors can be natural in origin (e.g. ocean productivity), human-caused (e.g. fisheries) or a combination (e.g. mainstem survival is dependent on both mainstem flows and dam operations). Out of subbasin effects are described by the TOAST (2004).

The Ecosystem Diagnosis and Treatment model was used to assess the effects of subbasin conditions on anadromous salmon populations. The out-of-subbasin conditions and assumptions used by the EDT model are described by Marcot et al. (2002) and TOAST (2004). Model parameters roughly represent a 1990 – 1999 base period and these conditions remained constant throughout the EDT assessments. The EDT model includes parameters representing the effects of the hydropower system, estuary and ocean conditions, and harvest regimes during the base period. Additional parameters represent the biological effects of density-dependent interactions in the mainstem Columbia and genetic effects of hatchery fish inter-breeding with naturally-produced adults.

Ocean conditions strongly affect overall salmon survival. Salmon spend most of their life in the ocean and early ocean survival is widely considered a time of particularly high and variable mortality. In addition to the steady state conditions represented in the EDT model, three climatic patterns affect ocean and freshwater conditions and, consequently, salmon production in complex interactions.

Pacific Decadal Oscillation

In recent years, a growing body of evidence from field, tagging, and correlation studies has shown that Pacific salmon experience large year-to-year fluctuations in survival rates of juvenile fish making the transition from freshwater to marine environment (Hare et al. 1999). Climate-related changes have the most affect on salmon survival very early in the salmon's marine life history (Pearcy 1992, Francis and Hare 1994).

The Pacific Decadal Oscillation is a pan-Pacific, recurring pattern of ocean-atmospheric variability that alternates between climate regimes every 20-30 years (Hare et al. 1999). The PDO affects water temperatures off the coast of Oregon and Washington and has cold (negative) and warm (positive) phases (Hare et al. 1999). A positive PDO phase brings warmer water to the eastern North Pacific, reducing upwelling of nutrient-rich cooler water off the coast of North America and decreasing juvenile salmon survival (Hare et al. 1999). The negative phase of the PDO has the opposite effect, tending to increase salmon survival.

Climatic changes are manifested in both returns and harvests. Mantua et al. (1997) found evidence of an inverse relationship between harvests in Alaska and off the coast of Oregon and Washington. The negative phase of the PDO resulted in larger harvests off Oregon and Washington and in the Columbia River and lower harvests in Alaskan waters. In the positive phase, warmer water off Oregon and Washington were accompanied by lower harvests (and runs) in the Columbia River, but higher harvests in Alaska. Phase reversals occurred around 1925, 1947, 1977, and possibly 1999. The periods from 1925-1947 and from 1977-1999 were periods of low returns to the Columbia River, while periods from 1947-1977 and the current period are periods of high returns.

El Nino/Southern Oscillation

The El Nino-Southern Oscillation (ENSO), commonly referred to as El Nino and La Nina, like the PDO, affects water temperatures off the coast of Oregon and Washington and has both a cold (negative) and warm (positive) phase. ENSO events are much shorter than PDO events in that events typically occur every 2-7 years and last 12-18 months. Positive ENSO events occur more frequently during positive PDO phases and less frequently during negative PDO phases (Hare et al. 1999). ENSO events either intensify (during congruent negative or positive events) or moderate (when one cycle is positive and the other negative) the effects of the PDO cycle on salmon survival.

A positive ENSO (El Nino) event also results in higher North Pacific Ocean temperatures, while a negative ENSO (La Nina) results in lower temperatures. Positive ENSO events occur more frequently during positive PDO phases and less frequently during negative PDO phases (Hare et al. 1999).

PDO and ENSO also affect freshwater habitat of salmon. Positive PDO and ENSO events generally result in less precipitation in the Columbia Basin. Lower stream flows result in higher water temperatures and a longer out-migration period. It is likely that less water will be spilled over mainstem Columbia and Snake River dams to assist smolt out-migration (Hare et al. 1999).

Climate Change

Climate change on a longer term than the PDO could have a large impact on the survival of Columbia Basin salmon. Finney et al. (2000) used lake sediment elemental composition to find evidence of very long-term cycles of abundance of sockeye salmon in the Bristol Bay and Kodiak Island regions of Alaska over the past 300 years. No doubt there have been similar variations in the abundance of Columbia Basin salmon.

Computer models generally agree that the climate in the Pacific Northwest will become, over the next half century, gradually warmer and wetter, with an increase of precipitation in winter and warmer, drier summers (USDA Forest Service 2004). These trends mostly agree with observed changes over the past century. Wetter winters would likely mean more flooding of certain rivers, and landslides on steep coastal bluffs (Mote et al. 1999) with higher levels of wood and grass fuels and increased wildland fire risk compared to previous disturbance regimes (USDA Forest Service 2004). The region’s warm, dry summers may see slight increases in rainfall, according to the models, but the gains in rainfall will be more than offset by losses due to increased evaporation. Loss of moderate-elevation snowpack in response to warmer winter temperatures would have enormous and mostly negative impacts on the region’s water resources, forests, and salmon (Mote et al. 1999). Among these impacts are a diminished ability to store water in reservoirs for summer use, and spawning and rearing difficulties for salmon.

Climate models lack the spatial resolution and detailed representation of critical physical processes that would be necessary to simulate important factors like coastal upwelling and variation in currents. Different models give different answers on how climate change will affect patterns and frequencies of climate variations such as ENSO and PDO.

For the factors that climate models can simulate with some confidence, however, the prospects for many Pacific Northwest salmon stocks could worsen. The general picture of increased winter flooding and decreased summer and fall stream flows, along with elevated stream and estuary temperatures, would be especially problematic for in-stream and estuarine salmon habitat. For salmon runs that are already under stress from degraded freshwater and estuarine habitat, these changes may cause more severe problems than for more robust salmon runs that utilize healthy streams and estuaries.

While it is straightforward to describe the probable effects of these environmental patterns individually, their interaction (PDO, ENSO, climate change) is more problematic. The main question appears to be the duration of the present favorable (for salmon) PDO period and the timing and intensity of the subsequent unfavorable period. Prudence suggests planning for a shorter favorable period and a subsequent longer, if not more intense, unfavorable period.

5.1.1. Effects on Deschutes Subbasin Populations

We are unable to specifically calculate the within-subbasin and out-of-subbasin performance of the Deschutes Subbasin steelhead and Chinook salmon populations because of the lack of detailed population data. However, Deschutes River steelhead must pass only two mainstem Columbia River dams (Bonneville and The Dalles) compared to many Columbia River Basin populations. Consequently, the populations appear to be capable of at least maintaining or increasing their numbers. Wild steelhead returns in recent years are significantly greater and could be used to reach subbasin goals more rapidly, although the number of unmarked hatchery strays or stray wild fish may have inflated the recent escapement numbers.

Improved survival within the Deschutes River subbasin will likely have larger positive impacts on the naturally spawning populations than any likely changes outside the subbasin. Considering that anticipated future climate changes are likely to make summer rearing conditions less favorable than during the base period, strategies that improve summer rearing areas should receive higher priority than other restoration strategies.

5.1.2. Effects of Hatchery Strays

Summer Steelhead

The Interior Columbia Basin Technical Recovery Team identified two demographically independent Deschutes River summer steelhead populations and one historic, but unoccupied, habitat within the Deschutes Subbasin as ESA threatened species within the Mid-Columbia ESU. Rationale for this listing includes the genetic risks posed to the wild population by thousands of stray, upper Columbia River Basin, hatchery-origin, steelhead. The incorporation of genetic material from large numbers of stray steelhead could have a long term effect on the subbasin steelhead production through reduced resilience to environmental extremes and diverse survival strategies. Out-of-basin strays also pose a threat to steelhead population health. About 5% of the hatchery stray steelhead have tested positive for whirling disease (Engleking 2002).

Many Snake and Upper Columbia River summer steelhead enter the lower Deschutes mainstem at least temporarily in summer to seek refuge from warm Columbia River mainstem temperatures, which often exceed 70°F in July and August. The influx of out-of-basin stray steelhead started in the early 1980's and appears to be related to an increase in the number of hatchery origin steelhead smolts released in the upper Columbia basin, and an increase in the number of steelhead smolts transported from upper Columbia River collection points for release below Bonneville Dam.

The annual estimated number of stray steelhead passing upstream from Sherars Falls to the Pelton Fish Trap averaged 8,592 (45%) fish from 1978 to 2002, with a range of 300 (5%) to 23,618 (73%) fish (Table 22). From 1978 to 1983, the average number of stray steelhead passing Sherars Falls annually was 360 fish. This number climbed to an annual average of 16,587 stray steelhead from 1997 to 2002 (French and Pribyl 2003).

An unknown, but probably significant proportion of these hatchery strays and Deschutes hatchery fish spawn in the wild (Cramer et al. 2001). More hatchery steelhead have been observed in tributary spawning areas. In 1970 and 1990, hatchery steelhead made up 17% of the steelhead spawning in Bakeoven and Buck Hollow creeks. This increased to 71% in 1996 and 1997 (French and Pribyl 2003).

Spring Chinook

A few stray hatchery spring Chinook are recovered annually in the Deschutes River sub-basin. They have included jacks and adults coded wire tagged and released as juvenile fish at sites located over a wide geographical area. Coded wire tags have been recovered from spring chinook released as juveniles in subbasins located in Washington and Idaho, as well as coastal subbasins that include the Rogue River in Oregon and the Trinity River in California (ODFW 1997). Initially, some out-of-subbasin stray hatchery spring chinook captured at the Pelton Fish Trap each year could potentially have been used for brood stock in the Round Butte Hatchery program if they were unmarked or marked with the same fin mark as Round Butte Hatchery origin returns. Hatchery brood stock identification measures have now been implemented to insure that stray fish are not incorporated into the hatchery brood stock. Only coded-wire tag verified Round Butte Hatchery origin adults have been used for the hatchery brood stock since 1995 (French and Pribyl 2003). The consequences of the past use of potential out-of-basin strays in the Round Butte Hatchery brood stock are unknown.

Fall Chinook

Few stray, out-of-subbasin origin fall chinook had been observed in the Deschutes River until the past two years. However, managers now believe there is substantial interaction between wild Deschutes fall chinook and other stray, hatchery origin summer or fall chinook within the lower reaches of the Deschutes River. This conclusion reflects recent radio telemetry data and an ongoing Tribal fall chinook study.

A Columbia Basin adult fall chinook radio telemetry study shows that a significant number of fall chinook stray into the Deschutes River. Of the adult salmon radio tagged and released at Bonneville Dam, 47% and 54% of the adults tagged in 2001 and 2002, respectively, entered the Deschutes River but most did not remain to spawn. In 2001, 13% of these “dip-ins” migrated upstream to or above Sherars Falls (Brun 2002; Brun 2001). Tribal biologists recovering fall Chinook salmon carcasses following spawning estimate that only about 1% of the carcasses examined were fin-marked, out-of-subbasin stray salmon during 2001 and 2002. Coded wire tag recoveries from these fin-clipped carcasses originated predominantly from Klickitat River and Lyons Ferry fish hatcheries (Brun 2003).

It is difficult to thoroughly evaluate the extent of straying by out-of-basin fall chinook since many Columbia Basin hatchery-origin fall chinook can not be distinguished with any external mark or tag. The population co-exists with wild and hatchery-origin summer steelhead and spring Chinook salmon, but there are no known adverse effects from this association. It will be impossible to accurately estimate the number of stray hatchery salmon spawning in the river or estimate their effect on the Deschutes River population until all Columbia Basin hatchery-origin fall chinook are distinctively marked.

Pacific Lamprey

Little is known about straying of lamprey in the Deschutes River subbasin, including the straying of lamprey from other subbasins into the Deschutes.

5.1.3. Effects of Dam Development and Operations

TOAST (2004) provided the following estimates for Chinook and steelhead survival while migrating through the Columbia River hydropower system.

Chinook Salmon

The Multi-Species Framework Assessment Report (Marcot et al. 2002) developed in-river juvenile and adult Chinook salmon survival rates. The juvenile survival rate, based on yearling survival data from 1993 to 1999 from Lower Granite Dam to the Bonneville Dam tailrace ranged from 31% to 51%. This equated to a survival rate per mainstem dam of 86% – 92%, or a point estimate of 88% per project.

Marcot et al.(2002) assumed in-river survival of sub-yearling Chinook from the head of Lower Granite Reservoir to the Bonneville Dam tailrace was 29% or a per dam survival rate of approximately 85% for active migrants. It was also noted that juvenile survival through the Columbia River reservoirs is affected by the time juveniles spend in each reservoir.

Adult Chinook survival past each Columbia River mainstem dam was assumed to average 93% (Peters et al. 1999).

The juvenile to adult Chinook ratios (JARs) used in the Multi-Species Framework Assessments were provided by Mobrand Biometrics. The rates are the total survival rate of juvenile fish from the mouth of the Deschutes River to their return to the Deschutes Subbasin as adults. Mobrand Biometrics (2003) estimated yearling Chinook out-migrant survival at 2% and sub-yearling survival at 0.9%.

Summer Steelhead

TOAST (2004) used smolt-to-adult ratio (SAR) survival estimates for steelhead populations above Lower Granite Dam (C. Petrosky 2004). The geometric mean for steelhead since 1992 has been 1.69%. The SAR ranged from 1.04% in the 1992 smolt year to 4.68% in the 2000 smolt year. It was assumed that steelhead smolts experienced the same per dam survival rate as that for spring Chinook salmon. It was then estimated that the average SAR for Deschutes summer steelhead is 3.76%, with a range of 2.31% to 10.4%.

Hydroelectric development on the Columbia River may have had some rather subtle adverse affects on Deschutes Subbasin summer steelhead. Summer steelhead adults begin entering the Deschutes River as early as July and then spawn the following year generally from March through May. ODFW steelhead life history studies in the river discovered, through tag and recapture and scale sampling, that Deschutes summer steelhead almost exclusively spawned only once, since none of the steelhead observed during research in the late 1960s and 1970s had made a second spawning migration.

Historically steelhead could spawn and then rapidly migrate downstream to saltwater, where the ocean environment helped to heal wounds and abrasions and treat fungus and parasites encountered during their time in freshwater. The sooner fish could find their way back to saltwater the greater were their chances of survival. This return journey to the ocean was typically expedited by high spring flow in the Deschutes and Columbia Rivers. The damming of the Columbia River has appreciably slowed river velocity, prematurely warmed the river water temperature and placed formidable obstacles to adult downstream passage. It is assumed most steelhead kelts now die before they can find their way to the ocean. The repeat spawning life history characteristic for Deschutes summer steelhead, and likely all summer steelhead originating upstream from The Dalles Dam, has been lost. The importance of the historical life history characteristic is unknown, but there could have been appreciable negative genetic implications to the steelhead population.

Sockeye Salmon

Sockeye SARs were estimated from three existing stocks (Fryer 2004). Estimated SARs for potentially re-introduced Deschutes Subbasin Sockeye averaged 3%, with a range of 0.9% to 9.9% (TOAST 2004).

5.1.4. Effects of Harvest

Because of their small size, there is little ocean harvest of Deschutes spring chinook. Coded wire tag recoveries from wild spring chinook tagged as juveniles in the Deschutes River from 1977-79 brood years, the only lower Deschutes River subbasin wild spring chinook to be coded wire tagged, showed that 33% of total harvest for those brood years was in the ocean, 24% in the Columbia River, and 43% in the lower Deschutes River (ODFW 1997). Since this time, however, ocean and mainstem Columbia harvest rates have dropped significantly.

5.2. Effects on Terrestrial Species

5.2.1. Effects of Out-of-Subbasin Harvest

Local populations of mule deer move between winter and summer ranges, which are not always located within the Deschutes Subbasin. Deer ranging outside the subbasin are subject to harvest in these watersheds during deer hunting season.

5.2.2 Effects of Disease Transmission

The potential for wildlife disease is an ongoing threat to subbasin wildlife populations. Confirmed mule deer deaths have been associated with viral hemorrhagic diseases. An outbreak of Adenovirus Hemorrhagic Disease was diagnosed in the Crooked River drainage in recent years. Blue Tongue, another viral hemorrhagic disease has been detected periodically at other locations within the subbasin. Both diseases can be carried into the subbasin by infected animals (Kohl 2004).

Chronic Wasting Disease is a form of transmissible spongiform encephalopathy affecting elk and deer in North America. This degenerative neurological illness has affected both farmed and wild cervids in the US. Disease outbreaks have generally appeared in or around captive game farming or ranching operations. The incidence of CWD in wild animals is of great concern. The disease was originally described in captive animals 35 years ago in Colorado. However, over the last five years, Chronic Wasting Disease has been found in wild herds in several surrounding states and Canada. In early 2002, Chronic Wasting Disease was detected in wild deer in South Dakota, Wisconsin and New Mexico. Researchers speculate that Chronic Wasting Disease could be transported long distances because of interstate shipment of infected animals (National Biological Information Infrastructure, 2004). There have been no confirmed cases of Chronic Wasting Disease in Oregon or the Deschutes Subbasin. However, the mobility of large wild ungulates, interstate commerce in captive big game animals and the presence of local game ranches could pose risks to subbasin wildlife.

Western Oregon has experienced deer losses in recent years from Hair Loss Syndrome. This malady is apparently caused by unusual lice concentrations plaguing animals to the point that they scratch or rub way most of their fir. This can result in hypothermia, especially during cold, wet winter weather. Losses from Hair Loss Syndrome have occurred west of the Cascade Mountains, but have not been observed in the Deschutes subbasin (Kohl 2004).

Environment/Population Relationships
Section 6

"Diversity is how the salmon cope with environmental variation"
(Independent Scientific Group 1996)

Fish populations develop unique life history strategies that reflect genetic adaptations to the ecological conditions, and changes, in their environments. Adult focal fish species return to spawn in areas of their origin because the environmental conditions in natal streams are most suited to their survival. This diversity in life history strategies allows a population to survive various environmental conditions and protects it against extinction.

Wildlife also develop life history strategies based on conditions in their environments. Mule deer, for example, often summer in higher elevation areas and move to lower areas, their winter range, as temperatures drop and snow begins to accumulate.

This section identifies the environmental attributes, or key environmental correlates, that are particularly important for survival of the focal species during various life stages. It defines the characteristics that constitute optimal conditions for species health and the ability of the environment to provide these characteristics. It also assesses the long-term viability of focal species and populations based on habitat availability and condition. In addition, it identifies key ecological functions that the species play in the Deschutes Subbasin, and key relationships between the species.

6.1. Key Environment — Aquatic Population Relationships

Certain environmental attributes — or key environmental correlates — are critical for the continual health and survival of fish during various life stages. These attributes define the environmental capacity of a stream reach, which limits the size of a fish population given finite space and food resources. They include physical stream features, condition of riparian areas and floodplains, stream flow, fine sediment and water quality. All of these attributes are connected, and influenced by upland conditions and ecosystem interactions. Identifying how key environmental attributes influence fish populations during different life stages allows us to project a stream's current and potential fish producing capability. It also allows us to identify and focus our efforts to improve fish productivity and performance within different drainages.

6.1.1. Key Environmental Correlates for Aquatic Species Survival

Several key environmental correlates (KECs), or critical environmental factors, are believed to most influence a species distribution, abundance, fitness and viability. The following factors are believed to be the KECs influencing fish survival and productivity in the Deschutes Subbasin.

Channel Stability

Channel substrate is often extremely important for salmonid and lamprey survival and productivity. Aquatic organisms use different areas in the substrate as sites to deposit or incubate eggs, over-winter, for refuge from floods, or for extended rearing (i.e. lamprey ammocoetes). As a result, disruption of the channel substrate can have a profound effect on survival and production of a variety of species. Scouring of bed materials during high flows can affect the survival of incubating salmonid eggs and over-wintering juveniles, and the production of juvenile lamprey and aquatic insects (Mobrand Biometrics 2003). Lateral stream channel scour can result in reduced water depth, extreme fluctuations in water temperature, and intermittent stream flow as water passes through, rather than over expansive areas of porous gravel. This condition can isolate fish and block adult and juvenile migration.

Fine Sediment

High-suspended sediment concentrations occur naturally in some streams, such as White River in the lower Deschutes Subbasin, where glacial melt is a major source of flow. Some watersheds, including Upper Crooked River, may have highly erodible clay soils that produce minute particles that tend to remain in suspension. In other streams, high suspended sediment concentrations may occur during and following thunderstorms and other high flow events due to streambank erosion or overland runoff, or as a result of land use actions, such as construction, mining, logging, and farming. Turbidity, a measure of water cloudiness, is often used to measure suspended sediment levels.

Chronically turbid waters, particularly during the spring, can substantially reduce fish productivity by reducing feeding success, growth, and competitive ability. Turbidity may also cause physical discomfort or injury to fish, depending upon the concentration and the duration of exposure. Adult fish may experience gill tissue damage from excessive turbidity that lasts between 5 and 10 days (ODFW 1996). High levels of turbidity can also act to concentrate fish in stream segments with reduced water velocity, which can make them more vulnerable to predation.

Fine sediment particles within the substrate of pool-tailouts, glides, and riffles can affect the survival of incubating salmonid eggs and alevins, and lamprey eggs, by altering oxygen exchange across the organisms and by entombment (Mobrand Biometrics 2003). Fish require clean gravel to spawn, and typically lay their eggs in graveled riffle areas where oxygenated water can flow through the gravel and allow the eggs and fry to breath. Fine sediment can plug these gravel nests, forming a cap over the redds and consequently suffocate the eggs and prevent juvenile salmonids and lamprey from emerging. High levels of suspended sediment can also reduce macroinvertebrate species diversity and abundance, which directly affects fish production.

Riparian Function

The riparian corridor provides a variety of ecological functions, which can generally be grouped into energy, nutrients and habitat as they affect salmonid performance (Mobrand Biometrics 2003). Riparian stream corridors are the natural buffer between streams and uplands and they act as filters to prevent sediment, pollutants and other items from reaching the streams. Riparian plants in this subbasin provide important overhead shade and cover, which helps to moderate stream water temperature extremes. The roots of riparian vegetation help to bind and stabilize stream banks to resist channel erosion. By slowing high stream flow, riparian corridors play an integral function in the recharge of groundwater and ultimately the moderation of late summer stream flow. Riparian corridors are generally very productive and naturally support the greatest biological diversity of any habitat type. Being the single most important wildlife habitat, these corridors also provide migration corridors and cover for a wide variety of wildlife species. The ability of the riparian corridor to provide these functions is dependent on the health of its vegetation — trees, brush, grass, and sedges.

Instream Habitat Diversity

Healthy stream systems contain a variety of physical features that provide for different needs during the fish life cycle. Instream habitat in the form of undercut banks, large woody debris, large boulders, and water turbulence and depth create complex instream cover for fish and other aquatic life. Overhanging vegetation can also provide important cover. Such habitat can be critically important in providing fish shelter and aquatic food production, and in promoting rejuvenation of natural river channels.

Large woody debris once provided much of the habitat complexity in Deschutes Subbasin streams, as well as throughout the Columbia River Basin. Along with riparian vegetation, large woody debris acts to provide diverse and stable channel habitat conditions. The structure produces habitat complexity and the water depth, duration, and temperature necessary for fish production. Such areas also contribute to aquatic food webs. Cover elements can be particularly important in providing physical shelter from high flow events or refuge during low flows.

Streamflow

Fish abundance is often directly related to the volume of water available in streams and rivers. Salmonids and lamprey require clean, cool water flowing at a natural rate for all stages of freshwater life. Fish populations native to different stream systems show unique life history strategies that reflect the natural flow regimes, low flows and typical high flow events that occur within their environments during various seasons. These natural changes in flows often trigger the timing of adult and juvenile salmonid migrations and spawning.

Alterations in natural flow patterns — whether within a day, year or between years — can impact fish production and survival during different life stages. Significant changes in flow over a short period, such as changes associated with flow regulation, water withdrawal or storm runoff, can result in displacement and stranding and loss of juvenile and adult fish. Low stream flow can restrict fish movement in the stream system or alter water quality by causing high temperatures, decreasing the amount of available dissolved oxygen, or increasing the concentration of pollutants. Seasonal flow reductions may also increase predation as fish are more concentrated and exposed to predators. Rapid flow changes can also affect other environmental attributes, including availability of instream structure, amount of streambank erosion, and quality of riparian habitat.

Summer Water Temperature

Since salmonid behavior is heavily influenced by water temperature, the thermal environment — perhaps more than any other aquatic habitat feature — influences the distribution, health and survival of our native salmonids (McCullough et al. 2001). Being cold-blooded, salmonids respond to an uncomfortable water temperature by moving from one spot to another to maintain their thermal comfort.

Salmonids have definite ranges of tolerance and optimal temperatures at different life stages. Shifts in maximum and minimum stream temperatures can have profound effects on species composition of both vertebrates and invertebrates (Mobrand Biometrics 2003). Bull trout are especially adapted to cold water and have more stringent temperature requirements than most other salmonids. Conversely, various non-game fish species thrive with higher water temperatures.

Channel Width

The shape of a stream channel at any location is a function of flow, the quality and character of the sediment moving through the section, and the character or composition of the materials making up the bed and banks of the channel (Leopold 1963). Channel width and depth are often directly linked to the condition of a stream's watershed and riparian vegetative corridor. How much a channel changes in response to natural or human influences is largely determined by the health and functionality of the associated floodplain and these other characteristics.

Stream channel width has direct implications for stream flow, temperature and water quality. Degraded channels frequently have a high width to depth ratio, which generally means more flow is required to meet various fish life history requirements than in a pristine channel. Streams channels suffering from lateral scour commonly experience seasonal flow and temperature extremes and low dissolved oxygen during periods of unusually high temperature.

Pathogens

Like all animals, fish have their full complement of diseases and parasites. There is no question that most fish die from such disorders, natural enemies other than man, or old age – certainly not from being caught by fishermen (Lagler 1966). The subbasin has a variety of fish diseases and parasites that likely have co-existed with the native fish populations and generally do not pose any particularly unusual risk of a pandemic fish kill. Indigenous fish populations have likely evolved some natural resistance to these diseases and parasites. However, it is apparent that anadromous fish can carry and introduce exotic fish diseases and parasites into the subbasin downstream from the Pelton Round Butte Complex. The incidence of large numbers of out-of-basin stray salmon and steelhead exacerbate this potential problem.

Two diseases of particular concern to subbasin focal fish species are Infectious Hematopoietic Necrosis (IHN) Type 2 and Whirling Disease, caused by a virus and a myxosporean parasite, respectively. IHN has been found in anadromous salmonids and anadromous salmonid strays carrying Whirling Disease spores have been found in the lower subbasin. The upstream distribution of the disease or carrier fish has been blocked by the Pelton Round Butte Complex. During the relicensing process, Portland General Electric contracted with the ODFW Fish Pathology Section and Oregon State University Department of Microbiology to evaluate the presence of pathogens downstream of the hydroelectric project and assess the risk that some or all of these diseases could have if they were to become established in the upper subbasin if fish passage is restored at the project.

Five fish hatcheries are located within the Deschutes Subbasin. The concentration of large numbers of various fish species within confined rearing spaces at a fish hatchery can lead to epizootics from any number of fish diseases or parasites. Hatchery managers, however, are constantly observant about any unusual loss of fish and utilize regular pathological examinations and prophylactic treatments to prevent or avoid disease outbreaks. There is also the potential for higher than normal concentrations of infective agents to enter subbasin streams in the effluent from the fish hatcheries. Nevertheless, there has been no recorded incident where an observable loss of native resident or anadromous focal fish species has been attributable to this source of infection.

Food

Subbasin focal fish species utilize a variety of food items ranging from microscopic plankton to macroinvertebrates to other fish. For example, Pacific lamprey and anadromous salmonid adults do not feed in freshwater. Lamprey ammocoetes are filter feeders that feed on plankton and tiny macroinvertebrates. Juvenile redband and bull trout begin feeding on plankton and small macroinvertebrates, but bull trout sub-adults and adults include small fish in their diet. Redband trout adults appear to feed primarily on aquatic and terrestrial insects, but will also include small mollusks (snail) and crustaceans (crayfish) in their diet. Sockeye salmon juveniles are strictly plankton feeders in natural lakes or reservoirs.

Streams with good year-long flow and high water quality generally support a more diverse assemblage of aquatic insect species with more abundant populations than streams that are flow and water quality limited. Food production can directly affect fish growth and productivity.

Predation

A wide variety of predatory species, including aquatic and terrestrial species, may prey on focal fish during some life stages within and outside the subbasin. Human influence and habitat modification within the subbasin over the last 150 years has influenced the traditional and historic predator-prey relationships. Freshwater life stages of most focal fish species are generally considered prey species. The notable exception is bull trout that generally evolve into efficient fish predators as sub-adults and adults.

The degradation of streams, including the loss of instream structure and complexity and the loss of riparian and emergent aquatic vegetation, coupled with appreciable reductions in seasonal stream flow and water quality, has generally favored predators over the subbasin focal fish species. Fish have been more susceptible to a variety of predators when concentrated in degraded habitat by low or intermittent flow.

Competition with Hatchery Fish

Subbasin fish managers have worked in recent years to minimize the potential competition between hatchery-reared fish and indigenous focal fish species. Initial releases of rainbow trout into subbasin waters began nearly 100 years ago. Hatchery rainbow trout were released into many streams and lakes and reservoirs until the last 20 years. Today hatchery trout releases are generally confined to subbasin lakes and reservoirs.

Past releases of exotic salmonids into subbasin waters has produced appreciable competition with redband and bull trout. Brown trout in the Middle Deschutes, Upper Deschutes and Cascade Highlands assessment units have effectively competed with redband trout as habitat conditions deteriorated. Redband populations are depressed in most streams within these assessment units. Brook trout have effectively competed with redband and bull trout in a number of headwater streams. In several instances (such as in Mill Creek, a Warm Springs River tributary) brook trout have displaced bull trout populations or are hybridizing with bull trout.

Fish managers have conscientiously worked to maintain the characteristics of the hatchery produced spring Chinook as close to the wild population as possible. As discussed in the Focal Species Section, most hatchery produced spring Chinook are released as smolt-sized fish that readily emigrate and have little opportunity to interact with wild fish. Steelhead reared at Round Butte Hatchery are also released as smolt-size fish that rapidly migrate from the river. Fall Chinook in the subbasin are supported strictly by natural reproduction

The large numbers of stray, out-of-basin, hatchery origin anadromous fish entering the lower Deschutes River and remaining to spawn with the Deschutes populations pose the largest risk to indigenous subbasin populations. The genetic implication of this invasion was a primary factor leading to the listing of Deschutes summer steelhead as an ESA threatened species.

Competition with Other Species

The deterioration of stream habitat, including reduced flow and elevated water temperature, has favored the more warm water tolerant subbasin fish species, including suckers and northern pike minnow. Redband trout generally declined or were extirpated in some stream reaches as flows diminished and temperatures and competitor numbers increased.

Unauthorized releases of cyprinids, including Three-Spine Stickleback and Tui chub have resulted in appreciable competition for indigenous salmonids in a number of subbasin lakes and reservoirs. The unauthorized releases of a number of centrarchids, including large and smallmouth bass, bluegill and green sunfish have established naturally reproducing populations in lakes, reservoirs and some stream reaches resulting in increased competition and predation with focal fish species.

Obstructions to Passage

Partial or total passage barriers due to waterfalls, cascades, debris jams or manmade structures (such as dams or culverts) can restrict fish movement. Some obstructions are only passable at a certain range of flows, which may only be available for a short time each year. Still in other streams, such as in the Crooked River system, low flows and high water temperatures may obstruct passage. Such obstructions may block fish from historically important spawning and rearing areas. The loss of connectivity can also cause fish to become isolated and fragmented, thus reducing the population’s productivity, genetic diversity and overall chances of survival.

6.1.2. Optimum Conditions for Aquatic Species Health

Migration

Adult salmonids generally return to natal spawning areas for reproduction. These returning spawners need adequate flows and water quality during their upstream migration. Migration for some anadromous species is rapid. For example, spring Chinook salmon generally begin entering the Lower Deschutes River in early April and immediately move upstream to the Warm Springs River or Shitike Creek where they hold through the summer before spawning. Summer steelhead enter the Deschutes River from early July through October and then hold in the river through the winter prior to spawning.

Some waterfalls or other physical barriers may only be passable at a specific range of flows that typically occurs during a short period of the year, and then only by fish that have particular physical capabilities for jumping or "scooting" over the barrier. The entire sequence of migration behavior must be properly timed to meet such windows of opportunity (Independent Scientific Group 2000).

Once they near spawning areas, large adult migrant fish can be highly visible and vulnerable to terrestrial (including human) and avian predators. The availability of deep resting pools, riparian canopy, undercut banks, and large woody debris in the proximity of spawning habitats can be critical for survival and successful reproduction of migratory salmonids, particularly those that venture far upstream and that are required to spend long periods holding in small river and stream environments. Cover and channel structural elements can provide particularly critical shelter during high flows, or refuge from low flows.

Spawning and Incubation

The season of spawning, egg incubation, and juvenile emergence varies by species and sometimes by population. The focal fish species generally have their own particular preferences for preferred spawning habitat, which includes water depth, velocity and substrate particle size. There is typically spatial and/or temporal separation between species during spawning. The relative success of spawning can vary, depending on climate and hydrologic regime, channel stability and sedimentation, water temperature patterns, the influence and availability of groundwater seeps or springs, and controls exerted by seasonal flow conditions and physical barriers that can restrict the ability of adult fish to gain access to spawning sites.

Adult fish search out and select high-quality habitat patches for spawning. These areas contain suitably sized gravel and cobble, with high rates of interstitial flow to modulate temperatures, oxygenate the eggs and carry away metabolic wastes. Lamprey and many smaller salmonids, such as spring chinook, bull trout, and some steelhead and redband trout spawn in smaller, headwater streams and in spring snowmelt-fed streams. These areas are generally protected from excessive peak flows and they provide a good environment for their eggs and offspring. Fall Chinook salmon spawn exclusively in the lower Deschutes River. They are able to utilize marginal quality substrate because of their ability to till the gravel, which flushes many fine sediments prior to egg deposition.

Water temperature can help to trigger the onset of spawning and it directly affects the time required for egg incubation. Warmer winter stream temperatures, associated with reservoir releases, could accelerate Chinook salmon hatching and emergence. Early emergence could increase mortality if alevins and fry are exposed to hostile conditions with reduced food availability.

Juvenile Growth and Feeding

Once young salmonids emerge from the gravel they generally seek nearby areas that provide food, good rearing habitat, and protection from predators. Since their mobility is still limited, suitable habitat and food must be near the spawning areas for successful first-year survival. Key habitat areas for juvenile growth and feeding include quiet-water side margins, off channel sloughs, backwaters, and spring-fed “seep” areas. The presence of large woody debris, bank structures and riparian vegetation or aquatic

plants in these areas provides a steady supply of small food particles, and refuge from large predators.
Very young fry typically feed on plankton and small invertebrates and, in high quality alluvial habitats, they grow rather rapidly. As water temperature increases beyond about 59°F (15°C), metabolic costs escalate rapidly and available food resources support progressively lower densities of juvenile salmonids (Li et al. 1995b).

As they grow, juvenile salmonids move away from quiet shallow areas to deeper, faster waters. Some species, such as steelhead, retain a diversity of rearing strategies that allow them to persist in headwater stream reaches, even when opportunities for downstream migration are poor. Other species, such as fall chinook, begin moving progressively downstream after emergence, stopping to feed and grow in lower velocity habitats created by eddies in constrained reaches and, in particular, the complex habitats of floodplains.

Lamprey eggs hatch within 2-3 weeks, depending upon water temperature. The juveniles emerge from the spawning gravel at approximately 1 cm in length. The ammocoetes burrow into the soft substrate downstream from the nest and may spend up to six or seven years in the substrate. They are filter feeders that feed on algae and diatoms. The ammocoetes will move gradually downstream, moving primarily at night, seeking coarser sand/silt substrates and deeper water as they grow. They appear to concentrate in the lower parts of Subbasins before undergoing their metamorphism (Kostow 2002).

6.1.3. Watershed’s ability to provide important environmental characteristics

Generally, fish habitat in much of the Deschutes Subbasin has deteriorated from historical conditions due to watershed alterations. These alterations have reduced the watershed’s ability to capture and slowly release precipitation, resulting in altered hydrologic regimes in the mainstem and tributary drainages, with low or intermittent late spring, summer and fall flows; loss of riparian habitat and floodplain function; elevated stream temperatures; stream channel simplification; loss of instream cover and connectivity between habitat areas; sedimentation and increased predation. Efforts are currently underway to improve conditions within individual watersheds; however, these programs could be greatly expanded.

Habitat Evaluations Using EDT and QHA

Two methods were used to assess fish habitat — population relationships in the Deschutes Subbasin during the planning process. The Quantitative Habitat Assessment Method was used to evaluate conditions for resident species. The Ecosystem Diagnosis and Treatment model was used for anadromous species.

The QHA is essentially a spreadsheet that correlates stream segments (or small watersheds) with important population and habitat factors. The model provided a systematic means for recording data and making qualitative decisions concerning the relationship between environmental attributes and species survival. Information gained from the QHA assessment generally reflects past physical stream habitat surveys or professional judgment in the subbasin.

The EDT Model (Mobrand Biometrics, Inc.) was used to assess the fish habitat in the mid and lower subbasin within the current range of anadromous focal fish species and in historical habitat where plans are progressing for re-introduction of anadromous species. The EDT Model allowed planners to define different steelhead and Chinook salmon populations and then produce reports that combined population and habitat data (current, historic and future with restoration). Three scenarios involving low, moderate and extensive habitat restoration were modeled to determine potential affects on future salmon and steelhead production in subbasin plan assessment units.

The EDT habitat assessment summaries identified stream habitat deficiencies by fish life stage for each stream reach with current or potential anadromous fish production. Identified habitat deficiencies provided the primary guidance used to develop habitat restoration scenarios that included potential management strategies or actions that would individually and holistically help to restore degraded fish habitat. EDT scenario attributes included aggradations of similar or linked attributes rated in the habitat assessment process and summarized in EDT Diagnostic reports. For example “habitat diversity” addresses instream habitat complexity (i.e. pools, riffles, glides, structure and cover), “channel stability” includes consideration of channel scour, riparian function and flow variation and “predation” relates to predator abundance and stream cover and structure.

During the process, planners selected a twenty-five-year planning horizon for the EDT Model restoration scenarios, since appreciable habitat recovery in this subbasin and eco-province would require several decades. This extended recovery period is particularly important for potential restoration of riparian and floodplain function, as well as channel aggradations.

The preferred or moderate intensity habitat restoration scenario was deemed to have the best opportunity to meet the biological and habitat objectives of the subbasin plan in the twenty-five-year planning horizon. This preferred alternative was based on the percent of improvement for a number of habitat attributes. The actual habitat improvement percentage was based on the potential difference between the template and current, or patient, habitat condition. Habitat attribute improvement was not strictly a percentage based on the current habitat condition. For example, if a stream channel width had increased from 20 to 40 feet from the template to current condition, a 50 percent reduction in channel width would result in a channel 30 feet wide (i.e. 50% x 40’ – 20’ = 10 foot reduction in width and 40 foot channel minus 10 feet = a 30 foot channel width) when the objective was achieved. The same restoration scenario could be applied to all subbasin stream reaches, whether the current habitat was in poor, fair or good condition. The better the current stream condition the less habitat improvement would be required or projected.

The three potential habitat restoration scenarios were considered to meet the plan objectives and they are described in Table 6.1. The following habitat attributes and anticipated rate of change were generally considered for each scenario, if the restoration measures were implemented.

Table 6.1. EDT Habitat Restoration Scenarios

	Scenario		
Habitat Attribute	**Low Intensity Restoration (% change)**	**Moderate Intensity Restoration (% change) PREFERRED**	**High Intensity Restoration (% change)**
Riparian Function	+25%	+50%	+75%
Channel Width	-25%	+50%	-75%
Minimum Stream Flow	+15%	+25%	+40%
Maximum Stream Temperature	-15%	-25%	-40%
Large Wood/Structure	+15%	+25%	+50%
Fine Sediment – Intragravel	-15%	-25%	-50%
Fine Sediment – embeddedness	-15%	-25%	-50%
Primary Pool Habitat	+10%	+20%	+30%
Fish passage at barriers	+100%	+100%	+100%

Watershed Ability to Provide Key Environmental Correlates

The environmental attributes, or correlates, that are currently limiting fish production reflect the geology, hydrology and climates of individual watersheds. In the Deschutes Subbasin — which contains a diverse array of environmental conditions shaped by geology, hydrology and climates — stream systems can generally be segregated into three distinct categories. These categories including:

- Ground water/spring fed streams, including the Metolius, Fall and Spring rivers and the upper Deschutes River system above Crane Prairie Reservoir. Streams generally display stable flows, riparian and instream habitat conditions, and water temperatures.
- Cascade Mountain, snowmelt driven streams, including the Warm Springs and White rivers, and Shitike and Squaw creeks. Snowmelt dominated runoff causes flows to peak in spring, taper off through summer, and drop to base flows in late summer or early fall.
- Streams draining the more arid portions of the subbasin, including Crooked River and Trout, Willow, Bakeoven, and Buck Hollow creeks. Stream flows peak in winter or early spring with runoff, and rapidly drop to low levels in summer. Streams are also subject to flash flooding during high intensity summer storms.

Results from the EDT and QHA habitat analyses show some commonality of habitat limiting factors across all three stream categories, but there were also generally marked differences in importance between the stream categories. The apparent limiting factor variations between the three stream categories are summarized in Table 6.2.

Table 6.2. Significance of Environmental Correlates as Limiting Factors to Focal Fish Species Production by Stream Category

Habitat Attribute	Groundwater / Spring-fed Systems	Cascade Snowmelt Systems	Semi-Arid Systems
Riparian function	Low to Moderate	Moderate to High	High
Channel width	Low	Low to High	High
Channel stability	Low	Moderate	High
Flow	Low	Moderate to High	High to Extreme
Temperature	Low	Low to High	High to Extreme
Obstructions	Low	Low to Moderate	High
Habitat diversity	Moderate to High	High	High
Pathogens	None	Low	Moderate to High
Predation	Moderate	Low to Moderate	Moderate to High
Fine sediment	Moderate to High	Low to High	Moderate to High
Food	Low to Moderate	Low	Low to Moderate
Competition (with hatchery fish)	Moderate	Low to Moderate	Low to Moderate

Examination of physical conditions and the past studies indicates that because of the physical nature of some watersheds, which may contain highly erodible soils and currently experience extreme stream flow fluctuations and erosion, restoration of riparian and instream habitat will not occur unless actions are also taken to improve overall watershed health. This is particularly true for habitats in semi-arid systems.

6.1.4. Long-Term Viability Based on Habitat Availability and Function

Analysis of environment/population relationships using the QHA and EDT models projected focal species performance and identified habitat limitations that need to be addressed.

Steelhead population data generated from the EDT Report 3 are summarized in Table 6.3. The data for the westside and eastside populations include the results of a moderate habitat restoration scenario, which used a 50 percent increase in riparian function, 50 percent reduction in channel width, 25 percent increase in instream structure, 30 percent reduction in fine sediments and a 20 percent increase in primary pool habitat over 25 years when comparing template to current conditions. The data generated from the scenario for the Mid-Deschutes also included results from fish passage restoration at Pelton Round Butte and artificial barriers on Squaw Creek and Lower Crooked River.

Spring Chinook population data generated from the EDT Report 3 are summarized in Table 6.4. The data for the Warm Springs River and Shitike Creek populations include the results of a moderate habitat restoration scenario, which used a 50 percent increase in riparian function, 50 percent reduction in channel width, 25 percent increase in instream structure, 25 percent reduction in fine sediments, 25 percent Increase in minimum flow, 25 percent reduction in maximum stream temperature and a 25 percent increase in salmon carcasses over 25 years when comparing template to current conditions.

The data generated from the scenario for Squaw Creek and the Metolius River included the results of a moderate habitat restoration scenario, which used a 50 percent increase in riparian function, 50 percent reduction in channel width, 25 percent increase in instream structure, 25 percent reduction in fine sediments, 25 percent Increase in minimum flow, 25 percent reduction in maximum stream temperature, 20 percent increase in primary pool habitat, restoration of fish passage at artificial barriers and a 25 percent increase in salmon carcasses over 25 years when comparing template to current conditions.

The data generated from the scenario for the Middle Deschutes River included the results of a moderate habitat restoration scenario, which included a 50 percent increase in minimum stream flow, 40 percent increase in instream structure, 100 percent increase in fish passage and a 50 percent increase in riparian function.

The data generated from the scenario for Crooked River included a habitat restoration scenario that included a 100 percent increase in minimum river flow and a 50 percent increase in tributary minimum stream flow, 50 percent increase in riparian function, 30 percent reduction in fine sediment, 25 percent increase in instream structure, 30 percent reduction in maximum stream temperature, 40 percent reduction in channel width and fish passage restoration at Pelton Round Butte and artificial barriers on Lower Crooked River and Ochoco Creek..

Table 6.3. Deschutes River TRT Steelhead Population Performance projected by EDT analysis (Newton 2004).

Deschutes River Steelhead Population Projections

Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Deschutes River Westside Tributaries Steelhead Population					
TRT Steelhead DR West (4-25)	Current without harvest	89%	6.4	2,806	2,369
	Deschutes R West TRT Moderate Habitat Restoration	99%	9.0	3,117	2,770
	Historic potential	100%	28.9	7,198	6,949
Deschutes River Eastside Tributaries Steelhead Population					
TRT Steelhead DR East (4-25)	Current without harvest	26%	1.6	3,870	1,447
	Deschutes River East TRT Moderate Habitat Restoration	57%	2.9	5,206	3,415
	Historic potential	98%	19.8	15,454	14,672
Middle Deschutes River Tributaries Steelhead Population					
TRT Steelhead Middle Deschutes (4-26)	Current without harvest	21%	5.7	1,646	1,359
	Mid-Deschutes River TRT Moderate Habitat Restoration	74%	8.2	5,476	4,807
	Historic potential	99%	28.3	15,304	14,763

Table 6.4. Deschutes River Spring Chinook Salmon Population Performance projected by EDT analysis (Newton 2004).

Deschutes R. Spring Chinook Population Projections

Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Warm Springs River Spring Chinook Salmon Population					
Warm Springs R. Spring Chinook (3-26)	Current without harvest	95%	5.4	2,458	2,001
	Warm Springs River Mod. Habitat Restoration	97%	6.6	2,843	2,409
	Historic potential	100%	12.0	4,576	4,195
Shitike Creek Spring Chinook Salmon Population					
Shitike Creek Spring Chinook (4-28)	Current without harvest	97%	5.0	860	690
	Shitike Creek Mod. Habitat Restoration	100%	6.3	989	831
	Historic potential	100%	12.4	1,666	1,531
Squaw Creek Spring Chinook Salmon Population					
Squaw Creek Spring Chinook (4-13)	Current without harvest	7%	4.0	277	208
	Squaw Creek Mod. Habitat Restoration	50%	3.4	403	285
	Historic potential	100%	12.5	1,792	1,649
Metolius River Spring Chinook Salmon Population					
Metolius River Spring Chinook (4-13)	Current without harvest	75%	5.4	1,676	1,364
	Metolius River Mod. Habitat Restoration	75%	5.5	1,706	1,399
	Historic potential	100%	10.2	1,394	1,256
Middle Deschutes River Spring Chinook Salmon Population					
Mid Deschutes Spring Chinook (4-18)	Current without harvest	0%	-	-	-
	Mid Deschutes Mod. Habitat Restoration	100%	4.6	217	170
	Historic potential	100%	9.7	317	285
Lower Crooked River Spring Chinook Salmon Population					
Crooked R Spring Chinook Salmon (3-26)	Current without harvest	0%	-	-	-
	Lower Crooked River Passage, Minimum Flow and Habitat restoration	93%	5.5	1,052	861
	Historic potential	100%	12.2	1,999	1,835

Fall Chinook population data generated from the EDT Report 3 are summarized in Table 6.5. The data for the Lower Deschutes River population include the results of a moderate habitat restoration scenario, which used 50 percent increase in riparian function, 50 percent reduction in channel width, 25 percent increase in instream structure, 25 percent reduction in fine sediments, 25 percent Increase in minimum flow, 25 percent reduction in maximum stream temperature and a 25 percent increase in salmon carcasses over twenty five years when comparing template to current conditions.

Table 6.5. Lower Deschutes River Fall Chinook Salmon Population Performance projected by EDT (Newton 2004).

Lower Deschutes River Fall Chinook Salmon Population					
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**
Deschutes Fall Chinook-3-26A	Current without harvest	53%	6.0	16,277	13,578
	Lower Deschutes River Mod. Habitat Restoration	60%	7.1	18,039	15,493
	Historic potential	92%	7.8	19,255	16,794

Many opportunities are available for improving fish habitat in the Deschutes River subbasin. These opportunities include flow recovery, riparian and floodplain function restoration and protection, restoration of instream structural diversity, installation of fish screens, and supplementation of spawning gravel. The following discussion suggests how environmental attributes may respond to restoration measure implementation.

- ***Riparian Function.*** Improvement potential will vary depending upon the presence or absence of soil, length of the growing season, native plant species present or found nearby, water table height or water availability, etc.

- ***Channel Width.*** Recovery depends upon physical channel type, presence or absence of riparian vegetation, channel and stream bank stability and watershed function.

- ***Minimum Stream Flow.*** Increase may depend upon recovery of upland watershed health, riparian and floodplain function, or water conservation or acquisition projects. State instream water rights, designated for many streams, were often developed to meet minimum fish life stage requirements with degraded stream channels that frequently had a high width to depth ratio. With channel stability and narrowing less flow can often satisfy these same fish habitat requirements.

- ***Maximum Stream Temperature.*** Reduction in peak stream water temperatures will depend on upland watershed improvements, increased minimum stream flow, channel narrowing, shading from riparian vegetation and recovery of the adjacent water table.

- ***Large Wood/Structure.*** Structural recovery may depend on placement of structure in-channel in the near term until riparian recovery progresses to the point where the stream corridor is naturally contributing large wood to the channel. Some streams or stream reaches may not retain wood, but large boulders could provide the habitat diversity.

- ***Fine sediment.*** Input of fine sediment to the stream channel will be influenced by watershed soil types and health, stream channel stability and anthropogenic causes. Restoration will depend upon stream flow variation or natural flushing characteristics combined with reduction in sediment sources.

- ***Primary Pool Habitat*.** Amount of primary pool habitat will depend upon the physical channel type and gradient, as well as instream structure, channel width to depth ratio, sinuosity and stream bank stability.

- ***Fish Passage at Barriers*.** Restoration of fish passage to historic habitat will depend upon the modification or removal of manmade structures built with no provision for upstream or downstream fish passage. Barriers in need of treatment could also include de-watered stream reaches or debris accumulation often associated with upland management practices (i.e. logging debris).

6.2. Key Environment — Terrestrial Population Relationships

6.2.1. Key Environmental Correlates for Terrestrial Species

Key environmental correlates for terrestrial species are also referred to as habitat elements in the IBIS planning system. These Key environmental correlates “refer to wildlife habitats, habitat elements, and other nonhabitat influences on the distribution and abundance of organisms,” and “those components of the environment believed to most influence wildlife species distribution, abundance, fitness, and viability” (Johnson, et. al. 2001).

KECs for the focal terrestrial species, optimal characteristics of the KECs, and environmental potential for the KECs are presented in Appendix III.

6.2.2. Long-term viability of focal species based on habitat availability and condition

Estimated long-term viability for focal species based on projected habitat availability and condition are presented in Table 6.6.

Table 6.6. Estimated Long-term Viability of Terrestrial Focal Species based on Habitat Availability and Condition (Hostick 2004).

Long-term Viability of Focal Species Populations Species	Long-term viability
American beaver	Increasing in areas where riparian habitat is recovering. Decreasing in areas where riparian habitat degradation continues.
Columbia spotted frog	Increasing in areas where riparian habitat is recovering. Decreasing in areas where riparian habitat degradation continues.
White-headed woodpecker	Stable or increasing in areas where restoration projects occur and habitat is recovering. Stable or declining in areas with continued loss of large-diameter ponderosa pine trees and snags due to increasing human population and more intensive forest management.
Mule deer	Decreasing. Continued loss and fragmentation of winter range capability due to human development.
Greater sage grouse	Decreasing. Continued vegetative succession is expected to degrade shrub-steppe habitat in the absence of vegetative management options such as controlled burning.
Golden eagle	Decreasing. Loss of cliff and large tree nest sites will occur to due increasing human population, and other sources of mortality will increase.
Sharp-tailed grouse	(presently extirpated) Continued absence, unless action is taken by wildlife and habitat managers to restore populations.

6.3. Key Ecological Functions

Anadromous and resident fish species and wildlife species provide a number of Key Ecological Functions (KEFs) that support the trophic structure of the ecosystems, including energy flow, food webs and nutrient cycling. The differing live history characteristics of the anadromous fish species distributed fish through streams varying in size from the Deschutes River to small headwater creek. Historically these species served as an important food source for a variety of animals, including man. Nutrients from fish carcasses helped to nourish aquatic invertebrates and vertebrates, which was important to the maintenance of their robust populations. The aquatic insect populations flourished with the readily available nutrients provided by the fish carcasses and they in turn provided a food source for other populations, including resident and juvenile anadromous fish, neo-tropical birds, bats, spiders and other predatory insects. Various terrestrial predators utilized the fish carcasses as food sources that were not always consumed in or adjacent to subbasin streams. Fish carcass remains and predator droppings left near streams provided nutrients that helped produce vigorous and diverse riparian vegetative communities that stabilized stream banks, while providing important habitat to a wide variety of wildlife species. The distribution of fish carcass-related nutrients to upland areas provided benefit to a variety of plant species, which in turn provided benefits to grazers and browsers. The extirpation of the anadromous species from the upper subbasin appreciably reduced this historic nutrient source.

Large anadromous fish routinely till the stream substrate during their spawning activities. This disturbance acts to flush fine sediment from the substrate for the benefit of incubating eggs and aquatic insects utilized the interstitial spaces in the substrate for feeding and refuge. The annual tilling of the substrate prevents or reduces the accumulation of fine sediment and the potential invasion of rooted aquatic plant species. The actual digging of the fish redd also dislodges aquatic insects that may then be preyed upon by opportunistic feeding fish.

Historically beaver populations were found throughout the subbasin. This species was instrumental to the maintenance of functional riparian vegetative communities and associated floodplains. Beaver dams slowed stream flow, recharged ground water and provided fish rearing habitat. The beaver activity acted to maintain perennial stream flow and moderate stream water temperature, while stabilizing stream banks. Beaver also helped to recruit large woody structure to the stream channels. Beaver populations provided important habitat for a diversity of aquatic and terrestrial wildlife populations. Ungulates benefited from sub-irrigated meadows and lush riparian vegetation maintained by high water tables. Predator species found abundant prey associated with these functional riparian and floodplain habitats.

Ecological functions are also performed by other focal wildlife species. The White-headed woodpecker consumes seeds and invertebrates, and disperses seeds and fruits through caching or ingestion. It is a primary excavator of cavities in snags or live trees. The greater sage grouse and Columbian sharp-tailed grouse consume foliage, fruit, and flowers, and terrestrial invertebrates. They disperse seeds or fruits through ingestion and may carry diseases into the system. The Columbia spotted frog is a consumer of vegetation and invertebrates, both terrestrial and aquatic. It is also prey for other “consumers” in the system. Mule deer provide prey for other consumers in the system. They also create runways for other users, feed on trees, shrubs, grasses, and forbs and may alter the vegetation in the environment by their foraging behavior. The golden eagle consumes terrestrial vertebrates and carrion, and salmon carcasses. The golden eagle is associated with aerial structures within the habitat in that it constructs large nests that may be used by other wildlife.

6.3.1. Functional Redundancy

Functional redundancy refers to more than one species performing an ecological function; therefore, if two or more species are shown with the same KEF, functional redundancy is indicated. Functional redundancy would be shown at the most specific end of the KEF hierarchy.

Subbasin focal fish species share a number of similar life history characteristics. All species prefer to spawn in clean gravel substrate in streams with good water quality. Juvenile fish generally feed on macroinvertebrates before beginning their ocean migration. Most of their growth occurs during their time at sea. Returning adults are recycling nutrients from the ocean to the subbasin. The fish provide an important food source for a variety of subbasin wildlife species.

The variety of anadromous fish species historically present in the subbasin provided the functional redundancy for the food web and nutrient cycling. If the numbers of one species were depressed, there was the opportunity that other species could compensate with the same or similar ecological functions. However, when anadromous species were extirpated from the upper portion of their historic range local resident species did not have the capability of fully compensating for the subsequent loss to the food web, and nutrient cycling.

The Columbia and Oregon spotted frogs and the American beaver are heterotrophic consumers, but this would not show a high degree of functional redundancy until carried down the hierarchy to the lowest level where both species are shown to be aquatic herbivores. The ecological function provided by beaver, however, is not duplicated by other species. When aggressive fur trapping in the early to mid-1800's led to a dramatic reduction in subbasin beaver numbers, it also contributed to the degradation of streams, floodplains, and in some instances sub-irrigated valleys. The resulting increased seasonal variation in stream flow adversely affected focal fish species and accelerated stream channel and stream bank erosion. There was no suitable redundant species to provide the same ecological functions and the ecosystem was adversely impacted by the reduction in beaver numbers and distribution.

Other wildlife species also provide similar functions in the ecosystem. For example, both sage grouse and sharp-tailed grouse are bud and catkin feeders. Functional redundancy for focal terrestrial species is identified in Appendix III.

6.3.2. Critical Functional Link Species

Critical functional link species are wildlife that are the only species or are one of only a few species that perform a particular key ecological function in a particular wildlife habitat. Of the focal species, American beaver was found to be a critical functional link species. The KEFs performed by the beaver are listed in Table 6.7.

Table 6.7. KEFs performed by American beaver, a critical functional link species, in habitats in the Deschutes Subbasin.

KEF Description	Wildlife Habitat	Other species that perform KEF
bark/cambium/bole feeder	Open water	Black bear
Creation of aquatic structures	Forest habitats	None
Impounds water by damming or diverting	Forests, wetlands, open water	None
Creation of ponds or wetlands by wallowing	Open water, forest habitats	Rocky Mountain elk

6.4. Interspecies Relationships

6.4.1. Aquatic Interspecies Relationships

All subbasin focal fish species prefer streams with perennial flow and good water quality. All species spawn in gravel substrate, although preferred particle size and location in the stream system may vary with species. All anadromous fish species have a freshwater juvenile life stage that prefers readily available hiding and escape cover. Juvenile anadromous species and redband trout rely heavily on a macroinvertebrate food source. Out-migration of juvenile anadromous fish generally occurs during the spring or early summer, after undergoing a physiological transformation that will allow them to successfully adapt from a freshwater to saltwater environment.

Redband trout and mountain whitefish generally compete for the same food items when they reside in the same stream reaches. Bull trout and brook trout prefer cold headwater streams for spawning and juvenile rearing. Interspecific spawning between bull and brook trout has serious genetic consequences, with hybridization a serious threat to bull trout survival. Bull trout are opportunistic feeders and include most other subbasin fish species as potential food items.

6.4.2. Wildlife Interspecies Relationships

The first indication of inter-specific relationships might be shared KEFs or KECs between two or more species. For example, both sharp-tailed grouse and white-headed woodpeckers share a KEF in that they both disperse seeds through ingestion or caching. Similarly, both golden eagles and white-headed woodpeckers share the KEC of utilizing snags.

Other indications of relationships might be more difficult to recognize. For example, one KEF for the golden eagle is that this species is a vertebrate consumer or predator. What this actually means is that the golden eagle could (and would) prey on all other six focal wildlife species, which would indicate a type of inter-specific relationship. This is also shown by the KEC information that shows all six other focal species as “prey for secondary or tertiary consumer.”

6.4.3. Key Relationships between Fish and Wildlife

The interaction between focal fish species and wildlife is generally a prey - predator type relationship. The fish species are food items for a wide variety of wildlife species, including birds, furbearers, and other predators.

Salmonids generally co-exist with beaver and benefit from the animal’s ability to modify the aquatic environment. The relationship between focal fish species and beaver was historically important in the smaller tributary streams. Beaver activities in these small streams helped to moderate stream flow and water temperature, while providing instream habitat complexity and often large wood structure recruitment, all of which are desirable for the focal fish species.

Limiting Factors and Conditions
Section 7

While many people are now more aware of how different land and water management actions influence stream habitats and overall watershed health, and are changing their management practices, anthropogenic influences since the mid-1850s have weakened the natural biophysical processes that create and maintain healthy habitats. Watershed conditions began to change as trappers aggressively removed beaver from subbasin streams. Ranchers, farmers and other settlers of European background followed the trappers, and their practices further modified the landscape. Human disturbances to aquatic and terrestrial environments in the Deschutes Subbasin are discussed in the Overview, Section 3.1.7.

This section discusses the factors that are leading to decline of Deschutes Subbasin aquatic and terrestrial species, including key limiting factors within the different assessment units of the Deschutes Subbasin and outside the subbasin. It also identifies the key limiting factors that can or cannot be addressed through human intervention.

7.1. Factors Leading to Decline of Aquatic Focal Species

Factors leading to the decline of the aquatic focal species are summarized below.

Low Streamflows

Seasonally low or intermittent stream flows and high water temperatures are probably the most significant factors limiting fish production in much of the Deschutes River subbasin today. The amount of stream flow affects all fish life stages including spawning, incubation, rearing, and migration. Degradation of the aquatic environment in the Deschutes River from Wickiup Dam to Lake Billy Chinook is primarily due to extreme seasonal flow fluctuations caused by irrigation releases and winter water storage in the reservoirs.

From Wickiup Dam to Bend, low winter flows in the Deschutes River impose the most serious limitations on fish production and their habitat. Low flows, particularly above Pringle Falls, concentrate fish into a few, generally coverless, pools where they are vulnerable to predation. High flows aggravate the lack of cover by pushing much of the remaining large woody debris to stream margins where it still provides cover for fish during high flows, but becomes unavailable once flows recede. As a result, many aquatic organisms must semiannually redistribute themselves, and find themselves in winter pools that lack adequate cover (ODFW 1996a). Low winter flows also leave the limited spawning gravel along the stream margins unavailable or barely usable by fall spawning fish (ODFW 1996a). Production is also lost because small fish and aquatic invertebrates become stranded in pools and side channels when flow recedes and they soon perish. Further, the freezing and thawing of exposed stream substrate and streambanks during low winter flows results in accelerated erosion and water turbidity when substantial irrigation flows are released downstream the following spring.

From Bend to Big Falls, summer flow in the Deschutes River is very low because of substantial upstream irrigation water diversions. Summer flows declined to about 30 cfs until recently when conservation efforts increased the minimum to 35 cfs.

Low summer flows also restrict fish populations in many Deschutes River tributaries. Some of these tributaries, such as Trout Creek, also have permitted water withdrawals that cumulatively exceed natural summer stream flow. For the most part, the best stream habitat in the upper Deschutes Subbasin remains in headwater portions of basin streams on Forest Service land. Many stream and river reaches below these headwaters areas have been severely degraded.

High Water Temperatures

The thermal environment also influences the distribution, health and survival of native salmonids. In many Deschutes River tributaries — where summer water temperatures may have been marginal to begin with — seasonal low streamflow associated with consumptive water uses, grazing pressure and other uses have altered the thermal qualities of stream waters. High water temperatures result in stress, disease or direct mortality of coldwater fish species and aquatic invertebrates. They also increase competition from more temperature-tolerant nongame species such as suckers, chiselmouth, and pikeminnow. In addition, high water temperatures can fragment fish populations. They can create a physical barrier that constrains life history possibilities and keeps salmonids from migrating to cooler, more favorable reaches. For example, as a result of water temperature and physical barriers most redband trout populations in the Crooked River system today are fragmented and isolated (Stuart and Thiesfeld 1994). Many of these isolated populations are thought to be depressed, while some populations have apparently been lost in the more severely degraded streams.

Most tributaries utilized by wild summer steelhead for spawning and rearing experience low summer flows and high summer temperatures, both of which are related to stream bank degradation, past stream channel alterations, poor riparian habitat conditions, loss of functional floodplains and poor upland watershed conditions. Small westside tributaries to the lower Deschutes River have similar habitat deficiencies.

Riparian and Floodplain Degradation

Stream bank and floodplain degradation are problems throughout the subbasin both in tributaries and in portions of the mainstem. Accelerated erosion has caused increased sedimentation and turbidity that reduce spawning habitat quality, egg survival, and production of aquatic insects and plankton. Sedimentation affects habitat quality by increasing the amount of fine sediments that cause embeddedness of the stream substrate.

Degradation of stream riparian vegetation frequently is associated with reduced stream cover and shade, which generally increases the likelihood of seasonal stream water temperature extremes. The loss of or lack of instream habitat complexity is also directly related to the health or functionality of the riparian corridor. Streams with compromised riparian corridors may experience either lateral or vertical channel scour, which can isolate the stream from its floodplain. This loss of contact with the floodplain can appreciably reduce groundwater discharge. Water tables adjacent to the stream can drop, which may further exacerbate the problems of extreme flow and water temperature variation.

Loss of Instream Habitat Complexity

The loss of large woody debris has also affected aquatic food production, trout cover, migration, and streambank protection. Large woody material helps to form pools that provide trout rearing habitat, traps and sorts spawning gravel, provides a refuge for fish during high flows, provides cover from predators, stabilizes streambanks, and provides structure for aquatic insect production. Large woody material has been removed from basin streams by historic log drives, exaggerated flow flows, artificial flow manipulation, fires, construction of upstream impoundments and removal by streamside landowners. Past logging operations in or adjacent to the riparian corridor removed trees that could have fallen into the stream channel as natural structural recruitment.

Large woody material is severely lacking in most of the Deschutes River from Wickiup Dam downstream to the river's mouth. Other streams with insufficient quantities of large woody material in the upper subbasin include the Deschutes River above Crane Prairie Reservoir, the Little Deschutes River below Gilchrist, lower Crescent Creek, Fall River, Spring River, Tumalo Creek, and Squaw Creek below the town of Sisters (ODFW 1996).

Natural recruitment of spawning gravel from upstream sources was eliminated by the construction of Wickiup and Crane Prairie dams, Bowman and Ochoco dams, and the Pelton Round Butte dam complex. Original gravels in the upper Deschutes River have been moved downstream by excessively high summer flows or deposited along stream margins that are dewatered during the fall spawning period. The primary sources of alluvial gravels in this upper section of river are the streambanks.

7.2. Key Factors In-Subbasin Limiting Aquatic and Terrestrial Populations

7.2.1. Lower Westside Deschutes Assessment Unit

- High glacial sediment loading degrades substrate habitat and precludes most steelhead and trout spawning in the Deschutes River downstream from White River confluence.
- Water quality, including elevated temperatures and pH seasonally exceeds water quality standards.
- River temperatures and dissolved oxygen levels immediately downstream from the Pelton Round Butte Complex do not meet State water quality standards.
- Two Beaver Creek tributaries, Coyote and Quartz creeks, occasionally contribute significant turbidity to the Warm Springs and Deschutes rivers.
- Degraded or the lack of riparian vegetation reduces bank stability and cover, especially in small tributaries.
- Instream habitat complexity is reduced or lacking in some reaches
- Predation has increased as riparian and instream habitat complexity has been reduced
- Intermittent flow in small tributary streams limits juvenile fish rearing habitat.
- Steelhead and trout access to small tributaries is frequently blocked by subsurface flow through alluvial deposits at the stream mouths.
- Fish migration may delayed by the sub-standard fish ladder at Sherars Falls.

- Road and railroad crossings at some small tributaries obstruct upstream fish passage.
- Large numbers of out-of-basin stray steelhead and fall Chinook salmon spawning with indigenous populations pose serious genetic risks.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.
- Conversion of ungulate winter ranges to other uses has degraded ungulate ranges, resulting in the decline or loss of ungulate populations such as bighorn sheep, mountain goat, black-tailed deer and mule deer.
- Conversion to home sites or other uses threatens cliff and rimrock habitats.
- Loss of native grassland habitat has precluded the restoration of wildlife species associated with this habitat, such as Columbian sharp-tailed grouse.
- Clearing of cottonwood and oak groves has resulted in a reduction of these habitats and associated wildlife.

7.2.2. Lower Eastside Deschutes River Assessment Unit

- Seasonal flow extremes limit juvenile fish rearing habitat.
- Steelhead and trout movement is generally blocked by intermittent flow or sub-surface flow through the stream substrate.
- Degraded, or the lack of, riparian vegetation reduces bank stability and cover.
- Stream channels have been altered and channelized, and stream length and sinuosity have been lost.
- Stream channels generally lack instream cover or complexity.
- Channel degradation has frequently resulted in lateral or vertical scour, which has produced high channel width-to-depth ratios, or channel incision and unstable banks.
- Fish are more vulnerable to predation because of reduced stream flow and the general lack of instream and overhead cover.
- Seasonal irrigation diversion structures/push-up dams obstruct fish passage.
- Water temperatures in Buck Hollow Creek, Willow Creek, and Bakeoven Creek (including Bakeoven Creek (mouth to Deep Creek), Salt Creek, Robin Creek and Deep Creek) exceed State water quality criteria for salmoinids production.
- The entire length of Trout Creek and a number of tributaries (Auger, Big Log, Bull Cartwright, Dick, Dutchman and Potlid creeks) exceed State water quality criteria for temperature and sedimentation.
- There are potentially serious genetic implications associated with large numbers of out-of-basin stray steelhead and fall Chinook salmon spawning with indigenous populations.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.
- Loss of large, contiguous blocks of native grassland habitat led to the loss of wildlife populations associated with this habitat, such as Columbian sharp-tailed grouse, and restricts restoration of these populations.

7.2.3. White River Assessment Unit

- Upstream fish passage is blocked at White River Falls (RM 2.0).
- Reduced summer flows — some lower basin tributaries have seasonally dry or intermittent reaches.

- The cumulative affect of a variety of watershed management actions, including timber harvest, livestock grazing and road construction and maintenance, has altered the natural stream flow regimes resulting in higher peak flows and lower low flows.
- Seasonal and permanent irrigation diversion structures block fish passage on tributary streams.
- White River has heavy, natural glacial sediment loads.
- Stream sedimentation from forest, range and crop land, and an extensive road system affects water quality and stream substrates.
- Large irrigation storage dams block fish passage on several tributaries.
- Water temperatures in lower White River and several tributaries often exceed State water quality standard for salmonid rearing during summer months.
- Tributaries Gate Creek and Rock Creek are also included on the State's 303(d) list for sediment concerns.
- Stream channel alterations, channelization and loss of sinuosity have degraded stream habitat.
- Stream reaches downstream from the national forest generally lack instream channel cover and/or complexity.
- Fish are exposed to increased predation because of reduced flow and instream and overhead cover.
- Most irrigation water withdrawals are unscreened.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.
- Some oak groves are threatened by clearing for other uses, and wildlife species such as Lewis' woodpecker are associated with these groves.
- Substantial losses of ponderosa pine forests have reduced habitat for species such as white-headed woodpecker.

7.2.4. Middle Deschutes Assessment Unit

- Terrestrial habitats such as aspen and cottonwood groves, ungulate winter ranges (mule deer), ponderosa pine forests, and late-seral stage forests with large diameter trees and snags are believed to be declining in the assessment unit.
- Loss of ponderosa pine and lodgepole pine forest since mid-1800s has reduced habitat available for species such as white-headed woodpecker.

Pelton Round Butte Complex

- The lack of fish passage at the Pelton Round Butte Complex has fragmented redband and bull trout populations and extirpated upstream anadromous fish populations.

Metolius River System

- Lack of instream structure, including large wood, limits habitat complexity and fish rearing potential in the upper half of the river.
- Riparian degradation reduces overhead stream cover and increases bank instability.
- Sedimentation from forest practices, catastrophic fire and extensive road system impacts stream substrate quality.
- Fish passage barriers are located on Link and Spring creeks.

- Most irrigation diversions are unscreened.
- Natural glacial silt and sediment may affect habitat quality in Whitewater River (tributary to Metolius River).
- Water temperatures in the lower Metolius River may restrict bull trout production during certain seasons of the year. Lake Creek temperature exceeds State water quality criteria for salmonid spawning and rearing.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.

Middle Deschutes River

- Seasonally low flow in the upper reach results from upstream irrigation withdrawals.
- Natural topography limits riparian vegetation.
- Large boulders rather than large wood generally provide instream structure.
- Upstream reservoirs and flow reductions generally restrict appreciable gravel or large wood recruitment.
- Seasonal fish passage at Steelhead Falls is dependent upon adequate flow.

Squaw Creek System

- Seasonal low flows limit adult migration and spawning and juvenile fish rearing habitat below RM 25.
- Fish movement is generally blocked by intermittent flow or sub-surface flow in the middle stream reach (i.e. Sisters to Camp Polk Road).
- Degraded stream corridors and the lack of riparian vegetation reduces bank stability and cover.
- Stream channel alterations, channelization and loss of sinuosity have resulted in degraded fish habitat.
- The lower stream reaches generally lack instream channel cover, including large wood, or other structural complexity.
- Channel degradation and unstable banks are prevalent from RM 18.8 to 23.5
- Sedimentation, associated with stream bank erosion, impacts stream substrate quality.
- Fish are exposed to increased predation associated with general lack of instream and overhead cover and reduced stream flow.
- Irrigation diversion dams obstruct fish passage.
- Summer water temperatures frequently fail to meet State water quality standards.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.

7.2.5. Lower Crooked River Assessment Unit

- The substantial loss of native grasslands, lodgepole pine forests, juniper forest, ponderosa pine forest, and shrub-steppe have resulted in less habitat for wildlife such as Columbian sharp-tailed grouse, sage grouse, golden eagle, and mule deer.

Lower Crooked River

- Low summer flow from Hwy 97 crossing to RM 53.8.
- Low winter flow from Bowman Dam (RM 68.2) to Hwy 97 crossing.

- Summer water temperatures in the lower Crooked River from the mouth to the Rice-Baldwin Dam (RM 0-51) do not meet State water quality criteria. The reach also does not meet criteria for bacteria (summer) and pH (all year).
- The reach from Rice-Baldwin Dam to Prineville Reservoir (RM 51-70) generally does not meet water quality criteria for total dissolved gases during periods of reservoir spill and/or substantial discharge.
- The river channel has been altered or simplified.
- The river channel isolated from floodplain in some reaches.
- Riparian vegetation has been degraded along most river reaches.
- Several artificial barriers lack provisions for fish passage or protective screening
- Spawning gravel of marginal quality and has limited distribution.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.

McKay Creek System

- Degradation of upland watershed conditions, including loss of native grasslands, has contributed to a flashier stream flow regime.
- Low or intermittent summer flows are common in most reaches.
- Plant diversity and the condition of shrub-steppe habitat have degraded.
- Channel simplification, including bermed and channelized stream reaches has degraded fish habitat.
- There are some seasonal artificial barriers without fish screening or passage provisions.
- Stream reaches generally lack large wood or instream habitat complexity.
- Riparian corridors are generally degraded.
- Summer water temperatures frequently fail to meet State water quality standards.
- Sedimentation from stream channel erosion and upland sources affects the stream substrate.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.

Ochoco Creek

- Low winter flow is associated with upstream water storage in Ochoco Reservoir.
- Summer water temperatures frequently fail to meet State water quality standards.
- Channel simplification, including bermed and channelized stream reaches, has degraded fish habitat.
- There is an artificial barrier without fish screening or passage.
- Large wood or other instream structure is generally lacking.
- The riparian corridor is generally degraded.
- Sedimentation from stream bank erosion affects stream substrate quality.
- Plant diversity and the condition of the shrub-steppe habitat have degraded.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.

7.2.6. Upper Crooked River Assessment Unit

- Substantial loss of native grasslands, and reduction of shrub-steppe and ponderosa pine and lodgepole pine forests caused a major wildlife habitat shift in the assessment unit. These losses reduced habitat for wildlife such as

Columbian sharp-tailed grouse, sage grouse, white-headed woodpecker, mule deer, and golden eagle. Gains in juniper woodlands and mixed conifer forests created similar habitats for some wildlife species.
- Riparian habitats such as willow swamps are significantly below historic levels in the assessment unit. This reduces habitat for species such as Columbia spotted frog and American beaver.
- Terrestrial habitat components such as cottonwood groves and aspen groves are below historic levels, reducing the habitat available for wildlife species such as American beaver.

Upper Crooked River (Bowman Dam to the headwaters)

- Low or intermittent summer flow is typical of most stream reaches.
- High summer water temperatures in many reaches fail to meet State water quality standards. Standards for pH are also exceeded in Crooked River from Prineville Reservoir to N.F.Crooked River.
- Degraded watershed conditions contribute to the flashy stream flow regimes.
- The riparian corridor is degraded along most stream reaches.
- Channel simplification, including bermed and channelized stream reaches has adversely affected focal fish species habitat.
- Channel degradation, including lateral or vertical scour has contributed to the extreme variation in stream flow and temperature.
- Seasonal and permanent artificial barriers are present without fish screening or passage provisions.
- Natural waterfalls on North Fork Crooked River block upstream fish passage.
- Redband trout populations have been extirpated, fragmented or isolated by stream habitat conditions.
- There is a general lack of large wood or other instream structure.
- Sedimentation from bank erosion and upland sources has degraded stream substrate quality.
- Deteriorating habitat conditions have favored warm water tolerant fish species that compete with focal fish species.
- Fish are more vulnerable to predation because of reduced stream flow and cover.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.
- Loss of grasslands and reduction of ponderosa pine and shrub-steppe habitats have affected wildlife such as the greater sage grouse, and white-headed woodpecker.

Upper Ochoco Creek System (Ochoco Dam to headwaters)

- Seasonally low stream flows are common in most stream reaches.
- Lower reaches and lower tributary reaches have low or intermittent summer flow associated with water withdrawals.
- High summer water temperatures from the upper end of Ochoco Reservoir to RM 36.4 fail to meet State water quality standards.
- Channel manipulation and lack of stability has affected fish habitat quality.
- There are a number of seasonal and permanent artificial barriers without fish screening or passage.
- There is a general lack of large wood or other instream structure.

- Most riparian corridors have been degraded.
- Sedimentation from stream bank and upland erosion affects the quality of the stream substrate.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia spotted frog and American beaver.

7.2.7. Upper Deschutes River Assessment Unit

- Loss of lodgepole pine forests, native grasslands and shrub-steppe habitat reduced habitat for wildlife species such as sage grouse, golden eagle, and mule deer in the assessment unit.

Deschutes River System – Big Falls to North Unit Dam

- Low summer stream flow results from significant upstream irrigation withdrawals.
- Summer water temperatures and ph fail to meet State water quality standards.
- Natural waterfalls are fish passage barriers.
- There is a general lack of gravel and large wood recruitment because of upstream impoundments and flow manipulation.
- Tumalo Creek experiences low flow in the lower reach (below RM 2.5) during the irrigation season.
- Tumalo Creek has a fish passage obstruction at an irrigation diversion structure.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Columbia and Oregon spotted frog and American beaver.

Deschutes River System –North Unit Dam to Wickiup Dam

- This section of river has a seasonally reversed hydrograph with extreme low winter flow and high summer flow in upper stream reaches.
- Low winter water temperature can produce icing problems.
- Competition with exotic species has affected redband trout and other salmonid production.
- There is a general lack of good spawning habitat.
- Fish are more vulnerable to predation during periods of extreme low river flow.
- Dams in the City of Bend are total and partial fish passage obstructions.
- Fine sediments associated with bank erosion and reservoir sediment collection affect the river substrate.
- Eroding and unstable stream banks increase stream sedimentation and water turbidity.
- Loss of riparian vegetation and instream habitat complexity is associated with the extreme variation in flow.
- Loss of riparian vegetation contributes to reductions in wildlife habitat, such as for the Oregon spotted frog.
- Urban storm runoff may contribute to water pollution.
- There are no fish passage or screening facilities at Wickiup Dam.
- Loss of permanent stable water levels may have reduced or eliminated beaver colonies

Little Deschutes River System

- There has been a general loss of riparian vegetation and instream habitat complexity.

- Fine sediments associated with bank erosion and low stream gradient impact stream substrate quality.
- Summer water temperatures and dissolved oxygen in several reaches fail to meet State water quality standards.
- Discharge of industrial cooling water and process wastewater into the Little Deschutes at the town of Gilchrist may affect water quality.
- Low winter flows in some reaches are associated with upstream water storage.
- Winter icing problems are generally associated with low stream flow.
- There are fish passage obstructions and barriers.
- Competition with exotic species has affected redband trout and other salmonid production.
- Reduction in riparian vegetation contributed to the loss of wildlife, such as the Oregon spotted frog and American beaver.

Fall and Spring Rivers

- The stream substrate has a naturally high percentage of fine sediment associated with the stable spring-fed flow regime.
- There is a general lack of good spawning habitat.
- Instream habitat complexity is generally lacking.
- Fall River Falls is a fish passage barrier for most fish.
- The stream banks have some degraded riparian habitat.

7.2.8. Cascade Highlands Assessment Unit

Deschutes River System (upstream of Wickiup Dam)

- Flow manipulation between Crane Prairie Dam and Wickiup Reservoir results in seasonal flow extremes and most notably low winter flow.
- Summer water temperatures fail to meet water quality standards below Crane Prairie Dam.
- High natural fine sediment is a major component to the stream substrate.
- Riparian degradation is associated with some concentrated use at recreation sites.
- Stream reaches have experienced a general reduction in instream habitat complexity – loss of large wood.
- Loss of habitat complexity (large wood) in Crane Prairie Reservoir has reduced habitat quality.
- Competition with exotic species has affected redband trout and other salmonid production.
- There is a lack of fish passage and screening provisions at Crane Prairie Dam.
- Fish passage is obstructed at a number of road culverts.

Odell Creek System

- Summer stream water temperatures and pH in (Odell Creek) fail to meet water quality standards below Odell Lake.
- Fine sediment from road system drainage affects substrate quality.
- Riparian degradation from concentrated recreation site affects Trapper Creek habitat quality.
- Competition with exotic species has affected focal fish species.
- Some stream reaches have undergone channel manipulation and confinement.

- Fish passage obstructions at natural water falls (Trapper Creek), road culverts and temporary rock dams limits fish distribution.

7.3. Key Out-of-Subbasin Factors Limiting Aquatic and Terrestrial Populations

Key factors limiting Deschutes Subbasin aquatic and terrestrial populations outside of the Deschutes Subbasin include:

- Mortality of anadromous species associated with mainstem Columbia River dam passage.
- Migration delays in the Columbia River associated with large reservoirs and water quality.
- Predation associated with alterations of the mainstem Columbia River with large reservoirs and flow regulation.
- Disease associated with migration delay and the variation in Columbia River water quality.
- Fish harvest in the Columbia River and Ocean.
- Harvest of mule deer out of subbasin during hunting season.

7.4. Limiting Factors that Can or Cannot be Corrected Through Human Intervention

Most of the limiting factors identified above are being managed, or can be corrected, through human intervention. Changes in land management, for example, can improve upland and riparian conditions, and consequently increase channel structure and instream habitat diversity. Actions can also be taken to increase summer streamflows to levels that support salmonid production.

The management strategies identified in the Deschutes Subbasin management plan address all limiting factors identified above, except for providing fish passage around water falls and other natural obstructions, or eliminating natural glacial sediments in the White River system. The Oregon Department of Fish and Wildlife and the Confederated Tribes of the Warm Springs have not expressed desire to provide anadromous passage into portions of the subbasin that historically did not provide anadromous fish habitat.

A few factors cannot be addressed through human interventions. For example, humans cannot stop sedimentation caused by glacial runoff, which affect salmonid production in the White River system and lower Deschutes River, though they can reduce potential impacts by maintaining healthy riparian conditions. Humans also cannot control changes in the landscape caused by changes in climate. However, again, humans can reduce the impacts of climatic change by restoring watershed health.

Synthesis and Interpretation
Section 8

This section builds on assessment findings to form a holistic view of the subbasin's biological and environmental resources. This information provides a foundation for the development of scientific hypotheses concerning the ecological behavior and the ways that human intervention might prove beneficial. The section addresses the question:

What does the assessment imply regarding the health and functioning of the Deschutes subbasin ecosystem?

8.1. Key Assessment Findings

In some respects, the Deschutes Subbasin is data-rich. There are anadromous fish data strings for the lower subbasin that provide continuous data on estimated run size, in-river harvest and escapement for nearly forty years. There is also appreciable data for the redband trout, and to a lesser extent subbasin bull trout populations. These data provided some general insight into how changes in habitat may have affected various focal fish populations. The EDT Model estimated historic, current and potential future fish population production and life history and habitat capacity for steelhead (two populations and one extirpated population) and Chinook salmon (fall and spring races).

The QHA and EDT models provided information on the quantity and quality of stream and riparian habitat. The wildlife habitat assessment provided information about upland watershed habitat changes over the past 150 years. When the QHA/EDT and wildlife habitat information was considered together, it provided good insight into how the ecosystem has changed from the mid-1800's and why.

Information generated during the assessments showed that, as the ecosystems in the semi-arid segments of the subbasin unraveled from changes in land use and watershed health, some fish and wildlife populations became isolated, fragmented or extirpated. The important role that beaver played to maintain valley water tables, instream habitat and riparian and floodplain function grew more evident. It also became evident that as important upland habitat types were converted or lost a number of wildlife species were directly impacted, as were watershed characteristics that influence stream flow and water quality.

The QHA, EDT and the wildlife assessment processes helped to identify key factors that have limited, or are limiting, ecological function and biological performance. For example, a general reduction in summer stream flow combined with a general increase in summer water temperatures appreciably reduced fish populations and numbers in some stream systems. The development of extensive irrigation systems and hydroelectric projects placed seasonal and permanent barriers in a number of streams. Out-of-stream water use significantly diminished or altered the natural stream flow regimes. Watersheds degraded by western juniper and exotic plant invasions reduced capabilities to retain precipitation, and flashy stream flow regimes were often the result.

These shorter duration, higher peak, stream flows contributed to the scouring or incision of a number of stream channels and loss of natural water storage features.
The significant reduction, fragmentation or loss of some important upland habitat types associated with land management and development resulted in the extirpation of Columbia sharp-tailed grouse and the ESA-listing of the Greater sage grouse, as well as apparent reductions in numbers of other focal wildlife species.

Results from the assessments suggest that significant habitat restoration efforts are needed to meet fish, wildlife and habitat objectives in most of the assessment units. Examination of physical habitat conditions and past studies provides planners with further insight about restoration approaches that may provide the most benefit with a reduced rate of failure. Together, this information indicates that riparian and instream habitat restoration work will not be effective unless actions are also taken to improve overall watershed health.

8.2. Interpretation and Hypotheses

A working hypothesis summarizes a scientifically based understanding of the subbasin at the time the management plan is developed and begins to bridge the gap between the science and strategies. The hypotheses provide an explicit rationale for considering alternative biological objectives and strategies. They can be used to evaluate and derive biological objectives and strategies to achieve the subbasin vision. In addition, they provide the elements needed for scientific review of the plan.

8.2.1. Working Hypotheses for Aquatic Species

Each hypothesis has three main components. They identify 1) types of changes that have occurred in the subbasin, 2) how focal species have responded to these changes, and 3) most important, future changes that are expected to lead to achievement of the plan objectives and goals.

1. Important types of changes that have occurred in the subbasin.

- **Reduced fish distribution and connectivity**
  Artificial barriers have significantly reduced fish distribution and connectivity in the Deschutes Subbasin. Dams operated for hydroelectric power production, irrigation water diversion and storage, and flood control blocked historic fish passage at numerous sites in the subbasin and resulted in fish population fragmentation, isolation or extirpation. Stream channel alterations, road and railroad crossings and water withdrawal created effective seasonal or permanent barriers to fish passage in some stream reaches.

- **Conversion of native upland vegetation**
  Human activities on the uplands (such as timber harvest, crop production, roading, livestock grazing and development) converted native upland vegetation and led to the introduction of exotic plant species and invasion of western juniper. These changes reduced the watershed’s ability to collect, store, and slowly release runoff and maintain soil stability.

Changes in upland watershed health occurred throughout the system. They generally led to accelerated erosion, altered stream flow regimes - often with temperature and flow extremes (sometimes moving a perennial stream to an intermittent condition), lost natural floodplain and riparian function, channel scouring and/or incision.

- **Stream flow extremes, especially seasonally low or intermittent flows**

  Stream flow extremes, especially seasonally low or intermittent flows, are probably the most significant factors limiting fish production in much of the Deschutes River subbasin today.

  The quantity of stream flow affects all fish life stages including spawning, incubation, rearing, and migration. Reductions in stream flow are frequently associated with exaggerated peak stream flows that have generated lateral and vertical channel scour. Laterally scoured stream channels spread flow over a wide area as they often have a high channel width-to-depth ratio. Vertical channel scour, or incision, generally eliminates natural flow and temperature moderation affects of a high floodplain water table. Both forms of stream channel degradation can result in seasonally intermittent stream flow

- **Reduced water quality**

  Reduced water quality has limited the subbasin's focal fish species distribution and productivity. It has also reduced connectivity between populations and in some cases fragmented populations. Presently, a number of subbasin stream reaches fail to meet State water temperature standards (ODEQ 2002). Salmonids have ranges of temperature tolerance and optimal temperatures. Exposure to temperatures above 25°C (77°F) for an extended period is generally lethal to coldwater salmonids. Egg survival is significantly impaired at temperatures above 16°C and there is little survival for eggs exposed to temperatures at or above 18°C (65°F) (Mobrand, 2003). Seriously elevated water temperatures can block fish movement resulting in population fragmentation or isolation. High temperatures can also increase the risk of disease and parasites for already stressed focal fish species and negatively impact other aquatic vertebrates and invertebrate prey species.

  Some stream reaches also regularly fail to comply with water quality standards for dissolved gases and pH (ODEQ 2002). Warm water associated with degraded stream channels or water discharged from great depths of large reservoirs can have dissolved oxygen deficiencies. Water spilled over high dam spillways or through pressurized penstocks can produce water that is super-saturated with nitrogen gas. Both extremes can have adverse to lethal implications for focal fish at all life stages.

- **Loss of riparian and floodplain function**

  Loss of riparian and floodplain function due to timber harvest, livestock grazing, agricultural production, channel alteration, and other land developments has reduced habitat complexity, contributed to water quality problems, accelerated erosion, reduced water quantity, lowered water tables, and reduced beaver numbers and distribution.

Riparian stream corridors create a natural buffer between streams and uplands, and act as filters to prevent sediment, pollutants and other items from reaching the streams. Riparian plants are particularly important in semi-arid parts of the subbasin, where they help moderate water temperatures by providing important overhead shade and cover. Riparian corridors are generally very productive and naturally support the greatest biological diversity of any habitat type.

During the EDT analysis, loss of riparian function arose as one of the critical factors limiting focal fish species production in many stream systems (see Environment/Population Relationship section). Focal fish species numbers and distribution declined in many reaches with the loss of riparian function. Riparian function directly influences water quality, water quantity, habitat diversity and vulnerability to predation.

- **Loss of instream habitat diversity**

  Flashy stream flow regimes associated with upland watershed degradation, loss of riparian and floodplain function and channel manipulation and clearance eliminated instream habitat variability from many stream reaches. Stream corridor manipulation associated with development, roading, agricultural and forest practices reduced the potential for natural recruitment of large wood into many stream reaches. The reduction in beaver numbers and distribution has also reduced another source of channel diversity.

  Instream structural habitat complexity, which may include large wood, boulders or emergent or aquatic vegetation is important for formation and maintenance of pools, braided channels and back waters. It also regulates the transport of sediment, gravel, and organic matter (Mobrand, 2003b). The loss of instream habitat complexity has reduced focal fish species carrying capacity because of degraded habitat conditions for all fresh water life stages.

- **Interactions with hatchery fish**

  The most serious issue related to interactions between Deschutes focal fish species and hatchery fish involves stray hatchery fish from the Upper Columbia River Basin. Deschutes River summer steelhead, which includes two demographically independent populations, are within the Mid-Columbia ESU, and have been designated as a threatened species under the federal Endangered Species Act. Rationale for this listing included the genetic risks posed to the wild population by thousands of stray, upper Columbia River Basin, hatchery-origin, steelhead. The incorporation of genetic material from large numbers of stray steelhead could have a long term effect on the subbasin steelhead production through reduced resilience to environmental extremes and diverse survival strategies. Out-of-basin strays also pose a threat to steelhead population health. About five percent of the hatchery stray steelhead have tested positive for whirling disease, indicating that these fish were exposed to the disease earlier in their life and are carriers of whirling disease spores or infective agents (Engleking 2002).

  Managers believe there is substantial interaction between wild Deschutes fall Chinook and other stray, hatchery origin summer or fall Chinook within the lower reaches of the Deschutes River. This conclusion is based on recent radio telemetry data and an ongoing Deschutes River fall Chinook study being conducted by CTWS

(Brun, 2002). The initial indications of no appreciable straying into the Deschutes River were masked by the difficulty of identifying stray fish with no distinctive external markings. The potential for genetic intergression could have similar adverse affects to those described for summer steelhead.

The effect of stray, out-of-basin origin spring Chinook into the Deschutes Subbasin is unknown. There have been stray spring Chinook adults observed in the subbasin, but numbers have apparently been low. In the past, hatchery-produced spring Chinook from other locations in the Columbia Basin have been released without distinguishing tags or external marks. This has made it impossible to determine the origin of some adult salmon captured at the Pelton and Warm Springs River fish traps or to speculate on the incidence of straying (ODFW 1997).

Managers believe interactions between wild Deschutes salmonids and hatchery fish produced in the subbasin are minimal. Hatchery summer steelhead and spring Chinook salmon released in the lower Deschutes River from Round Butte Hatchery are from indigenous stocks. These hatchery fish are released as smolt-sized fish for rapid out-migration to minimize their potential interaction with wild fish. About 90 percent of the Deschutes stock spring Chinook produced at Warm Springs National Fish Hatchery are also released as smolt-sized fish for rapid migration. The remaining 10 percent are released as 0-age fall migrants that over-winter in the Deschutes.

- **Interactions with exotic species**

  Indigenous focal fish species have been negatively impacted by the introductions of a variety of exotic fish species. Brook trout are of special concern where they have displaced indigenous focal fish species (redband and bull trout), and particularly in headwater streams where they are hybridizing with remnant bull trout populations (U.S. Fish and Wildlife Service, 2002). Brown trout appear to effectively compete with redband trout, especially in areas with reduced water quality. Other exotic fish like three-spine stickleback and Tui chubs are efficient competitors with redband trout for food and space. Out-of-basin exotic introductions, such as walleye, are efficient predators affecting survival of juvenile anadromous out-migrants in the Columbia River.

- **Susceptibility to Predation**

  Existing habitat conditions in many subbasin stream reaches make focal fish species particularly vulnerable to predation, especially during periods of low stream flow. A number of streams in the eastern half of the subbasin are degraded and have undergone significant lateral or vertical channel scour, often resulting in a loss of instream habitat complexity (structure and pools), as well as seasonally low to intermittent flow. These conditions favor the predator over the prey species and a wide variety of predators benefit from the increased fish vulnerability. Reaches of the Deschutes River between Lower Bridge and Wickiup Dam also experience drastic seasonal flow fluctuation that may strand individual fish or concentrate fish in a few isolated pools during periods of very low flow, making them particularly vulnerable to a wide spectrum of predators.

  Stream reaches that have lost or degraded riparian vegetative stream corridors are often deficient in the important fringe habitat of emergent and terrestrial vegetation associated with the stream margins. This narrow band of complex cover, with reduced water velocities, is critical for survival of 0-age salmonids and their ability to avoid predators.

2. How focal species have responded to these changes.

Subbasin changes over the past 150 years have resulted in appreciable reductions in the number of populations, species abundance, diversity and habitat productivity. Robust populations of bull trout have been reduced to four known local populations within the lower Deschutes Core Area and one remnant population in the Odell Lake Core Area. Bull trout in the Deschutes Recovery Unit are at an intermediate threat of extinction category (USFWS 2002). In recent years, bull trout in the Metolius River habitat complex have responded favorably to habitat protection and harvest restrictions, and the population trends are upward.

Anadromous focal fish species experienced a loss of approximately half their historic range when water withdrawals and habitat degradation culminated with the construction of an impassable series of Deschutes River dams by the late 1960's. This drastic reduction in historic habitat — combined with degradation of much of the remaining habitat — appreciably reduced populations, species abundance, genetic diversity and habitat productivity. However, recent out-of-basin changes including reduced ocean harvest and increased ocean productivity have resulted in increased adult escapement to the river for all species, except Pacific lamprey. The long-term genetic implications from the intergression of significant numbers of out-of-basin stray fish with indigenous Deschutes Subbasin spawners have yet to be determined.

Some resident redband trout populations scattered throughout the subbasin were fragmented, isolated and extirpated as watershed health and summer stream flows deteriorated. Remnant populations declined because of competition from warm water tolerant fish species, exotic fish introductions and habitat deterioration associated with development of extensive irrigation systems, and stream flow, corridor and channel manipulation.

Fall Chinook salmon, which spawn and rear in the lower 100 miles of the Deschutes River, have been buffered against some of the other subbasin habitat issues. This population likely lost little habitat to the Pelton Round Butte Complex, but may have seen subtle adverse impacts from water quality and quantity variations associated with the hydroelectric project operation. Escapement to the river in recent years appears to approach potential historic levels, although spawning distribution has fluctuated between the upper and lower river reaches.

Extent of Lost Production from Historic to Current

The EDT Model gives some indication of how current production of summer steelhead and Chinook salmon differs from historic (pre-European influence) production. Findings shown in the EDT Diagnostic Reports (Appendix --) are discussed below.

- Summer steelhead, distributed through the three population areas identified by the NOAA Fisheries Technical Recovery Team, historically could have ranged between 36,000 and 38,000 adults annually returning to the subbasin (EDT Diagnostic Reports). In contrast, current production of indigenous steelhead results in annual runs of 4,000 to 9,000 adult fish to the river (French and Pribyl 2003).

- Spring Chinook, distributed between three subbasin plan assessment units, historically could have ranged between 10,000 and 12,000 adults annually returning to the subbasin (EDT Diagnostic Reports). In contrast, current natural production of spring Chinook salmon produces annual runs of 1,000 to 2,000 adult fish to the river (French and Pribyl 2003).
- Fall Chinook, confined to the mainstem Deschutes River, historically may have ranged between 16,000 and 19,000 adults annually returning to the subbasin. From 1999 to 2003, an average of 9,942 adult fall Chinook salmon returned to the river annually, and the adult run ranged from 4,388 to 13,668 fish (French and Pribyl 2004).

There are no known estimates of the historic production of sockeye salmon, Pacific lamprey or resident focal fish species within the subbasin. Anecdotal information suggests that these populations were generally robust and, with the exception of sockeye salmon, well distributed throughout the subbasin. Sockeye salmon were extirpated by 1940. Other anadromous focal fish species were extirpated upstream of the Pelton Round Butte Complex by 1968 because of habitat degradation and lack of fish passage. Today, redband trout populations are depressed through much of the subbasin, except for important core populations. These core populations are found in the lower mainstem of the Deschutes River, scattered reaches of the Deschutes River between Lake Billy Chinook and Little Lava Lake, the Metolius River, two reaches of Crooked River between Lake Billy Chinook and Bowman Dam and smaller headwater stream systems.

3) Important future changes leading to the plan objectives

Recovery of Habitat

Habitat recovery is underway throughout the subbasin. Collaborative programs involving a wide variety of subbasin stakeholders are moving ahead with a wide range of habitat restoration programs, some of which have already produced beneficial results. Ongoing and planned projects include: 1)substantial improvement or restoration of fish passage at manmade structures, 2) upland watershed improvement (re-establishment of native plant species, control of noxious weeds, exotic plants and invasive species), 3) riparian and floodplain restoration, 4) restoration of stream channel sinuosity and complexity, and 5) increased minimum stream flows and reduced maximum water temperatures – water conservation, water right conversions, leases and acquisitions.

Stream minimum flow recovery will be the single most important future change that will lead toward achievement of the subbasin plan's biological objectives. Some specific flow restoration projects have already been completed, while others are underway or in the final planning stages. Conversion, leasing and acquisition of water rights will provide instantaneous instream flow recovery – most notably in the Squaw Creek system. Water conservation projects throughout the subbasin, including more efficient water delivery and application practices will also return appreciable summer flow to a number of streams. Changes in Central Oregon land use from agriculture to urban/suburban may reduce the demand and need for irrigation water, which would translate into reduced water diversions from the Deschutes River and a reduction in the extreme flow fluctuations common to the Deschutes River from Lower Bridge to Wickiup Dam.

Restoration of fish passage at the Pelton Round Butte Complex and other smaller migration barriers could restore anadromous fish species to a large portion of their historical spawning and juvenile rearing habitat. Efficient fish passage would not only appreciably increase anadromous fish production, but would help to re-connect fragmented resident focal fish populations. The success of the sockeye salmon re-introduction program in the Metolius River system is directly dependent upon the re-establishment of fish passage at the Pelton Round Butte Complex.

Upland watershed restoration will be a tremendous challenge, because of the land acreage and ownership complexities involved, but the results could ultimately pay dividends in the form of increased retention and absorption of seasonal precipitation. This will translate into reduced erosion and stream sedimentation and increased summer stream flow.

Restoration of riparian and floodplain function is underway on a number of stream reaches through revised grazing management, land use restrictions, protection enclosures and development of alternative upland watering facilities. There are indications, based on summer steelhead and fall Chinook salmon escapement data, that these ongoing projects have already produced additional focal fish (French and Pribyl 2004). Similar future stream corridor restoration projects, coupled with fish passage restoration, increased minimum stream flows and improved upland watershed health will further increase focal fish species production.

Reductions in extreme stream water temperature variation — associated with the recovery of minimum stream flows, riparian and floodplain function and stream channel stability — will also increase fish production. Restored connectivity will increase production of currently fragmented fish populations.

Recovery of instream habitat diversity associated with riparian and floodplain recovery, upland watershed recovery, low flow recovery and stream channel recovery will improve the habitat fish production capacity. This fish production increase will result from the improved spawning and rearing habitat components, including escape and hiding cover to reduced vulnerability to predation.

Recovery of Listed Species

Summer steelhead and bull trout are the two ESA-listed focal fish species found in the subbasin. The EDT Model projections indicate that there could be appreciable recovery of steelhead population numbers, life history diversity and population productivity if a moderate amount of habitat restoration occurs over the next twenty-five years, and if fish access is restored to historic habitat in the Middle Deschutes and Lower Crooked River assessment units. However, the long-term recovery of the three NOAA Fisheries TRT identified Deschutes steelhead populations could be jeopardized by the genetic intergression resulting from large numbers of out-of-basin steelhead spawning with indigenous Deschutes populations.

The Deschutes Bull Trout Recovery Unit is one of 22 recovery units designated for bull trout in the Columbia River Distinct Population Segment. Current bull trout distribution is limited to the Odell Lake Core Area and the lower Deschutes Core Area, which includes the five local populations in Shitike Creek, the Warm Springs River, and the three Metolius River population complexes. Bull trout in the five Lower Deschutes Core Area populations appear stable or increasing as a result of protective angling regulations and habitat restoration and protection. The status of these populations will appreciably improve when fish passage at the Pelton Round Butte Complex and other manmade barriers restores historic population connectivity. Re-connecting these populations will also provide the opportunity for the expression of various life-history forms. However, hybridization with brook trout poses a threat for fish in a number of stream reaches, including upper sections of Shitike Creek and the Warm Springs River.

Bull trout in the Upper Deschutes Core Area were extirpated and fish in the Odell Lake Core Area are in very low numbers and are restricted to only the Odell Lake Habitat Complex population. Spawning is known to occur in only one small tributary to Odell Lake. The population is isolated from the remainder of the subbasin by a lava flow. The Odell Lake population is at a heightened risk because of the apparent small number of spawning fish in the population. The Odell Lake habitat complex population should be increased to a minimum of 500 fish to avoid long term genetic risks (USFWS, 2002).

Recovery of Non-listed Species

Fall Chinook salmon numbers have increased substantially in recent years. From 1977 to 2002, the run size of adult fall Chinook salmon into the lower Deschutes River averaged 6,536 fish and ranged from 2,813 to 20,811 fish annually (French and Pribyl 2003). This increase in population size may reflect better ocean survival associated with reduced harvest resulting from the U.S. / Canada Salmon Treaty, improved ocean productivity, restored riparian habitat along the mainstem of the lower Deschutes River, and enhanced juvenile downstream passage at mainstem Columbia River dams (ODFW, 1997). Proposed restoration of additional lower Deschutes River margin habitat could produce even larger returns to the river in the future.

Spring Chinook salmon returns to the subbasin have varied considerably from 1997 to 2002, ranging from 241 to 3,460 fish (French and Pribyl 2003). Moderate levels of habitat and minimum stream flow recovery, combined with fish passage at the Pelton Round Butte Complex and other manmade barriers in the Middle Deschutes and Lower Crooked River assessment units, will substantially increase subbasin spring Chinook salmon production. The EDT Model estimates that potential adult returns to the subbasin with moderate habitat restoration and fish passage at current manmade obstacles could range from 5,000 to 6,000 fish.

Redband trout populations will increase in numbers and range as minimum flows increase in stream reaches throughout the subbasin. Populations will also respond favorably to restoration of riparian and floodplain function, channel stability and instream habitat diversity. Population connectivity, associated with re-established fish passage at manmade barriers, will also boost the recovery of redband trout populations.

Successful re-introduction of sockeye salmon and the establishment of a naturally self-sustaining population is dependent upon fish passage at the Pelton Round Butte Complex. The stream habitat in the historic sockeye salmon production area remains some of the best quality habitat in the subbasin. If successful adult and juvenile fish passage is re-established, this species could once again flourish in the subbasin.

Pacific lamprey population numbers in the subbasin appear to be low. Lamprey limiting factors include erratic, intermittent or diminished stream flow, increased water temperatures, poor riparian areas, predation in all life stages, artificial barriers and the lack of appropriate water withdrawal screening. The lamprey juveniles or ammocoetes live in substrate burrows for up to seven years and are particularly vulnerable to pollution and erratic stream flows. Restoration of minimum stream flows, riparian and instream habitat complexity and re-establishment of passage at subbasin manmade barriers could result in appreciable recovery of lamprey numbers.

8.2.2. Working Hypotheses for Terrestrial Species

1. Important types of changes that have occurred in the subbasin

- **Loss and fragmentation of large blocks of ponderosa pine, lodgepole pine, and shrub-steppe habitats**

  Comparison of historic (mid-1860) and current habitat shows fragmentation of the large blocks of ponderosa pine, lodgepole pine, and shrub-steppe habitats that formerly existing in the subbasin (Maps 15-17) (IBIS 2004). Historically, broad bands of habitats ran north and south. Beginning on the west side of the subbasin, a band of mountain fir and hemlock forest habitat types existed in higher elevations of the Cascade Mountains. A band of ponderosa pine forest, mixed with some lodgepole pine forest, ran from the Columbia River southward, approximately along the eastern foot of the Cascades. At the southern end of this band of mostly ponderosa pine woodland, larger blocks of lodgepole pine forest began to break into the band of ponderosa pine. East of the Deschutes River, a band of mostly shrub-steppe habitat with interspersed interior grassland and Western juniper woodland areas again ran north to south. A large block of shrub steppe habitat covered the southeastern section of the subbasin, and a large block of Western juniper woodland existed southeast of Redmond. Along the east edge of the subbasin, ponderosa pine forests dominated the Blue Mountains east of Prineville,

  Today, a band of mixed conifer forests running north-south in the Cascade Mountains on the west side of the subbasin has encroached into the lower-elevation ponderosa pine and lodgepole pine forests along the eastern foothills of the Cascades. A large block of juniper woodland south and east of Redmond and Prineville has spread throughout the former shrub-steppe habitat running through the center and into the southeastern part of the subbasin, fragmenting the shrub-steppe habitat. Other conifer forest types have encroached into the former ponderosa pine forests in the Blue Mountains east of Prineville. The Wildlife Habitat Changes maps for Ponderosa Pine and Interior White Oak, Lodgepole Pine Dominant, and Shrub-Steppe show changes from historic condition.

- **Loss of riparian and herbaceous wetland habitats**

  There has been an appreciable reduction in the quantity and quality of riparian and herbaceous wetland habitats over the past 150 years. While there is a lack of historic or current riparian wetlands or herbaceous wetlands data in the subbasin, members of the wildlife technical team considered these two habitats to be the highest priority habitats for restoration or conservation in the subbasin. Other habitats also are not shown in large enough scale, or for other reasons are not considered to show significant results (Ibid). Canyon shrublands, for example, was a recent addition to the habitat type list, and could not be compared with historic data. There was also an unsuccessful attempt to display this habitat as a linear habitat and therefore is not discussed.

- **Loss of the grassland habitats**
  Comparison of historic and current habitats (Map 18) shows the loss of a large block of interior grassland habitat in the northeastern section of the subbasin southeast of The Dalles. The loss or conversion of over 600,000 acres of estimated historical interior grassland habitat in the subbasin, nearly all of the grassland habitat in the subbasin, is a large-scale shift in habitat types. This loss of grassland habitat in the subbasin can be partially attributed to encroachment by juniper woodland and conversion to agriculture.

- **Large-scale increases in habitats in the subbasin.**

  Increases in mixed conifer forests, juniper woodlands, and agriculture areas are large-scale changes in habitat in the subbasin. Encroachment of other forest types into historic ponderosa pine and lodgepole pine forests created a major habitat shift in the subbasin (Table 8.1.).

- **Loss of habitat in connected watersheds**

  The Deschutes Subbasin is part of the larger Columbia Plateau Ecoprovince, a group of eleven connected watersheds that includes the Deschutes Subbasin. Maps of wildlife habitats thought to occur historically and currently in the Columbia Plateau Ecoprovince show that some habitat changes that have occurred in the larger ecoprovince are similar to changes that have occurred in the Deschutes Subbasin (Maps 19-23). Specifically, historic and current data changes to the four focal habitats, shown by IBIS for the Deschutes subbasin, are also shown to have changed in a similar manner throughout the ecoprovince. Shrub-steppe and grassland habitats have been largely replaced by agricultural uses, and ponderosa pine and lodgepole pine habitats have been reduced and fragmented. Montane mixed conifer habitats have apparently increased, as have juniper woodlands.

Table 8.1. Current and Historic Wildlife-Habitat Acreage Changes, Deschutes Subbasin.

Habitat ID	Habitat Name	Current Acreage	Historic Acreage	Change from Historic	Percent change
1	Mesic Lowlands Conifer-Hardwood Forest	2,267	34,970	-32,703	n/a
3	Southwest Oregon Mixed Conifer-Hardwood Forest	173	0	173	n/a
4	Montane Mixed Conifer Forest	546,968	194,288	352,680	182%
5	Interior Mixed Conifer Forest	676,086	350,133	325,953	93%
6	Lodgepole Pine Forest and Woodlands	213,432	532,706	-319,274	-60%
7	Ponderosa Pine & Interior White Oak Forest and Woodlands	1,320,270	1,860,264	-539,994	-29%
8	Upland Aspen Forest		741	-741	n/a
9	Subalpine Parkland	38,839	25,361	13,478	n/a
10	Alpine Grasslands and Shrublands	14,636	12,425	2,211	n/a
12	Ceanothus-Manzanita Shrublands	2,996	0	2,996	n/a
13	Western Juniper Woodlands	1,347,101	790,348	556,753	70%
14	Interior Canyon Shrublands	82,856	0	82,856	n/a
15	Interior Grasslands	4,684	630,630	-625,946	-99%
16	Shrub-steppe	1,982,194	2,299,065	-316,871	-14%
17	Dwarf Shrub-steppe	127,843	5,683	122,160	n/a
18	Desert Playa and Salt Scrub Shrublands	3,225	1,418	1,807	n/a
19	Agriculture, Pastures, and Mixed Environs	337,369	0	337,369	n/a
20	Urban and Mixed Environs	22,026	0	22,026	n/a
21	Open Water - Lakes, Rivers, and Streams	57,774	76,139	-18,365	n/a
22	Herbaceous Wetlands	51,512	20,263	31,249	n/a
24	Montane Coniferous Wetlands	15,781	0	15,781	n/a
25	Interior Riparian-Wetlands	7,568	21,251	-13,683	n/a
	Total Acres:	6,855,591	6,855,680		

*Acreages are estimates only. Subbasin total acreage may vary slightly between Current and Historic due to mapping procedures.

*Copyright 1998-2003. Please visit the IBIS web site (www.nwhi.org/ibis) for Copyright and Terms of Use limitations. This data is continually updated and therefore subject to change.

*Subbasin Habitat Acreages Generated by IBIS on 10/13/2003 11:45:52 AM.

2. How focal species have responded to these changes

The reduction in the quality and quantity of riparian and herbaceous wetland habitats has adversely affected beaver, Columbia and Oregon spotted frog populations, and other wildlife. Beaver numbers and distribution has declined throughout the subbasin, but particularly in areas where perennial streams have evolved into intermittent or ephemeral water courses. The Columbia and Oregon spotted frog populations have experienced precipitous declines associated with the losses and fragmentation of riparian and wetland habitats. Remnant Columbia spotted frog populations are now confined to small, disconnected habitats in the Lower and Upper Crooked River assessment units.

The reduction and fragmentation of lodgepole pine and ponderosa pine woodland habitats, combined with the reduction of shrub/steppe habitat has resulted in some reductions in mule deer populations. These changes in habitat type and availability particularly affect mule deer winter range and seasonal migration routes. The current status of the white-headed woodpecker is unknown, but the population may have also been affected by the reduced or fragmented ponderosa pine habitats.

The overall loss or conversion of much of the interior grassland habitat was generally responsible for the extirpation of the Columbia sharp-tailed grouse within the subbasin. Much of this habitat was converted to cropland, or evolved into Western Juniper woodland habitat as a result of livestock grazing and the control of wild fires.

The loss or conversion of shrub-steppe habitat, combined with range improvement programs, livestock grazing and more frequent wild fire in some areas has resulted in an alarming decline in greater sage grouse numbers in the southeastern portion of the subbasin.

The status of canyon land – rimrock habitat, which provides important golden eagle nesting sites was impossible to assess from satellite imagery, but is assumed to have seen some reductions in quantity and quality associated with human population growth and development. The subbasin golden eagle population status is unknown. However, 57 active golden eagle nesting territories were recorded in 2000, which may indicate that the population is generally stable.

3. Important future changes leading to the plan objectives

Recovery of Habitat

Some wildlife habitat recovery/restoration is underway in the subbasin. The Conservation Reserve Program and other incentive programs are converting marginal cropland to permanent grassland (Map 24). Western juniper are being thinned or removed to restore upland watershed function. Thinning and under burning is being employed in some areas to push back the mixed conifer forest invasion of historic ponderosa pine or lodgepole pine woodland habitat. Water conservation and riparian habitat restoration projects are underway or planned. Some long-term riparian and floodplain restoration projects have already shown beneficial effects to a variety of wildlife species. Land use laws and various landowner incentive programs are making impressive in-roads in the restoration of riparian and floodplain function along anadromous fish streams.

Recovery of Listed Species

Restoration of watershed, riparian and floodplain function will have wide ranging benefits to focal wildlife species. Restoration of the riparian and floodplain areas will directly benefit the Columbia spotted frog and beaver populations. The beaver could also become an active contributor to the recovery of these habitats, assuming that there are sufficient numbers to re-seed the potential or historic habitat. Recovery of riparian and floodplain function, in conjunction with the ponding of water associated with increased beaver numbers, will likely increase habitat and habitat connectivity for the spotted frog.

Restoration of shrub-steppe habitat that has been invaded by western juniper and or exotic plants will contribute to better watershed function, while also benefiting the depressed populations of greater sage grouse.

Some lost ponderosa pine habitat may be recovered with measures aimed at restoring upland watershed function, which could reduce rapid snow melt or storm run-off. However, appreciable recovery of old growth ponderosa will be limited by timber management and harvest rotation. White-headed woodpeckers are dependent on large pine seeds as food in late summer, fall and winter. The availability of this resource may be the habitat factor most limiting its population. Ponderosa pines produce good cone crops only every four to five years in the Pacific Northwest and no other suitable pine species exist in this portion of the woodpeckers range. Seed production by ponderosa pines is also related to the age and size of the trees and the density of the stand; almost all seeds are produced by large, dominant trees in open situations. As a result of logging and subsequent fire suppression, many ponderosa pine forests are now characterized by dense stands of young trees or mixed stands with other conifers, which is not conducive to good seed production.

Reduced snag densities after selective logging or various types of development likely reduce the quality of White-headed Woodpecker nesting habitat. When the birds try to adapt to marginal habitat conditions by nesting in low snags they are more susceptible to predation. The outlook for this woodpecker population within this planning horizon will likely not improve appreciably.

Recovery of Non-Listed Species

The conversion of dry land fields or uplands to permanent grass, as part of the Conservation Reserve Program, or the restoration of natural vegetation to improve watershed function, could be beneficial to wildlife species that prefer a grassland habitat. Recovery of grasslands may increase a variety of wildlife species and thus benefit predators, including the golden eagle.

Mule deer populations may benefit from restoration of riparian and herbaceous wetland habitat, but restoration of winter range, including the ponderosa and lodgepole pine woodland and shrub steppe habitat, would provide the greatest potential benefit. Unfortunately, some habitat fragmentation associated with growth and development may appreciably limit the opportunities that would benefit this species.

8.3. Desired Future Conditions

This section discusses changes in species abundance and productivity, and habitat condition that assessment findings indicate will likely be achieved in a twenty-five-year planning horizon.

8.3.2. Desired Future Conditions for Aquatic Species

Listed Species

The NOAA Fisheries Interior Columbia River Basin Technical Recovery Team (TRT) identified seven Ecologically Significant Units (ESUs) containing ESA-listed anadromous fish populations in this recovery domain. The Deschutes Subbasin was included in the Mid-Columbia Steelhead ESU, which contains 16 populations in four major groupings and one unaffiliated area. The TRT determined from 1) genetic information, 2) geography, 3) life history traits, 4) morphological traits and 5) populations dynamics that the Deschutes subbasin contains two demographically independent summer steelhead populations and one unoccupied population habitat area. The Mid-Columbia ESU steelhead populations will ultimately be combined to determine alternative ESU viability scenarios.

The TRT concluded that the Mid-Columbia steelhead populations have been impacted by harvest, habitat alterations, inadvertent negative affects of hatchery practices and dam construction. The populations were listed as threatened in March 1999.

The EDT model projects that with moderate habitat restoration the number of wild Deschutes summer steelhead spawners in the existing subbasin steelhead habitat could range from 6,000 to 7,000 fish. Restoration of fish passage at the Pelton Round Butte Complex and access to historic habitat in the Middle Deschutes and Lower Crooked River systems could add an additional 4,000 to 5,000 summer steelhead to the subbasin, for a subbasin total of 10,000 to 12,000 fish.

Increases in summer steelhead production, as projected by the EDT model, meet the targets set by NOAA Fisheries. NOAA Fisheries has established an interim abundance target for the two Deschutes subbasin steelhead populations below the Pelton Round Butte Complex of 6,300 fish. This number was established to include eight years, or approximately two generations, and represents the mean of annual spawner numbers. Subbasin planners were unable to segregate existing Deschutes Subbasin steelhead population data for each of the TRT identified summer steelhead populations. The assessment units used for subbasin planning differ from the summer steelhead population and habitat areas identified by the TRT. Consequently, the copious quantity of steelhead data collected in the subbasin over the past forty years was accumulated for one population. The data presented in this plan, with the exception of the projected EDT habitat capacity, and population productivity and diversity data (Appendix I), reflects this one steelhead population assumption.

Inclusion of Deschutes River hatchery and out-of-basin stray hatchery fish into the spawning population calculations would substantially inflate current and future spawner escapement numbers. The total escapement estimates for all steelhead passing above

Sherars Falls (RM 43) for the 1997-98 through 2001-02 run averaged 26,418 fish. Total escapement during this five-year period ranged from 18,920 to 40,533 steelhead (French and Pribyl, 2003). Past Deschutes steelhead studies have confirmed that some stray hatchery fish passing above Sherars Falls drop out of the system and continue their migration to the upper Columbia River basin. Some Deschutes and stray hatchery steelhead are also removed from the system at the Pelton and Warm Springs fish traps. However, ODFW biologists have observed that hatchery origin steelhead comprise 40 to 50 percent of steelhead spawning in several eastside Deschutes River tributaries (French, 2004).

The potential increase in indigenous subbasin steelhead numbers up to 10,000 to 12,000 fish is directly dependent upon substantial habitat restoration. Restoration of steelhead access to historical habitat in Squaw Creek and the Middle Deschutes and Crooked rivers is essential to reach this population objective. Increased minimum stream flow in many mid and lower Deschutes tributaries is also critical to population recovery. Recovery of stream channel stability, habitat complexity, riparian and floodplain function and watershed health will also help to insure that steelhead numbers increase in subbasin streams. The genetic and disease risks associated with out-of-basin stray steelhead could ultimately determine the success of population restoration measures.

The EDT Model projected that life history diversity for the Deschutes River westside steelhead population could increase from 89 to 99 percent, and productivity could increase from 6.4 to 9.0 with moderate habitat restoration over the next twenty-five years. The model projected that the Deschutes River eastside population could see life history diversity increase from 26 to 57 percent, and productivity increase from 1.6 to 2.9 during the same period.

The U.S. Fish and Wildlife Service issued a final rule listing the Columbia River population of bull trout (*Salvelinus confluentus*) as a threatened species under the Endangered Species Act on June 10, 1998 (63 FR 31647). The Deschutes Recovery Unit forms part of the range of the Columbia River population. The USFWS Deschutes Recovery team identified the Lower Deschutes River Core Area and the Upper Deschutes River Core Habitat, which are separated by Big Falls (RM 132). The recovery team estimated the current population of bull trout in the Lower Deschutes Core Area at 1,500 to 3,000 fish. Bull trout were extirpated from the Upper Deschutes Core Habitat. The only other subbasin bull trout population is found in the Odell Lake Recovery Unit and is comprised of very low numbers of fish that apparently spawn in a short reach of Trapper Creek.

Lower Deschutes bull trout populations appear to be stable or increasing. Restoration of fish passage at the Pelton Round Butte Complex would restore connectivity for populations isolated by this series of impassable dams. Restored population connectivity would increase opportunity for genetic exchange and population diversity, and potentially the expression of all life history forms. If fish passage is restored at the Pelton Round Butte Complex additional fish passage obstacles should be modified to provide access to historic habitat in Squaw Creek and the Metolius and lower Crooked River systems. Stream habitat restoration described for recovery of subbasin summer steelhead populations (above) would also benefit bull trout populations. Aggressive measures may need to be implemented to reduce or eliminate brook trout from current and historic bull trout habitat to minimize competition and further hybridization.

Non-listed Species

The EDT Model projects that with moderate habitat restoration the number of Deschutes spring Chinook salmon spawners in the existing subbasin habitat could range from 2,500 to 3,000 fish. Restored fish passage at the Pelton Round Butte Complex and access to historic habitat in the Middle Deschutes, Metolius and Lower Crooked River systems could add an additional 2,000 to 2,500 spring Chinook salmon to the subbasin, for a subbasin total of 4,500 to 5,500 fish. Increased spring Chinook production in the lower subbasin depends upon restoration of riparian and floodplain function, improved in-channel habitat diversity, and reductions in fine substrate sediment. Increases in minimum stream flow combined with reductions in peak stream temperatures will also aid in the population recovery. The EDT Model projected that restoration of the lower Deschutes spring Chinook salmon population could improve life history diversity from 95 to 96 percent, and population productivity from 5.4 to 6.0.

The EDT Model projected that lower Deschutes fall Chinook salmon numbers would increase by approximately 1,700 fish with moderate habitat restoration over the next twenty-five years. Increased fall Chinook production would require restoration of instream habitat diversity and riparian function. Increases in minimum stream flow, combined with reduction in peak stream temperatures, will also aid in the population recovery. Aside from increasing the population size, habitat restoration could increase life history diversity of the population from 53 to 60 percent, and productivity from 6.0 to 7.1.

The objective of re-establishing a self-sustaining subbasin sockeye salmon population is entirely dependent upon restoration of fish passage at the Pelton Round Butte Complex. Habitat conditions in the Metolius River/Suttle Lake complex have changed little in the sixty plus years since the indigenous Sockeye salmon population was extirpated. The additional juvenile rearing habitat available in Lake Billy Chinook could increase production above historic levels. Potential habitat restoration measures, including providing fish passage and screening at several obstructions and increasing instream and riparian complexity, would be beneficial to a re-introduced sockeye salmon population.

Redband trout numbers and distribution would increase throughout most subbasin streams with habitat restoration. Increases in minimum stream flow and improved instream, riparian, floodplain and upland watershed conditions are prerequisites for significant population recovery. In addition, restoration of population connectivity associated with increased stream flow, improved water quality and restored fish passage at artificial barriers would contribute to increased population diversity and productivity.

Pacific lamprey numbers are likely at all time low levels. Habitat restoration, including increased minimum flow and improved water quality would encourage population recovery in subbasin streams. Restoration of fish passage at the Pelton Round Butte Complex and other artificial barriers would provide access to historic range and contribute to substantial population recovery. Habitat restoration measures designed to increase resident and anadromous salmonid production in subbasin streams will also benefit lamprey production.

Habitat

The quality of aquatic habitat is directly dependent on the amount of stream flow present in subbasin streams. Restoring stream flows to meet state instream water rights is a long-term goal, but it will likely not be achievable within this planning horizon. Implementation of collaborative restoration projects directed at restoring upland watershed, riparian and floodplain function will help restore perennial flow to subbasin streams. Perennial stream flow and recovering watersheds and riparian and floodplain habitats will reduce extreme seasonal and daily stream temperature variation and improve overall water quality.

This plan sets habitat restoration objectives that call for a percent recovery of individual habitat attributes. Achieving these objectives could be compared to reaching a highway milepost, but it is not intended to be the end of the journey. The habitat restoration objectives of this plan are presented as objectives that realistically can be met within the next twenty-five years if remedial measures are implemented. However, considering that most subbasin habitat degradation has occurred over the last one hundred-fifty years, it is unrealistic to assume that desired future conditions can be achieved in twenty-five years or less. Working towards or achieving habitat objectives within this plan should be considered an important interim accomplishment or milepost.

8.3.2. Desired Future Conditions for Terrestrial Species

Listed Species

Restoration of the Columbia and Oregon spotted frog populations to historical range is an ambitious objective. Achieving this objective is dependent upon restoration of suitable riparian and herbaceous wetland habitats. However, other than recovery of habitat, the most important limiting factor may be predation from the exotic bull frog. Restoration of the spotted frog populations may well depend on control or eradication of the bull frog.

The white-headed woodpecker is limited by suitable habitat, defined by large pine trees that have large cones and seeds for feeding and snags for nesting cavities. The status of the population within the subbasin is unknown. Current forest management and development generally limit the opportunities for providing an appreciable increase in large, or old growth, pine. The woodpecker population could remain stable or decline depending on future timber harvest and management activities on private and public timberlands.

Greater sage grouse numbers have declined because of the loss or conversion of shrub-steppe habitat and the corresponding reduction in sagebrush and associated herbaceous vegetation within the subbasin. Restoration of this population is dependent upon recovery of this habitat. Habitat recovery may include control or removal of invading western juniper and exotic plants and revisions in livestock grazing practices.

Non-listed species

Beaver numbers and distribution would increase in number and distribution throughout their historic habitat. This increase would be in response to riparian and floodplain restoration projects. The beaver could also act as an important tool to aid in the recovery of streams and associated focal fish populations.

Mule deer populations will fluctuate with climatic and local weather conditions. Loss, fragmentation or degradation of winter range, accidents and harvest will limit deer numbers. Numbers may increase in some areas as animals adapt and utilize developed rural/suburban areas where harvest opportunities are limited by development and safety concerns.

Golden eagle numbers are likely to remain static for the foreseeable future. The availability of desirable nesting habitat associated with roughed canyons and rim rock may limit population growth. However, restoration of upland grassland and shrub-steppe habitat may increase food sources and provide opportunities for increased population distribution and use of other suitable nesting habitat.

Habitat

The conversion of large blocks of former cropland back into permanent grass in the north and eastern portion of the subbasin has not only improved watershed health, but has reduced erosion and provided a substantial increase in grassland habitat. Grassland habitat restoration provides added benefit to a variety of wildlife species when native grass species are incorporated into the initial re-seeding mixture. Similarly treatment of large tracts of invading Western juniper will also help to restore grassland and shrub-steppe habitat important for sage grouse and mule deer. Both upland habitat restoration scenarios indirectly provide the opportunity to increase numbers of beaver and spotted frogs, in response to improved stream flows. The golden eagle and other predators can also benefit from increases in numbers of preferred prey species that respond to the change in habitat type.

Ongoing forest management restoration, aimed at reversing the pine woodland habitat invasion by mixed conifer species through selective harvest, thinning and under burns could help to stabilize the area currently designated as Ponderosa and Lodgepole pine woodlands. These measures may help to stabilize the white-headed woodpecker population or increase their numbers and distribution. However, the long-term outlook for old growth pine trees is dependent upon future subbasin development, forest management priorities and commodity valuation.

Riparian habitat restoration is a high priority throughout the basin. There are numerous examples of past and ongoing treatment projects that have already shown stream, fish and wildlife benefits. More projects are ongoing or in the planning phase. This projected recovery of this single-most important wildlife habitat will have far-reaching benefits to a wide variety of wildlife species. In addition, there are a number of state and federal incentive programs providing funding and technical support for many of these projects. This helps to insure the restoration and maintenance of this important habitat.

8.4. Near-term Opportunities

Based on analyses conducted during this planning process, resource managers concluded that for depressed, fragmented or isolated resident focal fish populations the most effective habitat and population restoration strategy is to begin with recovery of core populations and core habitat. Habitat restoration will preferably occur in a reverse domino effect. Core habitats will be expanded downstream to build on the benefits of previous restoration work. In areas where headwaters are degraded — or where the system is influenced by flashy or uncontrolled stream flows — habitat restoration for focal fish populations will take place progressively from the upper-most degraded reaches downstream, and restoration projects will include upland restoration work to maintain a ridge top-to-ridge top approach. Where headwater areas are in good condition, habitat restoration will begin in at the upper end of a degraded priority reach and work progressively downward. In areas where the system is hydrologically stable and habitat restoration is not at risk of loss from an uncontrolled flow situation, the most cost effective habitat restoration opportunities for restoring core fish populations may exist in lower watersheds. Substantial gains in fish potential production in lower reaches may be achieved if stream reaches are not subject to extremely flashy flows and opportunities become available to work with cooperating landowners.

Habitat restoration projects will focus on the focal fish limiting factors identified in the subbasin assessment. Remedial measures implemented to restore vegetative diversity and recovery of stream channel stability and diversity will require many years or decades to achieve the desired objective. Restoration of fish passage at manmade obstructions or unusual debris jams will frequently produce rapid response when fish begin to access historical habitat. The time required to implement these remedial fish passage projects could be substantially less than the time required for measurable stream or upland habitat recovery to produce measurable increases in fish production.

8.4.1. Habitat for High Priority Protection

EDT and QHA results indicated that a number of stream reaches provide core habitat for focal species, including important spawning and rearing habitat, and key habitat for ESA-listed species. The fish technical team determined that these stream reaches deserve high priority protection because of their importance in meeting desired biological objectives during the 25-year planning horizon. Stream reaches with high protection values for the Deschutes Subbasin are listed in Table 8.2 and displayed in (Map 25).

Further, twenty-one of the high priority protection reaches were identified as high candidates for future monitoring and evaluation. These twenty-one reaches display desired stream habitat conditions for the Deschutes Subbasin and will serve as reference reaches for monitoring and evaluation (Map 26). The list of reference reaches (Table 8.3) generally includes streams identified by the QHA and EDT habitat assessment procedures as assessment unit streams that had high habitat protection value. Streams were selected for each of the eight subbasin plan assessment units based from three broad stream type categories – Cascade Foothill - snowmelt driven; Groundwater or spring-fed; and Draining semi-arid landscapes. Reaches were also selected from a range of elevations and upland habitat types. Focal fish species use of these reaches was also considered. Some assessments units generally lacked good representative reaches and in these instances reaches were selected that may provide examples of some desirable attributes, rather than the complete ecosystem package.

Table 8.2. Deschutes Subbasin - Priority Protection Stream Reaches.

Reach Name	Reach Description	Importance
Lower Deschutes MS-2 to MS-8	From lower Moody Rapids to Buck Hollow Creek	Fall Chinook spawning/rearing, steelhead, spring Chinook rearing and migration corridor
Buck Hollow Cr-1 to Buck Hollow Cr-3	From mouth to Macken Canyon	Summer steelhead spawning/rearing
Little Badger Creek	From mouth to headwaters	Core redband population
Jordan Cr-3 to Jordan Cr-4	From Jordan Creek Falls to headwaters	Core redband trout population
Tygh Cr-5	From Tygh Creek Falls to headwaters	Core redband trout population
Threemile Cr-3	From irrigation upper diversion to headwaters	Core redband trout population
Boulder Cr-4 (White)	From irrigation diversion to headwaters	Core redband trout population
Bakeoven Cr-1 to Bakeoven Cr-4	From mouth to Deep Creek	Summer steelhead spawning/rearing
Deep Cr-1	Mouth to Cottonwood Creek	Summer steelhead spawning/rearing
Cottonwood Cr-1	Mouth to Ochoco Gulch	Summer steelhead spawning/rearing
L Deschutes MS-13 to L Deschutes MS-21	From Bakeoven Creek to Pelton Reregulation Dam	Fall Chinook, steelhead, redband trout spawning and rearing
Warm Springs R-3 to Warm Springs R-9	Warm Springs Hatchery Dam to Trapper Springs Meadow	Bull trout, Spring Chinook, steelhead spawning/rearing
Beaver Cr-1 to Beaver Cr-6	Mouth to headwaters	Spring Chinook and summer steelhead spawning/rearing
Mill Cr-1 to Mill Cr-3	Mouth to headwaters	Spring Chinook adult holding, spawning and rearing
Badger Cr	Mouth to falls	Spring Chinook and summer steelhead spawning/rearing
Trout Cr-5 and 6	From Antelope Creek to Little Trout Creek	Summer steelhead and redband trout spawning and rearing.
Trout Cr-11 to 15	From Amity to Potlid Creek	Summer steelhead and redband trout spawning and rearing.
Board Hollow Creek	Mouth to headwaters	Summer steelhead and redband trout spawning and rearing.
Foley Cr-1 and 2	Mouth to falls	Summer steelhead and redband trout spawning and rearing.
Big Log Cr-1 and 2	Mouth to headwaters	Summer steelhead and redband trout spawning and rearing.
Dutchman Cr	Mouth to headwaters	Summer steelhead and redband trout spawning and rearing.
Little Deschutes R-1 and 2	From mouth at U Deschutes R to Gilchrist Mill Pond Dam	Remnant redband trout population
Crescent Cr-1 and 2	From mouth at Little Deschutes to Big Marsh Creek	Remnant redband trout population
Odell Cr-1	From mouth at Davis Lake to outlet of Odell Lake	Redband trout spawning/rearing, bull trout rearing and foraging
Maklaks Cr	From mouth Odell Cr to headwaters at 5000 ft level	Potential bull trout spawning and rearing
Crystal Cr-2	From edge of Odell Lake to headwaters at 5500 ft level	Potential bull trout spawning and rearing
Trapper Cr-1	From mouth at edge of Odell Lake to falls near footbridge and 4920 ft level	Bull trout spawning/rearing
Jefferson Cr	Mouth to headwaters	Bull trout spawning/rearing
Candle Cr	Mouth to Cabot Creek	Bull trout spawning/rearing
Abbot Cr	Mouth to headwaters	Bull trout spawning/rearing
Canyon Cr-1 (Met)	Mouth to Roaring Creek	Bull trout and spring Chinook spawning/rearing

Reach Name	Reach Description	Importance
Roaring Cr	Mouth to headwaters	Bull trout spawning/rearing
Jack Cr-1	Mouth to Heising Spring	Bull trout and spring Chinook spawning/rearing
Heising Springs	Jack Creek to head spring	Bull trout and spring Chinook spawning/rearing
Jack Cr-2	Heising Spring to headwaters	Bull trout spawning/rearing
First Cr	Mouth to headwaters	Redband trout spawning
Metolius MS-12 to Metolius MS-14	From First Creek to head of the Metolius	Redband, bull trout and spring Chinook spawning/rearing
Lake Cr MF-1 and 2	From mouth to SF divergence	Steelhead and redband trout spawning/rearing
Lake Cr SF	From reconnection at MF Lake Cr to divergence from the MF of Lake Cr	Steelhead and redband trout spawning/rearing
Lake Cr-1	From SF/MF divergence from Lake Cr to Suttle Lake Dam #52262	Steelhead and redband trout spawning/rearing
Link Cr-1	From mouth at Suttle Lake to Blue Lake Outlet Dam #50324	Sockeye salmon spawning
Crooked MS-2 and 4	From Lake Billy Chinook to Highway 97	Bull trout, redband rearing
McKay Cr-3	From Little McKay Cr to spring at Harvey Gap	Redband trout core population
Ochoco Cr-1	From mouth at Crooked R to Ochoco Dam #50354	Redband trout core population
Mill Cr-2 (Ochoco)	From Nat'l Forest boundary at section line 10/15 to EF/WF confluence	Redband trout spawning and rearing
Mill Cr EF (Ochoco)	From confluence with WF and mainstem Mill Cr to spring near Whistler Point	Redband trout spawning and rearing
Mill Cr WF (Ochoco)	From confluence with EF and mainstem Mill Cr to Rock/Hawthorne Spring	Redband trout spawning and rearing
Marks Cr-4	From Res. Dam #50356 in section to spring NW of Ochoco Pass	Redband trout spawning and rearing
Ochoco Cr-6	From Marks Cr to Canyon Cr	Redband trout spawning and rearing
Canyon Cr (Och)	From mouth at Ochoco Cr to 5800 ft level	Redband trout spawning/rearing
Ochoco Cr-7	From Canyon Cr to Ahalt Cr	Redband trout spawning/rearing
Crooked MS-12 and 14	From Ochoco Irrigation Diversion to Bowman Dam	Redband trout, spring Chinook and steelhead spawning/rearing
Crooked NF-6 and 7	From Upper Falls in section 21 to lower end of Big Summit Prairie just W of Nelson Road	Core redband trout population
Deep Cr-1 and 2 (Crooked)	From mouth at NF Crooked R to Happy/Jackson Cr confluence	Core redband trout population
Little Summit Cr	From mouth at Deep Cr to junction of FS roads 12 and 4270 in section 20	Core redband trout population
Jackson Cr	From mouth at end of Deep Cr to Double Corral Cr	Core redband trout population
Double Corral Cr	From mouth at Jackson Cr to Blevins Springs	Redband trout spawning and rearing
Crooked NF-10 and 11	From upper end Big Summit Prairie at section line 29/32 to headwaters at Sera Springs	Redband trout spawning and rearing
Lookout Cr	From mouth at NF Crooked R to 6000 ft level	Redband trout spawning and rearing
Wolf Cr	From mouth at Beaver Cr to headwaters at Wolf Spring	Core redband trout population
Beaver Cr NF (SF Crooked)	From confluence with SF/mainstem Beaver Cr to headwaters at Hawk Res.	Core redband trout population
Beaver Cr SF-2 through 4(SF Crooked)	From Swamp Cr to headwaters at spring below 6000 ft level	Core redband trout population
Dobson Cr	From mouth at SF Beaver Cr to headwaters at Dobson Spring	Core redband trout population

Reach Name	Reach Description	Importance
Freeman Cr	From mouth at SF Beaver Cr to headwaters at spring below 6000 ft level	Core redband trout population
Squaw Cr-1	From mouth at Deschutes R to Alder Springs	Bull trout foraging, redband trout, steelhead, spring Chinook spawning/rearing
M Deschutes MS-10	From Steelhead Falls to Big Falls	Bull trout foraging, redband trout, steelhead, spring Chinook spawning/rearing
U Deschutes MS-9 through U Deschutes MS-15	From upstream end of Mill Pond/Southern Crossing bridge to Spring R	Core redband trout population
Odell Cr-1 and 2	From mouth at Davis Lake to outlet of Odell Lake	Redband trout spawning and rearing, bull trout foraging
Maklaks Cr	From mouth Odell Cr to headwaters at 5000 ft level	Bull trout foraging, potential spawning
Crystal Cr-2	From edge of Odell Lake to headwaters at 5500 ft level	Bull trout foraging, potential spawning
Trapper Cr-1 and 2	From mouth at edge of Odell Lake to 5200 ft level	Bull trout spawning and rearing

Table 8.3. Subbasin Reference Stream Reaches.

Stream Segment	Description / Location	Attribute	Fish Use	Other
Shitike Cr-3 and 4	Upper road crossing to headwaters	Pristine stream and riparian conditions, mid-elevation	Spring Chinook, Pacific lamprey and Bull trout Spawning and rearing	Steelhead and redband trout spawn downstream
Lower Deschutes MS-1	From Shitike Creek confluence to Pelton Reregulation Dam	Spawning and rearing habitat, stable flow, good riparian diversity, low elevation	Fall Chinook, Steelhead and redband trout spawning and rearing	Migration corridor if fish passage is restored at the Pelton Project
Trout Cr-14 though 16	From Cartwright Cr confluence to headwaters	Spawning and rearing habitat, good riparian diversity, mid-elevation	Summer steelhead and redband trout spawning and rearing	Part of ongoing habitat recovery project
Trout Cr-5	Antelope Cr to Tub Springs Cr	Adult holding, spawning and rearing habitat, low elevation	Summer steelhead and redband trout	Part of ongoing habitat recovery project
Tygh Cr-1	From mouth to Badger Cr confluence	Spawning habitat, riparian vegetation, low elevation	Redband trout – genetically unique population	Past habitat recovery project, some habitat deficiencies remain
Badger Cr-4	Highland Diversion to Pine Cr	Pristine, wilderness stream, mid-elevation	Redband Trout	Diverse instream and riparian habitat
Middle Deschutes R-8 and 10	From Lake Billy Chinook to Big Falls	Natural, canyon reach with good spawning gravel and instream structure	Redband trout and potential steelhead and spring Chinook spawning and rearing	Flow is mostly spring-fed, anadromous fish use dependent on Pelton fish passage
Metolius MS-14	Lake Cr to Head of Metolius Spring	Large spring-fed, constant flow, high water quality, mid elevation	Redband trout spawning and rearing, bull trout foraging, potential Chinook and steelhead spawning and rearing	Anadromous fish use dependent on Pelton fish passage
Mill Cr EF (Ochoco)	From confluence of East and West forks to headwaters	Natural Ochoco Forest stream, mid-elevation	Redband trout spawning and rearing	
Ochoco Cr-7	From Ahalt Cr to source.	Natural Ochoco Forest stream, mid-elevation	Redband trout spawning and rearing	
Canyon Cr (Ochoco)	From Ochoco Cr to headwaters	Natural Ochoco Forest stream, mid-elevation	Redband trout spawning and rearing	

8.4.2. Habitat to Reestablish Access

A number of manmade structures are obstacles or barriers to focal fish passage within the subbasin. Table 8.4 shows obstructions in the subbasin with a high priority for remedial measures to provide passage and protective screening, where needed. Stream Fish Passage Limitations in the subbasin are shown on Map 27.

8.4.3. Habitat for Restoration

Subbasin High Priority Stream Reaches

Ten high priority fish habitat restoration projects or scenarios were identified in the Deschutes Subbasin (Table 8.5). The reaches were selected based on several criteria. Those criteria included 1) consideration of priority ranking developed by the EDT habitat assessment model for Chinook salmon and summer steelhead and the QHA model for redband and bull trout in the eight subbasin assessment units; 2) the obvious benefits to be realized from restoration of fish passage at artificial barriers; 3) the number and significance of focal fish species that would benefit from project completion; 4) location in the subbasin in relation to identified core fish populations and habitats; and 5) location in relationship to remnant functional watershed, riparian and wetland habitats - usually in the uppermost stream reaches in a drainage, or downstream from a significant hydraulic control (i.e. reservoir dam or lake outlet).

For example, restoration of fish passage at the Pelton Round Butte Complex would re-establish access to appreciable historic anadromous fish habitat, connectivity for resident fish populations and thus benefit most focal fish species. Substantial planning and design work to provide passage has already been completed by Portland General Electric and the Confederated Tribes of Warm Springs, who are required by their federal hydroelectric license to restore fish passage.

Restoration of riparian and instream habitat along the lower Deschutes River is proposed for a stream segment below a three dam complex with generally stable flows. The QHA and EDT models both ranked these river reaches a high priority for restoration. The project would benefit all focal fish species by providing a migration corridor, adult holding, and spawning and/or rearing habitat.

It is also important to note that several high priority habitat restoration projects identified above the Pelton Round Butte Complex received their high ranking based on the assumption that fish passage will be restored. The priority of these projects would likely be significantly reduced if attempts to restore fish passage at the hydroelectric project are unsuccessful.

Stream Reaches with High Restoration Value

Other stream reaches with high restoration values in the Deschutes Subbasin are identified in Table 8.6 and displayed in Map 28. Stream reaches with high restoration value reflect historical focal fish species use and potential for increasing focal fish production, distribution and re-establishing population connectivity. Some stream reaches appear on both the Conservation and Restoration lists because — while they still provide critical habitat — they have experienced some past degradation. Although the habitat is important, restoration for some habitat attributes is needed to maintain or increase habitat quality.

Table 8.4. Deschutes Subbasin fish Passage Obstructions/Barriers.

Stream Reach	Description	Details
L Deschutes MS-10	Sherars Falls - #50360, Deschutes River RM 43	Important for upstream focal fish passage. Old, below standard fish ladder
Tygh Cr-1 through 3	Mouth to Tygh Creek Falls	Redband trout population connectivity Two seasonal stop-log and three push-up dams, no ladder or screen
Badger Cr-1 through 3 (Tygh)	Mouth to diversion dam/weir in section 29	Redband trout population connectivity. One permanent and one seasonal stop-log dam, one push-up dam, no ladder or screen
Badger Cr-6 (Tygh)	Badger Lake Dam #51837	Permanent earth-fill dam. No upstream fish passage or screening
White R MS-4	From Tygh Cr to Threemile Cr	Redband trout population connectivity. Unscreened diversion, no ladder or screen
Threemile Cr-2	Diversion Dam in NE corner of section 10	Redband trout population connectivity. Two permanent stop-log dams, no ladder or screen
Gate Cr-2	Diversion Dam in NE corner of section 21	Redband trout population connectivity. One permanent stop-log dam, no ladder or screen
Rock Cr-3	Rock Cr Res. Dam #50362	Redband trout population connectivity. One permanent earth-fill dam, no ladder or screen
Forest Cr-2	Diversion Dam near road crossing in NW corner of section 35	Redband trout population connectivity. One permanent stop-log dam, no ladder or screen
Boulder Cr-3 (White)	Diversion Dam at section line 27/26	Redband trout population connectivity. One permanent stop-log dam, no ladder or screen
Frog Cr-2	Diversion Dam in NE corner of section 34	Redband trout population connectivity. One permanent stop-log dam, no ladder or screen
Clear Cr-3	Diversion Dam in middle of section 10	Redband trout population connectivity. One permanent stop-log dam, no ladder or screen
Clear Cr-5	Wasco Dam #51292 at Clear Lake	Redband trout population connectivity. One permanent earth-fill dam, no ladder or screen
Nena Cr-2	Falls - #53183 just above 1200 ft level	Summer steelhead, redband trout population connectivity. Natural cascade, partial barrier at some flows.
Warm Springs MS-3	From National Fish Hatchery Dam at section line 19/24 to Beaver Cr	Operational fish ladder fish trap and screening
Mud Springs Cr-2	Culvert - RR #53204 in section 15	Summer steelhead, redband trout population connectivity. High gradient concrete box culvert with 10’ drop
Mud Springs Cr-5	Culvert - just upstream of Clark Drive crossing in the town of Gateway	Redband trout population connectivity. Concrete dam, no ladder or screen
Hay Cr-2	Falls - #53202 at gradient change in SW corner of section 17	Summer steelhead, redband trout population connectivity. Cascade from stream relocation
Antelope Cr-1	From mouth at Trout Cr to Ward Cr	Summer steelhead, redband trout population connectivity. One seasonal push-up dam screened, no upstream passage
Trout Cr-7 through 11	From Little Trout Cr to Board Hollow Cr	Summer steelhead, redband trout population connectivity. Numerous seasonal push-up and one stop-log dam, no upstream passage, except at stop-log dam, all screened
Clover Cr	From mouth at Trout Cr to tributary just above 3400 ft level	Summer steelhead, redband trout population connectivity. One seasonal push-up dam, no screen or upstream passage
Foley Cr-3	Falls - just upstream of road crossing in the center section 28	Summer steelhead, redband trout population connectivity. Debris jam, no upstream passage
L Deschutes MS-22	Pelton Reregulation Dam #50363	No fish passage or screen
M Deschutes MS-1	Pelton Dam # 50364	No fish passage or screen
M Deschutes MS-3	Round Butte Dam #50308	No fish passage or screen

Table 8.4. Deschutes Subbasin fish Passage Obstructions/Barriers (Continued)

Stream Reach	Description	Details
Willow Cr-3 through 6	From City limits of Madras to road crossings in headwaters section 20	Redband trout population connectivity. Several seasonal push-up dams, no screen or upstream passage
Willow Cr-5	Morrow Res. Dam	Redband trout population connectivity. No fish passage or screen
Spring Cr-2 (Met)	Barrier at top of pond in section 10	No fish passage or screen
Lake Cr MF-1	From mouth at Metolius R to SF Lake Cr	Redband trout, steelhead and sockeye population connectivity. Diversions with no screens and restricted passage.
Lake Cr SF	From reconnection at MF Lake Cr to divergence from the MF of Lake Cr	Redband trout, steelhead and sockeye population connectivity. Diversions with no screens and restricted passage.
Lake Cr MF-2	From reconnection of SF Lake Cr to area where SF diverges from MF Lake Cr	Redband trout, steelhead and sockeye population connectivity. Diversions with no screens and restricted passage.
Lake Cr-2	Suttle Lake Dam #52262	Redband trout, steelhead and sockeye population connectivity. Limited passage.
Link Cr-2	Blue Lake Outlet Dam #50324	Redband trout, steelhead and sockeye population connectivity. No passage or screens.
Crooked MS-3	Opal Springs Dam #50346	Redband trout, steelhead, spring Chinook and Pacific lamprey population connectivity. Restricted passage, no screens.
Crooked MS-6	North Unit Irrigation District flume crossing to McKay Cr	Redband trout, steelhead, spring Chinook and Pacific lamprey population connectivity. Seasonal diversion dam, no passage or screen
McKay Cr-1	From mouth at Crooked R to Allen Cr	Redband trout, steelhead and Pacific lamprey population connectivity. Seasonal diversions
Allen Cr (Crooked MS)	From mouth at McKay Cr to confluence of Fall Cr	Redband trout, steelhead and Pacific lamprey population connectivity. Seasonal diversions
McKay Cr-2	From Allen Cr to Little McKay Cr	Redband trout, steelhead and Pacific lamprey population connectivity. Seasonal diversions
Ochoco Cr-1	From mouth at Crooked R to Ochoco Dam #50354	Redband trout, steelhead, spring Chinook and Pacific lamprey population connectivity. One permanent dam no passage or screen
Ochoco Cr-2	Ochoco Dam #50354	Large earth-fill dam, no passage or screens
Mill Cr-1 (Ochoco)	Mouth to National Forest boundary	Redband trout population connectivity. One permanent dam no passage or screen
Ochoco Cr-5 and 6	Ochoco Reservoir to Canyon Creek	Redband trout population connectivity. Three permanent dams, one with no passage or screen, numerous push-up dams
Crooked MS-9	Peoples Irrigation Dist Diversion #50348 in SW corner of section 8	Redband trout, steelhead, spring Chinook and Pacific lamprey population connectivity. Permanent structure no passage.
Crooked MS-11	Ochoco Irrigation District Diversion just below Dry Cr	Redband trout, steelhead, spring Chinook and Pacific lamprey population connectivity. Permanent structure no passage.

Table 8.4. Deschutes Subbasin fish Passage Obstructions/Barriers (Continued)

Stream Reach	**Description**	**Details**
Crooked MS-13	Rice-Baldwin Diversion #50350 just upstream of Dry Cr	Redband trout, steelhead, spring Chinook and Pacific lamprey population connectivity. Permanent structure no passage.
Crooked MS-14	Rice-Baldwin Diversion #50350 to Bowman Dam	Redband trout, steelhead, spring Chinook and Pacific lamprey population connectivity. Permanent structure no passage.
Crooked MS-15	Arthur R Bowman Dam #50352	Large earth-fill dam. No passage or screening.
Bear Cr-2	From edge of Prineville Res. in section 19 to Little Bear Cr	Redband trout population connectivity. Channel incision with resulting waterfall.
Little Bear Cr	From mouth at Bear Cr to tributary at 4480 ft level	Redband trout population connectivity. Channel incision with resulting waterfall.
Bear Cr-4	Antelope Flat Dam #52019	Redband trout population connectivity. Large earth-fill dam. No passage or screening.
Crooked MS-18 through 21	Prineville Reservoir to Beaver Creek	Redband trout population connectivity. Numerous seasonal push-up dams. No passage or screening.
Horse Heaven Cr-2	Bonnie View Dam #51887 at Horse Heaven Res.	Redband trout population connectivity. Large earth-fill dam. No passage or screening.
Newsome Cr	Mouth to headwaters	Redband trout population connectivity. Road culvert seasonal barrier.
Pine Cr-2 (Crooked)	Pine Cr Res. Dam	Redband trout population connectivity. Earth-fill dam. No passage or screening.
Crooked NF-1	Mouth to lower falls	Redband trout population connectivity. Two permanent diversions, no passage or screens.
Crooked NF-8 and 9	From lower end Big Summit Prairie just W of Nelson Road to upper end of Big Summit Prairie	Redband trout population connectivity. Series of large check dams, passage only at high stream flow.
Howard Cr-1	From mouth at NF Crooked R to Allen Cr	Redband trout population connectivity. Series of large check dams, passage only at high stream flow.
Allen Cr-1 (NF Crooked)	From mouth at Howard Cr to Allen Cr Res. Dam #50343	Redband trout population connectivity. Series of large check dams, passage only at high stream flow.
Allen Cr-2 (NF Crooked)	Allen Cr Res. Dam #50343	Redband trout population connectivity. Earth-fill dam no passage or screens.
Crooked NF-11	Lookout Creek to headwaters	Redband trout population connectivity. Channel incision, headcuts are low flow barriers.
Camp Creek	Mouth at Crooked River to headwaters at Double Cabin Pond	Redband trout population (extirpated) connectivity. Permanent barrier dam at RM 3, no passage or screens.
Beaver Cr-1 and 2(SF Crooked)	From confluence with SF Crooked R to NF/SF confluence	Redband trout population connectivity. Seasonal push-up dams no passage or screens.
Wolf Cr	From mouth at Beaver Cr to headwaters at Wolf Spring	Redband trout population connectivity. Seasonal push-up dams no passage or screens.
Beaver Cr NF (SF Crooked)	From confluence with SF/mainstem Beaver Cr to headwaters at Hawk Res.	Redband trout population connectivity. Diversions and check dams passable only ay high flow, no screens.

Table 8.4. Deschutes Subbasin fish Passage Obstructions/Barriers (Continued)

Stream Reach	Description	Details
Beaver Cr SF-1 and 2 (SF Crooked)	From confluence with NF/mainstem Beaver Cr to Dobson Cr	Redband trout population connectivity. Seasonal push-up dams, permanent dams passage at high flow or no passage, no screens.
Dobson Cr	From mouth at SF Beaver Cr to headwaters at Dobson Spring	Redband trout population connectivity. Seasonal push-up dams no passage or screens.
Twelvemile Cr-2	Williams Res. Dam #50329	Redband trout population connectivity. Earth-fill dam no passage or screens.
Crooked SF-4	Logan Res. Dam #53322	Redband trout population (extirpated) connectivity. Large dam no passage or screens.
Squaw Cr-4	Sokol Diversion Dam in section 17	Steelhead and spring Chinook (extirpated) redband and bull trout connectivity, Permanent diversion no passage or screen
Squaw Cr-6	Squaw Cr Irrigation District Diversion in section 21	Steelhead and spring Chinook (extirpated) redband and bull trout connectivity, Permanent diversion no passage or screen
M Deschutes MS-9	Steelhead Falls	Steelhead and spring Chinook (extirpated) redband and bull trout connectivity, passage at high flow and old fish ladder.
Tumalo Cr-1 and 2	Mouth to Tumalo Feed Canal Dam #51308	Redband trout connectivity. Marginal upstream passage at higher flow
U Deschutes MS-1	North Unit Main Canal Dam #50317	Redband trout connectivity. No upstream passage, screened
U Deschutes MS-3	Steidl Dam (N Unit Div) #52147 at section line 29/32	Redband trout connectivity. Upstream passage limited by hydraulic conditions
U Deschutes MS-5	Bend Diversion Dam #50319 (Powerhouse)	Redband trout connectivity. No upstream passage
U Deschutes MS-7	Colorado Street Dam	Redband trout connectivity. Marginal upstream passage limited by marginal denil fishway
Crescent Cr-5	Crescent Lake Dam #51297	Redband trout connectivity. No upstream passage or screens
Little Deschutes R-3	Gilchrist Mill Pond Dam	Redband trout connectivity. Poor upstream passage, no screens
U Deschutes MS-19	Wickiup Dam #50322	Redband trout connectivity. No upstream passage, no screens
U Deschutes MS-24	Crane Prairie Dam #50323	Redband trout connectivity. No upstream passage, no screens
Odell Cr-1 and 2	Davis Lake to Odell Lake	Redband and bull trout connectivity, partial passage barrier at road culvert and rock dam at lake outlet.
Maklaks Creek	Mouth to headwaters	Potential bull trout habitat. Road culvert partial barrier.
Crystal Cr-2	Mouth to headwaters	Potential bull trout habitat. Railroad culvert partial barrier.
Deer Creek	Mouth to Little Cultus Lake	Redband trout connectivity. Partial passage at three road culverts and lake outlet.

Table 8.5. Top Ten Habitat Restoration Priorities for the Deschutes Subbasin.

Stream Reach(s)	Species Affected	Strategies	Feasibility	Cost
Trout Creek Riparian and Instream Habitat Restoration: Trout Cr-1 through 16	Summer Steelhead, Redband Trout, Pacific Lamprey, Bull Trout	• Increase minimum stream flow • Restore fish passage to historical habitat • Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Restore upland watershed, riparian and floodplain function • Reduce maximum water temperature • Reduce channel width • Reduce fine sediments in substrate	Good chance of success, some reaches are responding to treatment from ongoing project	**Low to moderate**
Squaw Creek Riparian and Instream Habitat Restoration: Squaw Cr-1 through 6	Summer Steelhead (extirpated), Spring Chinook (extirpated), Redband Trout, Pacific Lamprey (extirpated), Bull Trout (extirpated)	• Increase minimum stream flow • Provide fish passage and screening at diversions • Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Restore upland watershed, riparian and floodplain function • Reduce maximum water temperature • Reduce channel width • Reduce fine sediments in substrate	Good chance of success, collaborative projects planned and under way, broad-based support, anadromous species dependent on Pelton Passage	**Moderate**
Middle and Upper Deschutes River Instream and Riparian Habitat Restoration: M Deschutes MS-10 through MS-15 and Upper Deschutes MS-1 through MS-18	Redband Trout, Bull Trout (extirpated)	• Increase minimum stream flow • Provide fish passage and screening at diversions • Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Restore riparian function • Reduce maximum water temperature extremes • Reduce channel width • Reduce fine sediments in substrate	Good chance, but dependent upon significant water conservation measures for irrigation water transport and application	**High** (i.e. canal lining or piping)

(Table 8.5. Top Ten Habitat Restoration Projects in Deschutes Subbasin continued)

Stream Reach(s)	Species Affected	Strategies	Feasibility	Cost
Lower Crooked River Instream and Riparian Habitat Restoration: Crooked MS-5 through 14 McKay Cr-1 through 3 Allen Cr Little McKay Cr Ochoco Cr-1	Redband Trout, Summer Steelhead (extirpated), Spring Chinook (extirpated), Bull Trout, Pacific Lamprey (extirpated)	• Increase minimum stream flow • Provide fish passage and screening at diversions • Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Restore upland watershed, riparian and floodplain function • Reduce maximum water temperature • Reduce channel width • Reduce fine sediments in substrate	Success depends on collaborative restoration projects, including water allocation from Prineville Reservoir, anadromous species dependent on Pelton Passage	**Moderate to High** (i.e. fish passage and screening at diversion structures)
Lake Creek and Link Creek Fish Passage Improvement: Lake Cr-2 and Link Cr-2	Redband Trout, Bull Trout, Sockeye Salmon (extirpated), Summer Steelhead (extirpated)	• **Modify or breach dams to provide fish passage** • **Provide protective fish screening**	**High** Plans are underway to modify the Link Creek Dam. Lake Creek Dam is small structure	**Low to moderate**
North Fork Crooked River Instream and Riparian Habitat Restoration: Crooked NF-6 upstream to headwaters	**Redband Trout**	• Increase minimum stream flow • Provide fish passage and screening at diversions • Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Restore upland watershed, riparian and floodplain function • Reduce maximum water temperature • Reduce channel width • Reduce fine sediments in substrate	**Moderate to High** Success depends on collaborative restoration projects with good landowner cooperation	**Moderate**

Table 8.5. Top Ten Habitat Restoration Projects in Deschutes Subbasin continued)

Stream Reach(s)	Species Affected	Strategies	Feasibility	Cost
Beaver Creek (Warm Springs) Instream and Riparian Habitat Restoration: Beaver Cr-1 through 5	Spring Chinook, Summer Steelhead, Redband Trout, Pacific Lamprey	• Increase minimum stream flow • Restore channel length and sinuosity • Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Restore upland watershed, riparian and floodplain function • Reduce maximum water temperature • Reduce channel width • Reduce fine sediments in substrate	**Moderate to High** (i.e. could include relocation of Highway 26)	**Moderate**
Tygh and Badger Creek Instream and Riparian Habitat Restoration: Tygh Cr-1 and 2, Badger Cr-1 and 2	Redband Trout	• Increase minimum stream flow • Provide fish passage and screening at diversions • Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Restore upland watershed, riparian and floodplain function • Reduce maximum water temperature • Reduce channel width • Reduce fine sediments in substrate	**Good** Depends on significant water conservation measures including canal lining or piping.	**Moderate**
Riparian and Instream Habitat Restoration Lower Deschutes River: L Deschutes MS-5 through 21	Summer Steelhead, Spring Chinook, Fall Chinook Sockeye Salmon (extirpated), Redband Trout, Bull Trout, Pacific Lamprey	• Restore/increase riparian habitat diversity/complexity • Increase instream habitat complexity • Reduce channel width • Reduce fine sediments in substrate from Reregulation Dam to White River	Good chance of success, some reaches are responding to treatment	**Low to moderate**
Restore Fish Passage at Pelton Round Butte Project: L Deschutes MS-22 and 23, M Deschutes-1to 3	Summer Steelhead, Spring Chinook, Sockeye Salmon (extirpated), Redband Trout, Bull Trout, Pacific Lamprey	• Install multi-level outlet structure at Round Butte Dam • Efficiently collect and transport downstream migrants around the hydro project • Collect and transport upstream migrants from Reregulation Dam to Lake Billy Chinook • Prevent out-of-basin stray fish from passing above project	Model shows good feasibility, difficult engineering and hydrological problems	**HIGH** [Project licensee's responsibility]

Table 8.6. Deschutes Subbasin - High Priority Restoration Stream Reaches.

Reach Name	Reach Description	Importance
L Deschutes MS-2 through MS-8	From Lower Moody Rapids just upriver of mouth at lower end of second island to Buck Hollow Cr	Fall Chinook spawning/rearing, steelhead, spring Chinook rearing and migration corridor
Buck Hollow Cr-1 to Buck Hollow Cr-4	From mouth to Thorn Hollow	Summer steelhead spawning and rearing
Thorn Hollow	From mouth at Buck Hollow Cr to spring in section 23	Summer steelhead spawning and rearing
L Deschutes MS-12	From White R to Bakeoven Cr	Fall Chinook spawning/rearing, steelhead and redband trout spawning and rearing, bull trout foraging
Bakeoven Cr-1 to Bakeoven Cr-4	From mouth to Deep Creek	Summer steelhead and redband trout spawning and rearing
Deep Cr-1	Mouth to Cottonwood Creek	Summer steelhead and redband trout spawning and rearing
Cottonwood Cr-1	Mouth to Ochoco Gulch	Summer steelhead and redband trout spawning and rearing
L Deschutes MS-15 through MS-20	From Wapinitia Cr to Shitike Cr	Fall Chinook spawning/rearing, steelhead and redband trout spawning/rearing, bull trout foraging
Warm Springs MS-1 and 3	From mouth at Deschutes R to Beaver Cr	Spring Chinook spawning and rearing, bull trout rearing and foraging
Beaver Cr-1 through 5 (WS)	From mouth at Warm Sp R to Wilson Cr	Spring Chinook and steelhead spawning and rearing
Warm Springs MS-4 through MS-7	From Beaver Cr to Schoolie	Spring Chinook, steelhead and redband spawning and rearing and bull trout rearing/foraging
Mill Cr-1 and 2 (WS)	From mouth at Warm Sp R to Old Mill Camp in section 16	Spring Chinook holding, spawning and rearing
Trout Cr-3 through 16	From Mud Springs Cr to 4800 ft level	Summer steelhead and redband trout migration, spawning and rearing
Shitike Cr-1	From mouth at Deschutes R to upper road crossing above 2300 ft contour	Spring Chinook, steelhead and redband spawning and rearing and bull trout rearing/foraging
Willow Cr-2	From edge of Lake Simtustus to headwaters in section 20	Remnant redband trout population
Metolius MS-8 through 11	From Candle Cr to First Cr	Spring Chinook, redband and bull trout spawning and rearing
Crooked MS-3	Opal Springs Dam #50346	Fish passage obstacle
Crooked MS-5 through 14	From Hwy 97 bridge to Bowman Dam	Redband trout, steelhead, spring Chinook spawning and rearing
McKay Cr-1 through 3	From mouth Cr to spring at Harvey Gap	Summer steelhead and redband trout spawning and rearing
Ochoco Cr-1	From mouth at Crooked R to Ochoco Dam #50354	Redband trout, steelhead, spring Chinook spawning and rearing
Mill Cr-1 and 2 (Ochoco)	From mouth at Ochoco Res. to EF/WF confluence	Redband trout spawning and rearing
Ochoco Cr-5 through 7	From top of Ochoco Res. to Ahalt Cr	Redband trout spawning and rearing
Marks Cr-1 and 2	From mouth at Ochoco Cr to Res. Dam #50356 in section 3 at Mt Bachelor Academy	Redband trout spawning and rearing
Marks Cr-3	Res. Dam #50356 in section 3 at Mt Bachelor Academy	Fish passage obstacle

Table 8.6. Deschutes Subbasin - High Priority Restoration Stream Reaches, continued.

Reach Name	Reach Description	Importance
Marks Cr-4	From Res. Dam #50356 in section 3 at Mt Bachelor Academy to spring NW of Ochoco Pass	Redband trout spawning and rearing
Canyon Cr (Och)	From mouth at Ochoco Cr to 5800 ft level	Redband trout spawning and rearing
Bear Cr-2 and 3	From edge of Prineville Res. in section 19 to Antelope Flat Res. Dam #52019	Redband trout spawning and rearing
Little Bear Cr	From mouth at Bear Cr to trib at 4480 ft level	Redband trout spawning and rearing
Newsome Cr	From mouth at Crooked R to road crossing at 4280 ft level	Redband trout spawning and rearing
Pine Cr-1	From mouth at Crooked R to Pine Cr Rsv Dam	Redband trout spawning and rearing
Pine Cr-2 (Crooked)	Pine Cr Rsv Dam	Fish passage obstacle
Pine Cr-3 (Crooked)	From Pine Cr Rsv Dam to road crossing at 4640 ft level	Redband trout spawning and rearing
Shotgun Cr-1 and 2	From mouth at Crooked R to fork below 5080 ft level	Redband trout spawning and rearing
Drake Cr	From mouth at Shotgun Cr to fork at 5300 ft level	Redband trout spawning and rearing
Crooked NF-6	From Upper Falls in section 21 to Deep Cr	Redband trout core population
Deep Cr-1 and 2 (Crooked)	From mouth at NF Crooked R to Happy/Jackson Cr confluence	Redband trout core population
Little Summit Cr	From mouth at Deep Cr to junction of FS roads 12 and 4270 in section 20	Redband trout core population
Jackson Cr	From mouth at end of Deep Cr to Double Corral Cr	Redband trout core population
Double Corral Cr	From mouth at Jackson Cr to Blevins Springs	Redband trout core population
Crooked NF-8 through 11	From lower end Big Summit Prairie just W of Nelson Road to Lookout Creek	Remnant redband trout population – Core habitat
Howard Cr-1 and 2	From mouth at NF Crooked R to WF Howard Creek	Remnant redband trout population – Core habitat
Allen Cr-1 (NF Crooked)	From mouth at Howard Cr to Allen Cr Res. Dam #50343	Remnant redband trout population – Core habitat
Allen Cr-2 (NF Crooked)	Allen Cr Res. Dam #50343	Fish passage obstacle
Allen Cr-3 and 4 (NF Crooked)	From Allen Cr Res. Dam #50343 Dam to fork in SE corner of section 26	Remnant redband trout population – Core habitat
Lookout Cr	From mouth at NF Crooked R to 6000 ft level	Remnant redband trout population – Core habitat
Wolf Cr	From mouth at Beaver Cr to headwaters at Wolf Spring	Remnant redband trout population – Core habitat
Beaver Cr NF (SF Crooked)	From confluence with SF/mainstem Beaver Cr to headwaters at Hawk Rsv	Remnant redband trout population – Core habitat
Beaver Cr SF-1 through 4 (SF Crooked)	From confluence with NF/mainstem Beaver Cr to Tamarack Creek	Remnant redband trout population – Core habitat
Swamp Cr	From mouth at SF Beaver Cr to fork just above Wade Spring	Remnant redband trout population – Core habitat
Dobson Cr	From mouth at SF Beaver Cr to headwaters at Dobson Spring	Remnant redband trout population – Core habitat

Table 8.6. Deschutes Subbasin - High Priority Restoration Stream Reaches, continued.

Reach Name	Reach Description	Importance
Freeman Cr	From mouth at SF Beaver Cr to headwaters at spring below 6000 ft level	Remnant redband trout population – Core habitat
Crooked SF-1 through 3	From mouth at Crooked R to Logan Res. Dam #53322	Extirpated redband trout
Squaw Cr-1 through 6	From mouth at Deschutes R to upstream irrigation diversion	Spring Chinook, steelhead, bull and redband trout spawning and rearing
M Deschutes MS-12, 14 and 15	From Big Falls to North Unit Main Canal Dam #50317	Remnant redband trout population
U Deschutes MS-1,3,5 and 7	North Unit Main Canal Dam #50317, Steidl Dam (N Unit Div) #52147, Bend Diversion Dam #50319 (Powerhouse) and Shevlin-Hixon Dam #53342 (Colorado St Dam)	Redband trout habitat
U Deschutes MS-2,4,6, and 8 and 9 through 18	From North Unit Main Canal Dam #50317 to upper end of Mill Pond (Southern crossing bridge)	Redband trout
U Deschutes MS-9 through 15	From upper end of Mill Pond (Southern crossing bridge) to Spring River	Core redband trout population
U Deschutes MS-16 through 18	Spring River to Wickiup Dam	Remnant redband trout population
Little Deschutes R-1 and 2	From mouth at U Deschutes R to Gilchrist Mill Pond Dam	Remnant redband trout population
Crescent Cr-1 and 2	From mouth at Little Deschutes to Big Marsh Creek	Remnant redband trout population
Odell Cr-1 and 2	From mouth at Davis Lake to outlet of Odell Lake	Redband trout spawning and rearing, bull trout rearing and foraging
Maklaks Cr	From mouth Odell Cr to headwaters at 5000 ft level	Potential bull trout spawning and rearing
Crystal Cr-2	From edge of Odell Lake to headwaters at 5500 ft level	Potential bull trout spawning and rearing
Trapper Cr-1	From mouth at edge of Odell Lake to falls near footbridge and 4920 ft level	Bull trout spawning and rearing