Crooked River Watershed Assessment

July 2002

Crooked River Watershed Council

CROOKED RIVER WATERSHED ASSESSMENT

Acknowledgements

The Crooked River Watershed Assessment is a project of the Crooked River Watershed Council, whose members are dedicated to working together locally to improve watershed health for environmental and community sustainability. Financial assistance for completion of this document was provided by the Oregon Watershed Enhancement Board. Invaluable technical assistance was received from the Council's numerous technical partners including: Ochoco National Forest, Prineville Bureau of Land Management, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Department of Agriculture, Oregon State University Extension Service, Oregon Watershed Enhancement Board and the Oregon Department of Forestry.

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1. INTRODUCTION

Purpose

The Crooked River Watershed Assessment was prepared by the Crooked River Watershed Council to summarize existing information on watershed and stream conditions and support planning for watershed improvement efforts. Its geographic scope covers the entire Crooked River Basin, including the Lower Crooked, Upper Crooked and Beaver/South Fork Crooked River Sub-basins. The assessment is intended as an initial screening-level effort that will describe existing conditions and identify data gaps and research needs. The document will be updated or changed as new information becomes available or as conditions change. Information obtained through the assessment process will be applied in the adaptive management of the Council's Action Plan and is intended to inform other planning processes regarding natural resources in the basin, including agricultural water quality management plans. The watershed assessment process, technical advisory committee recommendations, and final document will provide an ecological basis for the Council's project efforts as well as for areas and topics requiring additional scientific scrutiny. Information on watershed conditions is essential to the development of relevant watershed objectives and the implementation of action items and projects designed to accomplish these resource objectives. Watershed condition data is also a key component of any long-term watershed monitoring or evaluation program within the basin. In addition, watershed assessments and action plans are increasingly used by government agencies and private foundations in the grant determination process, and help identify benchmarks for evaluating the effectiveness of Council activities.

Background

Watershed assessments and analyses have been conducted at a variety of scales within and including the Crooked River Basin. These documents range from large scale State of Oregon, Columbia River Basin and Deschutes Basin assessments that provide coarse scale information on Crooked River conditions, to individual watershed analyses conducted on federal lands at the watershed or sub-watershed scale and provide a much finer resolution of information but only for a small portion of the basin. The Upper Crooked River Sub-basin Review, a collaborative project among federal agencies initiated by the Interior Columbia Basin Ecosystem Management Project, used an interdisciplinary team and existing data and knowledge to conduct an assessment at the sub-basin scale; extensive information from that project is incorporated into this document (USDA FS 1998b).

There are 52 fifth-field watersheds in the Crooked River Basin, and while more detailed analysis of these areas may be necessary at some time in the future, a process was first needed to assess watershed conditions at the broad scale. The Crooked River Watershed Assessment attempts to answer the 'critical questions' outlined for each major section of the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999), but due to the large area included in the assessment of this eastside system, the assessment process incorporated a

variety of methodology as well as the professional judgement of the technical advisory team and additional experts who provided assistance. Assessment protocol used as reference and broad based guidelines for this process included: The Federal Guide for Watershed Analysis (USDA FS 1995a), the Oregon Watershed Assessment Manual (Watershed Professional Network 1999), the Bradbury Process (Nehlsen 1997), the Oregon Division of State Lands Stage One Watershed Assessment (ODSL 1994), EPA's Rapid Bioassessment Protocols for Use in Streams and Rivers (USDI EPA 1989), Restoring Watersheds: A Tribal Approach to Salmon Recovery (CRITFC 1999), and articles from the December 1997 issue of the Journal Restoration Ecology, devoted to riparian restoration (Harris and Olson 1997, Nehlsen 1997).

A technical team of regional natural resource experts was established to assist the Council in its assessment process. The technical team included representatives of the following disciplines: wildlife biology, fish biology, range, water quality, hydrology and watershed management, vegetation, and data interpretation and analysis. The technical team provided assistance to the Council in the definition of key issues, the development of assessment protocol, data collection and analysis, key findings, data gaps and management recommendations and review of the draft document.

Each section of the assessment includes broad basin-wide information as well as more detailed information, as data was available. A summary of key findings and data gaps is provided at the end of each topical section. Key findings, data gaps and management recommendations, arranged in the same order and topical sections as the main document, are provided in the last chapter of the document, Watershed Condition Summary. Key findings, data gaps and management recommendations were developed from the assessment process, technical team review and comments and existing reports on basin conditions. The final chapter of the document also includes information from an interagency planning process that defined management priorities for the Crooked River Basin (CRWC 2000). The assessment is based on existing data and the professional opinion of local and regional natural resource experts. Data gaps or areas of uncertainty are defined. Major issues for inclusion in the assessment were determined through a review of watershed assessment methodology and then refined in an iterative process between the council and the technical team based on their social and ecological significance and ability to inform the evaluation process given the scale of the project.

A list of potential topics for inclusion in the watershed assessment was compiled from the following sources: Watershed Assessment Manual (Watershed Professionals Network 1999); Upper Crooked River Sub-basin Review (USDA FS 1998b); watershed council board; council technical team; and a series of community meetings held throughout the basin in spring of 1999. The council and its technical advisory committee selected final topics for inclusion.

The assessment is arranged into the following major sections:

Introduction	Riparian Areas
Land Use	Water Quality
Historic Conditions	Fish
Hydrology and Water Use	Wildlife
Uplands	Watershed Condition Summary

Table 1-1: List of Acronyms

BLM	Bureau of Land Management
BOR	Bureau of Reclamation
CAFO	Confined Animal Feeding Operation
CFS	Cubic Feet Per Second
CRB	Crooked River Basin
CRWC	Crooked River Watershed Council
EDT	Ecosystem Diagnosis and Treatment (Warm Springs Power Enterprises)
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ICBMP	Interior Columbia Basin Ecosystem Management Plan
NRST	National Riparian Service Team
NWPPC	Northwest Power Planning Council
ONF	Ochoco National Forest
ODA	Oregon Department of Agriculture
OR DEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ONHP	Oregon Natural Heritage Program
OWEB	Oregon Watershed Enhancement Board
REMAP	Regional Environmental Monitoring and Assessment Program (EPA & DEQ)
SWOT	Strength, Weakness, Opportunity & Threat (planning analysis)
UGB	Urban Growth Boundary
USFS	United States Forest Service
WSPE	Warm Springs Power Enterprises

Physical Description

Located along the southern edge of the Columbia Basin Plateau and at the northern margin of the high desert, the Crooked River Basin of central Oregon falls within the Northern Great Basin physiographic province (Figure 1-1). The Crooked River Basin encompasses just under three million acres and includes a wide range of ecological conditions, from desert to moist forest. Landforms include a mix of valleys, plains, foothills, the Maury and Ochoco mountain ranges, headwaters, and downstream watersheds. The total drainage area of the Crooked River Basin is approximately 4,500 square miles. The Crooked River flows east to west from headwaters in North Fork Crooked River, South Fork Crooked River and Beaver Creek systems. The total length of the Crooked River from the headwaters of the North Fork Crooked River to the mouth at Lake Billy Chinook is approximately 155 miles. Average annual discharge of the Crooked River is 1,131,000-acre feet (at Lake Billy Chinook). The highest point in the basin is Lookout Mountain (elevation 6,926 feet), located in the Ochoco Mountains. The lowest point in the basin is at Lake Billy Chinook where the Crooked River joins the Deschutes, an elevation of approximately 1,900 feet. The Lower Crooked River Sub-basin makes up 40% of the basin, with 1,172,909 acres. The Beaver South Fork Sub-basin is 997,015 acres and comprises approximately 35% of the basin. The Upper Crooked River Sub-basin is the smallest sub-basin, with 736,677 acres, roughly 25% of the total basin acreage.

Climate

The Crooked River Basin is located in the South Central Oregon climatic zone; a semi-arid area of high desert prairie punctuated by small mountain ranges and isolated peaks. Average annual precipitation is between 8 and 10 inches per year at lower elevations and may reach 30-40 inches at higher elevations (falling primarily as snow in the winter). The highest monthly precipitation totals occur in the winter months, with a secondary maximum during the late spring and early summer. High intensity thunderstorms can contribute large proportions of annual rainfall locally and contribute to increased erosion. Late spring and summer precipitation events are characterized by short duration, high intensity storms that contribute to localized flash flooding. As distance increases to the east, away from the Cascade Mountains, the spring-summer peaks become much more pronounced. Summer temperatures are quite warm at lower elevations, but the growing season is relatively short, particularly at higher elevations, and frost has been recorded in every month. See Figure 1-2 and Appendix 1-A for additional climate data.

Figure 1-1: Crooked River Basin Location

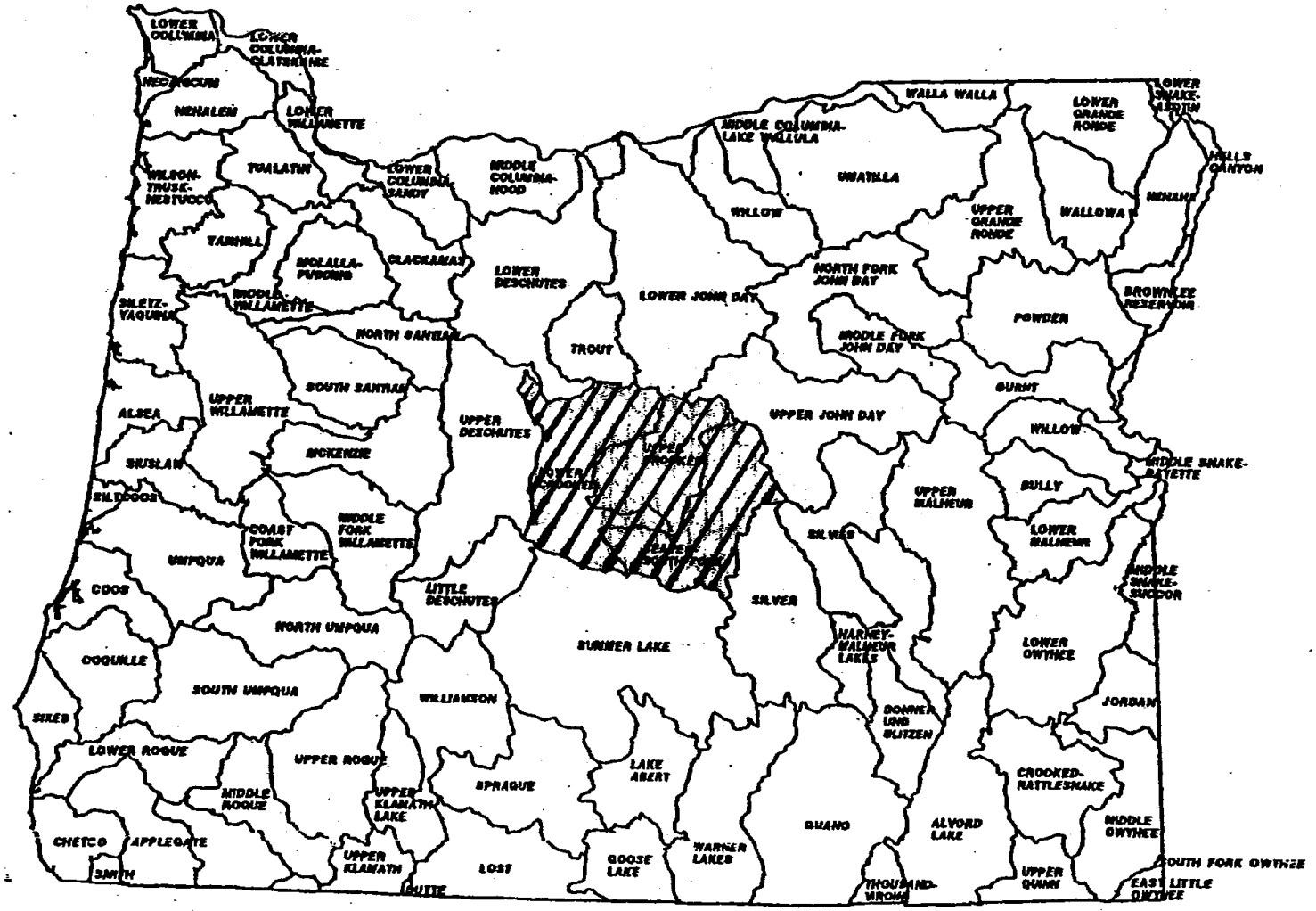
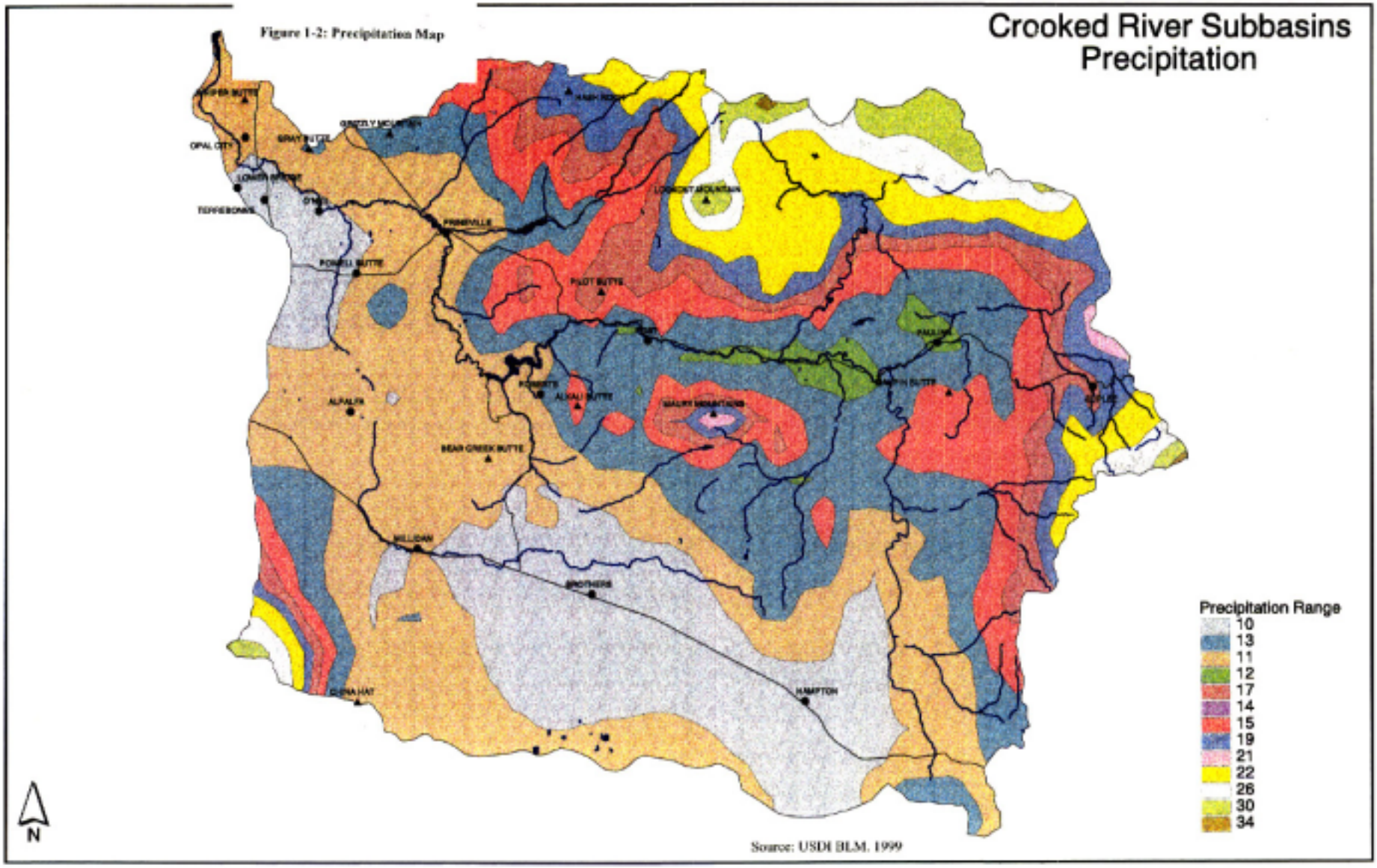


Figure 1-2: Precipitation Map



Source: USDI BLM. 1999

Ecological Provinces

The Crooked River Basin includes three ecological provinces, as defined by Anderson, Borman, and Krueger (1998), who describe fifteen ecological provinces for the State of Oregon based on broad soil plant relationships determined from an assessment of combined characteristics of geologic features and ecological sites. General descriptions of these provinces, including information on soils, climate, vegetation communities and management implications are provided below. For a map of county, basin, and ecological province boundaries, see Figure 1-3.

John Day Ecological Province

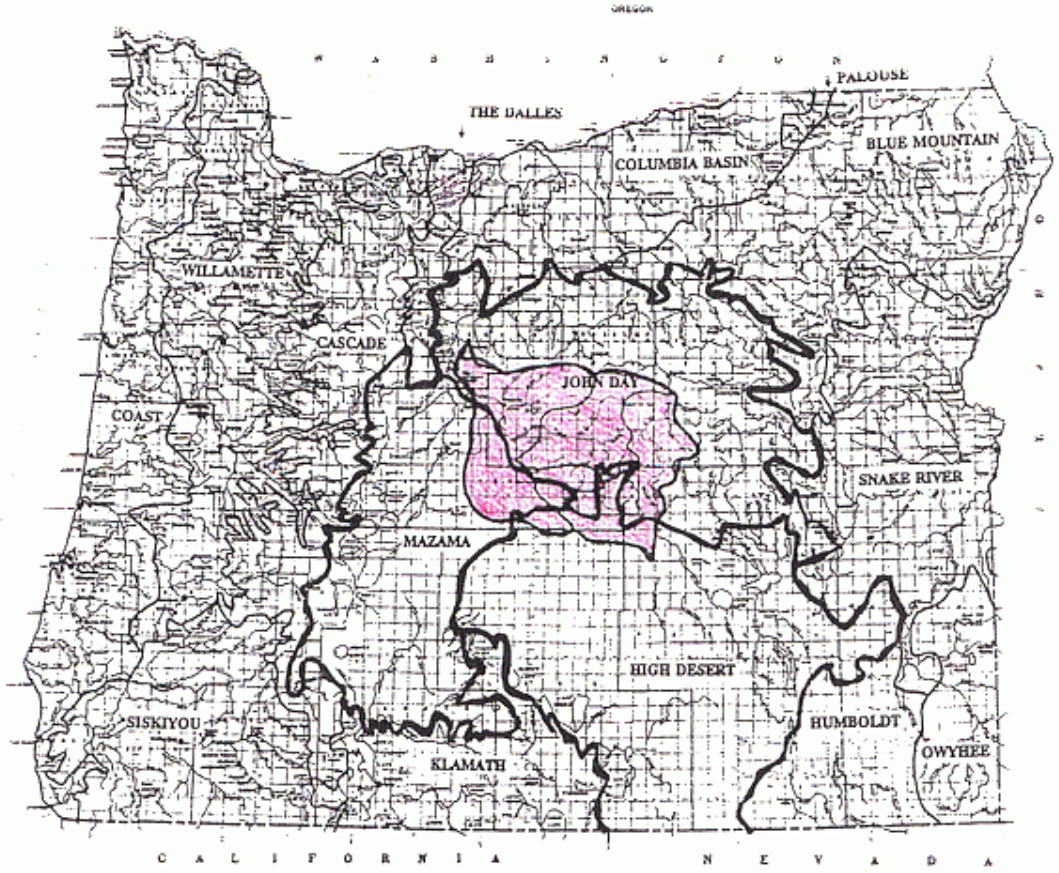
The John Day ecological province is characterized by extensive geologically eroded, steeply dissected hills of thick, ancient sedimentary materials interspersed with buttes and plateaus capped with basalt or tuffaceous rock. Elevations in the province range from about 1,000 feet near Lake Billy Chinook to 7,360 feet at Fields Peak in the Ochoco Mountains. The majority of the Crooked River Basin is located within the John Day ecological province, including the entire Upper Crooked River Sub-basin, and the majority of the Lower Crooked River and the Beaver South Fork Sub-basins. Communities within the Crooked River Basin portion of the John Day ecological province include Prineville, Paulina, Post, and a portion of Culver (all of Culver is in the John Day ecological province, but only about 50% of the community is located within the Crooked River Basin).

Precipitation in the John Day ecological province is highest at high elevation sites, such as those in the Ochoco Mountains, which have an average annual precipitation of between 25 to 30 inches; lower elevation sites average between 10 and 15 inches annually. Climate is characterized by cold nights throughout the year, particularly at higher elevations, and hot daytime summer temperatures.

The soils of the John Day province derived from ancient sedimentary and tuffaceous parent materials and are finely textured, sticky when wet, and highly susceptible to precipitation driven erosion. Irrigated agriculture occurs in this province around Prineville and Madras, but cropland in the remainder of the province is limited to narrow irrigated valleys. The dominant land use within this province is the production of livestock and livestock forage. The original potential of these sites, which has been observed to be high at relict sites where perennial grasses are present, has been lost or diminished throughout most of the basin. Control of juniper and noxious weed expansion, and reduced soil erosion can increase the potential for vegetation recovery on these arid rangelands.

According to a 1936 State of Oregon Forest Type Map, approximately 50% percent of the John Day ecological province was covered in pine, fir, and mixed pine-fir forests. About 40% of the province was non-forested with sagebrush-grassland communities dominant at the lower elevations. Less than 10% of the province was occupied by western juniper stands on the Forest Type Map. The portion of the province with historical juniper, however, was the southwest corner of the province, that area within the Crooked River Basin. The concentration of juniper within this area is likely a result of the seed source provided by

Figure 1-3: Crooked River Basin Ecological Provinces



junipers in the adjacent Mazama province, as juniper is considered a climax species for the pumice soil type characteristic of the Mazama province. Since the 1936 mapping project, western juniper has spread rapidly throughout the John Day ecological province, and into the Upper Beaver South Fork Sub-basin, the area of the Crooked River Basin with lowest juniper occurrences noted on the 1936 map. The spread of this species is primarily a result of the exclusion of fire and intensive grazing pressures at the turn of the century. In addition, juniper has an affinity for calcium, and the clayey ancient sediments of the John Day province are typically calcareous (Anderson et al. 1998).

Mazama Ecological Province

The area within the Mazama ecological province is covered by a continuous mantle of pumice and other volcanic material deposits distributed when Mt. Mazama erupted explosively about 6,500 years ago. Other volcanic eruptions and activity, as well as glacial actions, have created areas consisting of basaltic, andesitic, rhyolitic, and tuffaceous deposits, cinders and glacial till. Due to the predominantly southwestern winds, the Mazama province extends north from Crater Lake to northern Deschutes County, northeast to about Brothers, and southeast to Gearhart Mountain in Lake County. Elevation ranges from 2,500 feet in the northwestern portion of the province near where the Crooked and Deschutes Rivers join, to 8,390 feet at Gearhart Mountain. Most of the province lies between 4,000 and 5,000 feet elevation. The southwestern portion of the Crooked River Basin is located within the Mazama ecological province, including just under half of the Lower Crooked River Sub-basin and a small segment of the Beaver South Fork Sub-basin. Communities within the Crooked River Basin portion of the Mazama ecological province include Powell Butte, Brothers, Millican, Terrebonne, and the eastern portions of Redmond's urban growth boundary.

Soils of the Mazama ecological province have been developed in combinations of aeolian pumice and volcanic ash overlying basaltic bedrock or ancient soils at a depth from 10 inches to 15 feet. Soil characteristics of upland areas include thick deposits of aeolian pumice or aeolian pumice overlying loamy soil. Soil characteristics of low lying areas include deep, coarse, gravelly pumicy soils of basins and draws in forested uplands, and deep, gravelly loam adjacent to marsh areas.

The buried soils that lie beneath a pumice mantle throughout the Mazama ecological province are typically reddish brown stony to non-stony loams and are important because they lie in the root zone of vegetation and influence soil nutrient and moisture content. The angular nature of individual particles of pumice soil consist of volcanic glass shards which are porous and store water within as well as on the surface of each particle, increasing the water holding capacity and cation exchange potential of the soil profile. Despite the increased water holding capacity of pumice soils, upward capillary action is reduced in pumice soils and plant roots must grow down into the moisture. The pumice mantle overlying buried soil is also believed to act as a mulch, which aids vegetation. Pumice soils are one of the easiest to modify through management activities, such as compaction from equipment and livestock use. Pumice also weathers more rapidly than other volcanic rock types.

The northeastern portion of the province, that area within the Crooked River Basin, is characterized by annual rainfall of less than 10 inches and a sagebrush/bunchgrass vegetation zone. A small portion of the Mazama ecological province is used for irrigated agriculture; this portion lies largely within the Crooked River Basin portion of the province, as well as due west in the Middle Deschutes Basin. The primary soil series being irrigated is Deschutes sandy loam, and low ridges of basalt bedrock and rubble dot the landscape (Anderson et al. 1998).

High Desert Ecological Province

The High Desert ecological province encompasses the northern extent of the Great Basin of North America, located in south central Oregon. The High Desert province is characterized by closed basins surrounded by terraces formed in ancient lakes. Interspersed are low mountains, isolated buttes, basaltic ridges, and block faulted igneous formations that characterize the Crooked River Basin portion of the province. Elevations of basins and terraces in the High Desert Province of Oregon average between 4,000 and 4,500 feet. The very southern portion of the Crooked River Basin is located within the High Desert Ecological province; the majority of this area is within the Beaver South Fork Sub-basin, and a small segment of the Lower Crooked River Sub-basin is also located within this ecological province. The only community within the Crooked River Basin portion of the High Desert ecological province is Hampton.

Soils of the High Desert ecological province range from deep loam to deep clayey soils in basins and from deep sandy to shallow clayey soils on terraces and fans where hardpans are common. On most terraces and fans the soil surface is rocky, likely a result of fractured basalt.

The High Desert ecological province is a dry and cold region, with an average annual precipitation of approximately 10 inches and a probability of frost throughout each week of the year. Extremes of hot and cold temperatures are common throughout the province. Vegetation communities are dominated by shrub-grasslands and the limited conifer areas that are present are dominated by juniper.

Livestock ranching dominates the economic and land use activity of the High Desert ecological province. Crop alternatives are severely limited by the availability of water and the short growing season. Potential production of forage is low except in restricted meadow and high precipitation areas. Improved grazing management techniques have resulted in a gradual improvement in range quality over the past few decades. Recreation is a growing enterprise but the potential is constrained by the distance from populated areas, limited year round access roads, and the seasonal nature of most recreational activities (Anderson et al. 1998).

Soils

A soil survey has not been completed for the entire Crooked River Basin. Surveys were recently completed for Deschutes and Jefferson Counties, but final documents are not yet available. The Prineville/Powell Butte area of Crook County was surveyed in 1966 and is

currently being resurveyed by the Natural Resource Conservation Service. Plans to complete soil surveys and mapping for the remainder of Crook County are estimated to take the next four to six years. As a result, detailed soils information is only available for portions of the Lower Crooked River basin, with very little information for soils of the Upper Crooked or Beaver South Fork Sub-basins. Soils information outside of the Lower Crooked River Sub-basin has been collected by federal agencies on public lands, and the information is at a coarse scale of resolution.

Watersheds and Streams

The Crooked River Basin encompasses 2.9 million acres in central Oregon. There are 52 fifth field watersheds in the Crooked River Basin with an average area of 55,896 acres and a range from just under 20,000 acres to over 166,000 acres. Fifth field watersheds, their hydrologic unit codes, sub-basin, and acreage are listed in Appendix 1-B. There are 9,548 miles of streams and rivers in the Crooked River Basin. The Lower Crooked and Beaver South Fork Sub-basins each have approximately 36% of the total stream miles in the Crooked River Basin (3,428 and 3,391 stream miles, respectively), and the Upper Crooked River Sub-basin has 2,729 miles of streams, or 28% of the total stream miles in the basin. See Figures 1-4 and 1-5 for 5th field watershed and stream maps, respectively.

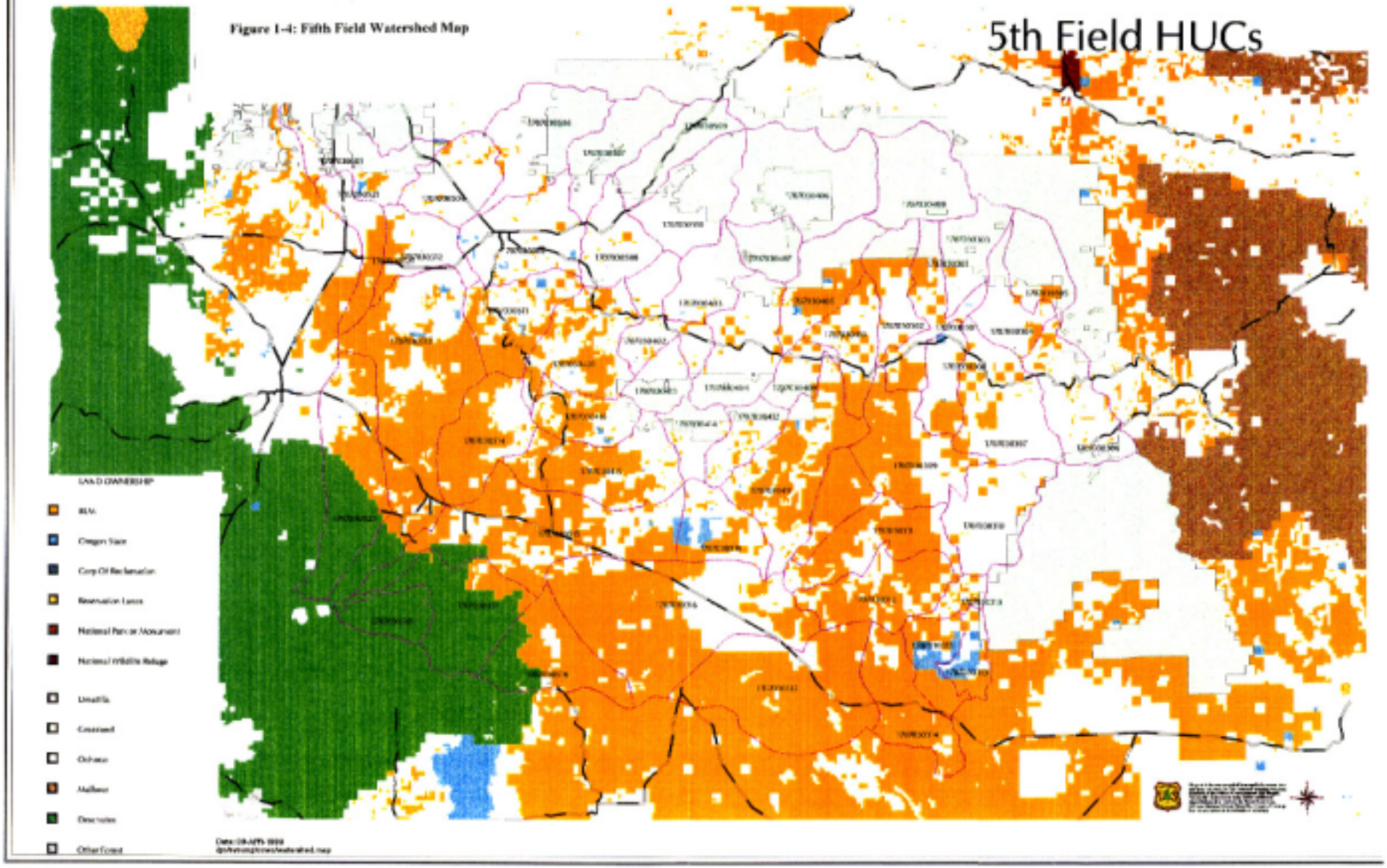
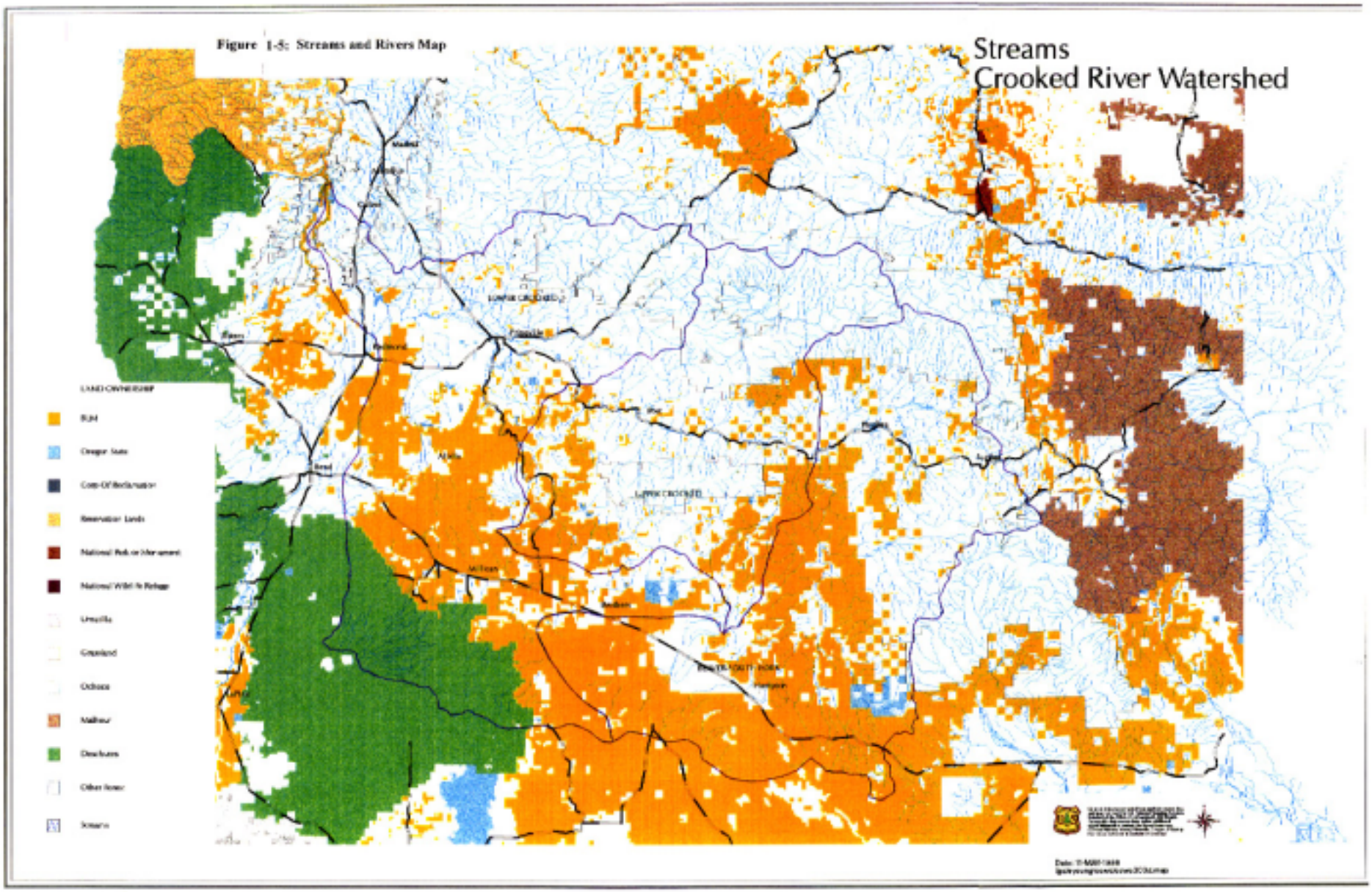


Figure 1-4: Fifth Field Watershed Map
5th Field HUCs
LAND OWNERSHIP
BLM
Oregon State
Corp Of Reclamation
Reservation Lands
National Park or Monument
National Wildlife Refuge
Umatilla
Deschutes
Other Forest

Figure 1-5: Streams and Rivers Map



Key Findings - Physical Description

Key findings were developed from information gained in the watershed assessment process and by members of the Council's assessment technical team.

- Arid, cool climate limits restoration of vegetation
- Incised stream channels and altered flow regimes limit riparian vegetation
- Soils in the majority of the basin (John Day Ecological province) are highly susceptible to precipitation driven erosion
- Exclusion of fire and other land management practices have led to large increases in young juniper woodland

2. LAND USE

Land Ownership

Nearly 60% of the Crooked River Basin is in public ownership. Federal land management agencies hold the majority of the public lands within the basin. The Bureau of Land Management (BLM) manages 35.2% of the basin (1,023,215-acres), and 22.8% is managed by the United States Forest Service (USFS, 463,587-acres in the Ochoco National Forest, 172,136-acres in the Deschutes National Forest, 27,365-acres in the Crooked River National Grasslands, and 75-acres in the Malheur National Forest). The remaining 26,650-acres of public lands, or 1%, are owned by the State of Oregon. Forty one percent of the Crooked River Basin (1,193,570 acres) is privately owned (USDA FS 1999). For a map of land ownership in the watershed, see Figure 2-1.

Land ownership adjacent to stream miles in the Crooked River Basin breaks down as follows: 51.4% of stream miles run through private lands, 31% of stream miles run through BLM ownership, 15.8% of stream miles run through United States Forest Service ownership (12% Ochoco National Forest, 2.5% Deschutes National Forest, and 1.3% Crooked River National Grassland). The remaining 1.8% of stream miles run through lands owned by the State of Oregon (USDA FS 1999).

Table 2-1: Crooked River Basin Land Ownership

Owner	Acres in Crooked River Basin	% of Crooked River Basin
Private	1,193,570 acres	41.0%
Bureau of Land Management	1,0213,215 acres	35.2%
United States Forest Service	663,163 acres	22.8%
State of Oregon	26,650 acres	1.0%

Source: USDA FS. 1999

County Jurisdiction

The seven Oregon Counties with area in the Crooked River Basin include Crook, Deschutes, Grant, Jefferson, Harney, Lake, and Wheeler (Figure 2-2). Acreages and percentages of the basin by county are as follows:

Table 2-2: Counties within the Crooked River Basin

County	Acres in Crooked River Basin	% of Crooked River Basin
Crook	1,843,932 acres	64.0%
Deschutes	755,004 acres	26.0%
Grant	39,887 acres	1.3%
Jefferson	56,855 acres	1.9%
Harney	43,716 acres	1.5%
Lake	103,566 acres	3.4%
Wheeler	57,340 acres	1.9%

Source: USDA FS. 1999

Figure 2-1: Land Ownership Map

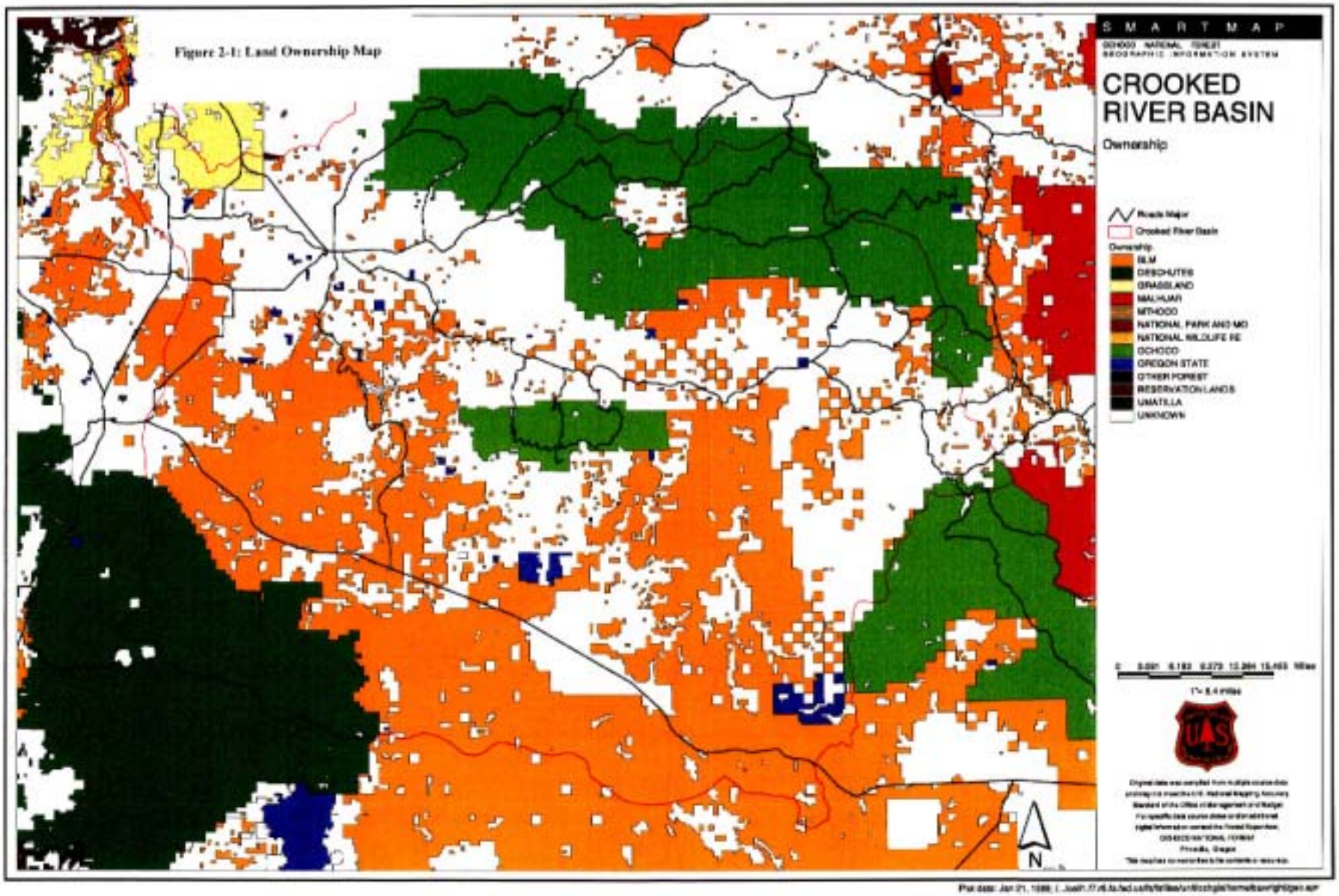
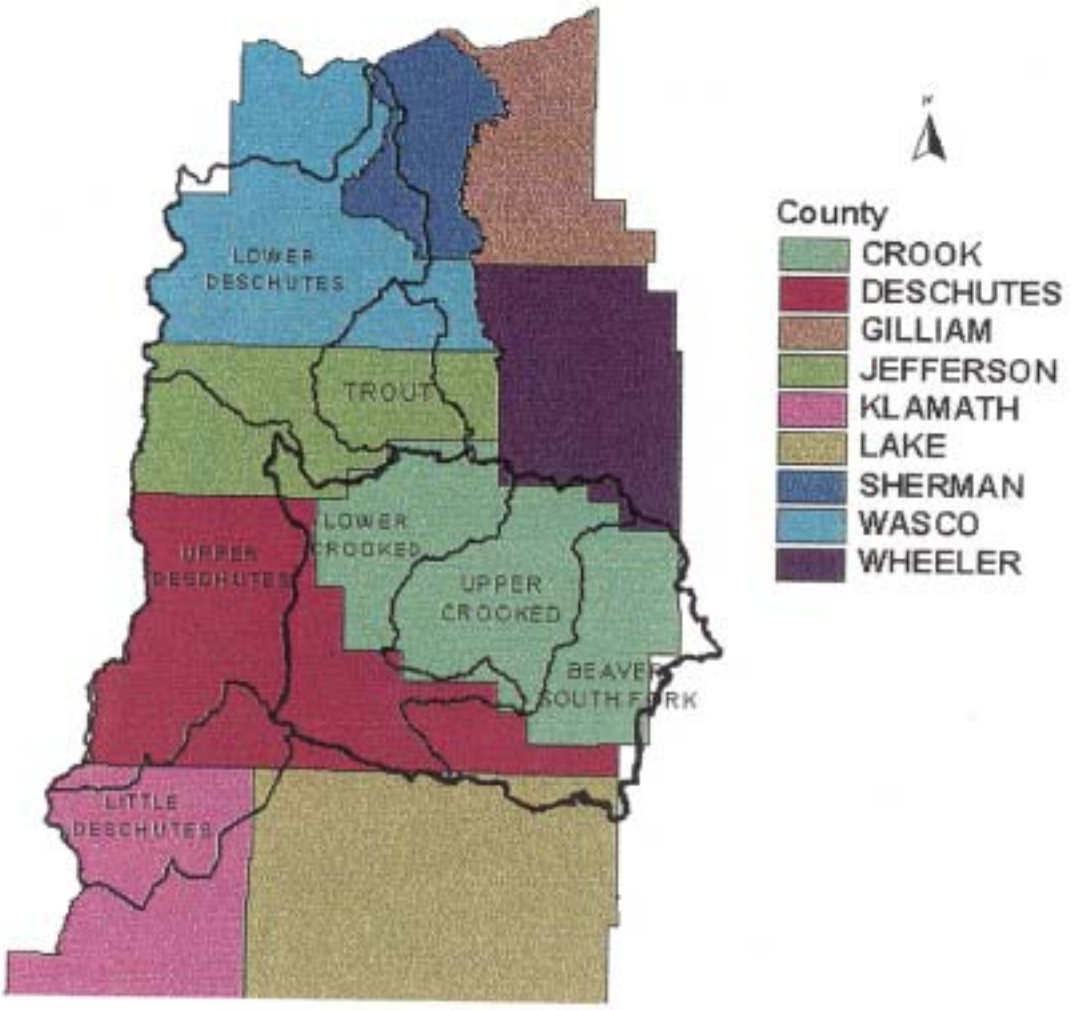


Figure 2-2: County Boundary Map



Source: Central Oregon Intergovernmental Council. 1999

Land Use

Much of the available information for the assessment process, particularly regarding human variables such as land use, is defined using county, not ecological boundaries. In this document, general trends provided for Crook County are extended to the basin as a whole, acknowledging the higher level of uncertainty inherent in this approach. If trends are believed to be significantly different for basin areas outside of Crook County boundaries, these differences will be noted.

Land use within the Crooked River Basin is dominated by agriculture and forestry (over 90%), with rural residential comprising the third largest category. In Crook County, which comprises 64% of the Crooked River Basin, 67% of the acreage is zoned for agricultural use and 28% is zoned for forestry. Deschutes County, which comprises 26% of the Crooked River Basin, has 36% of the acreage zoned for agriculture and 54% zoned for forestry. The remaining five counties, which together comprise 10% of the Crooked River Basin, have an average of 65% of the acreage zoned for agriculture and 27% zoned for forestry (USDA OASS 1997).

Information gathered in the late 1970's estimated that land use in the Crooked River Basin included approximately 73% range, with grazing as the primary use, 21% forest, 4% irrigated agriculture, and 2% urban and other uses (NRCS 1994). While the percent of forestlands has remained about the same, the proportion of irrigated lands has increased in relation to the proportion of grazed lands as the economic significance of crops has expanded and the region has returned to a wetter climatic period. In addition, the percentage of lands used for rural residential is increasing in the basin. Rural residential development is primarily impacting agricultural lands although some forestlands are also being converted (Crook County 1993).

Wild and Scenic Rivers

The Wild and Scenic Rivers Act was passed in 1968 to balance river development with river protection. To accomplish this goal, Congress created the National Wild and Scenic Rivers System. The Oregon Omnibus Wild and Scenic Rivers Act of 1988 designated 40 river segments in Oregon for inclusion in the wild and scenic rivers system and directed the USFS and the BLM to develop management plans for each designated river (USDI BLM 1992a). The following river segments in the Crooked River Basin designated Wild and Scenic are described below. For a map of wild and scenic river sections in the basin see Appendix 2-A.

North Fork Crooked River, Upper Crooked River Sub-basin.

- Total of 34.2 river miles, from mouth to headwaters, except private lands in Big Summit Prairie. Remarkable values for the Wild and Scenic portion of the North Fork Crooked River include scenic, recreation, bald eagle winter roost site presence, sensitive plant species presence, and native riparian conditions (USDI BLM 1993).

Lower Crooked River, Chimney Rock Section, Lower Crooked River Sub-basin

- Total of 8 river miles from Bowman Dam to State Scenic Hwy. 27, mile-marker 12. Remarkable values for the Chimney Rock segment of the Lower Crooked Wild and

Scenic River include scenic, recreational, and fish resources. This area is also managed as an area of critical environmental concern by the BLM, and the State Scenic Highway adjacent to the river is designated as a National Back Country Byway. The fisheries resource in this section of the Crooked River was determined to be an outstanding remarkable value based on its genetic diversity and adaptability of redband trout to a wide variety of habitats (USDI BLM 1992a).

Lower Crooked River, Lower Crooked River Sub-basin

- Total of 9.8 river miles from the National Grasslands Boundary to Opal Springs (river miles 8 to 17.8). Remarkable values for this river segment include recreation, scenic, geology, wildlife, and hydrology. This segment is adjacent to the community of Crooked River Ranch and approximately 10 miles from the communities of Redmond and Madras, and flows through Smith Rock State Park. Springs in the Lower Crooked River contribute to improved water flow, temperature, and quality, as flows are otherwise limited due to withdrawals for private and agricultural uses in the middle section of the Lower Crooked River (USDI BLM 1992b).

Mineral Extraction

The three primary minerals extracted from the Crooked River Basin include crushed stone (Lower Crooked River Sub-basin, Upper Crooked and Beaver South Fork to a lesser extent), volcanic cinders (Upper Crooked River Sub-basin), and bentonite (Beaver South Fork Sub-basin). On a much smaller scale, rockhounds collect ornamental rocks such as agates, thundereggs, jasper and obsidian, primarily in the western regions of the basin with volcanic origins. Historical mining activity in the basin included gold and cinnabar operations, see Historical Conditions (Section 3) for more information.

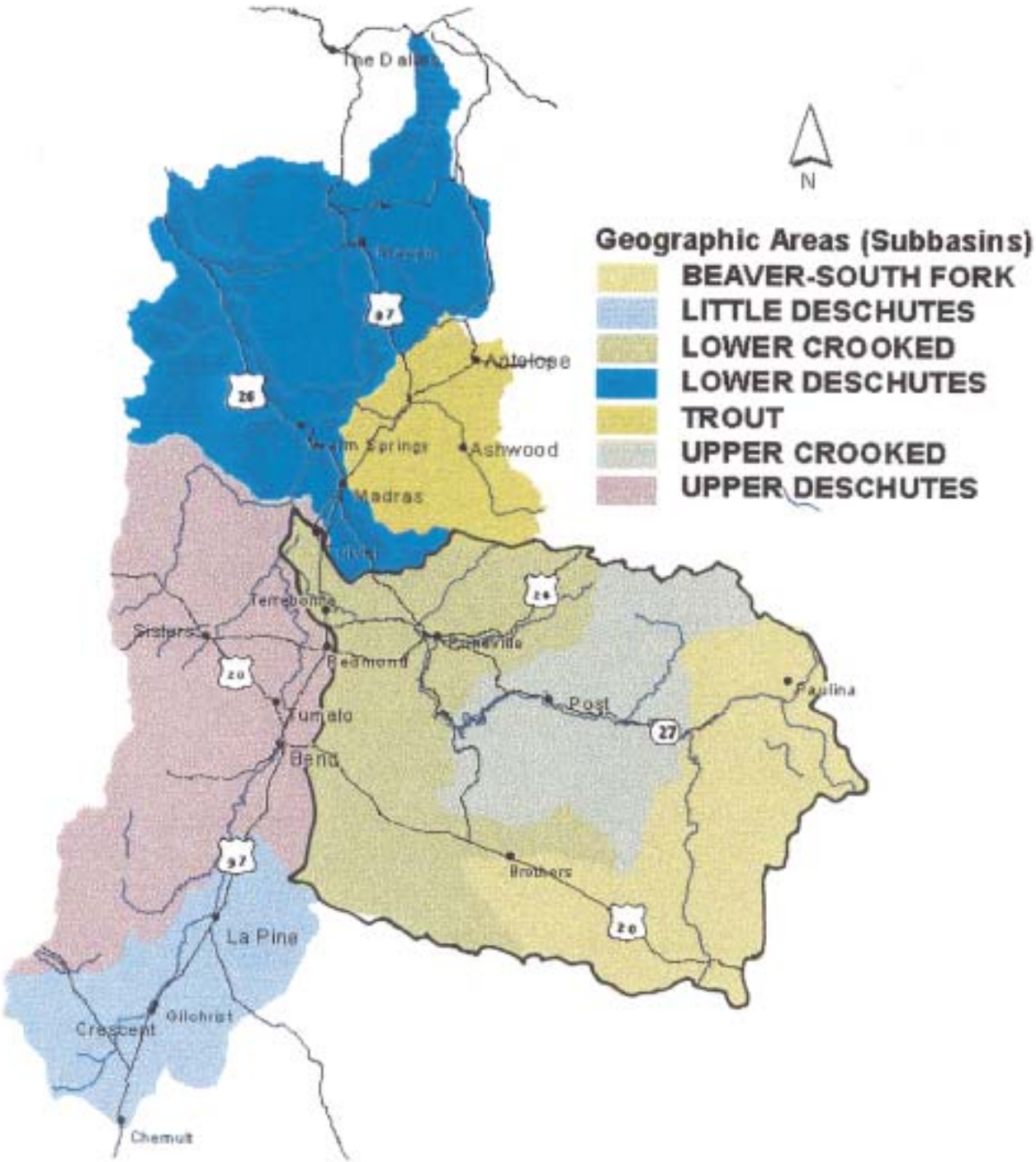
Urban Areas

The 6,832-acre greater Prineville Urban Growth Boundary (UGB) represents less than 1% of the 2.9 million-acre basin but accounts for roughly one-third of its human population (Prineville Planning Department 1997). Less than 1% of the basin is within the UGB of any incorporated community, including portions of Culver and Redmond and all of Prineville. All Crooked River Basin lands within an incorporated community or its urban growth boundary are located within the Lower Crooked River Sub-basin (Figure 2-3).

Greater Prineville Area Land Use

In a 1997 update to the 1978 Comprehensive Plan, the greater Prineville area urban growth boundary was expanded to 6,832 acres, up from the 5,375 acres designated in the 1978 Comprehensive Land Use Plan (Prineville Planning Department 1997) (Table 2-3). This increase is largely the result of two major expansions, the City-County airport and industrial development area and the community park and county fairgrounds. Smaller scale projects that also influenced urban growth boundary expansion include a Les Schwab warehouse, the Baldwin Industrial Park, and industrial developments totaling less than 30 acres.

Figure 2-3: Urban Areas, Towns



Source: Central Oregon Intergovernmental Council, 1998

Table 2-3: Greater Prineville Area Land Use Analysis (1995)

Designation	Acres
Total Land Area within Urban Growth Boundary	6,832.63 acres
Total Area Developed	4,883.06 acres (71.5%)
Total Area Vacant	1,949.57 acres (28.5%)
Vacant Residential	1,400.68 acres
Vacant Commercial	66.38 acres
Vacant Industrial	482.51 acres

Source: Prineville Planning Department. 1997

Greater Prineville Area Buildable Lands

Factoring in building restrictions, the vacant lands within City limits were assessed in 1995 to determine the buildable land area in residential, commercial and industrial designations. Restrictions include riparian, wetland, and stream setbacks, flood hazard areas, steep slopes, lot access or configuration, transportation setbacks (roads, railroads), and already committed developments. Of the 1,400 vacant residential acres, 557.91 acres are available for future development. Approximately 50 acres are available for future commercial development, and just over 282 acres are available for future industrial development (Prineville Planning Department 1997).

Greater Prineville Area Open Space

Within the greater Prineville area (City of Prineville and lands within the approximately 6,800 acre Urban Growth Boundary) there are numerous areas designated as open space. In general, the overall rural character of the area is enhanced by the City Park system, the location of agricultural lands adjacent to the urban areas, and rural residential development patterns throughout the urban area. City management of open space, scenic, historic and natural resource values are divided into two main categories in the comprehensive land use plan. The first designation, offering the highest level of protection to the resource is “protect the resource site”. Sites under this designation include: Meadow Lakes Golf Course, Ochoco Creek Park, Crooked River Park, Pioneer Park, Ochoco Wayside/Viewpoint State Park, and significant natural wetlands (along Crooked River, Ochoco Creek, Hudspeth Lake). The second land use designation for open space, historic, scenic and natural resources is “limit conflicting uses”. Sites under this designation include Barnes Butte, Crooked River Rimrocks, Hudspeth Lake, Crooked River and Ochoco Creek Greenways (Prineville Planning Department 1997, Crook County 1993).

Significant Wildlife Habitat (Greater Prineville Area)

The only specifically designated fish and wildlife habitat areas within the greater Prineville Urban Growth Boundary are the riparian and in-stream habitats of Ochoco Creek and the Crooked River. There are four Bald Eagle nest sites located within, or in close proximity to

the greater Prineville area UGB. Sites designated within the Greater Prineville Area Comprehensive Land Use Plan as significant natural areas for ecological, geological, or scientific significance include the Crooked River, Ochoco Creek, Barnes Butte and the Crooked River Rimrocks. Outstanding scenic views and sites noted in the plan include Ochoco Wayside, Crooked River Rimrocks, and Barnes Butte. Three thousand, three hundred and sixty acres around Prineville Reservoir are managed for fish and wildlife (Prineville Planning Department 1997).

Wetlands (Greater Prineville Area)

Significant natural wetlands identified in the City's 1995 wetlands inventory are primarily located along the Crooked River, Ochoco Creek, and Hudspeth Lake and its drainage. A wetlands inventory has not been conducted for the remainder of the basin. The United States Forest Service does identify wetlands using vegetation community maps within their boundaries but this information is at a coarse scale and only on Ochoco National Forestlands.

Air Pollution

Primarily a result of its valley location and the land use base dominated by agriculture and forestry, air pollution is a public safety concern in the greater Prineville area. Primary pollutants include wood stoves, automobiles, burning (primarily agriculture and forestry), and winter road sanding. Industries with air pollution discharge permits within the urban growth boundary include wood products manufacturing, aggregate sites, and tire manufacturing (Prineville Planning Department 1997).

Natural Hazards

Natural hazards identified for the greater Prineville urban area include flood potential along the mainstem Crooked River and Ochoco Creek, and slide potential in the steep sloped Crooked River Rimrock and Barnes Butte areas (Prineville Planning Department 1997).

Socio-Economic Conditions

Information on socio-economic conditions for the Crooked River Basin is based on statistics and analysis for Crook County and the City of Prineville, the social, political, and population hubs of the basin. While a substantial portion of the basin is located within Deschutes County, which has a very different economic profile, the portion of Deschutes County within the Crooked River Basin is heavily dominated by lands (public and private) that are related more closely to the socio-economic conditions and trends of Crook County than those of Deschutes County.

Population

The Crooked River Basin population in 1996 was 32,030, an average density of seven persons per square mile (Portland State University 1998). Population is concentrated in the Lower

Crooked River Sub-basin, where nearly 95% of the total basin population resides. The only incorporated communities in the basin also occur in the Lower Crooked River Sub-basin, in close proximity to Redmond and Bend, the major population areas of central Oregon. Deschutes, Jefferson, and Crook Counties are expected to grow at rapid rates over the next few decades, with population increases of 15-30% expected (Table 2-4). Communities within the Crooked River basin include the incorporated communities of Prineville, which is located entirely within the Crooked River Basin, Culver, with approximately half of its area located within the Crooked River Basin, and Redmond, whose easternmost portions of the urban growth boundary are within the Crooked River Basin. The remainder of the population of the Crooked River Basin is rural; unincorporated communities include Paulina, Powell Butte, Post, Crooked River Ranch, Terrebonne, O'Neil, Brothers, Millican, and Hampton. Ethnicity within the basin is predominately Euro-American (95%), with Hispanic Americans representing just under 3% of the population, Native Americans making up approximately 1.5% of the population and Asian and African American each representing less than 0.5% of the total population (Prineville-Crook County Chamber 1998).

Table 2-4: Projected Population Growth, Crook County

Year	Prineville Urban Area		Crook County	
	1.5%	**3.5%**	**1.5%**	**3.5%**
1996	9,500	9,500	15,900	15,900
1998	9,787	10,177	16,381	17,033
2000	10,083	10,902	16,876	18,246
2004	10,702	12,510	17,911	20,937
2008	11,359	14,356	19,010	24,026
2016	12,796	18,904	21,736	32,744

1.5% annual growth rate represents a continuation of the average growth rate over the past decade.
3.5% annual growth rate represents the average annual growth rate over the past 5 years.

Source: City of Prineville. 1997

Lower Crooked River Sub-basin

The human population of the Lower Crooked River Sub-basin was 31,540 in 1995. The sub-basin includes the City of Prineville, (population 6,920, 1999; UGB population 10,700, 1999), the very eastern edge of Urban Growth Boundary of the City of Redmond (total Redmond population 11,490, 1996), and approximately half of the City of Culver (total population 835, 1996) (Portland State University 1998, Prineville Crook County Chamber 1998). Unincorporated communities in the Lower Crooked Sub-basin include Crooked River Ranch, Terrebonne, O'Neil, Powell Butte, Millican, and Brothers. Population density in the Lower Crooked River Sub-basin is just under 17 persons per square mile.

Upper Crooked River Sub-basin

There are no incorporated communities within the Upper Crooked River Sub-basin, although the City of Prineville serves as the social, political, and economic center. The community of Post is the only named town in the sub-basin. The population of the Upper Crooked River

Sub-basin was 210 in 1996, with a density of 0.18 persons per square mile. Due to land ownership patterns in the sub-basin, with a high proportion of federal lands, particularly at higher elevations in the Ochoco and Maury Mountains, residential density is concentrated in the Southwest portion of the sub-basin, around Prineville Reservoir. Population growth and rural residential development around the reservoir is expected to be high over the next decade. Lower density residential and agricultural lands occur at lower elevations in the sub-basin and along the Crooked River.

Beaver South Fork Sub-basin

There are no incorporated communities within the Beaver South Fork Sub-basin. The population in the sub-basin was 280 people in 1996, a density of approximately 0.18 persons per square mile. Unincorporated communities include Paulina and Hampton.

Economics

The Oregon Economic Development Department in 1998 rated Crook County as a distressed area (OEDD 1999). The designation of distressed areas is based on economic factors, including but not limited to unemployment, poverty, and job loss. Crook County was also characterized as having a low socio-economic resiliency (OEDD 1999). This rating is based on a combination of factors including population density, economic resiliency (defined by diversity), and lifestyle diversity. Annual average unemployment rates in Crook County are above the State of Oregon average from the mid-1970's up to the present (OED1998). The economy is highly dependent on forest products and agricultural industries, which are characterized by a relatively high level of seasonal employment and a general declining trend in the overall number of jobs, which accounts for the higher unemployment levels in the County. A 1996 investigation by the United States Forest Service of economic indicators categorized the economy of Crook County as being between 30-40% dependent on forest products (USDA FS 1996a). The Oregon State Department of Employment rates Crook County as the most highly dependent of all Oregon's counties on lumber and wood products manufacturing (OEDD 1999).

Despite its low economic diversity, Crook County and Prineville are experiencing economic benefits from the general growth throughout central Oregon communities. Between March 1995 and March 2000, over 1,300 new jobs were added to the local economy and unemployment reached a five year low in April of 2000, indicating that the economic crisis of the 1980's is waning (Prineville-Crook County Chamber 1998).

Greater Prineville Area Strategic Planning and Community Visioning Process

In 1993 the City of Prineville and the Chamber of Commerce facilitated a community visioning and strategic planning process for the greater Prineville area. This included a SWOT (strengths, weaknesses, opportunities, and threats) analysis of the area and the development of six primary goals for the community. Information from this process significant to the watershed assessment and management process in the Crooked River Basin is described below in Table 2-5.

Table 2-5: Greater Prineville Area SWOT Analysis

Strengths

- Á agriculture has been an economic mainstay since settlement
- Á timber and wood products has been the most important industry in terms of employment and income since the 1920's; despite cutbacks primary wood products is still in the top three industries
- Á secondary wood products manufacturing is a growing industry
- Á recreation-tourism is the third ranking industry in terms of employment and income
- Á high quality of life in the city environment is enhanced by park system, rural atmosphere, western heritage, and proximity to natural resources

Weaknesses

- Á expansion and diversification of agriculture is limited by lack of new lands and availability of water for irrigation
- Á community is the highest 'single industry dependent' area in the state (wood products)
- Á no community based transportation
- Á planning and land use regulatory functions within the total urban area of the city need to be unified

Opportunities

- Á substantial opportunities exist to improve and expand recreation/tourism opportunities
- Á diversified small scale, non-polluting business and industrial development is an opportunity if pursued aggressively
- Á maintain quality of life environment

Threats

- Á reduced timber and other raw material supply for wood products industry
- Á natural droughts and federal actions further limiting water supply for irrigation

Source: Prineville Planning Department. 1997

Industry

The primary industries in the Crooked River Basin are livestock, wood products, agriculture, recreation and tourism. Livestock and wood products have dominated local economics since Euro-American settlement and still comprise two of the top three industries today. The wood products industry has been the most important in terms of employment and income production for most of the 20th century, with livestock production second in significance. While livestock production is still a major land use in the basin; the advent of irrigation in the mid-1900's brought large-scale agriculture to the basin and major crops grown in the area include mint, potatoes, wheat and alfalfa. Today, wood products, agriculture (including crops and livestock), and recreation and tourism are the primary industries in the basin.

Agriculture

While the number of farms in Crook County is increasing, to 521 in 1997 from 415 in 1987, the average size of farms is decreasing, down from an average of 2,074 acres in 1987 to 1,759 acres in 1997 (USDA OASS 1997). Livestock still comprises the largest percent of market value for agricultural industries in Crook County, 58% in 1997, but the importance of crops is increasing steadily, up to 42% of market value from 26% in 1987 (USDA OASS 1997). In relation to the increase in cropland and the end of a drought period, the amount of irrigated land is also increasing. In 1997, 72,355 acres in Crook County were irrigated, compared to 48,670 acres in 1987 (USDA OASS 1997). There were 91 farms with grazing permits for public lands in Crook County in 1997. Permits are issued through the Forest Service (n= 34), Bureau of Land Management (n= 74), Indian Land (n= 1) and other sources (n= 7). There are three dairies designated as confined animal feeding operations within the Crooked River basin (Hammond 1999). All are dairies with less than 1,000 cows, and all are located within the Lower Crooked River Sub-basin (ODA 1999). For a summary of agricultural data, see Table 2-6, below.

The top five agricultural commodities in Crook County for 1997 in terms of value of sales were 1. Cattle and calves ($17,329,000), 2. Other crops ($7,286,000), 3. Hay, silage, field seeds, grass seeds ($4,174,000), 4. Wheat ($790,000), and 5. Vegetables, sweet corn, and melons ($608,000) (USDA OASS 1997). Soil capabilities, a short growing season, and limited sources and supplies of water for irrigation limit agricultural cropland in the basin. For a summary chart of agricultural commodity sales in 1990 and 1998 see Figure 2-4.

Table 2-6: Crook County Agricultural Data

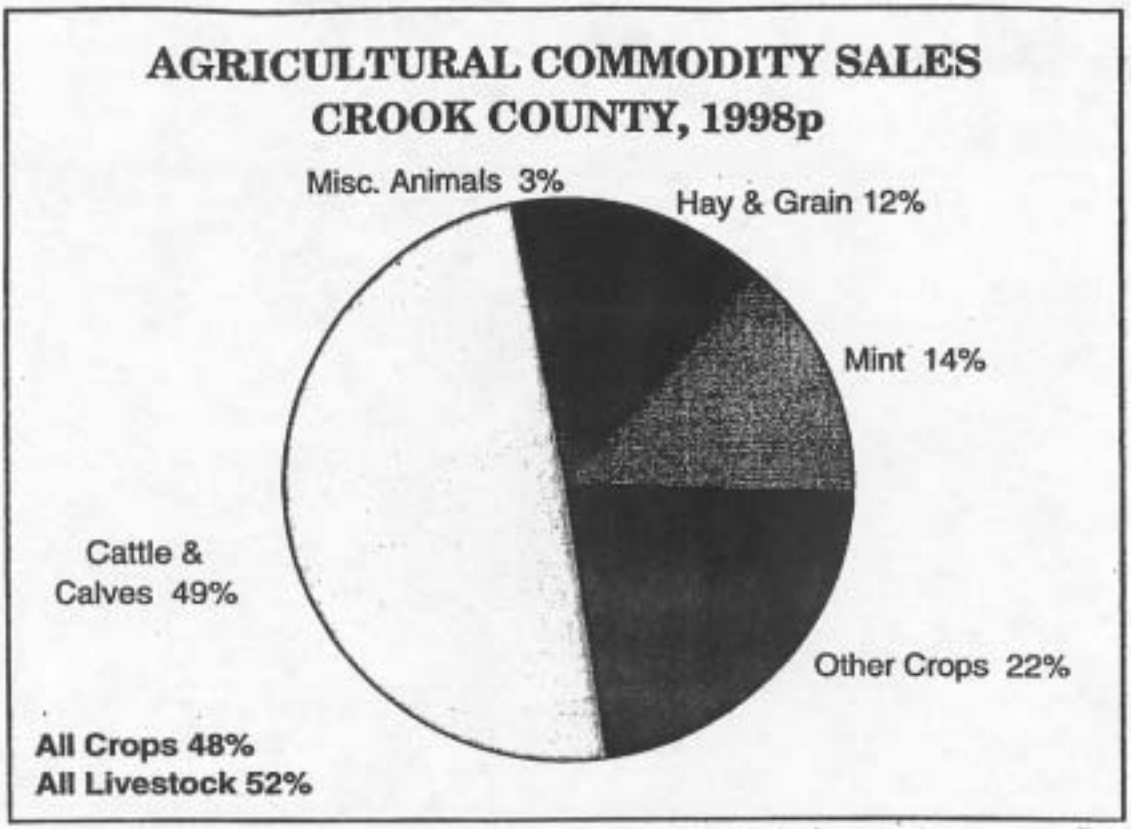
Indicator	1987	1992	1997	% Change
Number of Farms	415	503	521	+20%
Land in Farms	860,738 acres	894,853 acres	916,451 acres	+6%
Average Size of Farms	2,074 acres	1,779 acres	1,759 acres	-15%
Irrigated Land	48,670 acres	47,477 acres	72,355 acres	+33%
Market Value of Agricultural Products	$23,201,000	$28,073,000	$31,436,000	+26%
% of Market Value/Crop Sales	26%	35%	42%	+38%
% of Market Value/Livestock Sales	74%	65%	58%	-22%

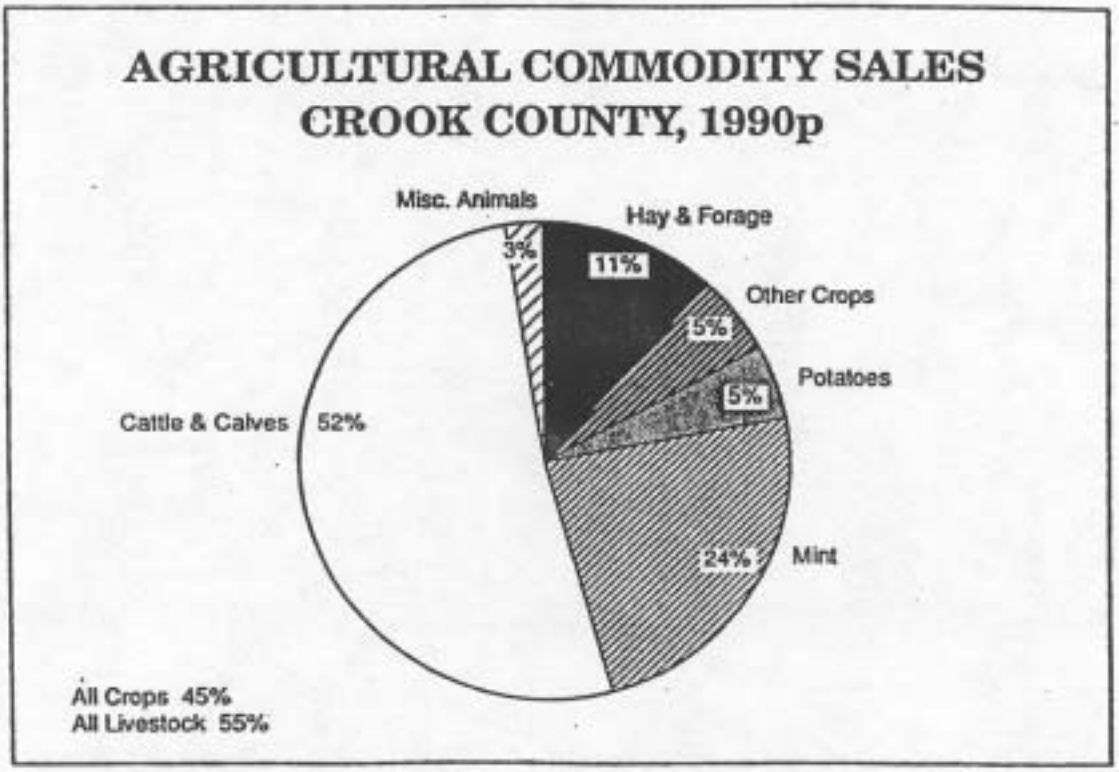
Source: USDA OASS. 1997

Wood Products

The wood products industry has been the top industry in terms of economic significance since the turn of the century. Despite changes in the forest industry and forest management, Crook County remains heavily dependent on wood products today. Prineville has the highest percentage of manufacturing-related employment in the State of Oregon and one in three Prineville jobs is manufacturing-related employment dependent on timber and wood products (OEDD1999). Seven of the eleven largest employers in Crook County are directly related to the forest and wood products industry (Central Oregonian 1999). These include, in order of significance (measured by number of employees): American Pine Products, Clear Pine Molding, United States Forest Service, Ochoco Lumber Company, Crown Pacific, Bureau of

Figure 2-4: Agricultural Commodity Data, Crook County





Source: Economic Information Office, Oregon State University. 1999

Land Management, and Pioneer Cutstock (Central Oregonian 1999). The forest land base in Crook County includes just over 1 million acres, with 100,000 acres in private commercial timberlands, 600 acres in state owned commercial timberlands, 353,000 acres of federally owned commercial timberlands, and 564,000 acres of non productive timber lands, primarily juniper (Crook County 1993). The Forest Service estimates the acreage of juniper woodland as significantly higher than this figure (Deboodt 2000). The market for juniper is slowly expanding as the technology to process it has increased, and it may also be marketable as firewood. See the Uplands section for recent forestlands harvest data.

Recreation

Recreation and tourism has become the third largest segment of the economy in Crook County and its significance is expected to grow throughout the Crooked River Basin and all of central Oregon. Public lands owned and managed by the Ochoco National Forest, Bureau of Land Management, Oregon State Parks, Bureau of Reclamation, Crooked River National Grasslands and Crook County provide opportunities for a variety of recreational activities, including fishing, boating, hunting, camping, snowmobiling and x-country skiing. The majority of recreation and tourism occurs in the summer months. Lake Billy Chinook, Prineville Reservoir, Ochoco Reservoir, other smaller reservoirs in the basin, and the Crooked River all receive high recreational use, primarily for fishing. The areas receiving the highest use include: Lake Billy Chinook, Cove Palisades State Park, Smith Rock State Park, Prineville Reservoir, and Ochoco reservoir. Prineville Reservoir State Park and Cove Palisades State Park on Lake Billy Chinook are in the top five Oregon State Parks for visitation and use.

Hunting

The Crooked River Basin is a popular area for big game hunting as well as the hunting of waterfowl. The following big game statistics provide an estimate of the total number of hunters, and hunter days for deer, elk, bear and pronghorn seasons (Table 2-7). The numbers are approximated for the basin from an average of the estimates for the Silvies, Ochoco, Grizzly, and Maury Units.

Table 2-7: Big Game Hunter Statistics

Hunt	# of Hunters	# of Hunter Days
Elk- archery	322	3,200
Elk- rifle	1,670	8,650
Deer-archery	515	5,000
Deer-rifle	2,450	12,000
Bear	180	2,400
Pronghorn	50	130
Totals	**5,187**	**31,380**

Note: values were generated from an average of the ODFW estimates for Silvies, Ochoco, Grizzly and Maury units; they provide only a rough estimate for the basin.

Source: ODFW. 1997a

Water-based Recreation

There is limited data available on water based recreation activities, but use at Prineville Reservoir is estimated to be above 500,000 visitors annually. Approximately half of the visitor use of Prineville reservoir is estimated to be for angling purposes. Visits to Prineville Reservoir have increased dramatically over the past two decades, from an estimated 95,000 recreation days in 1985 to over 500,000 visitor days in the late 1990's (USDA BLM 1992a). Cove Palisades State Park, located on the Crooked River arm of Lake Billy Chinook, also receives hundreds of thousands of visitors annually and day use levels increased by nearly 25% since 1990 (USDI BLM 1992b). Ochoco Reservoir also receives high use, primarily by anglers, as it is open year round. Use of area reservoirs is expected to continue to increase as central Oregon's residential and tourist populations grow.

Key Findings, Data Needs and Management Recommendations- Land Use

Key findings, data needs and management recommendations presented below were developed from information gained in the watershed assessment process and by members of the Council's assessment technical team.

Key Findings

- 60% of the land base is public, 40% is private
- 51% of streams are adjacent to private lands
- Public lands concentrated at higher elevations
- Lower elevation streams, those most sensitive to management activities, are located primarily on private lands; restoration efforts will need to focus on these areas
- Current economic conditions in the agricultural and timber industries are negatively affecting residents and communities in the Crooked River Basin
- Population growth in central Oregon is high, population pressures within the basin are expected to increase
- High population growth impacts watershed conditions including habitat fragmentation, water availability and fire risk
- Human populations are concentrated in the lower Crooked River Sub-basin
- There are three wild and scenic river segments in the basin
- Top three industries: wood products, agriculture and recreation/tourism are all dependent on healthy environmental conditions
- Wildlife populations impact the economy in both positive and negative ways, two major impacts are hunting and wildlife damage to agricultural producers
- Basin reservoirs receive high day use for recreation

Data Needs

- Soils - comprehensive soils mapping has never been completed for all of Crook County
- Wetlands
- Actual land use
- Impervious surface (changes in)
- Potential impacts of development (water availability, habitat fragmentation, and fire risk…)

Management Recommendations-Land Use

- Proactive approach to land use management by Crook County and City of Prineville
- Protection of key habitat (once identified) given increasing pressure on public lands (recreational use) and increasing private land development (residential developments, partitioning, etc.)
- Improved information on current conditions and trends in type and location of land use

3. HISTORIC CONDITIONS

Characteristics of Watershed Resources at the Time of European Exploration and Settlement

Vegetation

At the time of European settlement, in the mid-to-late 1800's, the watershed was characterized by a more open vegetation regime, in both forest and range areas. Overall western juniper distribution and density were much reduced, with juniper restricted to the rocky, moist draw areas naturally resistant to fire. In general, the western edge of the watershed (in the Mazama Ecological Province) had more juniper than the remainder of the basin. Early journals commonly note the valleys full of waist high grasses and the year round abundance of forage for livestock.

> "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).

Forested areas in the Ochoco Mountains had a higher occurrence of open Ponderosa Pine stands, larger individual tree sizes, and a more widely distributed population of western larch.

The riparian and floodplain areas of the watershed had significantly more woody vegetation than is currently present. Willows were a primary component of riparian species (Ochoco means willow in Pauite) but other common species included cottonwoods, aspen, alder, as well as shrub species such as chokecherry, hawthorn, or dogwood. The floodplains were dominated by bunchgrass, wild rye and swamp grass, with very little invasion of juniper and sage communities (USDA FS 1998b, CCHS 1994, Lent 2000).

Surface Water/Stream Channels

In general, there were more springs and watercourses in the basin. Many streams that are currently intermittent were perennial (a good example is Trout Creek in the Paulina/Beaver Creek drainage, this stream provided a source of food (salmon/trout) to locals in the late 1800's through the turn of the century). There was more riparian vegetation, including sedges, grasses, and woody species, and stream channels were still well connected to the broad valley bottom floodplains. The Crooked River 'flooded' practically annually, with a meandering channel that took up the entire valley floor. In 1887, the Prineville School was located "on the banks of the Crooked River" at the corner of 2nd and Deer Street. (USDA FS 1998b, CCHS 1994, Miller 1974, Lent 2000, ODFW 1996). Today this location is nearly one-fifth of a mile from the active channel of the Crooked River.

Natural Disturbance Patterns

The Crooked River functioned to handle high spring flows as it was connected to its floodplain. Fire was much more frequent and less severe, mostly burning grasses and low ground covers. There is not much information prior to the 1930's on fire regimes in the basin but two major forest fires are noted in the historical record. In the Paulina area in 1908 25,000 acres burned on what is now the Ochoco National Forest and in the 1930's 3,000 to 4,000 acres burned in the McKay Creek watershed (USDA FS 1998b, CCHS 1994, Lent 2000).

Native Populations

Native populations were not settled, and it was rare for them to return to the same seasonal camps. Groups primarily moved through northern portions of the basin, near water sources in the Ochoco Mountains. Native populations in central Oregon were hostile (to European settlers and each other) up until about 1868, which had a significant impact on settlement and land use patterns in the watershed up to this point. (Lent 2000, Ontko 1992).

Wildlife

Overall, there is very little information on pre-European settlement wildlife populations. They are believed to be much lower than currently, indicated by the facts that native human populations moved continually through the landscape, and early explorer's journals commonly note that they faced starvation due to a lack of available game. Populations of game species were lower than they are currently, especially for elk but also for deer and other species as well. The area was used by European fur trappers long before settlement, and was noted for good beaver populations and large individual animals. Ochoco and Beaver Creeks were noted for their good salmon and trout populations. Journals of early settlers and loggers note the presence of bighorn sheep, sage hens, deer, and bear in the Bear Creek and Crooked River Canyons. (USDA FS 1998b, CCHS 1994, Lent 2000, ODFW 2000).

Fish Species, Abundance, and Habitat

Little information exists in the historical record on early fish species, populations, and distributions. It is believed that Steelhead, Chinook Salmon, Bull Trout and Redband Trout were all present (Nehlsen 1995, ODFW 1996). Peter Skene Ogden noted the presence of a Native American fish weir at the confluence of the North Fork Crooked River and the mainstem in 1826 (Lent 2000). Ochoco and Beaver Creek watersheds were noted in journals for good salmon and trout populations and Trout Creek in the Beaver Creek watershed was noted as a good source of food in poor crop years for early settlers. Willa Nehlsen (1995) researched the topic extensively for the entire Deschutes Basin and information from her work is provided below in Tables 3-1 and 3-2.

Table 3-1: Timeline of Major Events that Helped Shape the Watershed

1800-1860's	Surveying missions for fur companies - trapping activity
1832	Crooked River named on European maps
1868	End of Indian Wars - European settlement begins
1870's	European settlers arrived- Prineville, lower Ochocos, Post, Paulina
1870's-1930's	Period of heavy livestock use (cattle, sheep, horses)
1870	Town of Paulina founded
1880's	Large influx of sheep and herders
1880's	Early water rights allocated in upper basin
1883	Prineville Fire, Flood
1884/5	Severe winters followed by open winter - no hay - 1,000's of livestock starve
1889	Flood caused major channel movement of the Crooked River, Prineville
1890	Mail route starts between Paulina and Prineville
1890-1905	Range wars - 8,000-10,000 sheep slaughtered
1894	Upper Ochoco Valley floods
1895	Rangeland fire
1902-6	Federal lands established
1908-1920	Irrigation systems installed
1908	28, 560 acres of USFS land near Paulina burned
1909	Railroad into central Oregon - line skipped Prineville
1919	City of Prineville develops own railroad with service to Terrebonne for timber
1921	Ochoco dam/reservoir constructed - complete fish passage barrier, altered flow
1921	Opal Springs dam installed (Crooked River) - partial fish passage barrier
1922	Fire in downtown Prineville
1930's-80's	Major timber mills in Prineville (6)
1952	Crooked River floods
1960	Two miles of South Fork Crooked River chemically treated to eliminate non-native fish
1961	Bowman dam/reservoir installed on the mainstem Crooked River - complete fish passage barrier, altered timing of flow
1962	Chemical treatment of mainstem Crooked River
1958-64	Construction of the Pelton and Round Butte Dams/Lake Billy Chinook complex - fish passage structures in original facility, major problems with downstream passage of juveniles due to thermal blocks
1964	Major flood in Oregon
1964, 65, 66	Army Corps of Engineers channelized most streams above Prineville
1968	Upstream passage of fish eliminated at Pelton Round Butte complex
1981	Entire South Fork Crooked River chemically treated to eliminate non-game fish, resulted in eliminating native redband populations as well
1982	Renovation of the Opal Springs hydroelectric facility - fish passage barrier
1988	Wild and Scenic River sections designated on the: North Fork Crooked River, Mainstem Crooked River below Bowman Dam (Chimney Rock section) and the Lower Crooked River (Smith Rock section)
1998	Flood in Ochoco Creek watershed - primary impacts felt below dam and within Prineville city limits

Sources: Lent, 2000. Crook County Historical Society, 1991 & 1992. Crook County Historical Society, 1994. Nehlsen, 1995. ODFW, 1996. Steber, 1989. Juris, 1975. Miller, 1974.

Table 3-2: Anadromous Fish Information Timeline

1826	Peter Skene Ogden noted a native American salmon weir just downstream of the confluence of the North Fork Crooked River and the Mainstem Crooked River (See Appendix 3-A for historic fish weir sites)
1921	Ochoco dam installed - complete fish passage barrier
1921	Opal Springs dam installed - partial fish passage barrier
1942	Reports of steelhead in lower Ochoco Creek and Beaver Creek
1948	Department of Interior states that chinook and steelhead gone from the Crooked River system around 1915
1951	Oregon State Game Commission noted that salmonids migrated through entire Crooked River system in late winter-early spring when flows were high
1952	Steelhead in Crooked River above Prineville
1952	Spent steelhead found in McKay, Ochoco, Drakes, Horse Heaven, and Beaver Creeks and the North Fork Crooked River.
1953	Steelhead redds in Twelvemile and Ochoco Creeks
1954	Steelhead adults in Paulina Creek
1960	Department of the Interior notes that steelhead and a few chinook still exist in the Crooked River System. Chinook reported in Ochoco Creek, Beaver Creek, and the Upper Crooked River.
1960	Two miles of the South Fork Crooked River chemically treated to eliminate non-native fish
1961	Bowman dam installed on the Crooked River - complete fish passage barrier
1962	Chemical treatment of mainstem Crooked River
1958-64	Construction of the Pelton Round Butte Dam/Lake Billy Chinook complex - fish passage structures in original facility, major problems with downstream passage of juveniles due to thermal blocks
1968	Upstream passage of fish eliminated at Pelton Round Butte complex
1980	Bull Trout caught in Lower Crooked River at Prineville
1981	Entire South Fork Crooked River chemically treated to eliminate non-game fish, resulted in eliminating native redband populations as well
1982	Renovation of the Opal Springs hydroelectric facility, complete fish passage barrier - no bull trout seen in Crooked River above this point since then

Source: Nehlsen, 1995. ODFW, 1996. Crook County Historical Society, 1994.

Historical Trends and Locations of Land Use and other Management Impacts in the Watershed

Livestock

Early explorers noted the abundance of lush valley grasses, calling the Crooked River Basin 'a veritable paradise for stock'. From the time of European settlement in roughly 1870 through the 1930's livestock grazing was the major land use throughout the entire basin. The first settlements in the basin were in the Mill, McKay, Marks, and Ochoco drainages and were based on livestock ranching. The Paulina and Post areas were also some of the earliest settled by Europeans for livestock. Initially, grazing was dominated by cattle, but sheep moved into the area around 1880. By the turn of the century the high numbers of sheep, cows and horses were depleting the grasslands, which were being replaced by sage communities. Horses were a significant source of range damage in the South Fork Crooked River/Hampton Buttes region of the basin (Lent 2000, CCHS 1994, CCHS 1991, CCHS 1992, Ontko 1992, Steber 1989).

The change from native grasses to sage impacted many of the streams in the watershed, resulting in major stream incision and loss of riparian vegetation in the late 1800's/early 1900's. Recent research (Buckley 1992) indicates that prior to 1885, floodplains in the Camp Creek watershed were dominated by bunchgrass, wild rye, and swamp grass, and that streams perennial and not incised. After 1903, floodplains in the Camp Creek watershed were dominated by sagebrush and the stream channel was described as a trench. This intense period of channel incision is believed to have been caused by the interaction between high grazing pressure and variable climate (drought followed by intense summer storms), as well as the loss of beaver and its associated habitats (Buckley 1992, USDA FS 1998b, Deboodt 2000).

Range damage meant that ranchers had to begin growing hay for feed and the period of resource depletion was accompanied by human conflicts over use of the range. From 1890-1905, in what were known as the range wars, 8,000-10,000 sheep and numerous men were killed, as cattle ranchers fought to establish control of the range (Lent 2000, Steber 1989). In approximately 1905 the federal forest system was established and grazing in these areas became a permitted activity. Despite these changes, grazing was still essentially uncontrolled until the creation of a grazing service (1936), which followed the Taylor grazing act of 1934 (Deboodt 2000).

Irrigated Agriculture

The majority of water rights in the upper basin were allocated in the 1880's (Deboodt 2000, Gorman 1999). Irrigated agriculture took off just after the turn of the century, with major diversion systems installed on the Crooked and Deschutes Rivers in 1908. Within the Crooked River Watershed these early systems predominantly served the areas of Powell Butte, Prineville and Post. Many other systems were also constructed around this time, including Horse Heaven Creek Dam (1910), which was the largest dam in central Oregon at

the time, with over 3 miles of canal and 130 acre feet of storage. The Ochoco Irrigation District was established in 1918, Ochoco Dam and reservoir was constructed in 1921 (CCHS 1994, Lent 2000, Moore 1999).

By 1912 diversion of water was so extensive that the riverbed of the mainstem Lower Crooked River, near river mile 35 where no springs provide water, was frequently dry. Lower reaches of most of the smaller tributaries were also dry in late summer and early fall; only the North Fork and uppermost tributaries contained water at this time of year. Overall effects of irrigation expansion included: decreased water quality; changed timing of water availability; fish passage barriers created by dams and diversions; and reduction in downstream flows in summer months (ODFW 1996).

Mining

Mining activity was limited in the Crooked River Watershed. There was some shaft mining for gold in the Ochocos from the 1870's through about 1920, as well as cinnibar/mercury mining in the 1930's. Gold was discovered at the Ochoco Mines in 1873 and small claims continued through the turn of the century. Cinnibar/mercury mining was much more detrimental to the resource than gold mining operations but was also fairly limited. The United States Forest Service is still dealing with legacy of mercury mining operations today at a few sites on the Ochoco National Forest. (CCHS 1994, Lent 2000, USDA FS 1989).

Timber Harvest

From the period of European settlement (1870) through 1910 timber harvest within the watershed was limited to small-scale operations for local utilization. Small sawmills were located in the Mill, Marks, and Ochoco Creek watersheds during this period. A small mill was also located in the Post area on Newsome Creek during this period. The advent of the railroad into central Oregon in 1910 brought on a boom in timber harvest as it created access to commercial markets.

- Settlement (1870's) to 1910's- timber harvest limited to small-scale operations for local utilization (mills located in Mill, McKay, Ochoco and Marks watersheds).
- First sawmill- Mill Creek watershed- 1870's
- Second sawmill- Grizzly Mountain/Willow Creek area- 1870's
- Sawmills: Newsome Creek (1910-1917); Post (1943-49); Sherwood Creek (1949-50); Paulina (1950); Dry Creek (1918)
- Railroad into central Oregon in 1910- brought on a boom in timber production. From 1910-1930's the major mills were located in Bend.
- 1930's – 1980's Prineville a major timber center, with six large mills operating.

(Lent 2000, Steber 1989, CCHS 1994, CCHS 1991, CCHS 1992)

Fur Bearers

- Surveying missions for fur companies moved through the Upper Ochoco Valley and central Oregon in 1800-1860's but a hostile native population keep white settlers out
- Ogden's 2nd Snake River Party had 100 trappers

(Lent 2000, Ontko 1992)

Human Settlement Patterns

- Crooked River named on maps proved in 1832 and 1833
- Secret surveying missions for fur companies moved through the Upper Ochoco Valley and central Oregon in 1800-1860's but a hostile native population kept white settlers out
- White settlement didn't occur in any number until the 1870's.
- 1868 - 26 families settled on Mill, Ochoco, and McKay Creeks
- First major settlements in 1870's - Prineville, Lower Ochocos, Paulina, Post.
- 1870-1920 - 11 homesteads in Post
- Prineville population in 1890-1900 = 450
- Federal laws that encouraged settlement of central Oregon included: Homestead Act of 1862 (160 acres); Desert Land Act of 1877 (land to those who would attempt to irrigate it); 1904 - Homestead Act acreage increased to 320 acres for non-irrigable lands; 1916 - Homestead Act acreage increased to 1640 acres for non-irrigable land; 1866 - public lands given to State of Oregon for construction of a military wagon road (Paulina Hwy.); and the timber grants program of the early 1900's.

(Lent 2000, Ontko 1992, CCHS 1994)

Historical Anadromous Fish Information

The first formal fish surveys in the basin took place in the 1950's after substantial habitat and population declines had already occurred. Despite the major habitat changes that had been underway for 75 years, the 1952-54 surveys located steelhead up to 120 miles from the mouth of the Crooked River (Nehlsen 1995, ODFW 1996). Historical accounts indicate that most historical spawning and rearing of salmon and steelhead in the Upper Deschutes Basin occurred in the main tributaries - Crooked River, Squaw Creek, and Metolius. Species of interest believed to be present in the basin included: spring chinook salmon, summer steelhead, bull trout (in mainstem up to the town of Prineville) and redband trout (ODFW 1996).

Key Findings- Historic Conditions

Key findings were developed from information gained in the watershed assessment process and by members of the Council's assessment technical team.

- Anadromous fish species were eliminated from the basin and resident fish populations were fragmented by the construction of major dams in the Lower Crooked River Sub-basin (Pelton, Bowman, Ochoco, Opal Springs)
- Populations of big game are greater now than at pre-settlement
- Riparian vegetation communities are less diverse and less extensive than at pre-settlement
- Water rights were mostly allocated in the basin by the 1880's
- Construction of the Prineville Railroad supported the establishment of major timber harvest and wood products industries in the basin over the last century
- Timber harvest and livestock grazing were the dominant resource uses of the basin over the last 150 years
- Earliest settlements in the basin were concentrated around Ochoco, Mill and McKay Creeks and in the Prineville, Post and Paulina areas

4. HYDROLOGY and WATER USE

Climate and Streamflow

The Crooked River Basin is located in the South Central Oregon climatic zone, a semi-arid area of high desert prairie punctuated by small mountain ranges and isolated peaks. Average annual precipitation is between 8 and 10 inches per year at lower elevations and may reach 30-40 inches at higher elevations (falling primarily as snow in the winter) (USDA FS 1998b). The highest monthly precipitation totals occur in the winter months, with a secondary maximum during the late spring and early summer. High intensity thunderstorms can contribute large proportions of annual rainfall locally and contribute to increased erosion. Late spring and summer precipitation events are characterized by short duration, high intensity storms that contribute to localized flash flooding. As distance increases to the east, away from the Cascade Mountains, the spring-summer peaks become much more pronounced. Summer temperatures are quite warm at lower elevations, but the growing season is relatively short, particularly at higher elevations, and frost has been recorded in every month.

Natural flow in the streams of the Crooked River Basin is relatively low. The streams possess characteristics of a semiarid climate, with low precipitation producing low runoff. Average annual precipitation ranges from 8-10" in the valley to 34" in the vicinity of Big Summit Prairie. Approximately 2/3 of the total annual precipitation comes in the form of snow during the months of October through April. Large variations occur on an annual and seasonal basis, with snowmelt and summer rainstorms contributing to high runoff and flow events. Tributary streams originating in the Ochoco Mountains contribute substantially to the flow of the Crooked River Basin with inputs from both snow and rain. Tributaries originating to the south of the Crooked River do not contribute as much water to the river, but can be influenced heavily by high intensity storm events such as summer thunderstorms. Flow within the Crooked River originates from springs in the upper headwaters and lower mainstem, and from snowmelt at the higher elevations.

The South Fork of the Crooked River is formed by the outflow of several springs. The mainstem Crooked River begins at the confluence of the South Fork and Beaver Creek, which receives its flow from springs as well as snow melt and rain from the Ochoco Mountains. The North Fork Crooked River, also fed by springs and snowmelt, adds considerable flow to the mainstem. Springs and tributary streams continue to contribute flow above Prineville. Below Prineville, there are no known springs of significant size until river mile 15 where large springs augment the flow to the confluence. The mean annual discharge of the Crooked River into the Deschutes River (at Lake Billy Chinook) is approximately 1,131,000-acre feet (OWRD 1998).

The closure of Bowman dam changed the timing of peak flows as well as their size in the Crooked River. Before closure of the dam, 75% of the average flow of the Crooked River occurred in the months of March, April, and May (McSwain 1999). In some cases, such as below Bowman and Ochoco Dams, natural seasonal flow patterns are reversed, with high flows during the irrigation season when water is released, and low flows while water is stored

for the next irrigation season. Altered streamflow has resulted throughout the basin from the numerous public and private reservoirs created for water storage. Post-reservoir characteristics below large reservoirs such as Ochoco and Prineville include: reduced annual maximum mean flow, elimination of peak high flows, reduction in late winter and early spring flows, and an increase in summer and fall flows (McSwain 1999, ODFW 1996). See Figures 4-1, 4-2, 4-3 for graphic examples of changed Crooked River flow regimes.

Prior to the closure of Bowman Dam in 1960, average peak discharges typically ranged from 3,000-7,000 cfs (OWRD 1998). Following closure, peaks never exceed approximately 3,300 cfs (OWRD 1998). This limits the ability of the stream channel to rejuvenate through landform developing processes such as large floods. Peak flows that used to occur every 2.5 years (i.e~4,000cfs) now occur about every 50 years on average which has a significant effect on channel morphology (McSwain 1999, ODFW 1996). In addition, the smaller channel maintenance flows were reduced following dam closure, thereby limiting the ability of the stream to move bedload. While channel forming flows have not been identified, the Prineville Reservoir Reallocation Study has recognized that in addition to their significance for fish, instream flows are needed for channel maintenance and bedload transport (Berggren 2001).

Impacts of Land Use

The Crooked River Watershed exhibits characteristics of a watershed that is not safely capturing, storing, and releasing water. Reservoirs exhibit a high rate of sedimentation and short-duration thunderstorms often result in large hydrologic events (USDA FS 1998b). Much of the Crooked River Basin is dominated by soils vulnerable to erosion due to steep slopes, high clay content, and poor vegetative cover. Timber harvest, fire suppression, and livestock grazing have occurred throughout the basin and have impacted basin hydrology (USDA FS 1998b). Loss of native vegetation in riparian areas throughout much of the basin has increased erosion and reduced the storage capacity of watersheds, resulting in larger peak and lower low flow events. Expansion of western juniper has reduced ground cover and it is believed these areas are contributing to increased overland flow and sedimentation; erosion and flashy flows are most common during and immediately following intense summer thunderstorms. Numerous irrigation diversions and storage structures also effect natural hydrologic processes in the basin (USDA FS 1998b, McSwain 1999, ODFW 1996).

Irrigation was so widespread throughout the basin by 1912 that many perennial streams were running intermittently and even sections of the mainstem Crooked River and Ochoco Creek were essentially de-watered. While the efficiency of water use has improved, the amount of irrigated cropland has increased over the past 60 years as water diversion and storage structures were implemented throughout much of the basin. Surface water rights are over-allocated for the entire basin, and water withdrawals impact streamflow conditions for fish and other aquatic species during certain times of the year. Intensive grazing pressures, irrigation, fire suppression, beaver removal and road construction (crossings) have resulted in downcut stream channels and a lowered water table throughout many of the stream and floodplain areas in the basin (ODFW 1996, USDA FS 1998b, WSPE 1997).

Figure 4-1: Mean Daily Flow, Lower Crooked River

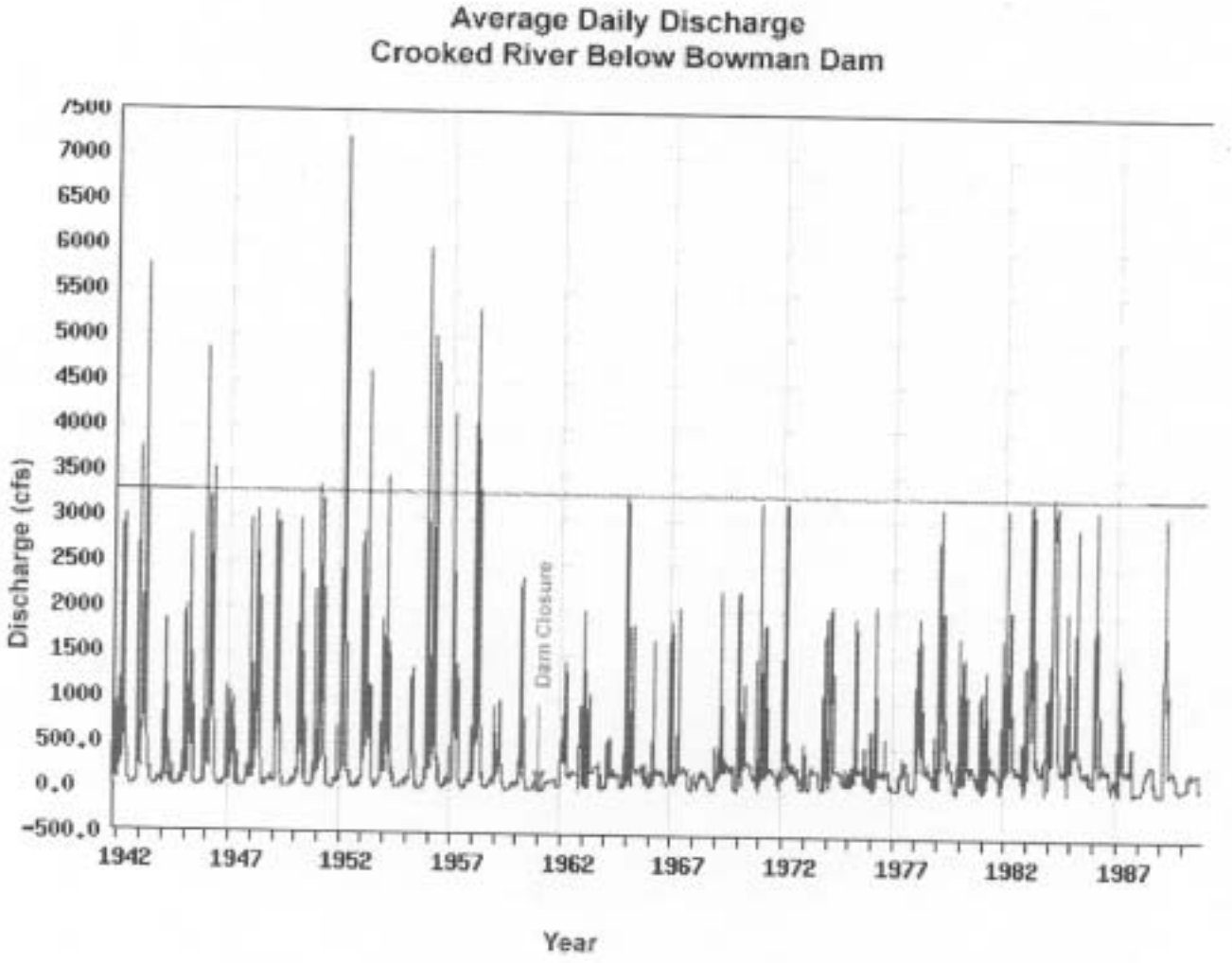


Figure 4-2: Annual Maximum Mean Flow, Lower Crooked Rover

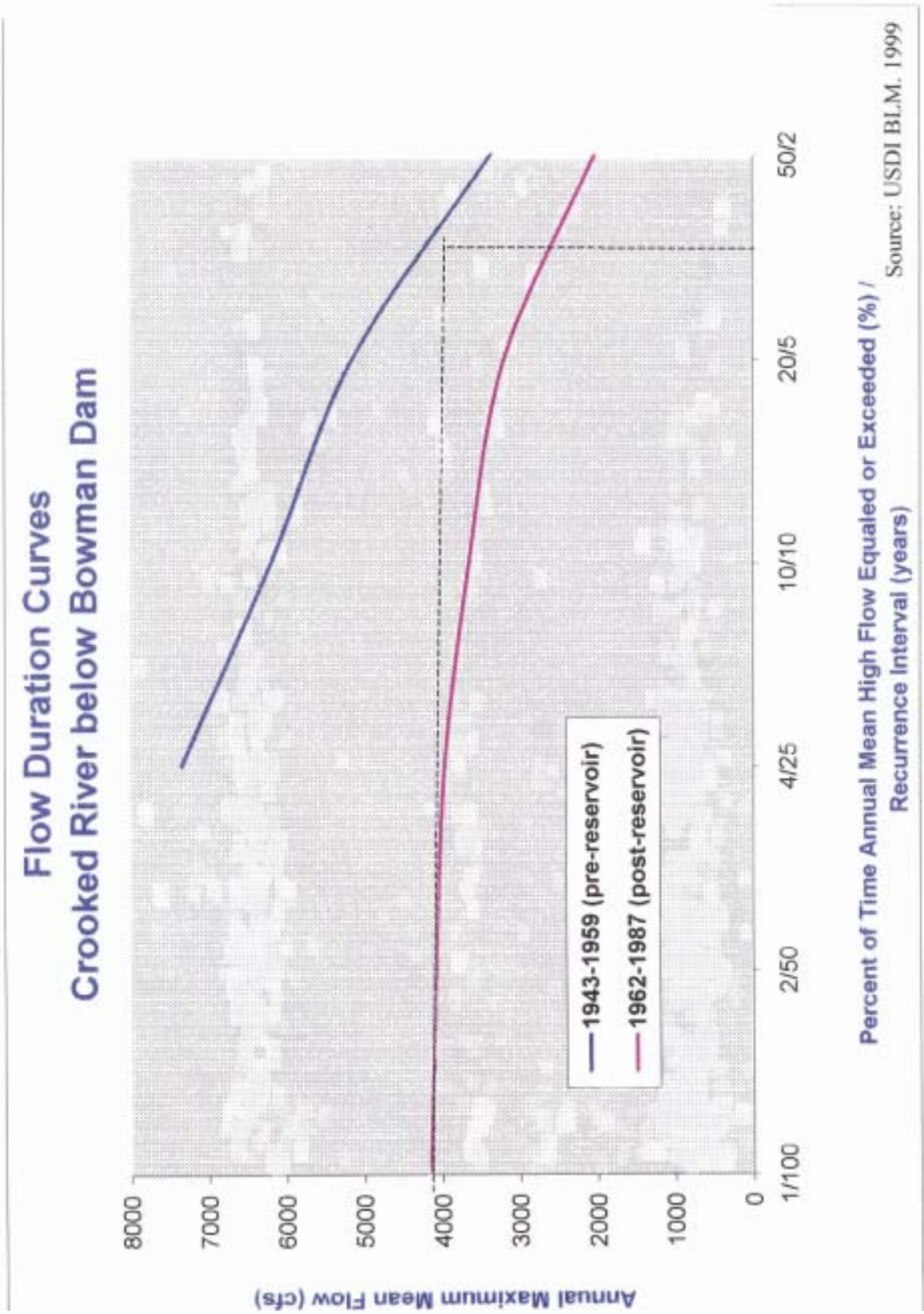
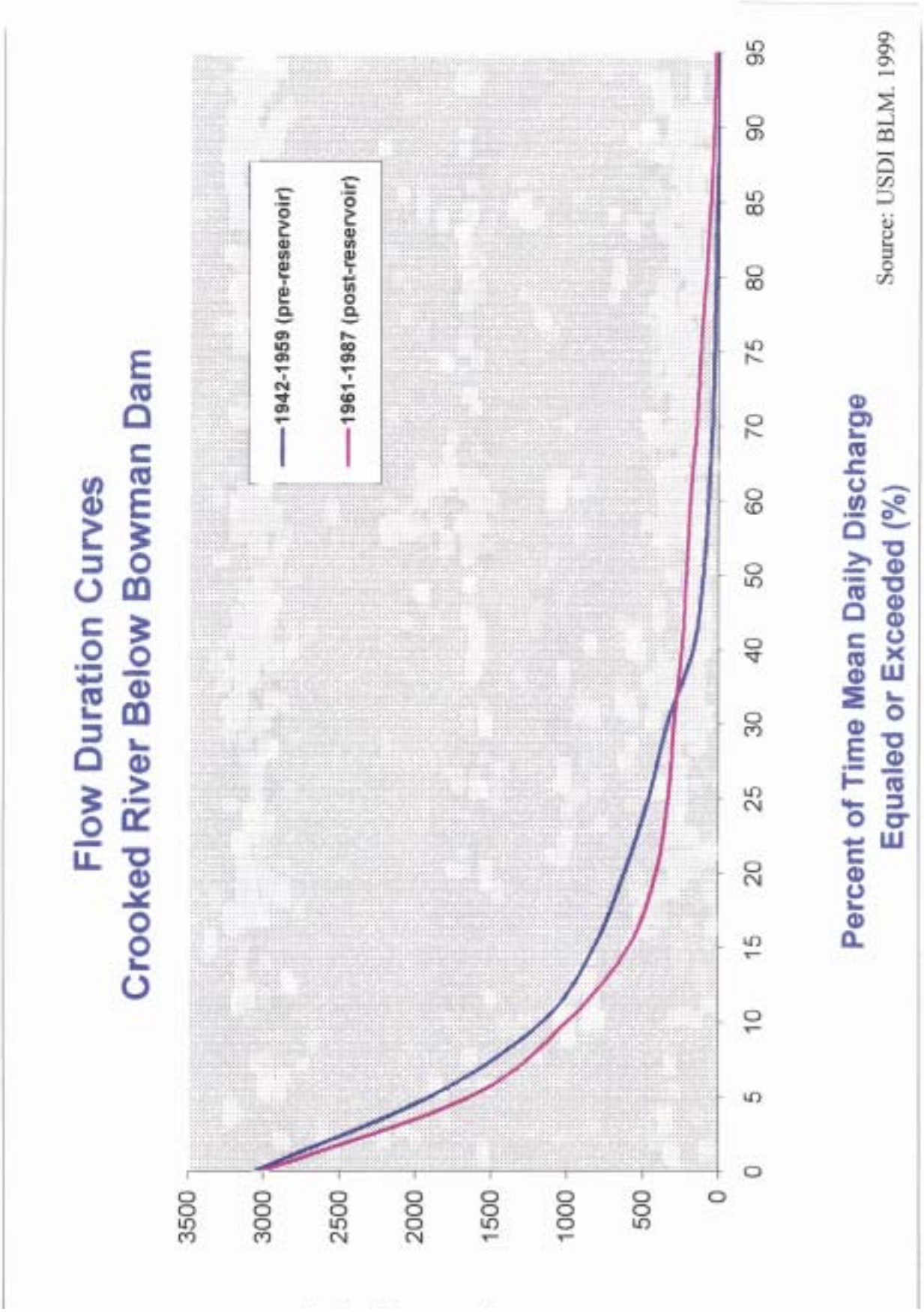


Figure 4-3: Mean Daily Discharge, Lower Crooked River



Channel modification, particularly along Ochoco Creek and McKay Creek through the greater Prineville urban area and almost the entire length of the mainstem Crooked River, has resulted in a stream system disconnected from its floodplain and essentially designed as a water transport system (ODFW 1996, WSPE 1997). This channel straightening, along with degraded vegetation conditions in riparian and upland areas, and the erodable soils present throughout much of the basin, contribute to the now characteristic flashiness of flows within the basin.

Water Storage

There are three major dams within the Crooked River Basin, Opal Springs, Ochoco, and Bowman. Two of these dams, Ochoco and Bowman were developed to create storage reservoirs for irrigation, the third, Opal Springs, is a hydroelectric facility. An extensive system of reservoirs and transport ditches has been developed in the Crooked River Basin, predominantly for irrigation. Numerous smaller water impoundments also exist throughout the basin and are used to store water for use in the growing season. Significant wet meadow systems exist within the basin, primarily in the Ochoco Mountains, although many of these systems have been altered by land use practices and may not be functioning properly. The majority of the basin is located within the John Day ecological province, a region of highly erodable soils, and changes in the upland and riparian vegetation communities over the past century have further depleted the capacity of the soils to effectively capture, store, and release water without excessive runoff and erosion (USDA FS 1998b).

Over 300,000-acre feet of water storage is available in the reservoir system in the Crooked River Basin, not including Lake Billy Chinook (USDI EPA 1999) (Figure 4-4 & Table 4-1). The primary reservoirs are Prineville Reservoir (233,000 acre feet capacity), and Ochoco Reservoir (44,500 acre feet capacity), but there are numerous smaller reservoirs throughout the basin. The two largest reservoirs, Prineville and Ochoco account for nearly 90% of the storage capacity in the Crooked River Basin. Both of these reservoirs were developed for the purposes of irrigation, flood control, and storm water management. Both are publicly owned and also receive high recreational use. Remaining larger dam and reservoir systems within the basin are primarily intended for irrigation but also serve other purposes. In the lower Crooked Sub-basin, 4 are used for irrigation purposes, 1 provides recreational opportunities and 1 (Opal Springs) is a hydroelectric facility (USDI EPA 1999). These six are all privately owned. In the Upper Crooked River Sub-basin, there is a publicly owned reservoir that is managed by the Forest Service for recreational purposes (USDI EPA 1999). The remaining 16 systems are privately owned and used for irrigation and recreation. In the Beaver South Fork Sub-basin, all 11 reservoirs are private and used predominantly for irrigation purposes (USDI EPA 1999). Along with changed flow regimes, the existence of dams and reservoirs also changes sediment delivery to the lower rivers and streams. Impacts of the lack of sediment moving downstream to aid in channel forming and maintenance processes are most pronounced for Prineville Reservoir and the Lower Crooked River.

Figure 4-4: Basin Reservoirs and Ponds

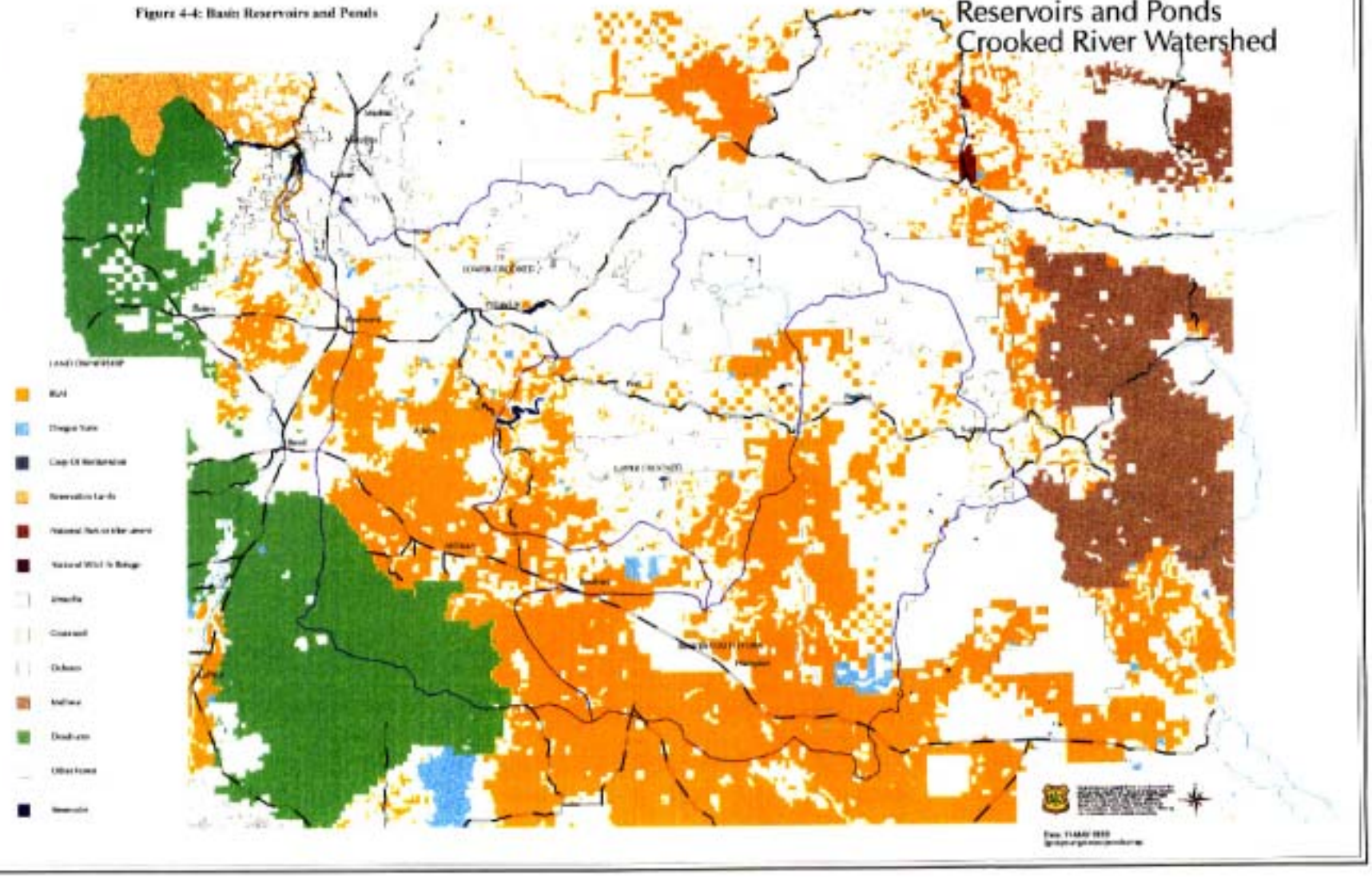


Table 4-1: Crooked River Basin Reservoir Storage Capacity

Sub-basin	# Reservoirs (large)	Total Storage Capacity (acre feet)
Lower Crooked (excluding Lake Billy Chinook)	7	65,944 acre feet
Upper Crooked	18	244,055 acre feet
Beaver South Fork	11	2,944 acre feet
Total Crooked River Basin	36	312,943 acre feet

Note: 1 acre-foot equals 0.5 cubic feet per second for 1 day

Source: USDI EPA. 1999

Wetlands

A comprehensive inventory of wetlands and associated special habitats such as seeps, springs, wet meadows and bogs does not exist. However, based on historic documents, a general decline in these habitats is assumed as a result of land and water use and development trends. High elevation wet meadow systems are an important feature of hydrologic systems for much of the Ochoco Mountains and were impacted historically by agricultural uses. Springs are also an important hydrologic feature throughout the Crooked River Basin, providing major inputs to the system on the South Fork Crooked River, higher elevation Ochoco Mountain streams and lower reaches of the Crooked River. Additional information is needed on wetland and special habitat conditions within the basin.

Floodplains

Stream channelization and land use practices have resulted in downcutting of many of the streams and rivers within the Crooked River Basin (USDA FS 1998b, McSwain 1999, ODFW 1996). As such, these channels do not connect with their floodplains and water moves quickly through the system. In addition, upland soil and vegetation conditions contribute to a flashy response to precipitation events. The "upper country" (Post/Paulina area) of the watershed is heavily impacted by floods due to landscape conditions that lead to flashy flows and a lack of control structures (USDA FS 1998b). Channelization of Ochoco Creek also influences high flow events through the City of Prineville (NRST 1998). Prineville and Ochoco reservoirs play a large role in controlling floodwaters in the Lower Crooked River Sub-basin. Area estimates within the 100-year floodplain includes 168 linear miles along the Crooked River and 320 acres within the City of Prineville metro area (Prineville Planning Department 1997).

Water Use

Over 99% of the water allocated in the Crooked River Basin is used for agriculture and approximately 95% of total water use (agriculture, domestic, and commercial) comes from surface water (OWRD 1999). See Table 4-2 for a breakdown of water use by sub-basin. Surface water resources are over-allocated throughout the Crooked River Basin, as well as throughout the entire Deschutes Basin. The effects of current and future groundwater withdrawals on overall basin hydrology and surface water flows is the subject of an intensive

scientific and policy inquiry within the Deschutes Basin. Initial results from the United States Geological Survey research into the connectivity between ground and surface waters in the basin indicate a close linkage between groundwater withdrawals in the Upper Deschutes basin and flows in the lower Deschutes River, and indicates areas of the lower Crooked River may also be hydrologically connected to groundwater (USGS 2000).

Table 4-2: Water Use and Source by Sub-basin

Water Use Category		
Lower Crooked River Sub-basin	**Upper Crooked River Sub-basin**	**Beaver South Fork Sub-basin**
Irrigation-98.5%	Irrigation-99.4%	Irrigation-99.5%
Livestock Use-.002%	Livestock Use-.3%	Livestock Use-.4%
Commercial & Domestic-1.3%	Domestic-.3%	Domestic-.1%
Source		
Lower Crooked River Sub-basin	**Upper Crooked River Sub-basin**	**Beaver South Fork Sub-basin**
95% Surface water	95% Surface water	95% Surface water
5% Groundwater	5% Groundwater	5% Groundwater

Source: OWRD. 1999

Surface Water Rights

There are approximately 750 surface water rights in the Crooked River Basin (excluding reservoir rights), representing over 4,000 cfs. The Lower Crooked River Sub-basin has the largest number of water rights and the largest allocation of surface water of the three basins, with approximately 350 water rights and over 3,500 cfs. The Upper Crooked River Sub-basin has approximately 240 water rights for a total of just under 500cfs, while the Beaver South Fork sub-basin has over 150 water rights and an approximate total of 260 cfs allocated (OWRD 1999). See Appendix 4-A for a description of surface water rights by sub-basin and Table 4-3 for a summary of water rights by sub-basin.

Table 4-3: Crooked River Basin Water Rights

Hydrologic Unit	**Surface Rights (cfs)**	**Reservoir Rights (acre-feet, does not Include Lake Billy Chinook)**	**Average In-Stream Rights (cfs) (peak cfs and month of peak, averaged across streams)**
Lower Crooked River Sub-basin	3,566 cfs	56,878 acre feet	284 cfs (636 cfs, April)
Upper Crooked River Sub-basin	497 cfs	167,823 acre feet	299 cfs (517 cfs, April)
Beaver South Fork Sub-basin	257 cfs	3,160 acre feet	99 cfs (223.9 cfs, April)
Totals: Crooked River Basin	4,320 cfs	227,861 acre-feet	965 cfs (1,376 cfs, April)

Note: 1 acre-foot equals 0.5 cfs for one day

Source: OWRD. 1999

Reservoir Water Rights

Over 200,000-acre feet of water are allocated to reservoir rights in the Crooked River Basin (not including Lake Billy Chinook) (OWRD 1999). The primary reservoirs are Prineville Reservoir (155,000 acre feet), and Ochoco Reservoir (44,500 acre feet), but there are numerous smaller reservoirs throughout the basin. The Lower Crooked River Sub-basin has approximately 50 reservoir rights representing just under 57,000 acre feet of water; the Upper Crooked River Sub-basin has approximately 110 reservoir rights representing just under 168,000 acre feet of water; and the Beaver South Fork Sub-basin has approximately 160 reservoir rights, representing over 3,000 acre feet of water (OWRD 1999). *(Note: 1 acre-foot equals 0.5 cfs for one day).*

Instream Water Rights

Instream flow protections have been established for many of the streams and rivers within the Deschutes River Basin, including those segments designated as wild and scenic waterways. Surface water is overallocated throughout the Crooked River Basin; with the seniority water rights system used in the western United States, this means that the majority of in-stream rights are unlikely to be actually fulfilled during periods of high water use and/or low flows due to their junior status. In-stream water rights were filed in all three sub-basins of the Crooked River Basin, primarily for the purposes of resident fish rearing. The majority of the instream water right applications in the Crooked River Basin were filed after 1990, and many of these have not been certified due to the large number of in-stream applications made throughout the State of Oregon at this time and the existing over-allocation of water within the entire Deschutes Basin. The amount of water requested or allocated to in-stream rights varies by month based on the life history requirements of resident fish species, with the highest flows generally requested between March and May.

The Oregon Department of Water Resources has in-stream water rights recorded for the following streams: Bear Creek, Crooked River, Horse Heaven Creek, Johnson Creek, North Fork Crooked River, Peterson Creek, Beaver Creek, North Fork Beaver Creek, South Fork Beaver Creek, South Fork Crooked River, Wolf Creek, Allen Creek, Johnson Creek, Marks Creek, McKay Creek, Mill Creek, and Ochoco Creek (OWRD 1999). The Oregon Department of Fish and Wildlife also filed for in-stream water rights on the following streams: Little McKay Creek, Brush Creek, Canyon Creek, Deep Creek, Gray Creek, Howard Creek, Lookout Creek, and Sugar Creek; to date these applications have not been certified (ODFW 1996). See Appendix 4-B for a description of in-stream water rights by sub-basin.

Management of public reservoirs in the basin (Prineville and Ochoco) also includes the allocation of flow to instream uses. The current Prineville Reservoir authorization requires that a minimum of 10cfs be released below Bowman Dam at all times (Berggren 2001). In 1990, Reclamation made an administrative decision to try and release 75cfs (35cfs in dry years) using uncontracted space. This release is not mandated and could change at any time. (Berggren 2001). Ochoco Irrigation District also tries to maintain minimum flow releases from Ochoco Reservoir; the dam also leaks approximately 7cfs, which helps maintain minimum instream flows (Moore 2000).

Water Availability

Surface water resources are overallocated throughout the Crooked River Basin. Based on an 80% exceedance streamflow, which determines the amount of water in the stream channel at least 80% of the time for a given month, consumptive uses exceed streamflow throughout the Crooked River Basin, particularly in the period from April to October (OWRD 1999). In some cases, consumptive uses exceed streamflow by over 2,000% (OWRD 1999). Water availability data is not available for the Beaver South Fork Sub-basin, but the trend of consumptive uses exceeding natural streamflow is observed throughout the entire Deschutes River Basin (Gorman 1999). Consumptive uses exceed the 80% exceedance streamflow for the following streams: Lower Crooked River (9/12 months), Ochoco Creek (12/12 months), McKay Creek (5/12 months), Allen Creek (5/12 months), Bear Creek (12/12 months), Upper Crooked River (3/12 months), Johnson Creek (6/12 months), North Fork Crooked River below Deep Creek (5/12 months), Camp Creek (5/12 months) (OWRD 1999).

When in-stream rights are factored in along with consumptive uses, water availability is below zero all of the time for all streams with data in the Lower Crooked River Sub-basin (OWRD 1999). In the Upper Crooked River Sub-basin water availability (80% exceedance streamflow minus consumptive and instream uses) is below zero all of the time for Bear Creek and Deep Creek. From June through September, water availability is below zero for all streams with data in the Upper Crooked River Sub-basin. Water availability data is not available for the Beaver South Fork Sub-basin but water availability is likely below zero for all streams at least throughout the summer months, like the remainder of the Basin (Gorman 1999). See Appendices 4-C and 4-D for consumptive use and water availability data for the Lower and Upper Crooked River Sub-basins. Water use and availability data is not available for the Beaver South Fork Sub-basin (OWRD 1999).

Groundwater

Surface water resources have been fully appropriated in the entire Deschutes Basin for many years, and stream flows below legally set minimum limits occur locally (Gorman 1999). Because surface water rights are unavailable, all new water development relies on groundwater resources. As central Oregon continues to grow at extremely rapid rates, concern over water resources, both surface and groundwater, is also increasing. Continued development of the groundwater resource has the potential to impact seasonal as well as long-term aquifer water levels, and may result in a further depletion of streamflow. The Oregon Water Resources Department and the United States Geological Survey are heading a multi-agency investigation of groundwater resources of the Upper Deschutes Basin (including a small portion of the Lower Crooked) in an effort to improve understanding of potential impacts to water resources through continued expansion of the use of groundwater (USGS 2000). Preliminary scientific finding from the USGS research finds strong hydrologic linkage between ground and surface waters in the entire Deschutes Basin; ground and surface waters in this area are well connected (USGS 2000). Until future impacts are better understood and mitigated, water availability is a limiting factor for essentially all uses in the basin. In response to this information, and the associated mitigation process, which is in the final planning stages, the City of Prineville has requested 5,000 acre-feet from the uncontracted

space in Prineville Reservoir. The City would use this water to mitigate impacts of projected increases in groundwater use for residential and municipal uses (Berggren 2001).

Key Findings, Data Needs and Management Recommendations - Hydrology and Water Use

Key findings, data needs and management recommendations presented below were developed from information gained in the watershed assessment process and by members of the Council's assessment technical team.

Key Findings

- Flow within the Crooked River originates from springs in the upper headwaters and lower mainstem, and from snowmelt at the higher elevations. Average annual precipitation ranges from 8-10" in the Crooked River Valley to 34" in the vicinity of Big Summit Prairie, with approximately two-thirds of that in the form of snow
- Changed upland and riparian conditions have led to increased flashiness of flows
- Irrigation use of surface flows from the Crooked River also contribute to summer low flows above dams/regulating facilities
- Below Bowman Dam, flows have been modified to decrease peak flows, increase summer low flows, and decrease average fall and winter flows. As a consequence, changes in both valley forming processes and stream channel processes have occurred.
- Surface water resources are overallocated in the entire Deschutes Basin
- Water withdrawals have changed flow regimes in many areas (season, amount)
- Water quantity issues are directly related to many of the water quality and fish passage problems in the basin
- Channel modification and straightening has occurred throughout the basin, particularly around the City of Prineville
- Irrigation diversion systems block passage and isolate and strand fish populations and individuals
- Extensive system of reservoirs (several large) exist and store water in the basin; these systems could potentially be used to restore/mimic flows for watershed health improvements (e.g.: fish habitat, water quality, channel maintenance)
- Majority of reservoirs in the basin exist for water storage for irrigation purposes; recreational use of larger reservoirs is also high
- Instream water rights hold late dates of appropriation. This junior status means that instream rights may not be fulfilled during periods of low flow and/or high water use

Data Needs

- Streamflow gaging data of more streams, sites
- Consumptive water use information (actual water use)
- Relationship between flows and fish populations/habitat (focus below large reservoirs, where management adjustments could be made)
- Impacts of flows on channel maintenance (focus below large reservoirs, where management adjustments could be made)
- Impacts of flows on water quality (focus below large reservoirs, where management adjustments could be made)
- Identify areas where water conservation could have a significant impact on flows

- Á Better understanding of relationship between ground and surface water in the basin
- Á Wetland information & riparian condition assessment information
- Á Water use and availability data for the Beaver South Fork Sub-basin

Management Recommendations

- Á Improve upland and channel conditions through vegetation management
- Á Significantly reduce juniper and improve watershed characteristics of uplands
- Á Reduce soil erosion
- Á Upland function- ensure soils exhibit infiltration and permeability rates, moisture storage, and stability that are appropriate to the soil, climate and landforms
- Á Riparian function- ensure that riparian and wetland areas are in properly functioning physical conditions and are moving toward desired conditions

5. UPLANDS

Land Use

Information gathered in the late 1970's estimated that land use in the Crooked River Basin included approximately 73% range, with grazing as the primary use; 21% forest; 4% irrigated agriculture, and 2% urban and other uses (USDA NRCS 1994). While the percentage of forestlands has remained about the same, the proportion of lands used for crop production has increased in relation to the proportion of lands used for grazing as the economic significance of crops has expanded in the region. In addition, the percentage of lands used for rural residential is increasing in the basin and the urban growth boundary of Prineville has also expanded. Rural development is primarily occurring in former agricultural areas or in forestlands dominated by juniper.

Much of the available information for the assessment process, particularly regarding human variables such as land use, is available by county, not ecological boundaries. General trends provided for Crook County can be extended to include the basin as a whole, acknowledging the higher level of uncertainty inherent in this approach. If trends are believed to be significantly different for basin areas outside of Crook County these differences will be noted.

Information on vegetation type or community off of public lands is limited, and even public land data is coarse. Ochoco National Forest is currently working to develop potential vegetation classifications for their lands; no effort is underway for either BLM or private lands in the basin. Using satellite imagery, the Interior Columbia Basin Ecosystem Management Project (1996), classified portions of the Crooked River Basin into forest and range vegetation types (Table 5-1). This information is at a coarse scale and should only be used as a rough estimate of vegetation classification. In addition, information was only available for the Lower and Upper Crooked River Sub-basins.

Table 5-1: Range and Forest Vegetation Groups by Sub-basin

Vegetation Classification	Upper Crooked	Lower Crooked
Forest		
Dry Forest	81%	51%
Moist Forest	11%	21%
Cold Forest	8%	28%
	100%	100%
Range		
Dry Rangeland	49%	49%
Cool Rangeland	34%	34%
Other Rangeland	17%	17%
	100%	100%

Note: information is not available for the Beaver/South Fork Sub-basin

Source: ICBEMP. 1996

Fire

In the late 19th and early 20th centuries, forests in the basin were characterized by an open, park-like structure at lower elevations, maintained by frequent ground fires. Large trees were primarily fire-resistant ponderosa pine at lower elevation, Douglas fir and western larch at middle elevation sites, and true firs at higher elevations. Fires were less frequent on cooler and higher elevation sites, but fires that did burn in these areas burned a high percentage of the trees. Decades of fire prevention and suppression have allowed shade-tolerant tree species to grow in, creating dense, closed stands of even aged trees. The once available mosaic of habitat types has been greatly reduced and the risk of damage from fire, insect, and disease has increased.

Changes to the fire regime can be summarized as follows:

- Low intensity, frequent fires (10-25 years, 40-50 years for some communities) have been essentially eliminated as a disturbance process;
- Fuels/vegetation which supports high intensity fires has increased from a low, pre-settlement level of under 10% to approximately 35%; and
- There is a relatively high occurrence of lightening caused fires, the higher fuel loads increase the risk of a high intensity wildfire covering a large area and significantly affecting habitat for fish and wildlife, water quality, and human uses.

(USDA FS 1998b)

Sediment Sources

Erosion, sediment movement and deposition are natural watershed processes. Many streams in the Crooked River Basin have naturally high sediment loads due to geology, topography and climate characteristics. This is particularly true for the steeper portions of the basin located within the John Day ecological province. Aquatic organisms have evolved with the local natural rate and pattern of erosion and sedimentation. Land management activities and changes in land cover patterns can accelerate the natural erosion rate and alter the timing and amount of sediment delivered to streams. Expansion of western juniper and noxious weeds as well as unmaintained roads have been identified as major components that reduce infiltration and lead to increased erosion in upland areas (USDA FS 1998b). Loss of riparian vegetation and an the presence of road crossings have also been identified as sources of increased sedimentation (USDA FS 1998b, ODFW 1996). High sedimentation rates within Prineville Reservoir reduce photosynthesis in the reservoir, thereby reducing available food and habitat for fish (Nichols 2001, ODFW 1996). While excessive erosion is a concern in many areas of the basin, a lack of bedload and sediment transfer due to Bowman Dam at Prineville Reservoir is a concern for maintenance and restoration of riparian and channel conditions on the lower Crooked River (McSwain 2000, Berggren 2001).

In forested watersheds, roads and undersized culvert problems are likely responsible for the majority of human-induced sediment loading in the watershed. The Ochoco National Forest has assessed its roads for sedimentation and other watershed problems and is currently implementing the top three projects to improve conditions. These include: road slumps in the

Mill Creek Watershed, culvert replacements in Deep Creek Watershed, and bridge replacement in the Marks Creek Watershed (Seymour 2000). The Crooked River Watershed Council and the Oregon Department of Forestry have discussed the need for a private lands forest road assessment and may try to spearhead this effort in the future.

Primary human-related factors related to increased erosion and sedimentation in the Crooked River basin on non-forest lands include: expansion of western juniper and noxious weeds, irrigation systems, roads, rural residential development and agriculture (USDA FS 1998b). The Ochoco Irrigation District has noted a sharp increase in the sediment load being transported by their ditch system in the past two years (Moore 2001). OID attributes this increase in sediment to the changing economic conditions in agriculture that currently favors high transition of crop types (past common crop types, such as mint, were left on field for longer periods). The City of Prineville Urban area (roughly 7,000 acres) currently has a population of just over 10,000 people (OR DEQ 2000). Increases in impervious surfaces will change flow and sediment transfer rates in the area. This could negatively impact Ochoco Creek, the Crooked River and McKay Creek water quality conditions, which are already limited.

Rangelands

Approximately two-thirds of the land within the Crooked River Basin is defined as rangelands. Rangelands within the basin exist on both private and public lands, with the BLM having a larger share of the public land portion than the Ochoco National Forest. Dominant trends related to the condition of rangelands in the Crooked River Basin include:

- An increase in the area and density of woody species (primarily juniper);
- Increasing fragmentation between blocks of native range habitat;
- Expansion of noxious weeds; and
- Slow recovery from past damage in lower precipitation regions of the basin.

(ICBEMP 1996, USDA FS 1998b)

The Interior Columbia Basin Ecosystem Management Project (ICBMP) report, Status of the Columbia Basin, Summary of Scientific Findings (1996) describes forest and rangeland conditions within the Columbia River system at the basin and sub-basin scale. Information was organized by general characteristics including land ownership, land use, precipitation, and changes in fire frequency and severity and fire risk as well as a summary of primary conditions, risks, and opportunities. Information for the ICBEMP process was primarily taken from aerial photographs and satellite imagery and should be considered a coarse assessment of conditions. Summaries of primary characteristics, risks and opportunities from the ICBMP project are described below. For additional ICBMP information on Crooked River Basin range conditions see Appendix 5-A.

All rangelands of the Crooked River Basin were rated as low integrity. Over one half of private rangeland was estimated to have condition problems related to increasing juniper densities. The primary characteristics used to describe range clusters within the Crooked River Basin included:

- A high level of juniper woodlands;
- High road densities (moderate or high for 80% of area);
- Low forest, range, and composite integrity;
- Moderate aquatic and hydrologic integrity; and
- Fire regimes that are more severe than historical conditions.

(ICBEMP 1996)

Three primary risks to ecological integrity were identified for rangelands in the Crooked River Basin:

- Juniper encroachment into shrubland;
- Reduction in forage for both wild and domestic ungulates through woodland encroachment; and
- Noxious weed expansion.

(ICBEMP 1996)

Four specific opportunities to address risks to ecological integrity in rangelands were identified:

- Reduction of forest stocking to improve forage/cover relationships for livestock and big game;
- Curtailment of juniper expansion;
- Curtailment of noxious weed expansion; and
- Management of riparian areas to enhance stream bank stability and riparian vegetation.

(ICBEMP 1996)

Cattle

The overall numbers of cattle in the basin have increased over the last century, with peaks in the periods 1910-1920, the early to mid 1960's and the early 1980's. Livestock numbers for Crook County remained above 20,000 after 1890, with approximate peaks of 40,000 in 1910, 65,000 in 1965, and just under 60,000 in the early 1980's (Steber 1989). Low periods in the expansion of cattle populations within the basin were 1940 (25,000), the late 1970's (under 50,000) and the 1990's (under 45,000). The same general trend of peaks and low points is seen for the other counties within the basin, although the total number of cattle differs, with Deschutes, Wheeler, and Jefferson Counties having lower overall numbers of cattle than Crook County, and Lake and Harney Counties having higher overall numbers. Cattle trend information was not available for Grant County.

Sheep

The number of sheep in the basin was relatively high from the 1880's until about 1935 (50,000-250,000), after which it declined rapidly (Steber 1989). The number of sheep in the basin after 1970 is estimated at less than 5,000.

Horses and Ponies

The number of horses and ponies within the basin peaked at the height of sheep herding days, declined until the mid-1970's, and has since begun to increase. Numbers peaked from about 20,000 from 1900-1920, declined to approximately 2,000 in 1970 and increased to roughly 4,000 in the 1990's.

Western Juniper Expansion

The expansion of western juniper into rangelands is a primary watershed health concern in the basin. Juniper expansion is largely a result of fire suppression policies, although land management trends have also impacted its expansion. Juniper expansion has reduced ground cover, contributing to increased overland flow, loss of topsoil, and sedimentation of streams during high intensity precipitation events. Juniper expansion is also changing vegetation communities and reducing forage values for livestock and wildlife, in addition to increasing erosion potential. The Bureau of Land Management is involved in an aggressive juniper control program utilizing cutting and burning methods and many private landowners are also involved in control programs (hundreds of acres per year). The use of fire on private lands is uncommon due to liability issues associated with prescribed fires; control methods on private lands generally involve cutting programs. Cooperative burn efforts between public and private ownerships are increasing. Markets for juniper are also being explored and expanded in the region as the need for cost-effective juniper control methods is high. Despite these efforts, juniper expansion is outpacing treatment efforts (USDA FS 1998b, ICBEMP 1996, Deboodt 2000, USDA FS 1994b).

Forestlands

Approximately 20% of the land within the Crooked River Basin is described as forestlands (excluding juniper areas), with the majority of these lands falling within the Ochoco and Deschutes National Forests. The forested land base in Crook County is estimated at just over 1 million acres, with 100,000 acres in private commercial timberlands, 600 acres in State owned timberlands, 353,000 acres of federally owned commercial timberlands and 564,000 acres of non-productive timberlands, primarily juniper (Prineville Planning Department 1997). The current pattern and occurrence of forested vegetation in the Crooked River Basin has changed from historic conditions, which is influencing overall ecosystem conditions including erosional processes and disturbance regimes.

Major changes to forest communities in the basin include:

- Overall increase in stand density;
- Increase in small to medium sized trees;
- Shortage of large structure and old trees (> 21"d.b.h.);
- Increase in the expanse and density of western juniper; and
- Major decrease in riparian vegetation, most notably the reduction in quaking aspen and black cottonwood stands.

(ICBEMP 1996, USDA FS 1998b, USDA FS 1994b)

The Interior Columbia Basin Ecosystem Management Project (ICBMP) report, Status of the Columbia Basin, Summary of Scientific Findings (1996) describes forest and rangeland conditions within the Columbia River system at the basin and sub-basin scale. Information was organized by general characteristics including land ownership, land use, precipitation, and changes in fire frequency and severity and fire risk as well as a summary of primary conditions, risks, and opportunities. Information for the ICBEMP process was primarily taken from aerial photographs and satellite imagery and should be considered a coarse assessment of conditions. Summaries of primary characteristics, risks and opportunities from the ICBMP project are described below. For additional ICBMP information on Crooked River Basin forest clusters see Appendix 5-B.

For the forested lands within the Crooked River Basin, only the Lower and Upper Crooked River Sub-basins were described. Information on forest clusters was not available for the Beaver South Fork Sub-basin. The primary characteristics used to describe forest clusters within these two sub-basins of the Crooked River Basin included:

- Dry forest types;
- Low to moderate aquatic integrity;
- Low forest and composite integrity;
- Moderately to highly roaded (60-75% of forest area); and
- Containing watersheds sensitive to disturbance.

(ICBEMP 1996)

Three primary risks to ecological integrity were noted for forest clusters in the Upper and Lower Crooked River Sub-basins:

- Fish strongholds from sediment, erosion potential;
- Forest composition and structure; and
- Hydrologic integrity due to fire severity and intensity.

(ICBEMP 1996)

Opportunities to address these risks to ecological integrity in basin forests were identified:

- Restoration of forest integrity through forest management;
- Restoration of old/late forest structure;
- Restoration of aquatic and hydrologic integrity by reducing the risk of fire, insect, and disease, and road management; and
- Maintenance of existing aquatic strongholds.

(ICBEMP 1996)

In the most recent Ochoco National Forest Management Plan (USDA FS. 1989), forest watersheds were classified by sensitivity (determined primarily by physical factors, e.g. aspect, slope, soils) and assigned a threshold harvest level.

The following Crooked River Basin watersheds were ranked as low sensitivity, with a 35% threshold harvest level:

- Middle Crooked River,
- Dry Creek,
- Beaver Creek,
- Bear Creek, and
- Camp Creek.

Basin watersheds ranked as medium sensitivity, with a 30% threshold harvest level included:

- North Fork Crooked River,
- Marks Creek,
- McKay Creek,
- Howard/Porter Creek, and
- Mill Creek.

Crooked River watersheds ranked as high sensitivity, with a 25% threshold harvest level, included:

- Deep Creek, and
- Wolf Creek.

(USDA FS 1989)

Timber Harvest

Crook County is heavily dependent on the supply of timber to sustain a local economy that is dominated by wood manufacturing and the presence of federal forestlands. The area has been dependant on timber essentially since European settlement, and while the importance of agriculture and recreation has increased and several mills have closed in recent years, the wood products industry is still one of the largest employers in Crook County today.

From the period of settlement (1870's) until the early 1900's timber harvest in the basin was limited to fairly small-scale operations for local use. The first sawmill was located in the Mill Creek watershed in the 1870's and sawmills were also located in Ochoco, McKay, and Marks watersheds by 1910. Early sawmills in the upper country were located on Newsome Creek and in the general Post area by 1910. In 1910 the railroad came into central Oregon, supporting a boom in commercial timber production throughout the region. The railroad did not link to Prineville, which inhibited commercial timber harvest in the area until 1919, when the City of Prineville began it's own railroad with connections to the major line at Terrebonne. During the 1930's and 1940's Prineville became a major timber center, with six mills operating, earning the title "largest Ponderosa Pine Shipping Center in the World." From the 1930's through the 1980's timber harvest levels in the basin were high (Table 5-2). Despite changes in timber supply, Prineville remains heavily dependent on wood products as

many mills switched to secondary manufacturing operations. (Steber 1989, Lent 2000, USDA FS 1989, CCHS 1994).

Table 5-2: Crook County Harvest Data, 1987-1998

(In 1,000's of board feet)

Year	Forest Industry	Other Private	Indian Lands	State	BLM	USFS	Total
1987	7,857	1,604	0	0	0	75,448	84,909
1988	12,014	1,799	0	0	0	59,630	73,443
1989	26,115	1,529	0	0	0	83,337	110,981
1990	23,570	2,096	0	0	0	55,695	81,361
1991	26,141	4,354	0	0	0	75,100	105,595
1992	44,175	7,769	0	0	0	53,129	105,073
1993	35,507	4,954	0	0	0	43,025	83,486
1994	18,489	3,261	0	0	0	23,409	45,159
1995	30,110	7,648	0	0	0	21,934	59,692
1996	22,039	1,044	0	0	0	6,138	29,221
1997	29,531	630	0	0	0	16,553	46,714
1998	58,443	348	0	0	0	10,970	69,761
Totals	**333,991**	**37,036**	**0**	**0**	**0**	**524,368**	**895,395**

Note: includes all volume removed except from fuelwood cutting

Source: ODF. 2000

Forest Roads

Forest roads impact water quality, stream morphology, and fish passage conditions in the basin. Many roads were built along stream channels, disconnecting the stream from the floodplain along one side and contributing sediment. Impassable culverts or other obstacles at road crossings restrict movement of fish populations in the basin (See Section 8 Fish for more information on fish passage barriers). The Ochoco National Forest has assessed its roads for watershed problems and is currently implementing the top three projects to improve conditions. These include: road slumps in the Mill Creek Watershed; culvert replacements in Deep Creek Watershed, and bridge replacement in the Marks Creek Watershed (Seymour 2000). No good information exists on either public or private lands regarding road condition, stability, and contributions to increased erosion and sedimentation. A forest road assessment has been identified as a potential priority action item for the watershed council to facilitate. The Council and the State Department of Forestry are also piloting a cost-share program to identify potential improvement sites as harvest plans from private landowners are submitted and then implement improvements at the time of harvest activities.

Croplands and Irrigated Agriculture

Approximately 4% of land within the Crooked River Basin is used for irrigated agriculture, the significance of which has increased over recent decades due to agricultural and livestock market changes (USDA NRCS 1994, USDA OAS 1997). Irrigated crops within the basin are predominately hay, mint, seeds, and grains. The Natural Resource Conservation Service provided a coarse condition estimate for private resource lands within Crook County in 1994. The results of this assessment for cropland and irrigated lands are as follows:

- Irrigated crop and pasture lands: 60-80% of this land needs improved water conservation and management practices;
- Dry Cropland: 80% of this land could use improved erosion control practices.

(USDA NRCS 1994)

Noxious Weeds

Noxious weeds are a threat to native ecosystems, competing with native vegetation and changing forage availability for wildlife. Noxious weeds negatively impact watershed conditions, often leading to increased runoff and erosion. Invasive plant species are also recognized as a serious threat to agriculture, impacting both livestock and croplands. In Crook County, the Weed Board and Weed Control Department maintain prioritized lists of target weed species (Table 5-3) as well as estimates of acreages of infestations (Table 5-4). Both the Ochoco National Forest and the Prineville Bureau of Land Management also track weed species and populations on their lands and work to control infestations. Priority weed species on Ochoco National Forest lands include Spotted Knapweed, Russian Knapweed, Diffuse Knapweed, Yellow Starthistle, Leafy Spurge, Perennial Pepperweed, St. Johnswort and Dalmatian Toadflax (Rock 2000). Understanding of the potential threats of increasing noxious weed populations is high by agricultural landowners, many of which are actively working to eliminate or control infestations on their lands.

In the winter of 2001, the Crook County Weed Control Supervisor developed estimates for species and acreages for priority weeds on private lands within the County (See Table 5-4, below). Estimates are provided for the total acreage of weed infestations, not the total land area impacted; these numbers would be much higher as some weed populations are concentrated, while others are distributed sparsely over vast areas. Estimates were made using the professional opinion of the Crook County Weed Supervisor and Crook County Extension Service and private landowner estimates collected by the Crooked River Watershed Council and the Upper Crooked River Weed Management Area. Estimated material costs for implementing a three-year chemical treatment plan, with 100% landowner participation, is approximately four hundred thousand dollars (Crook County Weed Control 2001). Non-chemical management strategies significant to the success of any weed control efforts include outreach and education, biological and mechanical control, prevention, coordination of efforts across ownership and jurisdictional boundaries and restoration of impacted areas.

Table 5-3: Crook County Noxious Weed List

Class A Noxious Weeds (those receiving highest management priority due to small size of infestation, subject to eradication activities)

Yellow Starthistle	Jointed Goatgrass
Dalmatian Toadflax	Purple Loosestrife
Scotch Thistle	Mediterranean Sage
Wild Carrot	Squarrose Knapweed
Rush Skeleton Weed	Tansy Ragwort
Musk Thistle	African Rue
Skeleton Weed	Perennial Pepperweed

Leafy Spurge (all areas except Mill Creek drainage and within 50 feet of the high water mark on the Crooked River)

Class B Noxious Weeds (those receiving medium management priority due to widespread distribution in the county, subject to containment or control activities)

Canada Thistle	St. Johnswort
Common Groundsel	Scotch Broom
Poison Hemlock	Hounds Tongue
Russian Knapweed	Spotted Knapweed
Diffuse Knapweed	Whitetop
Spiny Sowthistle	Medusa Head
Puncture Vine	Sulfer Cinquefoil

Class C Noxious Weeds (those receiving lowest management priority due to the size and extent of the infestation)

Teasel	Yellow Sweetclover
Russian Thistle	Common Mullein
Kocia	Bur Buttercup
Bull Thistle	Field Bindweed
Western Water Hemlock	

Source: Crook County Weed Board. 2000

Table 5-4: Estimated Noxious Weed Infestations

Species	Estimated Acreage (estimates for private (lands within Crook County only)
Medusahead	3000 acres
Leafy Spurge	2000 acres
Common Groundsel	2000 acres
Russian Knapweed	1700 acres
Perennial Pepperweed and St. Johnswort	1500 acres
Spotted Knapweed	800 acres
Poison Hemlock and Puncture Vine	500 acres
Canada Thistle	500 acres
Scotch Thistle	200 acres
Diffuse Knapweed	200 acres
Mediterranean Sage	100 acres
Dalmatian Toadflax	100 acres
Yellow Starthistle	20 acres
Musk Thistle	5 acres

Source: Crook County Weed Control. 2001

Key Findings, Data Needs and Management Recommendations- Uplands

Key findings, data needs and management recommendations presented below were developed from information gained in the watershed assessment process and by members of the Council's assessment technical team.

Key Findings

- The area and density of woody species is increasing on rangelands
- Fragmentation is increasing between blocks of native habitats
- Noxious weeds are increasing in species and distribution
- Vegetative recovery from past damage in lower precipitation regions of the basin is slow
- Decreasing native grasslands and native shrublands
- Increasing roads, exotic species and soil disturbance
- Fire regimes are more severe than historical conditions
- Overall density of forest stands is increasing
- Large structure and older trees are declining
- Small, younger trees are increasing
- Riparian vegetation is fragmented, lacks diverse age and species classes
- Risk of catastrophic fire, disease or insect outbreak is increasing
- Many watersheds have high densities of unimproved roads

Data Needs

- Road assessment
- Noxious weed population inventory and trend monitoring
- Condition trends - private lands
- Effects of different management practices (timing, intensity, location, of grazing, prescribed fire, etc.)
- Information on potential and actual vegetation communities and trends is needed for public and private lands in the basin

Management Recommendations

- Noxious weed management and control
- Juniper control
- Restoration of native range plant community (diversity, health, …)
- Livestock grazing management
- Wild horse management
- Big game population coordination with ODFW
- Upland watershed function - ensure soils exhibit infiltration and permeability rates, moisture storage, and stability that are appropriate to the soil, climate and landforms
- Encourage forest management practices that maintain or improve the general health of forested uplands
- Road improvements and/or decommissioning throughout basin based on watershed analysis

6. RIPARIAN AND CHANNEL CONDITIONS

Historic Riparian and Channel Conditions

At the time of European-American settlement in the late 1800's the riparian and floodplain areas of the watershed had significantly more woody vegetation than is currently present. Willows were a primary component of riparian species and other common species included cottonwoods, aspen, alder, as well as shrub species such as chokecherry, hawthorn, or dogwood. The floodplains were dominated by bunchgrass, wild rye and swamp grass, with very 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 (Lent 2000, USDA FS 1998b).

In general, there were also more springs and watercourses in the basin. Many streams that are currently intermittent were perennial (a good example is Trout Creek in the Paulina/Beaver Creek drainage, this stream provided salmon and trout to locals in the late 1800's through the turn of the century). The Crooked River 'flooded' practically annually, with a meandering channel that took up the entire valley floor. There was more riparian vegetation, including sedges, grasses, and woody species, and stream channels were still well connected to the broad valley bottom floodplains (Lent 2000, USDA FS 1998b, CCHS 1994).

Vegetation in riparian areas declined rapidly after Euro-American settlement in the basin during the middle 1800's. Primary causes of the decline in riparian vegetation include the grazing of livestock, logging, agricultural and residential development of the floodplain, and beaver removal (which occurred in early 1800's). Changes in the management of livestock in riparian areas since the 1960's has resulted in increased vegetation in riparian zones; but the composition and extent of the riparian community has not been restored. Riparian communities in the basin today are dominated by non-native grasses or herbaceous vegetation that lacks the root stability of the woody vegetation or sedge communities that existed historically, particularly at lower elevation sites (WSPE 1987, ODFW 1996, USDA FS 1998b).

Riparian zone associations of the Ochoco Mountain Physiographic area (Ochoco National Forest - Maury and Ochoco Mountains) were described by Kovalchik (1987) and are summarized in Appendix 6-A. While this information focuses on the higher elevation portions of the basin, primarily on public forestlands, it does offer good general information on riparian plant communities in the region and major changes that have occurred within these communities.

Channel Modification and Hydrologic Function

The Crooked River and many tributary streams were channelized following the 1964 flood, disconnecting the streams from their floodplains and increasing the energy of the streams on the channel banks. In addition, the continued expansion of agricultural and residential developments in the valley bottoms has altered stream morphology and vegetation throughout

the basin. As a result, many streams have eroded vertically or laterally, water tables have dropped, and subsequent recovery of riparian vegetation communities in these systems is extremely slow. An extensive reservoir and irrigation system has altered the timing and intensity of flows in much of the lower basin, impacting the ability of native vegetation to remain established or re-colonize denuded areas. Prineville (1961) and Ochoco (1921) Reservoirs limit the amount of sediment available in streams throughout the Lower Crooked River sub-basin. Major changes in the timing and size of peak and channel maintenance flow events have restricted channel-forming processes in the Crooked River and Ochoco Creek. Natural wetland and riparian areas, particularly within the Prineville urban area, have been filled, removed or relocated, altering the storage and transport of water through this area of the basin and increasing the flashiness of flow events. Roads in the basin generally follow stream courses and many riparian areas are negatively impacted by the presence of roads and road crossings (ODFW 1996, WSPE 1997, McSwain 2000, USDA FS 1998b).

General Trends

- Riparian ecosystem function, determined by the amount and type of vegetative cover has decreased in most sub-basins;
- Abundance of mid-seral vegetation in riparian woodlands has increased and late seral vegetation has decreased; and
- Extensive spread of western juniper and exotic grasses and forbs into riparian areas in grass, shrub and rangelands.

(ICBEMP 1996, USDA FS 1998b)

In recent years, regulations to protect riparian areas have been implemented on federal and forested lands in Oregon, and involvement by private landowners in riparian improvements have also increased. In the Crooked River Basin, federal land management agencies have implemented riparian buffer zones and the State of Oregon Forest Practices Act has added riparian protection provisions for private forest operators. These provisions require forest landowners and operators to maintain riparian buffer zones where extra protection is required along fish bearing streams. These zones vary in size from 50’ to 100’ depending on stream size and include a 20’ no-harvest area. In addition to the state and federal guidelines, Crook County established a 100’ setback for new infrastructure (buildings, roads) in the County and the City of Prineville delineated a 50’ riparian setback building ordinance. In addition, both the County and the City have ordinances intended to protect existing riparian vegetation; these no-cut zones are 50’ within County boundaries and 25’ within the City of Prineville. Actions have been taken to reduce livestock impacts to riparian areas; primary management changes include riparian fencing to exclude cattle, the creation of riparian pastures and modified grazing schedules, and off-stream water developments to encourage livestock use of upland areas.

Riparian Condition Assessments

With over 9,500 miles of streams in the Crooked River Basin, a comprehensive assessment of riparian conditions has not been conducted. Riparian surveys have been conducted in portions of the basin, primary by public agencies. The Oregon Department of Fish and Wildlife has conducted stream surveys on portions of the mainstem lower Crooked River (lower Crooked River Sub-basin), lower McKay Creek (lower Crooked River Sub-basin), and Brush and Porter Creeks (Upper Crooked River Sub-basin). Federal land management agencies have completed watershed analysis and/or stream surveys for the following locations: Marks Creek, North Fork Crooked River, Upper Crooked River sub-basin, and the South Fork Crooked River (underway). Following the flood of 1998, the National Riparian Service Team conducted an assessment of lower Ochoco Creek, from the dam through the City of Prineville. In a recent project completed for the Crooked River Watershed Council, a University of Oregon graduate student conducted riparian assessments using the Oregon Watershed Enhancement Board methodology (Watershed Professionals, 1999) for Mill, Marks, Ochoco, and McKay Creeks in the Lower Crooked River Watershed. This assessment used aerial photo interpretation with field verification and included both public and private lands.

Riparian condition assessment information represents a wide range of agencies, years, methodology, and locations in the basin. This information has not been organized comprehensively. Summarized results from the various available riparian assessment information is provided below, organized by survey lead and stream reach. For more detailed information, see the referenced document or contact the lead agency or organization directly.

Oregon Department of Fish and Wildlife Stream Surveys

ODFW stream survey methodology involves a visual assessment of aquatic and riparian habitat conditions and is designed to be compatible with methods used by other agencies (USFS) and others (Rosgen 1985, Frissell et al 1986). Some of the survey work is contract work, conducted by ODFW field staff for the Prineville District BLM and Ochoco National Forest. Details of the survey methodology can be found in Moore et al.1999. Summary information on riparian vegetation conditions from ODFW surveys within the Crooked River Basin are provided below.

Brush Creek

Survey Site: Brush Creek is a tributary to the North Fork Crooked River. The upper reaches are on Forest Service lands and the lower reaches are on private land as they cross Big Summit Prairie.
Methodology/Date: Oregon Department of Fish and Wildlife survey, 1992.
Lower Reach Riparian Area Characteristics: Beaver activity high, livestock grazing high, riparian vegetation dominated by shrubs and grasses. Actively eroding stream channel.
Upper Reach Riparian Area Characteristics: Riparian vegetation dominated by mature conifers, land use predominantly forest harvest at higher elevation reaches with some livestock grazing. Many seeps and springs noted in upper reaches.

Bank Stability Summary: 95% vegetatively stable, 5% actively eroding banks (mostly in lower elevation reaches).
Channel Characteristics: Overall channel type is broad valley floor. Lower reaches- unconstrained, broad floodplain and multiple channels. Upper Reaches: channel constrained by hillslopes and terraces.

(ODFW 1992)

McKay Creek

Survey Site: ODFW's McKay Creek survey was conducted on the lower reaches, from its confluence with the Crooked River to the USFS boundary. Not all reaches were included due to access issues.
Methodology/Date: Oregon Department of Fish and Wildlife survey, 1997.
Riparian Area Characteristics: Riparian habitat dominated by shrubs and grasses with low canopy cover. Land uses within the riparian area (30m-width band) include agriculture and light grazing.
Bank Stability Summary: 50% vegetatively stable, 50% actively eroding banks.
Channel Characteristics: Overall channel type is broad valley floor. Stream channel constrained by terraces in all reaches. Stream channel in reach one constrained by land use (berms).

(ODFW 1997)

Porter Creek

Survey Site: Porter Creek is a tributary to the North Fork Crooked River, located entirely on USFS lands east of Big Summit Prairie.
Methodology/Date: Oregon Department of Fish and Wildlife survey, 1991.
Riparian Area Characteristics: Land uses within 30m riparian area (30m-width band) include livestock grazing and forest harvest. The forest has experimental cottonwood exclosures in a few sections. Riparian habitat dominated by grasses and shrubs in lower reaches and grass, shrubs and conifers in upper reaches.
Bank Stability Summary: 75% vegetatively stable, 25% actively eroding.
Channel Characteristics: Channel types are unconstrained, broad valley floor in the lower reach and a combination of broad valley flood constrained by terraces and hillslopes and narrow valley floor (mostly moderate v-channel) in upper reaches.

(ODFW 1991)

Lower Crooked River

Survey Site: Confluence to Smith Rock State Park
Methodology/Date: Oregon Department of Fish and Wildlife survey, 1997.
*Riparian Area Characteristics: L*and uses a combination of 'no use' based on the Wild and Scenic Waterway and agricultural use. Riparian area dominated by alder and some ponderosa pine in lower reaches, upper reaches dominated by shrubs and grasses and some juniper. Forest fire occurred in Smith Rock State Park area- reforestation efforts underway.

Bank Stability Summary: 40% non-erodable bedrock banks in lower reaches. Of potentially erodable sections (upper reaches) approximately 80% are vegetatively stable and 20% actively eroding.
Channel Characteristics: Channel type is a steep v-shaped, narrow valley floor for the lower reaches and a broad valley floor with constraining terraces in the upper reaches.

(ODFW 1997b)

Lower Crooked River

Survey Site: Stearns Dam to Bowman Dam
Methodology/Survey date: Oregon Department of Fish and Wildlife survey, 1997.
Riparian Area Characteristics: Beaver activity present. Common trees in riparian zone (30m- width) include juniper, with lesser amounts of willow and cottonwood. Land use agricultural and Scenic Waterway (BLM upper portion of reach- Chimney Rock segment). Ponderosa pine planting project in upper reaches on west bank
Bank Stability Summary: 90% Vegetatively stabilized, 10% actively eroding.
Channel Characteristics: Channel conditions for the three reaches are described as: moderate v-shape narrow valley floor, multiple terraces broad valley floor, and steep v-shaped narrow valley floor, from lower to upper reaches.

(ODFW 1997b)

Council Sponsored Riparian Condition Assessment Work

Mill, Marks, Ochoco and McKay Creeks were assessed in 2000 with OWEB methodology (Watershed Professionals 1999) using 1995, 1996, and 1998 aerial photos and slides from the USFS (public land) and Farm Services Agency (private land). There was considerable overlap along the margins between USFS and FSA flights so these areas were used to justify the different data sets. The OWEB methodology involved designating channel reaches and then determining channel habitat types, stream size, and stream sensitivity for all reaches. Different channel types vary in how they adjust to changes in flow, sediment, woody debris and other inputs, and some channel habitat types are more sensitive to land use activities and restoration activities than others (Watershed Professionals 1999). Stream sensitivity describes those channel habitat types that are most responsive, and thus priority sites for restoration efforts. Riparian vegetation type, vegetation density, and vegetation size were also estimated, as was recruitment potential, land use, ownership and irrigated area, measured in feet and miles. Stream shading is a component of the OWEB methodology but was excluded from this study due to time constraints and questions concerning the quality of information gained from this assessment tool in the Central Oregon environment. A summary of results for the riparian assessment conducted on Mill, Marks, Ochoco, and McKay Creeks utilizing the OWEB methodology is provided below in Table 6-1. Stream sensitivity data is provided in Table 6-2.

Table 6-1: Riparian Assessment Summary- Mill, Marks, Mckay, and Ochoco Creeks

Stream (total miles)	**Ownership** (miles)	**Riparian Land Use** (miles)	**Irrigated** (miles)	**Riparian Recruitment Potential** (miles)	**Riparian Recruitment Situation** (miles)	**Channel Habitat Type** (miles)	**Riparian Vegetation Condition** (miles)
Mill (21.3 miles)	18.9 – private 2.4 –public	17.7 – farm 2.8 – forestry 0.8 – road	17.6 – yes 3.7 – no	1.6 – yes 19.7 – no	1.6 – adequate 18.7 – agricultural 0.2 - small stands 0.8 – infrastructure	10.9 – LM 10.4 –FP1	18.7 - GNN 0.5 - BNN 0.2 - CMS 1.6 - CMD 0.2 - CLS
East Fork Mill (15.6 miles)	15.6 – public	15.6 – wilderness	15.6 – no	15.6 – yes	15.6 – adequate	7.9 – LC 1.9 – MC 2.2 –MH 3.7 - SV	1.5 – BNN 7.4 – CMS 6.8 – CMD
West Fork Mill (6.3 miles)	6.3 – public	0.3 – farm 3.1 – forestry 2.8 – road	6.3 – no	6.3 – no	0.6 – agricultural 4.5 - small stands 1.2 – infrastructure	3.0 –LC 3.2 – MH	1.8 – GNN 3.4 – CMS 1.1 – CMD
Marks (37.7 miles)	9.3 – private 28.5 – public	19.9 – farm 11.2 – forestry 3.3 – infrastructure	3.9 – yes 33. 9 – no	3.2 – yes 34.6 – no	3.2 – adequate 23.7 – agricultural 6.9 – small stands 3.3 – infrastructure	7.8 – LM 8.8 – MM 14.8 – FP2 6.4 – FP3	22.7 – GNN 8.3 – BNN 4.3 – CMS 2.4 – CMD
Ochoco (48.8 miles)	34.7 – private 14 – public	32.9 – farm 11.3 – forestry 4.6 – road	33.7 – yes 15.1 – no	9.1 – yes 39.7 – no	9.1 – adequate 33.6 – agricultural 2.5 – small stands 4.6 – infrastructure	5.9 – LM 2.5 – MC 6.0 – MM 5.5 – MH 28.8 – FP1	34.1 – GNN 6.7 – BNN 5.1 – CMS 2.9 – CMD
McKay (37.7 miles)	24.7 – private 13.0 – public	24.1 – farm 13.3 – forestry 0.3 – infrastructure	23.1 – yes 14.6 - no	4.5 – yes 33.2 - no	4.5 – adequate 23.3 – agricultural 5.6 – small stands 4.2 – infrastructure 0.1 - developed	2.7 – MH 7.9 – MC 8.3 – MM 2.4 – LC 4.7 – LM 11.7 – FP1	5.5 – NNN 15.8 – GNN 2.3 – BNN 12.9 – CMS 1.2 – CMD
Little McKay (12.5 miles)	12.5 – public	8.4 – forestry 4.2 – road	12.5 – no	4.0 – yes 8.6 – no	4.0 – adequate 3.6 – small stands 4.9 – infrastructure	7.8 – MC 3.0 – MV 5.8 – CMD	0.8 – CLS 6.0 – CMS 5.8 – CMD

Channel Habitat Type Key: VH= very steep headwater channel; **SV**= steep narrow valley channel; **BC**= Bedrock canyon channel; **MV**= moderately steep narrow valley channel; **MH**= moderate gradient headwater channel; **MC**= moderate gradient confined channel; **MM**= moderate gradient moderately confined channel; **LC**= low gradient confined channel; **LM**= low gradient moderately confined channel; **AF**= alluvial fan channel; **FP3**= low gradient small floodplain channel; **FP2**= low gradient medium floodplain channel; **FP1**= low gradient large floodplain channel; **EL**= large estuarine channel; **ES**= small estuarine channel.

Vegetation Key: TYPE: C= conifer (>70% of area); **H**= hardwood (>70% of area); **M**= mixed conifer/hardwoods; **B**= brush; **G**=grass/meadow; **N**= no riparian vegetation. **SIZE: R**= regeneration (<4" DBH); **S**= small (4-12" DBH); **M**= medium (>12-24" DBH); **L**= large (>24" DBH); **N**= nonforest. **DENSITY: D**= dense (<1/3 ground exposed); **S**= sparse (>1/3 ground exposed); **N**= nonforest (applies to vegetation types B, G, and N)

Table 6-2: Channel Sensitivity

	High		Moderate		Low		
Stream	miles	%	miles	%	miles	%	**Total**
Mill	10.8	100%	0.0	0%	0.0	0%	10.8 miles
East Fork Mill	0.0	0%	4.9	63%	2.9	37%	7.8 miles
West Fork Mill	0.0	0%	0.0	0%	4.7	100%	4.7 miles
Marks	18.8	100%	0.0	0%	0.0	0%	18.8 miles
McKay	14.2	74%	3.7	19%	1.4	7%	19.3 miles
Little McKay	0.0	0%	4.0	56%	3.1	44%	7.1 miles
Ochoco	20.4	84%	1.3	5%	2.7	11%	24.4 miles
Total	64.2 miles		13.9 miles		14.8 miles		92.9 miles

Source: Walter. 2000

Mill Creek

Survey Site: Entire creek, 21.3 miles
Methodology/Survey date: OWEB methodology. P. Walter. 2000. Based on 1995, 1996 and 1998 aerial photos and field verification.
Riparian Area Characteristics: Land use predominantly irrigated agriculture on private lands. Dominant riparian vegetation is grass. Riparian recruitment situation is inadequate for over 90% of riparian reaches.
Channel Characteristics: The predominant channel habitat types on Mill Creek are split evenly between large floodplain channel and low gradient, moderately confined channel. Channel sensitivity is rated as high for the entire channel.

(Walter 2000)

East Fork Mill Creek

Survey Site: Entire creek, 15.6 miles
Methodology/Survey date: OWEB methodology. P. Walter. 2000. Based on 1995, 1996 and 1998 aerial photos and field verification.
Riparian Area Characteristics: The entire length of the East Fork of Mill Creek is within the Mill Creek wilderness area. Some livestock grazing and timber harvest activities do occur in the riparian area. The dominant riparian vegetation types are medium sized, sparse to dense conifers. The riparian recruitment situation is adequate for 100% of riparian reaches.
Channel Characteristics: The predominant channel habitat type is a low gradient, confined channel with smaller upper reaches consisting of steep and moderately steep narrow valley channel types. Channel sensitivity is rated as moderate for 63% of the channel and low for 37%.

(Walter 2000)

West Fork Mill Creek

Survey Site: Entire creek, 6.3 miles
Methodology/Survey date: OWEB methodology. P. Walter. 2000. Based on 1995, 1996 and 1998 aerial photos and field verification.
Riparian Area Characteristics: West Fork of Mill Creek is located entirely within the Ochoco National Forest, on public lands. Riparian land use includes livestock grazing, forestry, and roads. Sparse, medium sized conifers with some reaches of grass dominate riparian vegetation and dense, medium sized conifers as well. The riparian recruitment situation is inadequate for 100% of riparian reaches.
Channel Characteristics: Predominant channel habitat types are split evenly between low gradient confined channel and moderate gradient headwater channels. Channel sensitivity is rated as low for the entire length of West Fork Mill Creek.

(Walter 2000)

Marks Creek

Survey Site: Entire creek, 37.8 miles.
Methodology/Survey date: OWEB methodology. P. Walter. 2000. Based on 1995, 1996 and 1998 aerial photos and field verification.
Riparian Area Characteristics: Land use in Marks Creek is primarily agriculture in the lower reaches and forestry in the upper reaches, with infrastructure uses dominating 10% of stream reaches. The upper 75% of stream reaches are on public lands (Ochoco National Forest) and the remaining 25% are private. Riparian vegetation is characterized by grass (60%), brush (21%), medium sized, sparse conifers (11%), and medium sized, dense conifers (6%). The riparian recruitment situation is inadequate for over 90% of stream reaches.
Channel Characteristics: The predominant channel habitat type is low gradient medium floodplain channel (40%). The remaining channel types are split evenly among low gradient moderately confined, moderate gradient moderately confined and low gradient small floodplain channel. Channel sensitivity is rated as high for all of Marks Creek.

(Walter 2000)

McKay Creek

Survey Site: Entire creek, 37.7 miles
Methodology/Survey date: OWEB methodology. P. Walter. 2000. Based on 1995, 1996 and 1998 aerial photos and field verification.
Riparian Area Characteristics: Land use in McKay Creek is predominantly irrigated agricultural (64%) and forestry (35%) with a small component of infrastructure (1%). The lower 25 miles are private while the upper 13 miles are on public lands (Ochoco National Forest). Riparian vegetation types are grasses in the lower watershed and medium sized, sparse conifers in the upper reaches. A significant portion (15%) of the riparian area is characterized as unvegetated. The riparian recruitment situation is inadequate for just under 90% of stream reaches.
Channel Characteristics: McKay Creek has a variety of channel habitat types. Predominant channel habitat types on McKay Creek include low gradient large floodplain channel,

followed by moderate gradient moderate to confined channels. Less common channel habitat types include: low gradient moderately confined, low gradient confined, and moderate gradient headwater channels. Channel sensitivity is rated as high for 74% of McKay Creek, moderate for 19% and low for 7%.

(Walter 2000)

Little McKay Creek

Survey Site: Entire creek, 12.5 miles
Methodology/Survey date: OWEB methodology. P. Walter. 2000. Based on 1995, 1996 and 1998 aerial photos and field verification.
Riparian Area Characteristics: All public ownership (Ochoco National Forest). Riparian land use dominated by forestry (2/3) and roads (1/3). Riparian area vegetation primarily conifer trees of medium size (12-24 DBH average), with roughly half of the vegetated areas in dense stands, and half in sparse stands. The riparian recruitment situation is inadequate for roughly two-thirds of stream reaches.
Channel Characteristics: The predominant channel habitat type is moderate gradient, confined channel. Channel sensitivity for Little McKay Creek is rated as moderate for 56% and low for 44%.

(Walter 2000)

Ochoco Creek

Survey Site: Entire creek, 48.8 miles
Methodology/Survey date: OWEB methodology. P. Walter. 2000. Based on 1995, 1996 and 1998 aerial photos and field verification.
Riparian Area Characteristics: Ownership is primarily private, with the upper 1/3 of the creek on public lands (Ochoco National Forest). Land use is dominated by agriculture (67%), forestry (23%), and roads (10%). Dominant riparian vegetation types are grass and brush, with sparse conifers in the upper channel. The riparian recruitment situation is inadequate for 80% of stream reaches.
Channel Characteristics: The predominant channel habitat type is a large floodplain channel, followed by low to moderate gradient, moderately confined channel. Channel sensitivity is rated as high for 84% of the creek, moderate for 5% and low for 2.7%.

(Walter 2000)

National Riparian Service Team Riparian Assessment

Ochoco Creek

Survey Site: Lower Ochoco Creek, from Ochoco Dam through the City of Prineville to the confluence with the Crooked River.
Methodology/Survey date: Team (NRST, ODFW, USFS, BLM) walked the creek at the request of City and County officials following the May 1998 flood event, looking specifically

at: channel stability, channel capacity, fish and wildlife habitat, flood damage and riparian management opportunities.
Riparian Area Characteristics: Upper Reaches: Low in woody vegetation, some willows and rose. Riparian areas mostly vegetated in grasses. Lower Reaches: Riparian area often mowed, predominantly grasses and some willows where vegetated.
Channel Characteristics: Channel was engineered to be straighter than expected given valley size and gradient. Flood flow energy, failure of a diversion dam and subsequent redistribution of bedload behind the dam caused dramatic erosion of the streambank and terrace, widening of the channel and formation of new gravel bars. Event began to recreate a more natural meander pattern. Channel capacity not changed through town from flood event.

(National Riparian Service Team 1998)

Federal Riparian Assessments

Bottom line surveys completed in 1992-1996 on the Ochoco National Forest indicate that approximately 3% of stream reaches have greater than 20% bank erosion and 17% have 10-20% bank erosion (USDA FS 1998b).

Marks Creek

Survey Site: Marks Creek, USFS portion
Methodology/Survey date: Federal watershed analysis (USDA FS 1995a)
Riparian Area Characteristics: Graminoids occur at over 70% of cross sectional sites (wooly sedge, beaked sedge, baltic rush, and small-fruited bullrush). Over 50% of cross sectional sites characterized as disturbed grass sites (non-native species and native species that indicate poor ecological condition (kentucky bluegrass, kentucky bluegrass/teasel, reed canary grass). Native grass communities (tufted hairgrass and wildrye) were characteristic of 10% of the cross sectional areas. Snowberry community characterized 10% of the cross sectional areas. Just over 10% of the cross sectional areas characterized by forested communities, of these, over 90% were dominated by ponderosa pine.
Channel Characteristics: not described

(USDA FS 1997)

North Fork Crooked River

Survey Site: North Fork Watershed Analysis Creek, USFS portion
Methodology/Survey Date: Federal watershed analysis (USDA FS 1995a)
Riparian Area Characteristics: Riparian and aquatic habitat has been simplified. In the period from 1870-1915 heavy livestock grazing altered riparian areas through channel widening, aggrading, and lowering of the water table. Historically, riparian vegetation was dominated by tufted hairgrass and sedge communities. Today it is dominated by exotics, notably kentucky bluegrass and timothy. Overstory vegetation currently consists of alder, quaking aspen, black cottonwood and some willow.
Channel Characteristics: Beaver trapping, changes in riparian vegetation species and amount and road construction have led to increased erosion throughout the North Fork Crooked River

Watershed. Erosion induced sediment delivery to streams is estimated to have increased (since the time of European settlement) by approximately 15%.

(USDA FS 1995b, USDI BLM 1993)

Upper Crooked River Sub-basin

Sites: Upper Crooked River Sub-basin (Watersheds: Bear Creek, Camp Creek, Deep Creek, Horse Heaven, Howard Johnson, North Fork Crooked River –upper and lower, Middle Crooked River).
Methodology/Survey Date: Interagency characterization based on existing data (USDA FS 1998b); no new field information conducted for this analysis. Information is of a coarser nature than that provided for other riparian assessments.
Riparian Area Characteristics: Riparian vegetation condition is below historic levels. Loss of riparian tree and shrub species has reduced vertical habitat complexity and reduced water storage capacity of the riparian area. Historically common quaking aspen and black cottonwood forests have been reduced to small, remnant populations. While density of riparian vegetation has improved since the 1960's with improved land management, riparian vegetation composition in the low gradient stream systems has not returned to historic conditions, due in part to incompatible current channel characteristics.
Channel Characteristics: Downcutting and channelization has occurred, disconnecting many streams in the sub-basin from their floodplains. Primary cause of downcutting includes removal of beaver, overgrazing of livestock and development of the floodplain which all reduced riparian vegetation, followed by the flood event of 1964, which detached these degraded streams from their floodplains.

(USDA FS 1998b)

South Fork Crooked River

In a cooperative effort between ODFW, Prineville BLM, the Crooked River Watershed Council and three private landowners, riparian and aquatic inventories were conducted on the South Fork Crooked River in the summer of 2001. This effort compliments other monitoring in the watershed (BLM- channel characteristics and vegetation, ODFW and CRWC- ambient instream temperature monitoring).

Key Findings, Data Needs and Management Recommendations- Riparian and Channel Conditions

Key findings, data needs and management recommendations presented below were developed from information gained in the watershed assessment process and by members of the Council's assessment technical team.

Key Findings

- Á Significant loss of riparian vegetation (distribution, diversity, age class) has occurred since the 1800's
- Á Changes in timing and level of peak flows have impacted channel and riparian conditions, particularly downstream of major reservoirs
- Á Channel sensitivity is highest on mid-to-lower elevations stream segments, these streams are predominantly located on private lands
- Á Major streams in the basin have been channelized (particularly following the 1964 flood and in the lower Crooked River sub-basin)
- Á A majority of riparian areas on USFS and BLM administered lands are not meeting management objectives
- Á Riparian conditions are limiting fish habitat and water quality in many streams in the basin
- Á Extensive spread of western juniper and exotic grasses and forbs in riparian shrub lands is negatively impacting riparian vegetation communities
- Á Vegetation has also declined at upper elevations, primarily due to fire exclusion and harvest of large trees

Data Needs

- Á Wetlands locations and condition
- Á Riparian vegetation - information needed on potential and current conditions
- Á Channel conditions
- Á Riparian condition information does not exist for the majority of streams in the basin
- Á Comprehensive assessment of current and potential channel, vegetation, and flow conditions and their impacts on riparian health
- Á Compile and analyze existing information from the range of methods, agencies and locations into a more useful riparian condition database

Management Recommendations

- Á Restore channel forming and maintenance flow regimes
- Á Protect and enhance riparian and wetland vegetation
- Á Identify and protect key riparian vegetation strongholds
- Á Recognize and address role of upland health in riparian function/condition
- Á Identify riparian vegetation potential

Ochoco Creek Management Recommendations

The National Riparian Service Team (1998) outlined specific riparian and channel management recommendations to the City of Prineville and Crook County for lower Ochoco Creek. The recommendations are included here as similar conditions and recommendations also fit other streams and stream segments in the Crooked River Basin, particularly inn the Lower Crooked River Sub-basin.

- Establish riparian vegetation communities with a higher stability rating
- Look for opportunities to increase floodplain
- Explore the option to use diversions and ditches above town to divert high flows away from the City of Prineville
- Consider the condition of riparian areas and watersheds above Ochoco Reservoir
- Accelerate the establishment of riparian vegetation on the floodplain and streambanks by planting woody species
- Manage streamflow changes in the main channel to gradually change water levels to accommodate plant establishment within the operation of the irrigation system
- Add to the stability of Ochoco Creek by having a 15-20 foot un-mowed, untilled buffer
- Develop a strategy to prevent the disposal of yard wastes along the stream channel. First address land use management, then evaluate the use of bioengineering methods as needed to address erosion problems
- Develop and manage a trail system for fishing and other recreation to reduce potential erosion problems
- When bridges are replaced, redesign bridges for increased channel capacity
- Re-engineer diversion structures to pass debris
- Consider ways of getting irrigation water without new dams or replacement of damaged ones
- Evaluate cross-fences concerning debris accumulation problems
- Consider the control of noxious weeds

7. WATER QUALITY

Beneficial Use

The Oregon Department of Environmental Quality (OR DEQ) establishes water quality standards to protect beneficial uses of the State's waters, as required by the Federal Clean Water Act (1972). Beneficial uses are designated by the Oregon Department of Water Resources and are compiled by basin under Oregon Administrative Rules, Division 41, and Chapter 340. Aquatic life, particularly salmonid spawning and rearing, is considered one of the most sensitive beneficial uses. Beneficial uses listed for water in the Crooked River Basin are listed in Table 7-1.

Table 7-1: Crooked River Basin Beneficial Uses

Public Domestic Water Supply	Private Domestic Water Supply
Industrial Water Supply	Irrigation
Livestock Watering	Anadromous Fish Passage
Salmonid Fish Rearing	Salmonid Fish Spawning
Resident Fish and Aquatic Life	Wildlife and Hunting
Fishing	Boating
Water Contact Recreation	Hydro Power
Aesthetic Quality	

Source: OR DEQ. 1998

The Federal Clean Water Act also requires that each state compile a list of water bodies that do not meet state standards, and submit that list to the U.S. EPA every two years. This list is called the "303d" list and the water bodies on it are considered to be "water quality limited". Figure 7-1 and Table 7-2 show a summary of water quality limited streams in the Crooked River Basin included on the 1998 303(d) list (OR DEQ 1998). Maps of listed stream segments by parameter are provided in Appendix 7-A. Water bodies are included on the 303(d) list only if sufficient data has been collected to show that a violation has occurred. Therefore, the 303(d) list is probably not a comprehensive list of streams since information is not available for many streams within the Crooked River Basin.

Figure 7-1: Water Quality Limited Streams

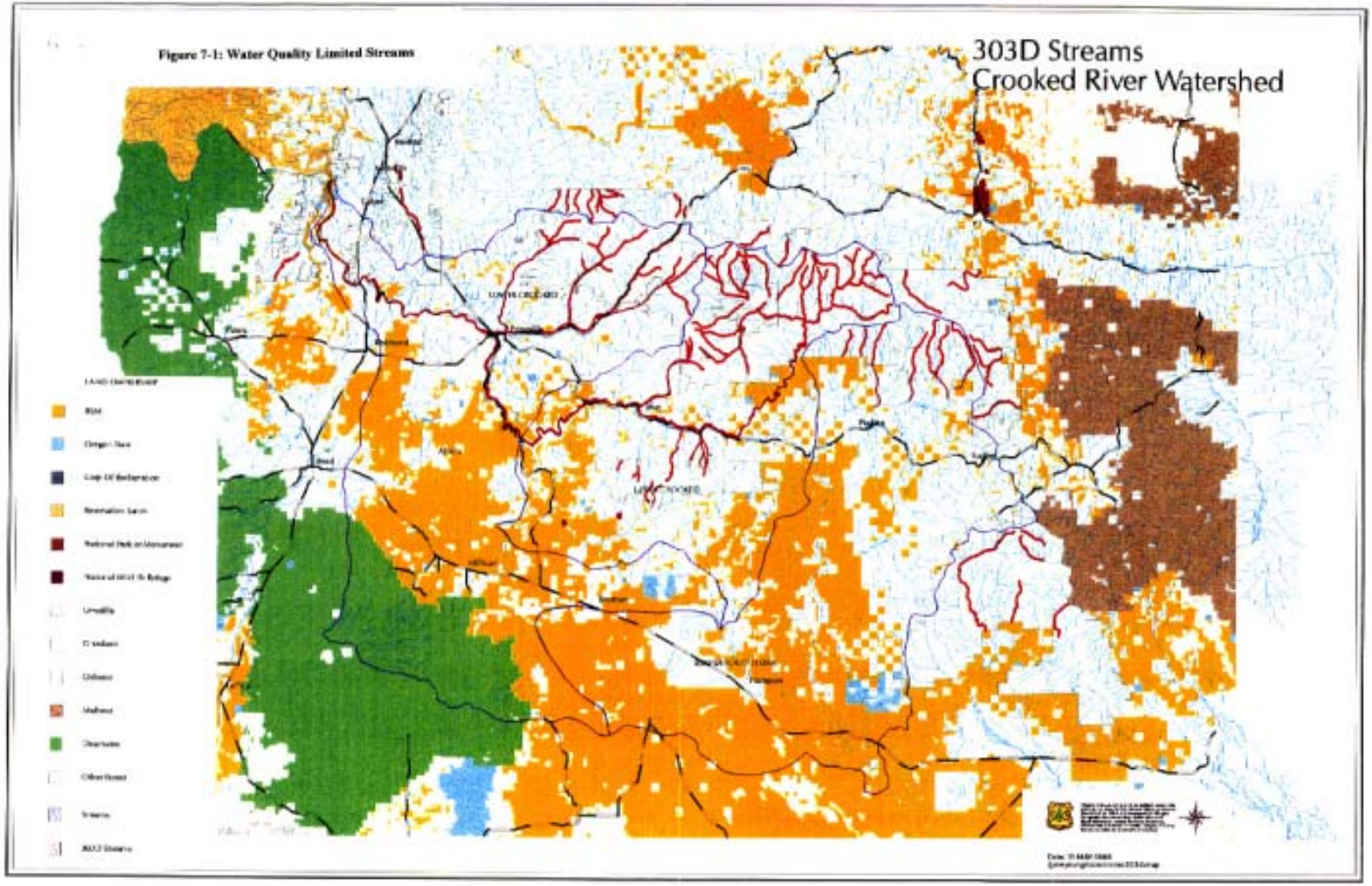


Table 7-2: Water Quality Limited Streams and Stream Segments

Water Quality Parameter	Sub-basin	Number of Water Quality Limited Streams or Stream Segments
Temperature	Lower Crooked, Upper Crooked, Beaver South Fork	12 - Lower Crooked River Sub-basin 30 - Upper Crooked River Sub-basin 7 - Beaver South Fork Sub-basin
pH	Lower Crooked, Upper Crooked	1- Mainstem Crooked River
Flow Modification	Lower Crooked, Upper Crooked	1- Mainstem Crooked River
Total Dissolved Gas	Lower Crooked	1- Mainstem Crooked River
Habitat Modification	Upper Crooked River	19 - Upper Crooked River Sub-basin
Bacteria	Lower Crooked	1 – Mainstem Crooked River

Source: OR DEQ. 1998

Water Quality Issues in the Crooked River Basin

A number of water quality parameters have been identified as potentially causing water quality impairment in the Crooked River Basin and are described below. The primary source for this summary is the 1998 303(d) list (OR DEQ, 1998). Land use practices that potentially influence water quality include water storage and diversion, agricultural and livestock runoff, failing septic systems, wastewater treatment and other discharges, toxic spills, soil erosion, and degraded upland and riparian vegetation conditions.

Temperature

Elevated water temperature is detrimental to cold-water fish species and other aquatic life. The biological rationale for these criteria are based on laboratory studies and have been evaluated for all life history stages of salmonids. The studies looked at the sublethal effects of warmer temperatures to fish, such as increase susceptibility to disease, inability to spawn, reduced survival rate of eggs, reduced survival and growth rates of juveniles, increased competition for limited habitat and food, and reduced ability to compete with other species. According to Oregon Administrative Rule (OAR) 340 41 525 (2) (b) (a):

"…no measurable surface water temperature increase resulting from anthropogenic activities is allowed … if surface water temperatures : (i)exceed 64 degrees F (17.8C) during times of salmonid rearing;..."

These numeric criteria are based on a seven-day moving average of the daily maximum temperatures. Surface water temperature increases can result from the following types of anthropogenic activities: water diversion, reservoir storage, reduced riparian (streamside) shade, altered stream channel morphology (activities that reduce sinuosity and decrease width to depth ratios).

Streams listed for violating the temperature standard on the 303(d) list include:

- Á 12 streams, stream segments or reservoirs within the Lower Crooked River Sub-basin
- Á 30 streams, stream segments or reservoirs in the Upper Crooked River Sub-basin
- Á 7 streams, stream segments or reservoirs in the Beaver South Fork Sub-basin (OR DEQ 1998).

Dissolved Oxygen

Adequate concentrations of dissolved oxygen are essential for supporting fish, invertebrates, and other aquatic life. Some species including salmonids are sensitive to reduced concentrations of DO, especially during early life stages as eggs and alevins. DO concentrations in the water column vary naturally over the day due to temperature changes and photosynthetic processes. DO levels in the water are typically at their lowest during the early morning hours. DO levels within gravels (intergravel DO or IGDO) directly affect the survival of salmonid embryos. IDGO concentrations are influenced by water column DO concentrations, the percentage of fine sediment in the gravel pores, sediment oxygen demand, and oxygen demand of the eggs. The water quality standard for dissolved oxygen is somewhat complicated, taking into account the salmonid life stage present, the IGDO concentrations, barometric pressure, altitude and temperature. The standard is summarized as follows:

"During the periods from spawning until fry emergence, DO in the water column shall not be less than 11.00 mg/l. However, if the minimum IGDO, measured as a spatial mean, is 8.0 mg/l or greater, then the water column DO criterion is 9.0 mg/l. During periods of salmonid rearing, DO in the water column shall not be less than 8.0 mg/l."

There are no streams or reservoirs within the Crooked River Basin listed for violating the dissolved oxygen standard on the 303(d) list (OR DEQ 1998). Crooked River Basin waterbodies identified in the 1988 non-point source report as having the potential for limitations related to dissolved oxygen include the mainstem Crooked River in the Lower Crooked River Sub-basin and the mainstem Crooked River in the Upper Crooked River Sub-basin, from Prineville Reservoir to the mouth of the North Fork (OR DEQ 1988).

Nutrients

"Nutrients" refer to the elements phosphorous and nitrogen that stimulate algae and plant growth in water. Algae and aquatic plants process sunlight into food for aquatic insects and crustaceans and are an important part of the stream ecosystem. However, excessive inputs of nutrients can over-stimulate plant growth and adversely impact beneficial uses by increasing pH, biological and biochemical oxygen demand, altering aquatic invertebrate and plant communities, and causing other detrimental impacts. The State of Oregon does not have a numeric standard for nutrients at this point but does have a narrative standard for weeds and algae that states:

" the development of fungi or other growths having a deleterious effect on stream bottoms, fish, or other aquatic life, or which are injurious to health, recreation or industry shall not be allowed."

Primary beneficial uses affected by nutrients include water contact recreation, aesthetics, and resident fish and aquatic life. Phosphorous and nitrogen are the principal growth limiting nutrients in water. Potential sources of these nutrients from human activities include wastewater discharge, agricultural and livestock runoff, and failing septic systems.

There are no Crooked River waterbodies on the 303(d) list for nutrients (OR DEQ 1998). Crooked River Basin waterbodies identified in the 1988 non-point source report as having the potential for limitations related to nutrients include: the mainstem Crooked River and Ochoco Reservoir in the Lower Crooked River Sub-basin; the mainstem Crooked River between Prineville Reservoir and the North Fork; and Antelope Flat Reservoir in the Upper Crooked River Sub-basin (OR DEQ 1988).

pH

The pH of water is the measure of the concentration or activity of hydrogen ions in the water expressed as the negative log of free hydrogen ions. Values from 0 to 7 indicate acid waters and from 7 to 14 indicate alkaline waters. Spawning and rearing of salmonid fish species are the most sensitive beneficial uses affected by pH. Values of pH outside the range in which a species evolved may result in both direct and indirect toxic effects. Elevated pH levels can cause dramatic increases in the toxicity of other pollutants and cause fish kills. The pH standard in the Crooked River Basin states that:

"pH values should not fall outside the range of 6.5 to 8.5"

There is currently discussion regarding the pH standard in the Crooked River Basin. There is a question as to whether the upper limit for the Crooked River Basin shouldn't be 9.0 rather than 8.5, as it is for the rest of eastern Oregon. The upper standard for the Deschutes River Basin is 8.5 due to the fact that much of that water originates in the Cascade Mountains. Conversely, the Crooked River Basin is geologically more aligned with the rest of eastern Oregon than the cascade region, which is characterized by a naturally higher range of pH (Lamb 1999, Nichols 2001).

Crooked River waterbodies on the 303(d) list for pH include: the Lower Crooked River, mouth to Baldwin Dam and the Upper Crooked River, from Prineville Reservoir to the North Fork (OR DEQ 1998). Crooked River Basin waterbodies identified in the 1988 non-point source report as having the potential for limitations related to pH include: the mainstem Crooked River in the Lower Crooked River Sub-basin and the mainstem Crooked River between Prineville Reservoir and the North Fork in the Upper Crooked River Sub-basin (OR DEQ 1988).

Bacteria

Water contact recreation is the beneficial use most directly affected by bacterial contamination of surface waters. Possible sources of bacterial contamination can include:

wastewater treatment plant discharges, failing septic systems, urban runoff, and livestock wastes. The State of Oregon bacteria standard for surface waters states:

" organisms of the coliform group commonly associated with fecal sources must not exceed the following limits: (a) a 30-day log mean of 126 E. coli organisms per 100ml, based on a minimum of 5 samples; or (b) 406 E. coli organisms per 100ml based on a single sample."

Crooked River waterbodies on the 303(d) list for bacteria include: the lower Crooked River, from the mouth to Baldwin Dam (OR DEQ 1998). Crooked River Basin waterbodies identified in the 1988 non-point source report as having the potential for limitations related to bacteria include: mainstem Crooked River from the mouth to Baldwin Dam in the Lower Crooked River Sub-basin and the mainstem Crooked River between Prineville Reservoir and the North Fork in the Upper Crooked River Sub-basin (OR DEQ 1988).

Total Dissolved Gas

The primary beneficial use affected by total dissolved gas is aquatic life and resident fish. The state standard for total dissolved gas states that:

" the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection shall not exceed 110 percent of saturation. The liberation of dissolved gases, such as carbon dioxide, hydrogen sulfide, or other gases, in sufficient quantities to cause objectionable odors or be deleterious to fish or other aquatic life, navigation, recreation, or other reasonable uses made of such waters shall not be allowed."

The Crooked River waterbody on the 1998 303(d) list for total dissolved gas is the lower Crooked River, from Baldwin Dam to Prineville Reservoir (OR DEQ 1998). Crooked River Basin waterbodies identified in the 1988 non-point source report as having the potential for limitations related to total dissolved gas include: the mainstem Crooked River between Baldwin Dam and Prineville Reservoir in the Lower Crooked River Sub-basin (OR DEQ 1988).

Turbidity and Sedimentation

Turbidity is a measure of water clarity using light penetration through a water sample. In many streams, turbidity serves as a useful surrogate for measuring suspended sediment – the smaller particles of soils such as silts and clays carried along in the water column. Suspended sediment can reduce the sight-feeding ability of fish and may damage gill tissue depending on exposure time, concentration, and particle form. Suspended sediment can carry other pollutants and can interfere with recreation, irrigation, and aesthetics. Sediment can deposit in gravel interstices and affect salmonid egg incubation survival and invertebrate communities. The State of Oregon has a narrative standard for sedimentation that states:

"the formation of appreciable bottom sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed."

As a surrogate for sedimentation, the State does have a numeric standard for turbidity, which states that:

"no more than a 10 percent cumulative increase in natural stream turbidities shall be allowed as measured relative to a control point immediately upstream of turbidity causing activities."

This standard is useful when assessing point source (i.e. individual or end-of-pipe discharges), but does not adequately address non-point sources (i.e. runoff) concerns. Potential human caused sources of turbidity can include: sediment runoff from roads and construction sites; return flow from eroding irrigation canals; denuded livestock areas that drain to streams; winter sanding of roads and parking lots; and slope failures from forest, road, or irrigation activities.

There are no Crooked River waterbodies on the 1998 303(d) list for sediment and/or turbidity (OR DEQ 1998). Crooked River Basin waterbodies identified in the 1988 non-point source report as having the potential for limitations related to sedimentation include: 5 streams or stream segments in the Lower Crooked River Sub-basin; 24 streams or stream segments in the Upper Crooked River Sub-basin; and 3 streams or stream segments in the Beaver South Fork Sub-basin (OR DEQ 1988). Crooked River Basin waterbodies identified in the 1988 non-point source report as having the potential for limitations related to turbidity include: Ochoco Reservoir in the Lower Crooked River Sub-basin; and Antelope Flat and Prineville Reservoirs in the Upper Crooked River Sub-basin (OR DEQ 1988).

Flow and Habitat Modification

Water quality criteria related to flow modification are narrative standards which focus on the need to maintain flows and habitat conditions which are sufficient to support aquatic life without detrimental changes to the resident biological communities. Beneficial uses that may be affected by flow modification include resident fish and aquatic life and salmonid spawning and rearing.

Crooked River waterbodies on the 303(d) list for flow and/or habitat modification include: lower Crooked River, mouth to Baldwin Dam (flow); Allen Creek (habitat); Brush Creek (habitat); Crazy Creek (habitat); upper Crooked River, Prineville Reservoir to North Fork (flow); North Fork Crooked River (flow); Deep Creek (habitat); Double Corral Creek (habitat); Fox Creek (habitat); Gray Creek (habitat); Happy Camp Creek (habitat); Howard Creek (habitat); Jackson Creek (habitat); Little Summit Creek (habitat); Lookout Creek (habitat); Lytle Creek (habitat); Peterson Creek (habitat) and Porter Creek (habitat) (OR DEQ 1998).

Crooked River Basin waterbodies identified as having the potential for limitations related to flow modification include: 7 streams or stream segments in the Lower Crooked River Sub-basin; 24 streams or stream segments in the Upper Crooked River Sub-basin; and 3 streams or stream segments in the Beaver South Fork Sub-basin (OR DEQ 1988).

Toxics

Water quality criteria related to toxics focus on preventing the introduction of potentially harmful toxic substances in levels greater than natural background levels. Beneficial uses affected by toxics include resident fish and aquatic life and drinking water.

Ochoco Reservoir is listed as a site of "potential concern" for mercury on the 1998 303 (d) list, although no fish consumption recommendations have been developed (OR DEQ 1998).

Point Sources of Pollution

A total of twelve hazardous waste sites are located in the Lower Crooked River Sub-basin and regulated under the Resource Conservation and Recovery Act including nine private businesses, the Oregon State Highway Division, and US Department of Agriculture, Forest Service (USDI EPA 1999). Three toxic release sites are regulated under the Toxics Release Inventory, including two private businesses and the US Department of Agriculture, Forest Service (USDI EPA 1999). There are two Superfund sites in the Lower Crooked Sub-basin, regulated under the Comprehensive Environmental Response, Compensation, and Liability Act; including one former private business and an U.S. Army range (USDI EPA 1999). There are seven State of Oregon permitted confined animal feeding operations (CAFO) in the Lower Crooked River Sub-basin; 3 are dairy operations with less than 1,000 animals and 4 are feed lots (ODA 2000). It is estimated that as many as 40 animal feeding operation (AFO) sites in the basin may fall under stricter Federal requirements once the State of Oregon's AFO/CAFO regulations are adjusted to meet Federal standards/interpretations under the Clean Water Act (ODA 2000).

Eighteen sites within the Lower Crooked River Sub-basin are permitted as point source pollution locations under the water quality-point source information system of the Oregon Department of Environmental Quality. Ten are located on Ochoco Creek (9 below Ochoco Dam, 1 above) and eight are on the Crooked River, between river miles 25 and 60 (Lamb 1999).

There are no hazardous waste sites regulated under the Resource Conservation and Recovery Act or toxic release sites regulated under the toxic release inventory located in the Upper Crooked River basin (USDI EPA 1999). There is one Superfund site regulated by the EPA under the Comprehensive Environmental Response, Compensation, and Liability Act; this site is a private business (USDI EPA 1999).

There are three hazardous waste sites regulated by the EPA under the Resource Conservation and Recovery Act in the Beaver-South Fork sub-basin, two of these sites are private businesses, and one is managed by the State of Oregon (USDI EPA 1999). There is one Superfund site regulated by the EPA under the Comprehensive Environmental Response, Compensation, and Liability Act; this site is a private business (USDI EPA 1999). There are no toxic release sites regulated under the toxic release inventory located in the Beaver-South Fork sub-basin (USDI EPA 1999).

Two sections of downtown Prineville have groundwater, soil and air contamination of benzene and gasoline from three leaking storage tanks at gas stations (OR DEQ 2001). Tank removal and monitoring of the problem began in 1998 and remediation systems were installed in 1999. Cleanup work continues and is being led by the Oregon Department of Environmental Quality. Fall 2000 well monitoring data indicate that contamination concentrations and the size of the plume are dropping significantly. Monitoring results indicate that contamination from these gas stations did not reach Ochoco Creek (OR DEQ 2001). See Figure 7-2 for a map of groundwater contamination plumes from the gas station leaks.

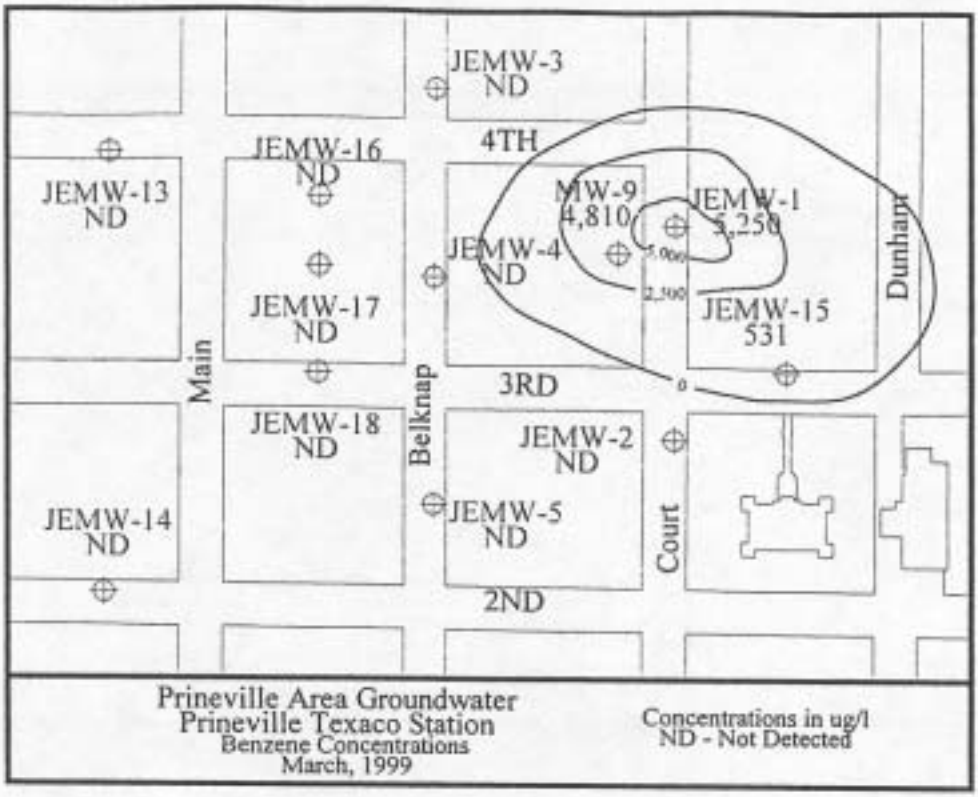
The City of Prineville handles wastewater through a combination of applying the effluent as irrigation for the City Golf Course in summer months and discharging into the Crooked River in the winter months. The minimum flow requirements for the City to discharge in the winter months without violating water quality standards is 35cfs. A recent draft Facility Management Plan (OR DEQ, 2000) has identified that the City of Prineville's wastewater system is rapidly approaching capacity and that additional effluent ponds will be needed, in addition to other system upgrades.

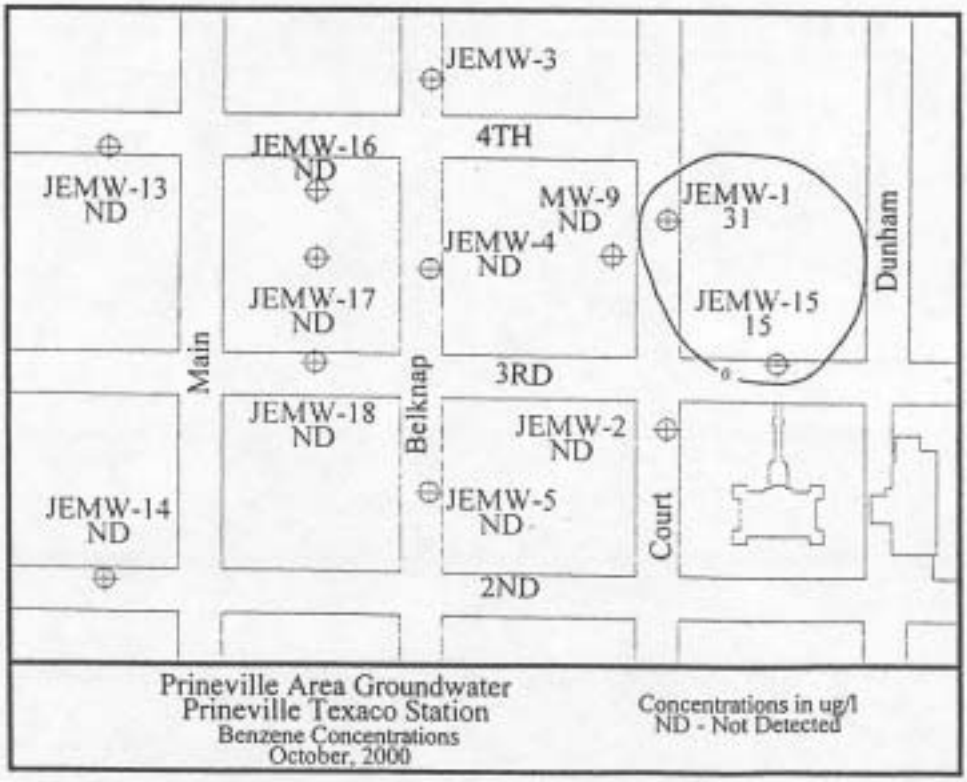
Monitoring Efforts

DEQ Ambient Monitoring Sites

The Oregon Department of Environmental Quality maintains three water quality monitoring stations on the Crooked River, located at Lone Pine Road (Lower Crooked River Sub-basin), Highway 126 (Lower Crooked River Sub-basin), and Conant Basin Road (Upper Crooked River Sub-basin) (OR DEQ 1999). These sites are monitored for 10 parameters, which are then used to develop a water quality index for the site. For the period of 1986-1995 all three sites are rated as having poor water quality due to high water temperatures, high pH, and low dissolved oxygen during the summer months, and high concentrations of total dissolved solids and total phosphates throughout the year (OR DEQ 1999). The Lone Pine Road site also showed signs of elevated fecal coliforms, nitrate and ammonia nitrate, indicating the effects of different land uses in this area of the basin (OR DEQ 1999). Land uses above the two upper sites (Conant Basin and Prineville) are predominantly timber harvest and livestock grazing. Land uses above the Lone Pine Road site include logging, grazing, irrigated and non-irrigated agriculture, and the release of treated wastewater from the City of Prineville land effluent site. Water quality index scores at the Lone Pine site are about ten points below the Upper Crooked River site (67/100 & 78/100) (OR DEQ 1999).

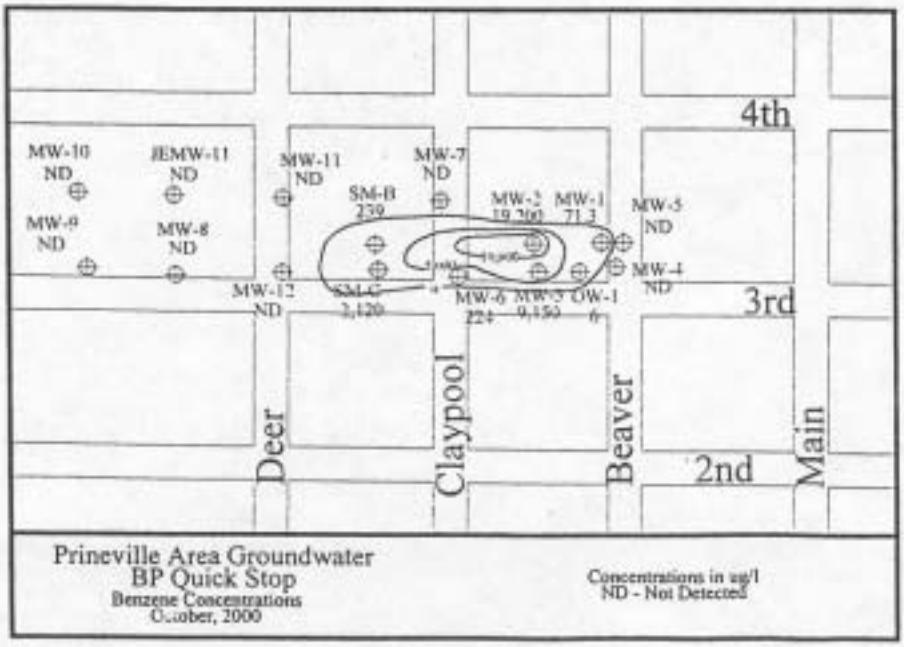
Figure 7-2: Prineville Groundwater Contamination





Source: OR DEQ. 2001

Figure 7-2: Prineville Groundwater Contamination



Source: OR DEQ. 2001

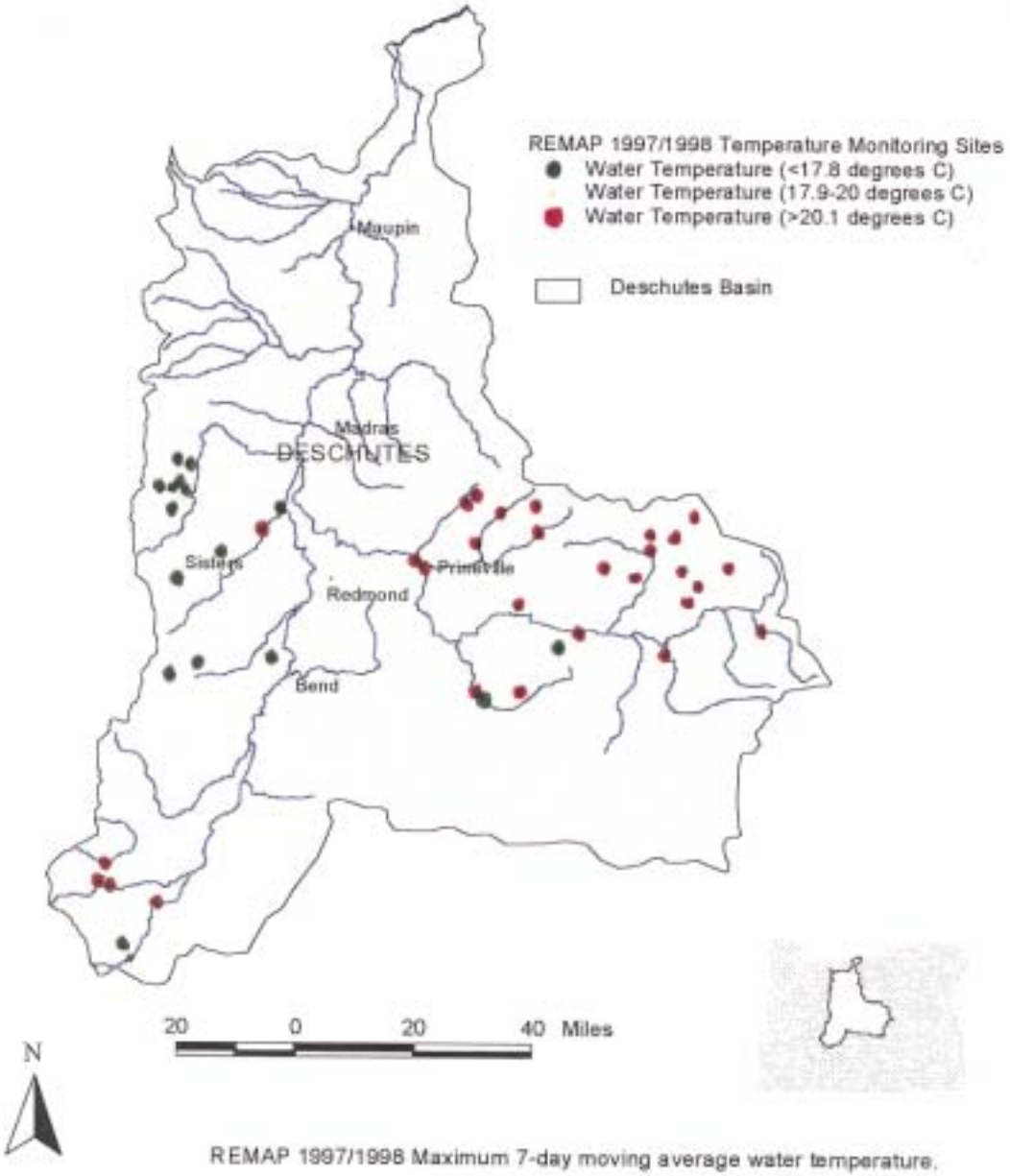
Water Chemistry and Temperature Data: REMAP Project

In the summer months of 1997 and 1998 the Oregon Department of Environmental Quality performed stream surveys for the federal Environmental Protection Agency's (EPA) Regional Environmental Monitoring and Assessment Program (REMAP). The REMAP program is a spin-off of the national Environmental Monitoring and Assessment Program (EMAP), which focuses on determining ecological conditions at a large scale—national, western states, Mid-Atlantic states, etc. The objective of EMAP is to provide decision-makers with objective and credible data to make informed and effective environmental policies and regulations. Also, EMAP is designed to detect changes (either improvements or degradations) in environmental quality over time through repeat sampling. REMAP uses similar methods as EMAP, but is focused at a smaller scale, such as a river basin or an ecoregion. The primary objective of the Deschutes REMAP project was to assess status and trends of the aquatic natural resources in the Upper Deschutes River Basin (above Lake Billy Chinook) (OR DEQ 1999). In order to assess conditions of the basin as a whole, all survey sites were selected randomly throughout the basin. During the summers of 1997 and 1998, the Oregon Department of Environmental Quality collected water samples for water chemistry analyses and monitored in-stream temperatures at over 50 randomly selected sites throughout the Upper Deschutes River Basin (OR DEQ 1999). For a map of the monitoring sites see Figure 7-3 below. A summary of results from the 1997 and 1998 temperature and water chemistry monitoring conducted by DEQ is provided below. See Figure 7-4 for results of the REMAP temperature surveys, and Appendix 7-B for more detailed REMAP data.

Parameters analyzed in the recent OR DEQ REMAP monitoring project included dissolved oxygen, pH, biochemical oxygen demand, total solids, ammonia-nitrogen, nitrate-nitrogen, total phosphorus, chloride, ortho-phosphate, sulfate, total Kjeldhl nitrogen, alkalinity, chemical oxygen demand, total organic carbon, total suspended solids, conductivity, temperature, and turbidity (OR DEQ 1999). Each location was rated from very poor to excellent, based on a slight modification of the Oregon Water Quality Index. Water quality in the Metolius basin was rated as excellent. Water quality in the Upper Deschutes Basin was primarily rated as excellent, with one site rated as poor. Water quality in the Crooked River Basin was rated from excellent to very poor, with conditions decreasing in the downstream sections of the basin (OE DEQ 1999). Water temperature was also calculated using a seven-day moving average at the 52 randomly selected sites in 1997 and 1998. All streams in the Metolius met the State of Oregon's 17.8 C water quality standard for temperature; all 26 streams monitored in the Crooked River Basin violated temperature standards (OR DEQ 1999). Streams in the Upper Deschutes basin varied, with 6 sites above, and 7 below, the temperature standard (OR DEQ 1999). The sites that met the temperature requirements were most likely groundwater influenced or at higher elevations, although an obvious elevation correlation was not found. Crooked River sites generally had larger daily fluctuations (ranging from 6 C to 22 C) than the Deschutes or Metolius locations (OR DEQ 1999).

Despite the fact that all sites monitored were within the Deschutes River Basin, the three regions in this study, Metolius, Upper Deschutes, and Crooked River, are highly variable

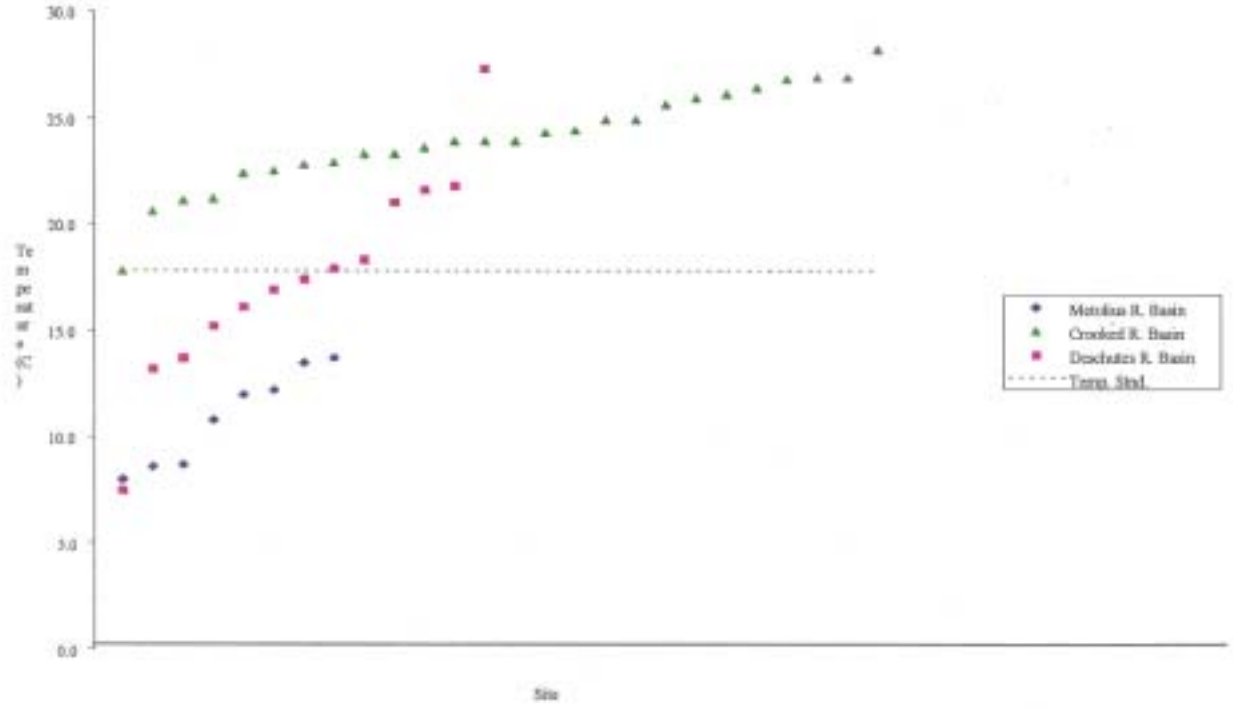
Figure 7-3: REMAP Site Map



REMAP 1997/1998 Maximum 7-day moving average water temperature.

Source: OR DEQ, 1999

Figure 7-4: REMAP Temperature Data



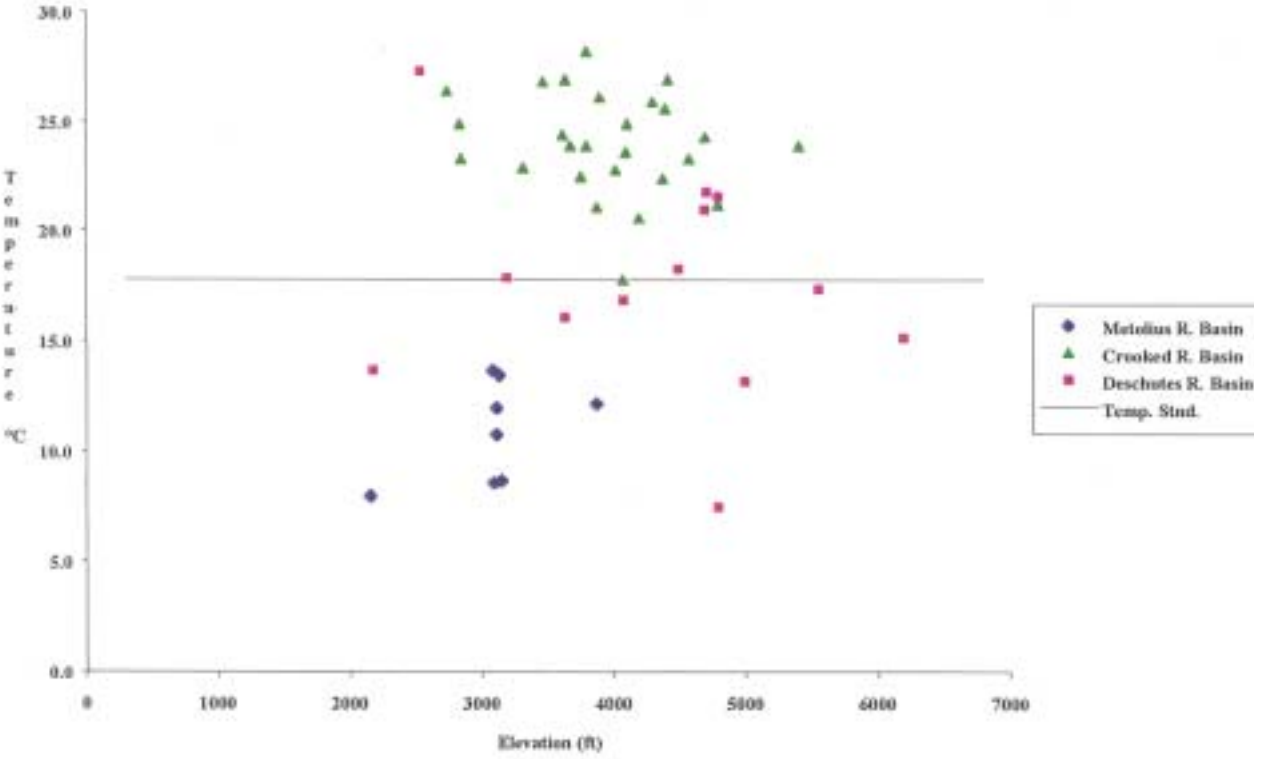


Figure 3. Elevation vs. maximum 7-day moving average temperature for 1997 and 1998 REMAP sites

geologically, chemically, and biologically. The majority of the Crooked River Basin falls within the John Day Ecological Province, an area of sedimentary parent materials, while the Upper Deschutes and Metolius study areas are within the Mazama ecological province, characterized by igneous rock. Evidence of the influence of ecoregion on water chemistry is seen in the location of the lowest scoring Upper Deschutes basin sites, Squaw Creek and the Lower Deschutes River. These sites were located in the transition zone between ecological provinces (Squaw Creek) or within a different ecological province (Lower Deschutes site was within the John Day Ecological Province). The different geology and soils that the Crooked River Basin drain through (primarily John Day ecoregion) result in different natural background levels of total solids, pH, alkalinity, and other water chemistry parameters.

Water quality conditions within the Crooked River Basin were highly variable, with higher elevation streams in the Ochoco Mountains generally having good to excellent water quality, and lower elevation sites having lower overall water quality (Table 7-3). In the Lower Crooked River Sub-basin, the mainstem Crooked River and McKay Creek were rated as poor, Little McKay Creek was rated as good, and Marks, Mill, and Ochoco Creeks were rated as excellent (OR DEQ 1999). In the Upper Crooked River Sub-basin, for Ochoco Mountain streams, Wildcat and Wikiup Creeks were rated as good, while Little Summit, Jackson, Fox, Porter and Grey Creeks were all rated as excellent (OR DEQ 1999). Fox Canyon Creek was rated as very poor (OR DEQ 1999). In the Upper Crooked River Sub-basin, for Maury Mountain streams, Bear Creek was rated as poor, and Cow and Little Bear Creeks were rated as good (OR DEQ 1999). Water quality conditions were variable in this region, with Bear Creek water quality indexes ranging from 62 to 80 points. In the Beaver South Fork Sub-basin, Dry Paulina Creek was rated as very poor to poor, the South Fork Crooked River and South Fork Beaver Creek were rated as poor, Wolf Creek was rated as fair, and Roba Creek was rated as good (OR DEQ 1999). See Appendix 7-B for water quality index data for the Lower Crooked, Upper Crooked, and Beaver South Fork Sub-basins, respectively.

Table 7-3: Crooked River Basin Water Chemistry REMAP Rating

Sub-basin	Streams	REMAP Rating
Lower Crooked	Mainstem Crooked River, McKay Creek	Poor
Lower Crooked	Little McKay Creek	Good
Lower Crooked	Marks, Mill, and Ochoco Creek	Excellent
Upper Crooked	Fox Canyon Creek, Bear Creek	Poor
Upper Crooked	Wildcat, Wikiup, Little Bear, and Cow Creeks	Good
Upper Crooked	Little Summit, Jackson, Fox, Porter, and Grey Creeks	Excellent
Beaver South Fork	Dry Paulina Creek	Poor
Beaver South Fork	Wolf Creek	Fair
Beaver South Fork	Roba Creek	Good

Source: OR DEQ. 1999

Additional Monitoring Efforts

Numerous water quality monitoring efforts are occurring throughout the basin, although the objectives, methods and sites are not currently being coordinated among and between agencies. Ochoco National Forest is currently attempting to compile all water temperature data from USFS and BLM lands within the basin. Other entities involved in some form of water quality monitoring in the basin include: ODFW, OR DEQ, Oregon State University Extension Service, Ochoco Irrigation District, the Bureau of Reclamation and the Crooked River Watershed Council. Improved coordination and collaboration of monitoring efforts and data is needed to provide a more accurate picture of current conditions and trends.

Key Findings, Data Gaps and Management Recommendations- Water Quality

Key findings, data needs and management recommendations presented below were developed from information gained in the assessment process and by members of the Council's assessment technical team.

Key Findings

Water quality conditions within the Crooked River Basin are highly variable, with higher elevation streams in the Ochoco Mountains generally having good to excellent water quality, and lower elevation sites having lower overall water quality. Primary contributors to the poor water quality are related to land and water conditions such as: low summer flows, the existence of reservoirs and diversions, degraded upland and riparian vegetation, and stream channels that lack stable banks and connection with the floodplain. Land uses that can influence water quality in the basin include logging, roads, grazing, irrigated and non-irrigated agriculture, confined feeding operations, recreation, urban and rural residential development, reservoirs and seasonal sewage treatment plant operations.

Because data have been collected from relatively few sites, the 303(d) list may not accurately reflect the extent of water quality problems in the Basin. The following summarizes what is generally known about water quality in the Basin.

Temperature - elevated summer temperatures are a concern throughout much of the Basin (OR DEQ 1998).

Nutrients - DEQ monitoring at their three ambient sites indicates high concentrations of nutrients both during periods of low flow (little dilution) and during heavy precipitation (high runoff) (OR DEQ 1999). Increased nutrient concentrations can affect both in-stream pH and dissolved oxygen.

pH - portions of the Crooked River below the North Fork Crooked River are included on the 303(d) list for pH; listings are based on DEQ data collected at three ambient sites (OR DEQ 1998, OR DEQ 1999). REMAP data also exceed the standard at the South Fork Crooked River site in August 1998 (OR DEQ 1999). The time of day data are collected is critical; pH peaks late in the afternoon, but that is not necessarily when data have been collected. There is some question as to whether the upper limit for the Crooked River Basin shouldn't be 9.0 rather than 8.5, as it is for the rest of eastern Oregon. The upper standard for the Deschutes River Basin is 8.5 due to the fact that much of that water originates in the Cascade Mountains. Conversely, the Crooked River Basin is geologically more aligned with the rest of eastern Oregon than the cascade region, which is characterized by a naturally higher range of pH (Lamb 1999, Nichols 2001).

Dissolved Oxygen - data collected on the Crooked River at the three DEQ ambient sites did not violate the D.O. standard, although data were not collected in the early morning when D.O. concentrations are likely to be lowest (OR DEQ 1999, Lamb 2000). The standard applied was for cold-water aquatic life; this may need to be re-evaluated for times of salmonid spawning

Bacteria - the mainstem Crooked River is listed for bacteria from the mouth to Baldwin Dam, based on DEQ data collected from their ambient site upstream of Smith Rock (OR DEQ 1998). Data from their ambient sites further upstream on the Crooked did not exceed standards; little other bacterial data have been collected.

Total Dissolved Gas - the mainstem Crooked River is listed for total dissolved gas from Baldwin Dam to Prineville Reservoir because of elevated saturation levels below Bowman Dam after periods of high flows (OR DEQ 1998). Rainbow trout captured at those times showed signs of "gas bubble disease (Lamb 2000).

Sedimentation/Turbidity - sedimentation and/or turbidity have been identified as possible water quality problems in many streams throughout the basin, although no data have been collected to document this (OR DEQ 1988). The concentration of total suspended solids has been high throughout the year at all three DEQ ambient sites (OR DEQ 1999).

Toxics - Ochoco Reservoir is listed as a site of "potential concern" for mercury, although no fish consumption recommendations have been developed (OR DEQ 1998).

Flow Modification - the mainstem Crooked River and North Fork Crooked River are listed for flow modification because of low flows due to irrigation diversions and reservoir refill during the non-irrigation season (OR DEQ 1998). Flow modification has been identified as a possible problem in many other streams throughout the basin, although no data have been collected to document this.

Habitat Modification - nineteen stream segments in the Upper Crooked Sub-basin are listed for habitat modification based on data collected for the North Fork Crooked River Watershed Analysis (OR DEQ 1998, USDA FS 1995b). Undesirable habitat conditions include limited large woody debris, low pool frequency, and high width/depth ratios (USDA FS 1995b). Habitat modification has been identified as a possible problem in many other streams throughout the basin, although no data have been collected to document this.

Data Needs

- Á More data on pH, nutrients, dissolved oxygen, bacteria, turbidity and sediment at sites in the basin in addition to DEQ's three ambient sites; pH and dissolved oxygen data collected should look at diurnal variations to ensure evaluations of "worst-case" situations
- Á Improved understanding of the relationships between flow and water quality, particularly below Ochoco and Prineville reservoirs where management could be adjusted in response to findings
- Á Determination of salmonid spawning and rearing times of year for rivers and streams in the basin; application of the appropriate temperature and dissolved oxygen criteria;
- Á Compile, analyze and summarize data from all sources in addition to OR DEQ
- Á Determine what natural pH conditions in the basin are (to help assess whether upper range of pH standard for the Basin should be 9.0 rather than 8.5)
- Á Determine anthropogenic sources of nutrients and flow reductions and characterize their impacts on in-stream pH and dissolved oxygen concentrations
- Á Determine source and extent of bacterial pollution observed in mainstem Crooked River
- Á Determine vegetative site potential of riparian areas on public and private lands
- Á Assess sources of sediment and impacts on beneficial uses
- Á Investigate relationship between operations at Bowman Dam and total dissolved gas concentrations in the lower Crooked River to determine if supersaturation is still a problem downstream of the dam and if so, make recommendations for management solutions
- Á Evaluate sources of mercury and level of mercury contamination in Ochoco Reservoir

Management Recommendations

- Á Implement a coordinated watershed-wide temperature monitoring network by agencies and watershed council
- Á Collect sufficient data to identify water quality problems and the source of water quality problems
- Á Ensure that sewerage facilities serving the basin are sufficiently sized to accommodate growth and are operated in a manner protective of water quality and public health
- Á Improve upland and riparian conditions

8. Fish

Fish Habitat

Declines in stream morphology function, riparian conditions, water quality and quantity, and habitat connectivity have led to severe declines or extirpation of native fish species within the basin. While management of riparian and aquatic habitats is improving in many cases, the extent of historical damage combined with the semi-arid climate has slowed recovery. Degradation levels limit management options as fish populations and habitat are severely depressed; active restoration efforts will be required throughout the basin (ODFW 1996, USDA FS 1998b, WSPE 1999). Grazing, agriculture, irrigation diversions, timber harvest, roads and recreation are the primary land uses and practices that affect fish habitat condition. The most significant habitat factor affecting fish populations in the basin is probably water quantity, as it influences numerous water quality, habitat and fish passage variables that are also severely limited (ODFW 1996, USDA FS 1998b, NWPPC 2001, WSPE 1999).

Historical accounts of the Crooked River Basin emphasize the abundant riparian vegetation, commenting on the prolific willow, aspen, and cottonwood communities. The earliest of these accounts dates to the 1826 expeditions of Ogden (Lent 2000). Wide valley bottoms covered in lush grasses and meandering stream channels were also noted in historical accounts.

Major changes have occurred in riparian and aquatic communities in the Crooked River Basin from the 1800's to the present. Primary changes affecting fish habitat and populations include:

- Á Decrease in pool habitat (frequency and depth);
- Á Loss of riparian vegetation;
- Á Changes in volume of water flow;
- Á Changes in timing and level of peak flows;
- Á Barriers to fish migration, including low flows;
- Á Channelization;
- Á Reductions in riparian areas;
- Á Changes in composition, distribution and status of fish and other aquatic species; and,
- Á Unscreened irrigation diversions.

(ODFW 1996, NWPPC 2001, WSPE 1999, USDA FS 1998b, USDA FS 1995b)

Lower Crooked River Sub-basin

Game fish species in the Lower Crooked River sub-basin include: Redband Trout, Bull Trout, Kokanee, Brown trout (each currently restricted to Crooked River arm of Lake Billy Chinook due to Opal Springs Dam), a remnant, landlocked population of Spring Chinook in Lake Billy Chinook, Mountain Whitefish, Smallmouth Bass, Largemouth Bass, Bluegill,

Black Crappie, and Brown Bullhead (ODFW 1996). Redband trout are the primary native game fish in the Lower Crooked River Sub-basin. All reaches of the mainstem lower Crooked River are managed for native redband trout, with some hatchery trout emigrating from Prineville Reservoir (ODFW 1996).

Mainstem Crooked River

Water in the Lower Crooked River is characteristically turbid, until approximately river mile 16 where spring and seep inflow adds substantial clear and cold water to the system in the springtime. The season of high and low flows have been reversed, with higher flows occurring in the summer months during the irrigation delivery season, and low flows occurring in the winter as water is stored for future use. Cold-water releases from the reservoir have substantially improved conditions and the twelve-mile stretch below the reservoir provides the best conditions for redband trout in the sub-basin (ODFW 1996, USDI BLM 1992a).

Typical flows in the Chimney Rock section of the Lower Crooked River are 200-250 cfs during the summer irrigation season, and 50-75 cfs during the winter storage season (USDI BLM 1992a, ODFW 1996). A study undertaken in 1993, determined that optimal flows for fry and juvenile redband trout were approximately 75-150 cfs, and exceeding 200 cfs for adult and spawning redband trout (Berggren 2001, ODFW 1996). Uncontracted storage in Prineville reservoir provides a potential for allocation by the Bureau of Reclamation for scheduled release into the Lower Crooked River to improve conditions for fish populations. The twelve-mile stretch of the Crooked River below Bowman Dam (Chimney Rock section) is classified as a wild and scenic river and managed by the BLM.

The middle section of the Lower Crooked River is characterized by a wider flood plain and a high proportion of private land ownership, used for livestock grazing, crop production, as well as residential, industrial, and commercial uses within the City of Prineville Urban Growth Boundary. Stream channel and aquatic habitat conditions in this section of the Lower Crooked River are characterized by fair riparian conditions and water quantity and quality problems due to the withdrawal of most of the streamflow during the irrigation season (ODFW 1996). Irrigation diversions in this section of river include the Crooked River Feed Canal, the Rice Baldwin Ditch, the People's Irrigation Ditch, and several smaller diversions below the City of Prineville (Moore 1999).

In the Lower Crooked River section downstream of the Highway 97 Bridge, the steep canyon topography has resulted in relatively undisturbed conditions, characterized by healthy riparian conditions. Natural springs augment flows beginning at river mile 18 and are responsible for improved flow and water quality and cooler water temperatures.

Ochoco Watershed Streams (Ochoco, Mill, McKay, Marks)

Mill, McKay and Marks Creeks flow into Ochoco Creek, a major tributary of the Crooked River. Streams in the Ochoco Watershed originate on Ochoco National Forest lands, with lower reaches flowing through mostly private lands. Ochoco Creek is impounded by Ochoco Dam at river mile 11 to form Ochoco Reservoir. Flows below the dam are regulated and managed for irrigation purposes. USFS land use in the watershed includes livestock grazing, timber harvest and recreation. Private land use is predominantly livestock grazing and timber harvest above Ochoco Reservoir, and livestock and crop production (primarily hay), and residential/industrial below the reservoir. The upper Ochoco watershed supports indigenous redband trout while the lower watershed supports a combination of wild and hatchery rainbow trout and mountain whitefish (ODFW 1996).

Stream habitat surveys in the late 1970's on Mill, Marks and Ochoco Creeks indicated that many of the upper reaches and tributaries were in moderate to good condition, although stream shading was low (ODFW 1996). The stream reaches with the best riparian vegetation conditions were the upper reaches of Canyon and Ochoco Creeks (ODFW 1996). Mill and Marks Creeks were found to be heavily impacted by irrigation structures, channelization and land use, with adverse bank, riparian vegetation, and aquatic habitat conditions (ODFW 1996, USDA FS 1997). Ochoco and Mill Creeks are frequently dry before reaching Ochoco Reservoir in the late summer months (ODFW 1996). Recent riparian assessment work (Walter 2000, ODFW 1997c) in this area of the basin is also described in Section 6.0, Riparian Conditions.

Upper Crooked River Sub-basin

Game fish species in the Upper Crooked River sub-basin include: Redband Trout, Brook Trout, Smallmouth Bass, Largemouth Bass, and Brown Bullhead (reservoirs only) (ODFW 1996). Water quality conditions in the Upper Crooked River Sub-basin are moderate to severe for water quality, fish, and aquatic life for many streams; and are characterized by low summer flows and high summer water temperatures (OR DEQ 1998, USDA FS 1998b). Wild populations of coldwater game fish, primarily redband trout, are the primary fishery management concern in the Sub-basin (ODFW 1996). The best habitat for redband trout that remains in the sub-basin is located on headwater streams in the Ochoco National Forest, although cool water and good fish habitat conditions are dependant on the amount and type of timber harvest that has occurred (ODFW 1996, USDA FS 1995b). At lower elevations, the impacts of upland vegetation conditions, water withdrawals and livestock grazing result in an overall reduction in fish habitat, reduced flows, and increased water temperatures. Current upland vegetation conditions in large portions of the Upper Crooked River Sub-basin, which are characterized by a dominance of western juniper, are a limiting factor in improving riparian and channel conditions throughout the sub-basin (USDA FS 1998b, ODFW 1996).

North Fork Crooked River

The North Fork Crooked River begins in the Ochoco Mountains approximately 75 miles east of Prineville, in the forested meadows of Williams and Big Summit Prairies, and is fed by snowmelt and spring fed streams. Land ownership in the North Fork Crooked River Basin is approximately 75% USFS, 12% BLM, and 13% private (Big Summit Prairie and lower North Fork). Ownership along the river is 26% USFS, 23% BLM, and 51% private. Over 32 miles of the North Fork Crooked River was designated in 1988 as a Wild and Scenic River. The upper river and its tributaries flow through high elevation areas of steep canyons and broad valleys. The lower river below the confluence with Deep Creek flows through a steep basalt and rimrock canyon, 500 feet in depth. Most streams in the system above Deep Creek were found to have low shade and low large woody debris, although cutbanks and erosion were also characterized as low (USDA FS 1995b, ODFW 1996). Low summer flows are another major concern regarding fish habitat in the North Fork Crooked River Watershed (ODFW 1996, USDI BLM 1993). Small impoundments and diversions have altered flows and isolated some redband trout populations in the North Fork Crooked River Watershed (ODFW 1996, USDA FS 1995b). Upper and Lower Falls have geographically isolated redband trout in the North Fork from the rest of the Crooked River system. Despite less than optimum habitat conditions in the North Fork Crooked River Watershed, redband populations in this watershed appear to be doing better than redband trout in the rest of the Crooked River System (ODFW 1996). The North Fork Crooked River system is managed for wild trout (ODFW 1996).

Mainstem Crooked River

Conditions in the mainstem Crooked River drainage in the Upper Crooked River Sub-basin are characterized by poor riparian and channel conditions, low summer flows, high erosion, lack of spawning gravel, and high summer temperatures (ODFW 1996, USDA FS 1998b). Land ownership along the mainstem is almost exclusively private, while headwater tributaries pass through a mixture of USFS, BLM, and private lands. Upland vegetation communities include wet meadows and forested areas, while lower elevation, private lands include sagebrush and juniper communities and irrigated pastures and hay fields. Soils around the Maury Mountains (Camp and Bear Creek Watersheds) are highly erodable, consisting of clays that tend to stay suspended in the water column. Native redband trout are the principal species observed on many headwater tributaries (ODFW 1996). Redband trout have been reported, but not observed recently, in Camp Creek (ODFW 1996). Many streams in this section of the Upper Crooked River Sub-basin are intermittent or ephemeral and thus provide only very limited or seasonal habitat. This area is managed as a basic yield ‘wild plus hatchery rainbow trout’ river (ODFW 1996).

Bear Creek Watershed

Bear and Sanford Creeks originate in the Maury Mountains and drain directly into Prineville Reservoir. The Bear Creek Watershed is a mixture of USFS, BLM, and private lands, with wet meadows, forests, and juniper and sagebrush communities in the uplands and irrigated pastures and hay fields along Bear Creek. The lower end of Sanford Creek is predominately private with BLM and USFS ownership in the upper portions of the watershed. Vegetation in this watershed is dominated by juniper and sagebrush. Information is limited for the aquatic and riparian conditions of these systems but streams are generally unshaded, with a low amount of woody riparian vegetation (USDA FS 1998b, ODFW 1996). Watersheds are characterized by flashy flows, particularly in response to spring/summer thunderstorms. The Bear Creek system is also composed of the highly erodable soils, and both the Sanford and Bear Creek Systems are characterized by eroded cutbanks, high summer water temperatures, and low flows (USDA FS 1998b).

Beaver South Fork Sub-basin

Game fish species in the Beaver South Fork sub-basin include Redband Trout and Smallmouth Bass (ODFW 1996). Water quality conditions in the Beaver South Fork Sub-basin are moderate to severe for water quality, fish, and aquatic life for many streams; and are characterized by low summer flows and high summer water temperatures (OR DEQ 1998). Wild populations of coldwater game fish, primarily redband trout, are the primary fishery management concern in the Sub-basin (ODFW 1996). Based on existing data, primarily from public lands, the best habitat for redband trout that remains in the Sub-basin is believed to be located on headwater streams in the Ochoco National Forest, although cool water and good fish habitat conditions are dependant on the amount and type of timber harvest that has occurred (ODFW 1996). At lower elevations, the impacts of past and current land use practices result in a reduction in fish habitat, reduced flows, and increased water temperatures. Grazing, timber harvest, roads and recreation are the primary land uses impacting riparian and stream channel habitat conditions on public lands in the sub-basin, while grazing, timber harvest, and irrigation are the primary uses impacting aquatic habitat conditions on private lands in the basin.

South Fork Crooked River

The South Fork Crooked River Watershed is characterized by intermittent or ephemeral streams and large areas of the drainage that do not contribute runoff in most years and are, for practical purposes, internally drained. The South Fork receives the majority of its flow from springs, with a lesser amount from precipitation. Land ownership along the South Fork Crooked River is approximately 2/3 private and 1/3 BLM (lower canyon portion). The system was treated with rotenone to remove non-game fish in 1981, this treatment also appears to have eliminated native redband trout (ODFW 1996). The river is currently stocked annually with hatchery rainbow trout (ODFW 1996). The stocked hatchery trout are believed to be incapable of establishing a successfully reproducing population due to habitat and water quality limitations that are dominated by high summer temperatures, low flows, lack of spawning gravel, and high turbidity (ODFW 1996). Mortality of released fish is high.

A coordinated BLM, ODFW, CRWC and private landowner monitoring program is being implemented to better understand the effects of water quality and livestock management on fish populations throughout the system and to evaluate the potential for a successful trout fishery.

Beaver Creek Watershed

The Beaver Creek Watershed includes several hundred miles of river and tributaries and encompasses multiple vegetation communities, including wet meadows and forested communities, juniper and sagebrush uplands, and irrigated pasture and hay fields. Land ownership in the Beaver Creek Watershed is approximately 21% USFS lands, 15% scattered BLM lands, and the remaining 44% is private. Private lands are concentrated along the mainstem, north and south forks of Beaver Creek. Irrigation diversions creating low summer flows and high summer temperatures are the primary factors limiting fish populations in this system (ODFW 1996). Native redband trout are the only fish observed in many headwater tributaries of Beaver Creek (ODFW 1996). The lower portions of these tributaries have increasing proportions of non-game species (ODFW 1996). The Beaver Creek system is currently managed for wild fish only (ODFW 1996).

Limiting Factors Affecting Fish

Fish production in the Crooked River Basin is limited by water quality and quantity, including flow reduction or loss, temperature, sedimentation, and turbidity (ODFW 1996, WSPE 1999, NWPPC 2001). Fish abundance is directly related to volume of water available in streams, which affects all life stages including spawning, incubation, rearing, and migration (ODFW 1996). Sedimentation and turbidity reduces spawning habitat, egg survival, and food production of insects and plankton. High water temperatures result in stress or direct mortality to cold-water fish species and increases competition from nongame species such as suckers, chiselmouth, and pikeminnow, which can tolerate higher temperatures (ODFW 1996, NWPPC 2001).

Good quality large woody debris is lacking in most of the Crooked River Basin (ODFW 1996, NWPPC 2001). Abundance and quality of large woody debris affects food production, rearing, stream flow, and migration of fish species. Large woody debris helps to form pools which provide rearing habitat, traps spawning gravel, provides a refuge for fish during high runoff events, provides cover from predators, stabilizes banks from erosion, and provides structure for aquatic insects.

Reservoirs for irrigation and hydroelectric production have created artificial habitats for native and introduced fish species. Habitat limitations for reservoir fisheries include seasonal and daily water level fluctuation or drawdown, water temperature, low minimum pool levels, turbidity, poor riparian conditions, and a limited amount of fish holding structure (ODFW 1996). Drawdown limits natural production of warmwater species by dewatering nests and causing mortality of eggs and young. In extreme cases, low pools limit survival of both cold and warmwater species from extreme temperatures or low dissolved oxygen. Drawdown also limits the establishment of shoreline and riparian vegetation. Turbidity and

sedimentation from wave action on barren soil banks and from degraded watershed conditions also limits fish production, spawning and survival. In many cases, artificial impoundments in the sub-basin have allowed nongame fish species such as northern pikeminnow and suckers to expand their range and compete effectively with preferred game species such as trout or bass (NWPPC 2001, ODFW 1996).

Major habitat limitations in Walton Lake include food availability for fish populations, seasonal water quality problems of blue green algae blooms, low dissolved oxygen, high summer temperatures, and occasional winter dieoffs of hatchery rainbow trout (ODFW 1996). Habitat limitations for fish in Prineville, Ochoco, Antelope Flat, Allen Creek, and Haystack reservoirs, and Reynolds Pond include seasonal and annual water level fluctuations and drawdown, high suspended sediments which limit photosynthesis, only moderate concentrations of nutrients in the water, very low abundance of aquatic vegetation, a lack of structural complexity, and water that is too cold for optimal warmwater fish production and too warm for optimal trout production (ODFW 1996, NWPPC 2001).

Outlet facilities at all reservoirs in the sub-basin are unscreened and likely cause losses in fish populations (ODFW 1996). Unknown numbers of fish emigrate through outlets at Prineville, Ochoco, Antelope Flat, and Allen Creek reservoirs, and Walton Lake, to the rivers or streams below.

Historic and Current Fish Species

Redband Trout *(Onchoryhnchus mykiss)*

Based on knowledge of existing barriers, the Redband Trout populations within the Crooked River Basin have been fragmented and are treated as distinct populations (ODFW 1996). Populations in the lower Crooked River have likely undergone a decline since the 1960's as a result of: 1.) The large increase in turbidity in the reservoir and lower Crooked River, reducing food production and effective reproductive success, 2.) The large flush of nutrients in the reservoir following construction has been consumed, 3.) The series of drought years in the late 1980's; and 4.) A large increase in out of stream water rights appropriations in the 1970's (ODFW 1996). The healthiest population of redband trout in the basin is located in the 12-mile stretch of the mainstem Crooked River below Bowman Dam; this population has been increasing in recent years (ODFW 1996, USDI BLM 1992a). For a summary of Redband Trout populations, see Appendix 8-E.

Concerns regarding redband trout populations are dominated by habitat quantity and quality issues including: minimum stream flows, warm summer temperatures, degraded riparian habitat, gas bubble disease from Bowman Dam, unscreened water diversions, and irrigation dam barriers that limit movement. Additional concerns include lack of data and harvest regulations (ODFW 1996, NWPPC 2001).

Redband trout distribution in the Lower Crooked River Sub-basin includes the following populations:

- Crooked River from Bowman Dam to Lake Billy Chinook (stable but lower than 1960's, may be multiple populations);
- McKay Creek System (depressed but stable);
- Ochoco/Marks/Mill Creek systems (depressed but stable);
- Bingham Springs (no hatchery program, less than 300 spawners; and
- Walton Lake (no wild fish, stocked annually).

(ODFW 1996)

Redband trout distribution in the Upper Crooked River Sub-basin includes the following populations:

- Prineville Reservoir (healthy population of hatchery fish);
- Upper Crooked River (severely depressed);
- Bear Creek system (depressed);
- Southern Ochoco and Maury Mountain Tributaries (depressed, may be multiple populations isolated by temperature and physical barriers);
- Antelope Reservoir (no wild fish, stocked annually); and
- North Fork Crooked River System (7 populations, depressed but stable).

(ODFW 1996)

Redband trout distribution in the Beaver South Fork Sub-basin includes the following populations:

- South Fork Crooked River System (no wild fish, stocked annually); and
- Beaver Creek System (depressed, may be multiple populations).

(ODFW 1996)

Bull Trout *(Salvelinus confluentus)*

Historically, Bull Trout were found throughout most of the Deschutes Basin, including the Lower Crooked River (ODFW 1996, Nehlsen 1995). Since construction of the hydroelectric facility at Opal Springs on the Crooked River, passage up the Crooked River has been at river mile 6.9 or approximately one half mile above the mouth of the Crooked River on Lake Billy Chinook. At present, Bull Trout in the Crooked River basin are found only in the Crooked River arm of Lake Billy Chinook. See Appendix 8-A for a map of historic and current Bull Trout distribution in the Basin. Problems and concerns regarding the status of current Bull Trout populations are primarily related to angling regulations, including bag limit, catch size and limit, and time of season (ODFW 1996).

Brook Trout *(Salvelinus fontalis)*

Brook Trout are not native to Oregon and impacts on native salmonid species are a concern of the Oregon Department of Fish and Wildlife (ODFW 1996). Remnant populations exist at low levels from the nearly ½ million fish that were stocked in the Crooked River Basin between 1925 and 1934 (ODFW 1996). Remaining populations are located within the North

Fork Crooked River Watershed (ODFW 1996, USDA FS 1995b). Because of their requirements for cold, clean water, they are a sensitive indicator of changes in water quality, and are used as an indicator species, along with redband trout, in the Ochoco National Forest (USDA FS 1995b). See Appendix 8-B for current distribution of Brook Trout in the Crooked River Basin. Information available on this species, and potential interactions with redband trout populations in the basin is low.

Mountain Whitefish *(Prosopium williamsoni)*

Mountain whitefish are found in the Lower Crooked River Sub-basin; in Lake Billy Chinook, the Crooked River below Bowman Dam, and in Ochoco Creek below Ochoco Reservoir (ODFW 1996). All populations appear to be healthy and stable but there is very little information on this species in the Crooked River Basin (ODFW 1996). The population below Bowman Dam is extremely abundant and appears to be increasing. Competition between this species and native redband trout is poorly understood (ODFW 1996). See Appendix 8-C for current distribution of Mountain Whitefish in the Crooked River Basin.

Chinook Salmon *(Oncorynchus tshawtscha)*

Historically, a native run of Spring Chinook Salmon spawned and reared throughout the Deschutes system (ODFW 1996, Nehlsen 1995). Information on Chinook presence in the Crooked River Basin is limited, but a Native American fish weir just below the confluence of the North Fork Crooked River and the Crooked River was reported by Peter Skene Ogden in 1826. Opal Spring released hatchery Spring Chinook from 1984-1988 as mitigation for hydroelectric projects (ODFW 1996). This project was terminated after 4 years due to low returns (n=2), and lack of fish in the catch (ODFW 1996). The only Spring Chinook Salmon present today are a remnant population, landlocked in Lake Billy Chinook. The population is extremely depressed and on the verge of disappearing altogether (ODFW 1996). See Appendix 8-D for 1990 distribution of Chinook Salmon in the Crooked River Basin.

Brown Trout *(Salmo trutta)*

Brown Trout are found in the Lower Crooked River Sub-basin, in Lake Billy Chinook and the Crooked River below Opal Springs (ODFW 1996). Brown Trout populations are currently low, but may be increasing, and are a result of naturalized hatchery stocks (ODFW 1996). There is little information on this species for the basin.

Kokanee *(Oncorhynchus nerka)*

Kokanee in the Crooked River basin are found in Lake Billy Chinook, and probably originated from a combination of hatchery stockings in the 1970's, a native run of sockeye salmon in the Metolius, and Kokanee from Suttle Lake (ODFW 1996). The population is high but growth rates and year classes fluctuate widely (ODFW 1996). Kokanee are the most abundant and widely distributed species in Lake Billy Chinook (ODFW 1996).

Smallmouth Bass *(Micropterus dolomieui)*

Smallmouth bass are found in the Lower Crooked River Sub-basin in Lake Billy Chinook (population moderate and stable) and Prineville Reservoir (population of small fish abundant and stable, population of large fish severely depressed) (ODFW 1996). Smallmouth bass populations in the Upper Crooked River Sub-basin include the mainstem Crooked River (status unknown, thought to be fair) and lower segments of the North Fork Crooked River (status unknown, thought to be fair) (ODFW 1996). Smallmouth bass conditions in the South Fork of the Crooked River are thought to be fair, although not much is known about this population, located in the Beaver South Fork Sub-basin (ODFW 1996). Smallmouth bass were introduced into Prineville Reservoir and Upper Crooked and Beaver South Fork Sub-Basin sites after chemical treatment for fish in 1982 (ODFW 1996). General problems and concerns primarily involve habitat degradation including: a lack of aquatic vegetation and woody debris and water withdrawals for irrigation in the reservoir populations, as well as habitat degradation from land uses including livestock grazing, irrigation diversions, logging, roads, unscreened diversions and occasional fish kills by irrigation ditch herbicides in the Upper Crooked and Beaver South Fork populations (ODFW 1996).

L**argemouth Bass *(Micropetus salmoides)***

Largemouth bass are found in the Lower Crooked River Sub-basin in Lake Billy Chinook and Prineville Reservoir (ODFW 1996). The population in Lake Billy Chinook is extremely depressed, and the largemouth bass is likely being out-competed by smallmouth bass in this system (ODFW 1996). The Prineville Reservoir population is stable and abundant for smaller fish, and stable but depressed for larger fish (ODFW 1996). Concerns in Prineville Reservoir are related primarily to habitat conditions including lack of aquatic vegetation and woody debris, water withdrawals for irrigation, lack of a forage base and competition (ODFW 1996).

Bluegill *(Lepomis macrochirus)*

Bluegill in the Crooked River basin are present in Lake Billy Chinook and two ponds below Ochoco Reservoir, in the Lower Crooked River Sub-basin (ODFW 1996). Bluegill were illegally introduced into Lake Billy Chinook and the population is extremely depressed (ODFW 1996). Status of the Bluegill in ponds below Ochoco Reservoir is unknown (ODFW 1996).

Black Crappie *(Pomoxis nigromaculatis)*

In the Crooked River Basin Black Crappie are present in Lake Billy Chinook and Prineville and Ochoco Reservoirs (ODFW 1996). Black crappie were illegally introduced to both reservoirs, and the populations are rapidly expanding. This likely will have negative impacts on angling opportunities for other game species (ODFW 1996).

Brown Bullhead *(Ictalurus nebulosus)*

Brown Bullhead are present in the Lower Crooked River Sub-basin in Prineville and Ochoco Reservoirs, both a result of illegal introductions (ODFW 1996). Population levels are rated as stable, and growth rates are exceptional (ODFW 1996). Problems affecting the population are primarily related to fluctuations in water level at critical spawning times (ODFW 1996). Stocks may exist in the Upper Crooked or Beaver South Fork Sub-basin but are undocumented.

Table 8-1: Crooked River Basin Stocked Fish

Water Body	Species	Size	Number
South Fork Crooked River	Rainbow Trout	Catchable	1,500
Antelope Flat Reservoir	Rainbow Trout	Fingerling	10,000
Prineville Reservoir	Rainbow Trout	Fingerling	169,000
Walton Lake	Rainbow Trout	Catchable	15,000
Ochoco Reservoir	Rainbow Trout	Fingerling	50,000
Ochoco Creek	Rainbow Trout	Catchable	3,000

Source: ODFW. 1996

Species Interactions

Introduced and exotic (non-native) fish may compete with, prey upon, or interbreed with native populations or otherwise alter the aquatic ecosystem. Little is known about the significance or extent of species interactions within the basin although it is believed that some introduced species such as smallmouth bass may outcompete and prey upon trout species in marginal habitat areas. A comprehensive list of fish species present in the basin is listed in Table 8-2. Current non-native or exotic species present in the basin include: brook trout, brown trout (Lake Billy Chinook), small and large mouthed bass, bluegill, black crappie and brown bullhead (ODFW 1996).

Historic Presence of Anadromous Fish

Intensive grazing, the development of irrigation systems, timber harvest, and fire suppression all combined to adversely affect watershed and stream conditions throughout the Crooked River Basin by 1920 (ODFW 1996). The first actual surveys of fish were not conducted until the 1950's, after substantial habitat and population declines had occurred (ODFW 1996, Nehlsen 1995). Earlier accounts of fish presence are based primarily on historical journals. A summary of documented anadromous fish reports are provided below.

Table 8-2: Historic and Current Fish Species in the Crooked River Basin

Common Name	Origin	Status	Abundance
Pacific Lamprey	Native	Extinct	
Summer Steelhead	Native	Extinct	
Redband Trout	Native	Present	Moderate
Bull Trout	Native	Present	Rare
Kokanee	Native	Present	Abundant
Chinook Salmon	Native	Present	Extremely Rare
Mountain Whitefish	Native	Present	Abundant
Brown Trout	Introduced	Present	Locally Abundant
Brook Trout	Introduced	Present	Rare
Rainbow Trout	Introduced	Present	Abundant
Atlantic Salmon	Introduced	Present	Very Rare
Brown Bullhead	Introduced	Present	Abundant
Largemouth Bass	Introduced	Present	Moderate
Smallmouth Bass	Introduced	Present	Abundant
Black Crappie	Introduced	Present	Locally Abundant
Bluegill	Introduced	Present	Rare
Redear Sunfish	Introduced	Present	Very Rare
Shorthead Sculpin	Native	Present	Unknown
Torrent Sculpin	Native	Present	Unknown
Slimy Sculpin	Native	Present	Unknown
Mottled Sculpin	Native	Present	Unknown
Prickly Sculpin	Native	Present	Unknown
Goldfish	Introduced	Present	Rare
Longnose Dace	Native	Present	Abundant
Speckled Dace	Native	Present	Abundant
Chiselmouth	Native	Present	Abundant
Largescale Sucker	Native	Present	Abundant
Bridgelip Sucker	Native	Present	Very Abundant
Northern Squawfish	Native	Present	Moderate
Carp	Introduced	Present	Rare
Redside Shiner	Native	Present	Very Rare

Source: ODFW. 1996

Steelhead Trout

1942: Reports of steelhead in Lower Ochoco Creek and Beaver Creek
1951: Salmonids migrated through the entire Crooked River system in late winter through early spring when flows were high enough
1952: Steelhead in Crooked River above Prineville
1952: Spawned out steelhead found in McKay, Ochoco, Drake, Horse Heaven, Beaver Creeks and the North Fork Crooked River
1953: Steelhead redds in Twelvemile and Ochoco Creeks
1954: Adult steelhead in Paulina Creek

(ODFW 1996, Nehlsen 1995)

Chinook Salmon

1826: Native American weir located just below the confluence of the North Fork Crooked River and the Crooked River. Reported by Peter Skene Ogden.
1948: Reports of presence in Upper Crooked River, Beaver Creek, and Ochoco Creek,
1960: Chinook salmon reported in Ochoco Creek, Beaver Creek and the Upper Crooked River

(ODFW 1996, Nehlsen, 1995)

The anadromous runs of spring chinook and summer steelhead within the Crooked River Basin were eliminated by a series of irrigation and hydroelectric dams on the Deschutes and Crooked Rivers. Ochoco and Bowman dams, completed in 1921 and 1961, respectively, blocked fish passage into Ochoco Creek and the Upper Crooked Basin. In 1958 and 1964 the Pelton and Round Butte dams were completed on the Deschutes River below its confluence with the Crooked River. Although fish passage facilities were constructed at these facilities, they were ineffective and passage efforts were terminated in 1968, eliminating anadromous fish from the Lower Crooked River (ODFW 1996, WSPE 1997). Federal re-licensing of the Pelton Round Butte complex will explore and address the potential for restoring fish passage. If this occurs, the lack of passage at Ochoco and Bowman Dams will also need to be addressed.

Habitat for Anadromous Fish

A major variable that will affect the success of reintroduction of anadromous fish given passage through the Pelton Round Butte Hydroelectric Project is the quality of habitat for anadromous species upstream of the project. ODFW and USFS have developed a combined database of habitat inventories to assess quality for the different life stages of spring chinook salmon, steelhead trout, and sockeye salmon. In the Crooked River Basin, high quality reaches for chinook included the Lower Crooked River and high quality reaches for steelhead included Little McKay Creek (Riehle 1999). There were no reaches identified in the Lower Crooked River Sub-basin as high quality for sockeye (Riehle 1999).

As a component of its re-licensing process for the Pelton Round Butte Hydroelectric Project the Confederated Tribes of the Warm Springs Reservation initiated a variety of collaborative planning efforts in the Deschutes Basin. One such effort was a process called Ecosystem Diagnosis and Treatment (EDT), used to evaluate habitat conditions throughout the project region. The process used a team of scientific experts to examine the past and current resource conditions and develop a strategy for restoration and enhancement of terrestrial and aquatic resources. Chinook Salmon were utilized as the indicator species for the EDT process and each stream reach assessed was evaluated for 16 habitat attributes and 12 life stages related to Chinook. The EDT system can model the potential effects of projects based on the 16 habitat indicators for the 12 life stages and aid in cost/benefit analysis and prioritizing projects for restoration or enhancement. Key findings of the EDT process within the Crooked River Basin are summarized in Table 8-3.

Table 8-3: Most Highly Degraded Conditions Affecting Fish and Aquatic Species

Degraded Conditions Affecting Fish and other Aquatic Species (compared with historic conditions)	Crooked River Sub-basin
Flow	Beaver South Fork Upper Crooked River
Habitat Diversity	Beaver South Fork Upper Crooked River
Obstructions	Beaver South Fork Upper Crooked River Lower Crooked River
Oxygen	Beaver South Fork Upper Crooked River
Pathogens	Beaver South Fork Upper Crooked River Lower Crooked River
Sediment Loads	Beaver South Fork Upper Crooked River Lower Crooked River
Temperature	Beaver South Fork Upper Crooked River Lower Crooked River
% Key Habitat (quantity)	Beaver South Fork Upper Crooked River Lower Crooked River

Source: Warm Springs Power Enterprises. 1999

In addition to describing watershed conditions affecting fish and aquatic species, the Warm Springs Ecosystem Diagnosis and Treatment process was used to develop specific strategies for improvements within the Crooked River Basin, outlined to represent a variety of effort levels.

Strategies for improving conditions for fish and other aquatic species within the Crooked River Basin that would require a moderate effort in terms of energy and resources directed towards restoration and enhancement included:

- A focus in the Lower Crooked River Sub-basin;
- Improved fish screening;
- Improved fish passage at diversions; and
- Improved municipal wastewater management.

(WSPE 1999)

Strategies for improving conditions for fish and other aquatic species within the Crooked River Basin, requiring a high effort in terms of energy and resources directed towards restoration and enhancement included:

- Improved forest, range, and agricultural management;
- Improved fish screening;
- Improved fish passage at diversions;
- Improved irrigation management;
- Improved road management;
- Habitat enhancement;
- Riparian corridor management;
- Floodplain management; and
- Re-establishment of a normal river hydrograph with irrigation.

(WSPE 1999)

Fish Passage

Fish passage barriers are a major resource problem within the Crooked River Basin. In addition to the large dams that block anadromous fish passage to the basin (Pelton, Round Butte), numerous dams, diversions, and culverts are passage barriers within the basin. The existing redband trout population is highly fragmented into small populations that are at a much greater risk of extinction than a connected, larger population would be (ODFW 1996, USDA FS 1998b). Fish passage problems within the basin are a result of low flows; dams, diversions, and impoundments; and culverts. There are three major dams in the Crooked River Basin and numerous smaller impoundments and irrigation diversions. Irrigation diversions cause passage problems and may strand fish if they are unscreened. Oregon Department of Fish and Wildlife have estimated that over 700 unscreened irrigation diversions exist currently within the basin (ODFW 1996). The three major dams are all barriers to fish passage, as are many of the smaller systems on private lands, particularly during low flows. The dam complex that created Lake Billy Chinook (Pelton/Round Butte) is also a fish passage barrier and blocks anadromous fish from the entire Upper Deschutes Basin, including the Crooked system. In a 1995 summary of potential fish passage obstructions in the basin, the Oregon Department of Fish and Wildlife estimated that potential barriers exist at 54 sites within the basin (ODFW 1995). Barriers were documented on 32 creeks and rivers, restricting access to approximately 640 miles of aquatic habitat (ODFW 1995). See Table 8-4 for more detailed fish passage barrier information.

Table 8-4: Potential Fish Passage Obstructions - Lower Crooked River Sub-basin

Sub-Basin	Stream	Facility Name (Type)	Species Present*	Habitat Miles	Habitat Quality	Priority
Lower Crooked	Crooked River	Opal Springs Dam	RT, BUT	40	Good	High
Lower Crooked	Crooked River	Rice Baldwin Dam	RT,WF	1	Good	High
Lower Crooked	Crooked River	Crooked River Feed Canal	RT,WF		Good	High
Lower Crooked	Crooked River	Stearns Ditch & Dam	RT,WF		Good	High
Lower Crooked	Crooked River	Stearns Dam	RT,WF	12	Good	High
Lower Crooked	Crooked River	Peoples Dam	RT,WF	5	Good	High
Lower Crooked	Crooked River	Crooked R. Central	RT,WF		Fair	Med.-High
Lower Crooked	Crooked River	Lowline	RT,WF		Fair	Med.-High
Lower Crooked	Ochoco Creek	(Concrete Dam)	RT	40	Fair	Medium
Lower Crooked	Ochoco Creek	(Concrete Dam)	RT	2	Fair	Medium
Lower Crooked	Ochoco Creek	(Diversion Dam)	RT	2	Poor	Medium
Lower Crooked	Ochoco Creek	(Diversion Dam)	RT	1	Poor	Medium
Lower Crooked	Ochoco Creek	(Concrete Dam)	RT,WF	2	Good	Medium
Lower Crooked	Ochoco Creek	Ochoco Dam	RT	100	Fair	Medium
Lower Crooked	Ochoco Creek	(Irrigation Dam)	RT	1	Fair	Medium
Lower Crooked	Marks Creek	Marks Creek Reservoir	RT	10	Good	Low
Lower Crooked	Crooked River	(Major Gravel Berm)	RT,WF	3	Fair	Low
Lower Crooked	Crooked River	(Concrete Dam)	RT, WF	7	Fair	Low
Lower Crooked	McKay Creek	(Canal pass-through)	RT,WF	3	Fair	Low
Lower Crooked	McKay Creek	(Dam)	RT, WF	40	Fair	Low
Lower Crooked	McKay Creek	(Dam)	RT,WF	1	Poor	Low
Totals	**4 Creeks/Rivers**		**3 Species**	**270 miles**		

Source: ODFW, 1995

* RT= Redband Trout; BUT= Bull Trout; WF= Whitefish

Table 8-4: Potential Fish Passage Obstructions - Upper Crooked River Sub-basin

Sub-Basin	Stream	Facility Name (Type)	Species Present*	Habitat Miles	Habitat Quality	Priority
Upper Crooked	Crooked River	Bowman Dam	RT,WF	200	Poor	High
Upper Crooked	Allen Creek	Allen Creek Reservoir	RT	10	Good	Low
Upper Crooked	Peterson Creek	Peterson Creek Reservoir	RT	6	Good	Low
Upper Crooked	Hickey Creek	Round Prairie Reservoir	RT		Poor	Low
Upper Crooked	Wickiup Creek	Gillen Reservoir	RT	3	Poor	Low
Upper Crooked	Horse Heaven Creek		RT		Poor	Low
Upper Crooked	Horse Heaven Creek		RT		Poor	Low
Upper Crooked	Lost Creek		RT	8	Fair	Low
Upper Crooked	North Fork Crooked River	(Concrete Dam)	RT	2	Poor	Low
Upper Crooked	Watson Creek	Merwin Reservoir #3	??		Poor	Low
Upper Crooked	Watson Creek	Merwin Reservoir #2	??		Poor	Low
Upper Crooked	Pine Creek	Pine Creek Reservoir	RT	3	Fair	Low
Upper Crooked	Sherwood Creek	(Irrigation Flume)	RT	3	Fair	Low
Upper Crooked	Sherwood Creek		RT	8	Fair	Low
Upper Crooked	Maury Creek		(RT)	3	Poor	Low
Upper Crooked	Kloochman Creek	Kloochman Reservoir	RT	4	Fair	Low
Upper Crooked	Bear Creek		RT	8	Fair	Low
Upper Crooked	W. Fork Camp Creek	Camp Creek Reservoir	(RT)	2	?	Low
Upper Crooked	M. Fork Camp Creek	Logan Butte Reservoir	(RT)		?	Low
Upper Crooked	Pole Creek		(RT)		?	Low
Upper Crooked	Clover Creek	Clover Creek Res. #1	??		?	Low
Totals	**18 Creeks/Rivers**		**2 species**	**260 miles**		

Source: ODFW, 1995

* RT= Redband Trout; BUT= Bull Trout; WF= Whitefish

Table 8-4: Potential Fish Passage Obstructions – Beaver/South Fork Sub-basin

Sub-Basin	Stream	Facility Name (Type)	Species Present*	Habitat Miles	Habitat Quality	Priority
Beaver South Fork	S. Fork Beaver Creek		RT		Poor	Medium
Beaver South Fork	S. Fork Crooked River	(dam with stoplogs)	RT	100	Fair	Medium
Beaver South Fork	Twelve Mile Creek	Twelve Mile Reservoir	(RT)		?	? Low
Beaver South Fork	S. Fork Twelve Mile Creek	Lillard Reservoir	(RT)		?	? Low
Beaver South Fork	Twelve Mile Creek	Williams Reservoir	(RT)	2	?	? Low
Beaver South Fork	Long Hollow Creek	Freezeout Reservoir	(RT)		?	? Low
Beaver South Fork	Paulina Creek	(2 concrete dams)	RT	8	Fair	Low
Beaver South Fork	Trout and Grindstone Creeks	Brennan Reservoir	(RT)		Fair	Low
Beaver South Fork	Grindstone Creek	Grindstone Reservoir	??		?	? Low
Beaver South Fork	Grindstone Creek		(RT)		Poor	Low
Beaver South Fork	Unnamed Trib. to Trout Creek		(RT)		Poor	Low
Beaver South Fork	Alkali Creek		??		?	? Low
Totals	**10 Creeks**		**1 species**	**110 Miles**		

Source: ODFW, 1995

* RT= Redband Trout; BUT= Bull Trout; WF= Whitefish

Current Passage Priorities and Projects

The Oregon Department of Fish and Wildlife priority area for fish passage and screening projects in the basin is the 12 miles of the Lower Crooked River just below Bowman Dam (ODFW 2000, USDI BR 1999b). This is currently the best redband trout habitat in the basin but fish get swept over spillways in high water events and are unable to return. The uppermost of the three diversions is the Stearns Dam, which is privately owned, located on BLM property, and has not functioned as an irrigation diversion for years. The second is the Rice-Baldwin diversion, and the third is the People's Irrigation Ditch. A cooperative effort is currently underway to: remove the Stearns dam, install a fish ladder into the spillway of the Rice-Baldwin diversion, and to install a ladder and screening to the People's irrigation ditch (USDI BR 1999b, ODFW 2000). Once the three barriers in this stretch are addressed the Lower Crooked River will have unblocked fish passage from Opal Springs to Bowman Dam.

Federal Land Culvert Inventory

Forest roads impact water quality, stream morphology, and fish passage conditions in the basin. Many roads were built along stream channels, disconnecting the stream from the floodplain along one side and contributing sediment. Impassable culverts or other obstacles at road crossings restrict movement of fish populations in the basin. The Ochoco National Forest has assessed its roads for watershed problems and is currently implementing the top three projects to improve conditions. These include: road slumps in the Mill Creek Watershed (Lower Crooked Sub-basin), culvert replacements in Deep Creek Watershed (Beaver South Fork Sub-basin), and bridge replacement in the Marks Creek Watershed (Lower Crooked Sub-basin) (Seymour 2000).

State and County Roads Fish Barrier Inventory

The Oregon Department of Transportation conducted a culvert inventory on State and County roads within the Crooked River Basin to assess barriers to fish passage (Table 8-6). Of the five culverts that blocked fish passage under County or State roads in the area, four are on intermittent streams (Sage Hollow, Salt Creek and Dry River), while the remaining one was on Lytle Creek, a perennial stream (ODOT 1999). Because of poor habitat conditions upstream of the culverts, and the lack of special status fish species in the basin, four of the five identified passage barriers were rated as low priority for replacement. The passage barrier on Lytle Creek was rated as moderate priority due to the presence of redband trout in that stream (ODOT 1999).

Table 8-5: Culvert Inventory and Assessment for State and County Roads

Stream	Sub-basin	Road	Stream miles above passage barrier	Habitat Quality	Priority for replacement
Salt Creek	Upper Crooked	Hwy. 27	5.5	Poor	Low
Lytle Creek	Lower Crooked	Hwy. 26	6.5	Poor	Medium (redband trout present)
Dry River	Lower Crooked	Hwy. 126	8	Poor	Low
Sage Hollow	Upper Crooked	Hwy. 27	0.6	Poor	Low
Sage Hollow	Upper Crooked	Hwy. 27	10	Poor	Low

Source: ODOT. 1999

Key Findings, Data Needs and Management Recommendations - Fish

Key findings, data needs and management recommendations presented below were developed from information gained in the assessment process and by members of the Council's assessment technical team.

Key Findings

- Á Status of redband trout populations is mixed. They are moderately abundant in the limited amount of headwater tributaries with good habitat and cool water. Redband trout are depressed in mainstem rivers and tributaries with degraded riparian zones, poor fish habitat, and warm water. Wild redband trout populations are limited by available habitat and are fragmented
- Á Anadromous fish have been eliminated from the basin by fish passage barriers
- Á Mainstem Crooked River above Prineville Reservoir and mainstem Crooked River between the Hwy 97 bridge and the City of Prineville have limiting habitat conditions and do not support significant trout fisheries
- Á Redband trout populations small and isolated due to natural and man-made passage barriers; these populations are at a greater risk of extinction than a larger, connected population would be
- Á Priority areas of the basin for native fish include the lower Crooked River, Prineville Reservoir, and Ochoco Mountain streams
- Á Water quality is limited
- Á Riparian vegetation is limited
- Á Irrigation and hydroelectric reservoirs have unscreened outlets
- Á Habitat and passage improvements will be needed to support anadromous fish if reintroduction occurs
- Á The lower Crooked River sub-basin has the best habitat for anadromous fish
- Á Fluctuating water levels due to irrigation withdrawal and storage

Data Needs

- Á Monitor fish populations throughout the basin
- Á Improve understanding of current stream flow regimes (temporal and spatial patterns) and their impacts on fish habitat, movement and water quality conditions
- Á Stream surveys and riparian habitat inventories
- Á Prioritized list of passage barriers for all land ownerships and plans for removing them

Management Recommendations

- Á Manage and protect watersheds for the production of perennial, high quality water
- Á Protect, maintain and/or restore riparian and wetland habitat
- Á Maintain and or restore performance (productivity, abundance and life history diversity) of wild, indigenous fish populations
- Á Improve water quality

- Á Prevent fish loss at unscreened diversions and provide adequate upstream and downstream passage for fish at dams, culverts and other artificial obstructions
- Á Improve stream complexity;
- Á Replace fish barrier and stranding structures
- Á Develop native Crooked River redband trout broodstock for hatchery stocking program

9. WILDLIFE

Wildlife Diversity

Terrestrial wildlife species in the Crooked River Basin include 78 mammals, 182 birds, 16 reptiles, and 10 amphibians (ONHP 1998). Total terrestrial biodiversity in the Lower Crooked River Sub-basin includes 77 species of mammals, 181 species of birds, 16 species of reptiles, and 10 amphibian species (ONHP 1998). Total terrestrial biodiversity in the Upper Crooked River Sub-basin includes 65 species of mammals, 175 species of birds, 14 species of reptiles, and 7 amphibian species (ONHP 1998). Total terrestrial biodiversity in the Beaver South Fork Sub-basin includes 68 species of mammal, 174 species of birds, 13 species of reptiles, and 7 amphibian species (ONHP 1998).

Special Status Species

Federal Endangered Species Act

The Endangered Species Act (ESA) of 1973 provides for the listing of native animal species as endangered, threatened or special status and provides means for their protection. The United States Fish and Wildlife Service is responsible for administering the ESA for inland fish and wildlife and the National Marine Fisheries Service is responsible for ESA administration of marine and anadromous fish.

State of Oregon Endangered Species Act

The Oregon Endangered Species Act of 1987 created criteria for a state list of threatened and endangered species and their protection. The Oregon Department of Agriculture has responsibility for listed plants and the Oregon Department of Fish and Wildlife has responsibility for the State's listed fish and wildlife. Oregon also has a sensitive species list that is divided into the following four categories: 1.) Critical (listing is pending or appropriate if immediate action is not taken), 2.) Vulnerable (listed can be avoided through protection), 3.) Peripheral (species whose Oregon populations are at the edge of their historic range) or naturally rare (species with historically low numbers due to naturally limiting factors), 4). Undetermined status (may be susceptible to population decline of sufficient magnitude that they may qualify for listing but scientific study is needed before a judgement can be made). See Table 9-1 for species in the Crooked River Basin listed under the Federal and Oregon Endangered Species Acts.

A total of 42 species are listed as threatened, endangered, or special status species in the Crooked River Basin by either the federal or state Endangered Species Act Listing (ONHP 1998). Listed species include 2 amphibians, 11 birds, 1 fish, 4 mammals, 2 invertebrates, and 22 plants (ONHP 1998). There are four federally listed or candidate vertebrate species in the Crooked River Basin, as well as 14 species designated species of concern on the federal list (ONHP 1998). The California Wolverine *(Gulo Gulo Luteus)*

Table 9-1: Protected Status Species

Common Name	Location			Federal Status	State Status
	Lower Crooked Sub-basin	Upper Crooked Sub-basin	Beaver-South Fork Sub-basin		
Amphibians					
Western Toad		X	X		Vulnerable
Columbia Spotted Frog		X	X	Candidate taxa	Status undetermined
Birds					
Northern Goshawk		X		Species of Concern	Critical (listing pending)
Upland Sandpiper		X			Critical (listing pending)
Swainson's Hawk		X	X		Vulnerable
Western Sage Grouse	X	X	X	Species of Concern	Vulnerable
Greater Sandhill Crane		X	X		Vulnerable
Bald Eagle	X	X	X	Listed Threatened	Listed Threatened
Long-billed Curlew		X	X		Vulnerable
Western Burrowing Owl			X	Species of Concern	Critical (listing pending)
Ferruginous Hawk			X	Species of Concern	Critical (listing pending)
Lewis' Woodpecker	X				Critical (listing pending)
Fishes					
Inland Columbia Basin Redband Trout	X	X	X	Species of Concern	Vulnerable

Source: Oregon Natural Heritage Program. 1998

Table 9-1: Protected Status Species

Common Name	Location			Federal Status	State Status
	Lower Crooked Sub-basin	Upper Crooked Sub-basin	Beaver-South Fork Sub-basin		
Mammals					
Pacific Western Big-eared Bat	X		X	Species of Concern	Critical (listing pending)
Western Small-footed bat			X	Species of Concern	Critical (listing pending)
California Wolverine	X	X		Species of Concern	Listed Threatened
Pygmy Rabbit			X	Species of Concern	Vulnerable
Invertebrates					
Silver-bordered Fritillary Butterfly		X			
Pristine Springsnail	X				
Plants					
Henderson Ricegrass	X	X	X		Candidate taxa
Sierra Onion	X	X	X		
Pumice Grape fern	X			Species of Concern	Listed Threatened
Peck's Mariposa-Lily	X	X	X	Species of Concern	Candidate taxa
Porcupine Sedge	X	X			
Green-tinged Paintbrush	X				Species of Concern
Bristle-flowered Collomia	X				
Smooth Desert Parsley	X				
Disappearing Monkeyflower	X				Candidate taxa
American Pillwort	X		X		
Columbia Cress	X			Species of Concern	Candidate taxa
Scapose Catchfly	X	X	X		

Source: Oregon Natural Heritage Program. 1998

Table 9-1: Protected Status Species

Common Name	Location			Federal Status	State Status
	Lower Crooked Sub-basin	Upper Crooked Sub-basin	Beaver-South Fork Sub-basin		
Plants Continued					
Bastard Kentrophyta			X	Species of Concern	Candidate taxa
Crenulate Grape fern		X	X	Species of Concern	Candidate taxa
Gray Moonwort		X	X		
Mountain Grapefern		X	X		
Inland Sedge			X		
Swamp Onion		X			
Many-flowered Onion		X			
Estes' Artemisia		X			Species of Concern
Ochoco Lomatium		X			
Howell's Thelypody		X			

Source: Oregon Natural Heritage Program. 1998

Table 9-1: Protected Status Species - Definitions

Listing Status	Definition
Endangered (federal)	Endangered taxa are those which are in danger of becoming extinct within the foreseeable future throughout all or a significant portion of their range
Threatened (federal)	Threatened taxa are those likely to become endangered within the foreseeable future
Candidate (federal)	Taxa for which USFWS or NMFS have sufficient information to support a proposal to list under the ESA
Species of Concern (federal)	Former candidate species that need additional information in order to propose as threatened or endangered. To reduce backlog on the candidate list in the mid-1980's, Congress created this special concern category.
Critical (State of Oregon)	Species for which listing as endangered or threatened is pending; or those for which listing may be appropriate if immediate conservation action is not taken.
Vulnerable (State of Oregon)	Species for which listing as threatened or endangered is not believed to be imminent and can be avoided through expanded use of protective measures and monitoring.

Source: Oregon Natural Heritage Program. 1998

and the Bald Eagle *(Haliaeetus Leucocephalus)* are listed as threatened and the Columbia Spotted Frog *(Rana Luteiventris)* is a candidate for listing as threatened (ONHP 1998). The remaining 14 special status species include the Inland Columbia Basin Redband Trout *(Oncorhynchus Mykiss Gairdneri*) as well as 4 birds, 4 mammals, and 5 plants of special concern (ONHP 1998). See Table 9-1 for a complete listing of federally listed protected species in the basin.

The State of Oregon has its own Endangered Species Act and keeps records of special status species. In the Crooked River Basin, 4 species are listed as threatened including the Wolverine *(Gulo gulo),* Bald Eagle *(Haliaeetus Leucocephalus),* and the Pumice Grapefern *(Botrychium Pumicola)* (ONHP 1998). Seven species are listed as critical with listing pending. These include the Northern Goshawk *(Accipiter Gentilis),* Upland Sandpiper *(Bartramia Longicauda),* Western Burrowing Owl *Athene Cunicularia Hyupea),* Ferruginous Hawk *(Buteo Regalis),* Lewis' Woodpecker *(Melanerpes Lewis),* Pacific Western Big-eared bat *(Corynorhinus Townsendii Towndsendii),* and the Western Small-footed Bat *(Myotis Ciliolabrum)* (ONHP 1998). Sixteen additional species of plants and animals are listed as special status species including 6 candidate plant taxa; 7 species listed as vulnerable,

including 1 amphibian, 4 birds, 1 fish, and 1 mammal; 2 plant species of special concern; and 1 amphibian listed with a currently undetermined status (ONHP 1998). See Table 9-1 for a complete listing of Oregon's protected status species in the basin.

Wildlife Populations

ODFW biologists conduct annual herd composition and trend surveys on mule deer (*Odocoileus hemionus hemionus*), pronghorn antelope (*Antilocapra americana*), and Rocky Mountain elk (*Cervus canadensis*) in the upper Deschutes River Basin, including the Crooked River Watershed. Elk populations appear to be increasing, deer populations are stable in the Upper Deschutes but appear to be declining in the Crooked River Basin, and antelope populations appear to be declining (ODFW 2000, NWPPC 2001).

Winter raptor, upland gamebird, and waterfowl surveys are also conducted annually to determine population trends in the sub-basin. Most of the bird populations that are monitored appear to be stable at this time (ODFW 2000).

Big Game

The Crooked River Basin is home to a variety of big game animals, including elk, deer, pronghorn, bear and cougar. Big Game hunting provides a major component of recreational activity within the basin, with over 5,000 hunters and 30,000 hunter days estimated in 1996 (ODFW 1997a).

Conflicts between big game and humans primarily involve deer, elk and agricultural producers. In 1996, the Department of Fish and Wildlife handled 90 big game damage complaints in the Ochoco District, including deer (52), elk (23), pronghorn (1), and cougar (14- 3 livestock and 11 public safety) (ODFW 1997a).

Wildlife Habitat

Greater Prineville Area

The only specifically designated fish and wildlife habitat areas within the greater Prineville Urban Growth Boundary (UGB) are the riparian and in-stream habitats of Ochoco Creek and the Crooked River (Prineville Planning Department 1997). There are four Bald Eagle nest sites located within or in close proximity to the greater Prineville area UGB (USDA FS 1999). Sites designated within the Greater Prineville Area Comprehensive Land Use Plan as significant natural areas for ecological, geological, or scientific significance include the Crooked River, Ochoco Creek, Barnes Butte and the Crooked River Rimrocks (Prineville Planning Department 1997). Outstanding scenic views and sites noted in the plan include Ochoco Wayside, Crooked River Rimrocks, and Barnes Butte (Prineville Planning Department 1997). Three thousand, three hundred and sixty acres on the east edge of Prineville Reservoir are managed for fish and wildlife by the Oregon Department of Fish and Wildlife (ODFW 2000).

Crooked River Basin

Wildlife habitat area and quality data was available at the scale of the entire Upper Deschutes Basin, which includes the Crooked River Basin. The habitat information provided below was compiled from existing reports and direct communication with State and Federal Wildlife Biologists. It was compiled by the Oregon Department of Fish and Wildlife for the Columbia Basin Intertribal Fish Commission and summarized in a report to the Northwest Power Planning Council (NWPPC 2001).

Riparian/Aquatic

The Upper Deschutes features hundreds of natural lakes, wetlands, springs and seeps in a variety of sizes, from high elevations in the Cascade and Ochoco Mountains to lower elevation valleys. Many of these are isolated water bodies fed by springs or snow runoff, with subterranean discharge into lava substrate. Others are connected by flowing streams. Numerous reservoirs were created by dams to store or divert irrigation water, provide municipal water and produce hydroelectric power. Hundreds of miles of canals distribute irrigation water throughout large areas of the sub-basin. These impoundments, diversions, and canals have had a profound impact on wildlife, providing new or improved habitat for some species, while inundating habitat for others. Dams, impoundments, diversions and canals represent barriers to many aquatic and terrestrial wildlife species, and have interrupted habitat connectivity resulting in isolated sub-populations of certain species. Reduced instream flows due to seasonal diversion for irrigation affects many stream reaches and depletes aquatic and riparian habitat.

The aquatic environment and associated riparian vegetation provided by the flowing and standing waters, seeps and springs of the sub-basin are critical features for myriad wildlife species. Furbearers including beaver, otter, muskrat, raccoon and mink are dependent on aquatic and riparian habitats for food, cover, travel, denning, and birthing. Amphibians (tailed frog, Oregon and Columbia spotted frogs, western toad, long toed salamander) require high quality water for spawning and development of larval stages, as well as the moist environment, cover, and rich insect forage base provided by healthy riparian zones. Reptiles often associated with riparian areas include the garter and gopher snakes, and western rattlesnake. Large mammals like Rocky Mountain elk and mule deer rely on riparian corridors for security, travel and thermal cover, calving and fawning areas, and abundant forage. Bats, including Townsend's big-eared, long-eared myotis, and silver-haired bats, feed heavily on abundant insects near lakes and streams. Many songbirds (bank swallow, willow fly catcher, water ouzel), upland birds (mountain quail, ruffed grouse), raptors (osprey, bald eagle), waterfowl (Barrow's goldeneye, bufflehead, mallard), and wading birds (least bittern, yellow rail, upland sandpiper) rely on aquatic and riparian habitat for nesting, roosting, forage and cover. Predators such as coyote, bobcat, cougar, and bear are attracted to riparian areas by abundant prey. Most terrestrial species are heavily dependent on riparian areas for at least part of their life history (NWPPC 2001).

Forest

Many of the mid and high elevation lands in the Upper Deschutes basin are forested, including the Cascade Mountain range, and the Ochoco Mountain complex. Ponderosa pine with shrub understory dominates moderate elevations, transitioning into dense lodgepole pine forests with gain in elevation, and mixed coniferous forests of fir, hemlock, and spruce at higher elevation.

Higher elevation forests provide summer habitats for large migratory mammals including mule deer, Rocky Mountain elk and black bear. Cougar, which depend heavily on a diet of deer and elk, follow their migratory prey. The mountain goat, once endemic to alpine habitats in the north Cascade Mountain range, is now extinct in the Basin. Biologists are evaluating opportunities to reintroduce mountain goat at higher elevations within the Deschutes River sub-basin, including the lower Crooked River canyon. Mid elevation forests provide transition range and migratory corridors as deer and elk move to low elevation winter ranges, then back up to summer range. Understory shrubs including bitterbrush, manzanita, ceanothus, big sage, and mountain mahogany afford cover and forage for browsing animals as well as fawning and calving sites.

Smaller carnivores including wolverine, fisher and American martin frequent these forests as well, preying on snowshoe hares, golden mantled ground squirrels, least and yellow pine chipmunks, pine squirrels, and other rodents, as well as birds. Chipmunks and other rodents develop seed caches, providing an important role in regenerating shrubs such as bitterbrush, and reseeding coniferous trees. Raptors such as goshawk, Cooper's hawk, and flammulated, great gray, and pygmy owls also prey on small mammals and birds, as well as insects. The bald eagle utilizes large, mature trees for nesting, roosting and perching. White-headed, black-backed, and three-toed woodpeckers, pygmy nuthatch, and mountain chickadee rely on cavities in snags to nest and roost, and on the insects produced by decaying dead-and-downed wood for forage. Ground-nesting birds such as ruffed and blue grouse, and mountain quail frequent these forests as well. The western toad and long-toed salamander frequent forest streams and ponds, but adults often travel far from water to forage on forest insects and other invertebrates. Garter snakes and rubber boas are relatively common forest reptiles (NWPPC 2001).

Juniper Steppe

Juniper steppe is a common feature of the arid mid and low elevation lands in the sub-basin, more common now than it was historically. Fire suppression and grazing have allowed juniper stands to dramatically increase in density, and to invade adjacent range and grasslands that historically burned periodically, keeping juniper in check. Approximately 95% of juniper trees today are less than 100 years old, indicative of this recent invasive trend. Associated with juniper stands are several species of shrubs including bitterbrush and several kinds of sagebrush. Native bunch grasses are also an important component, but in many areas have been displaced by invasive introduced grasses such as cheat grass, medusahead,

and crested wheat. Young juniper trees also displaced native shrubs and grasses as they invaded new sites in the past 100 years.

Much of the critical winter range for large grazing wildlife consists of juniper steppe at lower elevations. Mule deer, Rocky Mountain elk, and pronghorn forage on brush, grass, and forbs, while the junipers afford thermal and hiding cover. Small mammals, including the least chipmunk, bushy-tailed woodrat, and whitefoot mouse, are prey for predators such as bobcat and coyote. Junipers provide nesting and roosting habitat for many species of birds including Swainson's and ferruginous hawks, black-billed magpie and common raven, loggerhead shrike, as well as cavity nesters like red shafted flicker and mountain bluebird. Massive crops of juniper berries are a staple food for many birds, including robin, Townsend's solitaire, and pinyon jay. Rodents, coyote, and raccoon also supplement their diet with juniper berries. Western fence lizard and western skink are common reptiles. Studies indicate that mid-age stands of juniper with full complements of understory feature the highest diversity of wildlife, including 146 species. Old growth stands typically offer habitat to 81 wildlife species (NWPPC 2001).

Shrub Steppe/Rangeland

The lower elevations of the sub-basin consist largely of open shrub steppe rangelands. Native vegetation historically included several species of sagebrush, bitterbrush, bunchgrasses, buckwheats and diverse perennial and annual forbs. Because of the open nature of rangelands, adequate cover for wildlife is an important component. Undisturbed canyons, ravines, draws, rock outcrops and similar geological features provide travel, security, and thermal cover. Stands of tall sagebrush and adjacent juniper provide cover for large and small mammals, as well as nesting and perching sites for birds. These are generally arid lands, and availability of water may limit distribution of some species.

Low elevation rangelands are critical wintering areas for mule deer, pronghorn and Rocky Mountain elk. Black-tailed jackrabbit, pygmy rabbit, least chipmunk, and various small rodents are resident here. Predators include badger, coyote, bobcat, and occasionally cougar. Sage grouse are dependent on open rangelands of low sage, as are burrowing owls. Sage and Brewer's sparrows, and sage thrashers nest in the brush. Golden eagle, red-tailed hawk, and prairie falcon hunt these lands, as do scavengers like the common raven and turkey vulture. Reptiles include the gopher snake, western rattlesnake, short-horned lizard, and sagebrush lizard. The spadefoot toad ventures forth to spawn in temporary pools and springs, spending the dry season in burrows (NWPPC 2001).

Grassland

Grasslands consisting largely of native bunch grasses, with associated low shrubs and forbs, were historically a major feature of the Deschutes River Basin. Over 50% of these grasslands have been converted to farmlands, irrigated pasture, low- and high-density housing, urban developments, and roadways. The Crooked River Grasslands (more than 160,000 acres), managed by the U.S. Forest Service represent a large portion of the

remaining true grasslands in the sub-basin. Most other grasslands have been heavily altered by agricultural and residential development and are not in a natural condition.

Grasslands provide forage for grazing animals including pronghorn, mule deer and elk. Coyote, badger, and striped skunks hunt smaller mammals that are abundant here, including ground squirrels, field mice, and voles. Black-tailed, as well as the less abundant white-tailed jackrabbit frequent grasslands. Golden eagle, ferruginous and Swainson's hawks, prairie falcon and kestrel, and burrowing owl hunt abundant prey here. Grasslands in the Deschutes River Basin may offer an opportunity to reintroduce the sharptail grouse, which was once native in Oregon. Western meadowlark, horned lark, and savannah sparrow are songbirds typical of the grasslands. Pacific gopher snake, western rattlesnake, and western fence lizard are common reptiles (NWPPC 2001).

Limiting Factors Affecting Wildlife

Wildlife abundance has been affected by past hydropower development, past and current land management practices, and the spread of non-native plant and wildlife species. Factors influencing deer and elk populations include conversion of historic winter range to other uses and competition with native plant assemblages by noxious weeds (ODFW 2000, NWPPC 2001). Land prices continue to rise, making it economically difficult to preserve remaining undeveloped lands for wildlife. Continued decline in populations of fish species results in loss of overall biomass being contributed to the sub-basin. This reduction has negative effects on wildlife abundance. Opportunities to restore wildlife populations and improve wildlife habitat diminish over time as habitat loss and degradation continues (NWPPC 2001, ODFW 2000).

Key Findings, Data Needs and Management Recommendations- Wildlife

Key findings, data needs and management recommendations presented below were developed from information gained in the assessment process and by members of the Council's assessment technical team.

Key Findings

- 42 species are listed as special status by federal or state endangered species acts: 2 amphibians, 11 birds, 1 fish, 4 mammals, 2 invertebrates and 22 plants
- Deer winter range is declining in amount and connectivity
- Deer and pronghorn numbers are decreasing
- Elk populations are increasing
- Reduction in amount and continuity of wetland and riparian habitat
- Habitats have been simplified and fragmented
- Reduction in forage value on rangelands and grasslands
- High regional population growth and changing demographics are negatively affecting wildlife habitat
- Big game populations impact the basin positively (recreation) and negatively (impacts to producers)
- Western juniper and noxious weed expansion are negatively affecting wildlife habitat
- Projected continued high increases in the recreational and residential use of the Prineville reservoir will impact the wildlife management area

Data Needs

- Improved information on the life history and habitat requirements of potentially at-risk species (e.g.: Sage grouse…)
- Better information needed on potential and current vegetation communities and trends
- Inclusion of wildlife habitat concerns into land use planning decisions (fragmentation, increased fire risk, and noxious weeds…)

Management Recommendations

- Ensure habitats support healthy, productive, and diverse populations and communities of native plants and animals
- Balance wildlife populations, recreation, and private land management
- Land management - Protection of key habitat components (identification and mapping needed) in the face of increasing pressure on public lands (particularly recreation activities) and increasing private land development residential, partitioning, etc.)
- Terrestrial taxa in need of special management attention: amphibians; reptiles susceptible to ground disturbing activities; birds and mammals associated with scarce or declining habitats including native grasslands and late-seral low and mid elevation forests

10. Watershed Condition Summary

This chapter provides an overview of the key findings, data gaps and management recommendations for each section of the watershed assessment. The information is summarized here to provide a quick summary of conditions for the range of topics covered in the assessment. Key findings, data needs and management recommendations were developed from information gained in the assessment process and by members of the Council's assessment technical team. The final section of the chapter, priority management objectives for the basin, summarizes information resulting from an inter-agency planning process in the winter of 2000. Additional refinement of management objectives for the basin will be based on the results from the assessment process, the inter-agency planning process described below as well as the Council's own planning processes and incorporated into the Crooked River Watershed Council's Action Plan.

Key Findings, Data Needs and Management Recommendations

Key Findings- Physical Description

- Á Arid, cool climate limits restoration of vegetation
- Á Downcut stream channels and altered flow regimes limit riparian vegetation
- Á Soils in the majority of the basin (John Day Ecological province) are highly susceptible to precipitation driven erosion
- Á Exclusion of fire and other land management practices have led to large increases in young juniper woodland

Key Findings- Land Use

- Á 60% of the land base is public, 40% is private
- Á 51% of streams are adjacent to private lands
- Á Public lands concentrated at higher elevations
- Á Lower elevation streams, those most sensitive to management activities, are located primarily on private lands; restoration efforts will need to focus on these areas
- Á Current economic conditions in the agricultural and timber industries are negatively affecting residents and communities in the Crooked River Basin
- Á Population growth in central Oregon is high, population pressures within the basin are expected to increase
- Á High population growth impacts watershed conditions including habitat fragmentation, water availability and fire risk
- Á Human populations are concentrated in the lower Crooked River Sub-basin
- Á There are three wild and scenic river segments in the basin
- Á Top three industries wood products, agriculture and recreation/tourism are all dependent on healthy environmental conditions
- Á Wildlife populations impact the economy in both positive and negative ways, two major impacts are hunting and wildlife damage to agricultural producers

- Basin reservoirs receive high day use for recreation

Data Needs- Land Use

- Soils - comprehensive soils mapping has never been completed for all of Crook County
- Wetlands
- Actual land use
- Impervious surface (changes in)
- Potential impacts of development (water availability, habitat fragmentation, and fire risk…)

Management Recommendations-Land Use

- Proactive approach to land use management by Crook County and City of Prineville
- Protection of key habitat (once identified) given increasing pressure on public lands (recreational use) and increasing private land development (residential developments, partitioning, etc.)
- Improved information on current conditions and trends in type and location of land use

Key Findings- Historic Conditions

- Anadromous fish species were eliminated from the basin by the construction of major dams in the Lower Crooked River Sub-basin (Pelton, Bowman, Ochoco, Opal Springs)
- Populations of big game are greater now than at pre-settlement
- Riparian vegetation communities are less diverse and extensive than at pre-settlement
- Water rights were mostly allocated in the basin by the 1880's
- Construction of the Prineville Railroad supported the establishment of major timber harvest and wood products industries in the basin over the last century
- Timber harvest and livestock grazing were the dominant resource uses of the basin over the last 150 years
- Earliest settlements in the basin were concentrated around Ochoco, Mill and McKay Creeks and in the Prineville, Post and Paulina areas

Key Findings- Hydrology and Water Use

- Flow within the Crooked River originates from springs in the upper headwaters and lower mainstem, and from snowmelt at the higher elevations. Average annual precipitation ranges from 8-10" in the Crooked River Valley to 34" in the vicinity of Big Summit Prairie, with approximately two-thirds of that in the form of snow
- Changed upland and riparian conditions have led to increased flashiness of flows
- Irrigation use of surface flows from the Crooked River also contribute to summer low flows above dams/regulating facilities
- Below Bowman Dam, flows have been modified to decrease peak flows, increase summer low flows, and decrease average fall and winter flows. As a consequence, changes in both valley forming processes and stream channel processes have occurred.
- Surface water resources are overallocated in the entire Deschutes Basin

- Water withdrawals have changed flow regimes in many areas (season, amount)
- Water quantity issues are directly related to many of the water quality and fish passage problems in the basin
- Channel modification and straightening has occurred throughout the basin, particularly around the City of Prineville
- Irrigation diversion systems block passage and isolate and strand fish populations and individuals
- Extensive system of reservoirs (several large) exist and store water in the basin; these systems could potentially be used to restore/mimic flows for watershed health improvements (e.g.: fish habitat, water quality, channel maintenance)
- Majority of reservoirs in the basin exist for water storage for irrigation purposes; recreational use of larger reservoirs is also high
- Instream water rights hold late dates of appropriation. This junior status means that instream rights may not be fulfilled during periods of low flow and/or high water use

Data Needs- Hydrology and Water Use

- Streamflow gaging data of more streams, sites
- Consumptive water use information (actual water use)
- Relationship between flows and fish populations/habitat (focus below large reservoirs, where management adjustments could be made)
- Impacts of flows on channel maintenance (focus below large reservoirs, where management adjustments could be made)
- Impacts of flows on water quality (focus below large reservoirs, where management adjustments could be made)
- Identify areas where water conservation could have a significant impact on flows
- Better understanding of relationship between ground and surface water in the basin
- Wetland information & riparian condition assessment information
- Water use and availability data for the Beaver South Fork Sub-basin

Management Recommendations-Hydrology and Water Use

- Improve upland and channel conditions through vegetation management
- Significantly reduce juniper and improve watershed characteristics of uplands
- Reduce soil erosion
- Upland function- ensure soils exhibit infiltration and permeability rates, moisture storage, and stability that are appropriate to the soil, climate and landforms
- Riparian function- ensure that riparian and wetland areas are in properly functioning physical conditions and are moving toward desired conditions

Key Findings- Uplands

- The area and density of woody species is increasing on rangelands
- Fragmentation is increasing between blocks of native habitats
- Noxious weeds are increasing in species and distribution
- Vegetative recovery from past damage in lower precipitation regions of the basin is slow

- Á Decreasing native grasslands and native shrublands
- Á Increasing roads, exotic species and soil disturbance
- Á Fire regimes are more severe than historical conditions
- Á Overall density of forest stands is increasing
- Á Large structure and older trees are declining
- Á Small, younger trees are increasing
- Á Riparian vegetation is fragmented, lacks diverse age and species classes
- Á Risk of catastrophic fire, disease or insect outbreak is increasing
- Á Many watersheds have high densities of unimproved roads

Data Needs- Uplands

- Á Road assessment
- Á Noxious weed population inventory and trend monitoring
- Á Condition trends - private lands
- Á Effects of different management practices (timing, intensity, location, of grazing; prescribed fire, etc.).
- Á Information on potential and actual vegetation communities and trends is needed for public and private lands in the basin

Management Recommendations-Uplands

- Á Noxious weed management and control
- Á Juniper control
- Á Restoration of native range plant community (diversity, health, …)
- Á Livestock grazing management
- Á Wild horse management
- Á Big game population coordination with ODFW
- Á Upland watershed function - ensure soils exhibit infiltration and permeability rates, moisture storage, and stability that are appropriate to the soil, climate and landforms
- Á Encourage forest management practices that maintain or improve the general health of forested uplands
- Á Road improvements and/or decommissioning throughout basin based on watershed analysis

Four specific opportunities to address risks to ecological integrity in rangelands were identified by ICBEMP (1996):

- Á Reduction of forest stocking to improve forage/cover relationships for livestock and big game;
- Á Curtailment of juniper expansion;
- Á Curtailment of noxious weed expansion; and
- Á Management of riparian areas to enhance stream bank stability and riparian vegetation.

Opportunities to address risks to ecological integrity in basin forests were identified by ICBEMP (1996)

- Restoration of forest integrity through forest management;
- Restoration of old/late forest structure;
- Restoration of aquatic and hydrologic integrity by reducing the risk of fire, insect, and disease, and road management; and
- Maintenance of existing aquatic strongholds.

Key Findings- Riparian and Channel Conditions

- Significant loss of riparian vegetation (distribution, diversity, age class) has occurred since the 1800's;
- Changes in timing and level of peak flows have impacted channel and riparian conditions, particularly downstream of major reservoirs
- Riparian ecosystem function, determined by the amount and type of vegetation cover has decreased in most sub-basins;
- Channel sensitivity is highest on mid-to-lower elevations stream segments, these are predominantly located on private lands
- Major streams in the basin have been channelized (particularly following the 1964 flood and in the lower Crooked River sub-basin);
- A majority of riparian areas on USFS and BLM administered lands are not meeting management objectives;
- The abundance of mid-seral vegetation in riparian forests has increased and late seral vegetation communities are greatly reduced, particularly at lower elevations,
- Vegetation has also declined at upper elevations, primarily due to fire exclusion and harvest of large trees; and
- Extensive spread of western juniper and exotic grasses and forbs in riparian shrub lands is negatively impacting riparian vegetation communities,

Data Needs-Riparian and Channel Conditions

- Wetlands locations and condition
- Riparian vegetation- information needed on potential and current conditions
- Channel conditions - current, potential, channel maintenance and forming flows,..
- Riparian condition information does not exist for the majority of streams in the basin
- Comprehensive assessment of current and potential channel, vegetation, and flow conditions and their impacts on riparian health
- Compile and analyze existing information from the range of methods, agencies and locations into a more useful riparian condition database

Management Recommendations-Riparian and Channel Conditions

- Restore channel forming and maintenance flow regimes
- Protect and enhance riparian and wetland vegetation
- Identify and protect key riparian vegetation strongholds

- Recognize and address role of upland health in riparian function/condition
- Identify riparian vegetation potential

Ochoco Creek Management Recommendations

The National Riparian Service Team (1998) following the flood of 1998 made specific riparian and channel management recommendations to the City of Prineville and Crook County for lower Ochoco Creek. The recommendations are included here as similar conditions and recommendations fit many other streams and riparian areas in the Crooked River Basin.

- Establish riparian vegetation communities with a higher stability rating
- Look for opportunities to increase floodplain
- Explore the option to use diversions and ditches above town to divert high flows away from the City of Prineville
- Consider the condition of riparian areas and watersheds above Ochoco Reservoir.
- Accelerate the establishment of riparian vegetation on the floodplain and streambanks by planting woody species
- Manage streamflow changes in the main channel to gradually change water levels to accommodate plant establishment within the operation of the irrigation system
- Add to the stability of Ochoco Creek by having a 15-20 foot un-mowed, untilled buffer
- Develop a strategy to prevent the disposal of yard wastes along the stream channel. First address land use management, then evaluate the use of bioengineering methods as needed to address erosion problems
- Develop and manage a trail system for fishing and other recreation to reduce potential erosion problems
- When bridges are replaced, redesign bridges for increased channel capacity. Re-engineer diversion structures to pass debris
- Consider ways of getting irrigation water without new dams or replacement of damaged ones
- Evaluate cross-fences concerning debris accumulation problems
- Consider the control of noxious weeds

Key Findings-Water Quality

Water quality conditions within the Crooked River Basin are highly variable, with higher elevation streams in the Ochoco Mountains generally having good to excellent water quality, and lower elevation sites having lower overall water quality. Primary contributors to the poor water quality are related to land and water conditions such as: low summer flows, the existence of reservoirs and diversions, degraded upland and riparian vegetation, and stream channels that lack stable banks and connection with the floodplain. Land uses that can influence water quality in the basin include logging, roads, grazing, irrigated and non-irrigated agriculture, confined feeding operations, recreation, urban and rural residential development, reservoirs and seasonal sewage treatment plant operations.

Because data have been collected from relatively few sites, the 303(d) list may not accurately reflect the extent of water quality problems in the Basin. The following summarizes what is generally known about water quality in the Basin.

Temperature - elevated summer temperatures are a concern throughout much of the Basin (OR DEQ 1998).

Nutrients - DEQ monitoring at their three ambient sites indicates high concentrations of nutrients both during periods of low flow (little dilution) and during heavy precipitation (high runoff) (OR DEQ 1999). Increased nutrient concentrations can affect both in-stream pH and dissolved oxygen.

pH - portions of the Crooked River below the North Fork Crooked River are included on the 303(d) list for pH; listings are based on DEQ data collected at three ambient sites (OR DEQ 1998, OR DEQ 1999). REMAP data also exceed the standard at South Fork Crooked River site in August 1998 (OR DEQ 1999). The time of day data are collected is critical; pH peaks late in the afternoon, but that is not necessarily when data have been collected. There is some question as to whether the upper limit for the Crooked River Basin shouldn't be 9.0 rather than 8.5, as it is for the rest of eastern Oregon. The upper standard for the Deschutes River Basin is 8.5 due to the fact that much of that water originates in the Cascade Mountains. Conversely, the Crooked River Basin is geologically more aligned with the rest of eastern Oregon than the cascade region, which is characterized by a naturally higher range of pH (Lamb 1999, Nichols 2001).

Dissolved Oxygen - data collected on the Crooked River at the three DEQ ambient sites did not violate the D.O. standard, although data were not collected in the early morning when D.O. concentrations are likely to be lowest (OR DEQ 1999, Lamb 2000). The standard applied was for cold-water aquatic life; this may need to be re-evaluated for times of salmonid spawning

Bacteria - the mainstem Crooked River is listed for bacteria from the mouth to Baldwin Dam, based on DEQ data collected from their ambient site upstream of Smith Rock (OR DEQ 1998). Data from their ambient sites further upstream on the Crooked did not exceed standards; little other bacterial data have been collected.

Total Dissolved Gas - the mainstem Crooked River is listed for total dissolved gas from Baldwin Dam to Prineville Reservoir because of elevated saturation levels below Bowman Dam after periods of high flows (OR DEQ 1998). Rainbow trout captured at those times showed signs of "gas bubble disease (Lamb 2000).

Sedimentation/Turbidity - sedimentation and/or turbidity have been identified as possible water quality problems in many streams throughout the basin, although no data have been collected to document this (OR DEQ 1988). The concentration of total suspended solids has been high throughout the year at all three DEQ ambient sites (OR DEQ 1999).

Toxics - Ochoco Reservoir is listed as a site of "potential concern" for mercury, although no fish consumption recommendations have been developed (OR DEQ 1998).

Flow Modification - the mainstem Crooked River and North Fork Crooked River are listed for flow modification because of low flows due to irrigation diversions and reservoir refill during the non-irrigation season (OR DEQ 1998). Flow modification has been identified as a possible problem in many other streams throughout the basin, although no data have been collected to document this.

Habitat Modification - nineteen stream segments in the Upper Crooked Sub-basin are listed for habitat modification based on data collected for the North Fork Crooked River Watershed Analysis (OR DEQ 1998, USDA FS 1995b). Undesirable habitat conditions include limited large woody debris, low pool frequency, and high width/depth ratios (USDA FS 1995b). Habitat modification has been identified as a possible problem in many other streams throughout the basin, although no data have been collected to document this.

Data Needs-Water Quality

- Á More data on pH, nutrients, dissolved oxygen, bacteria, turbidity and sediment at sites in the basin in addition to OR DEQ's three ambient sites; pH and dissolved oxygen data collected should look at diurnal variations to ensure evaluations of "worst-case" situations
- Á Improved understanding of the relationships between flow and water quality, particularly below Ochoco and Prineville reservoirs where management could be adjusted in response to findings
- Á Determination of salmonid spawning and rearing times of year for rivers and streams in the basin; application of the appropriate temperature and dissolved oxygen criteria
- Á Compile, analyze and summarize data from all sources in addition to OR DEQ
- Á Determine what natural pH conditions in the basin are (to help assess whether upper range of pH standard for the Basin should be 9.0 rather than 8.5)
- Á Determine anthropogenic sources of nutrients and flow reductions and characterize their impacts on in-stream pH and dissolved oxygen concentrations
- Á Determine source and extent of bacterial pollution observed in mainstem Crooked River
- Á Determine vegetative site potential of riparian areas on public and private lands
- Á Assess sources of sediment and impacts on beneficial uses
- Á Investigate relationship between operations at Bowman Dam and total dissolved gas concentrations in the lower Crooked River to determine if supersaturation is still a problem downstream of the dam and if so, make recommendations for management solutions
- Á Evaluate sources of mercury and level of mercury contamination in Ochoco Reservoir; potentially make consumption recommendations for fish

Management Recommendations –Water Quality

- Implement a coordinated watershed-wide temperature monitoring network by agencies and watershed council
- Collect sufficient data to identify water quality problems and the source of water quality problems
- Ensure that sewerage facilities serving the City of Prineville are sufficiently sized to accommodate growth and are operated in a manner protective of water quality and public health
- Improve upland and riparian vegetation conditions

Key Findings-Fish

- Status of redband trout populations is mixed. They are moderately abundant in the limited amount of headwater tributaries with good habitat and cool water. Redband trout are depressed in mainstem rivers and tributaries with degraded riparian zones, poor fish habitat, and warm water. Wild redband trout populations are limited by available habitat
- Anadromous fish have been eliminated from the basin by fish passage barriers
- Mainstem Crooked River above Prineville Reservoir and mainstem Crooked River between the Hwy 97 bridge and the City of Prineville have limited habitat conditions and do not support significant trout fisheries
- Redband trout populations small and isolated due to natural and man-made passage barriers; these populations are at a greater risk of extinction than a larger, connected population would be
- Priority areas of the basin for native fish include the lower Crooked River Sub-basin and Ochoco Mountain streams
- Water quality is limited
- Riparian vegetation is limited
- Irrigation and hydroelectric reservoirs have unscreened outlets
- Habitat and passage improvements will be needed to support anadromous fish if reintroduction occurs
- The lower Crooked River sub-basin has the best habitat for anadromous fish
- Fluctuating water levels due to irrigation withdrawal and storage impact fish habitat and movement

Data Needs-Fish

- Monitor fish populations throughout the basin
- Improve understanding of current stream flow regimes (temporal and spatial patterns) and their impacts on fish habitat, movement and water quality conditions
- Stream surveys and riparian habitat inventories
- Prioritized list of passage barriers for all land ownerships and plans for removing them

Management Recommendations- Fish

- Manage and protect watersheds for the production of perennial, high quality water;
- Protect, maintain and/or restore riparian and wetland habitat
- Maintain and or restore performance (productivity, abundance and life history diversity) of wild, indigenous fish populations
- Improve water quality
- Prevent fish loss at unscreened diversions and provide adequate upstream and downstream passage for fish at dams, culverts and other artificial obstructions
- Improve stream complexity
- Replace fish barrier and stranding structures

Key Findings-Wildlife

- 42 species are listed as special status by federal or state endangered species acts: 2 amphibians, 11 birds, 1 fish, 4 mammals, 2 invertebrates and 22 plants
- Reduction in deer winter range
- Deer and pronghorn numbers decreasing
- Elk populations increasing
- Reduction in amount and continuity of wetland and riparian habitat
- Habitats have been simplified and fragmented
- Reduction in forage value on rangelands and grasslands
- High regional population growth and changing demographics are negatively affecting wildlife habitat
- Big game populations impact the basin positively (recreation) and negatively (impacts to producers)
- Western juniper and noxious weed expansion are negatively affecting wildlife habitat
- Projected continued high increases in the recreational and residential use of the Prineville reservoir will impact the wildlife management area.

Data Needs -Wildlife

- Improved information on the life history and habitat requirements of potentially at-risk species (e.g.: Sage grouse…)
- Better information needed on potential and current vegetation communities and trends
- Inclusion of wildlife habitat concerns into land use planning decisions (fragmentation, increased fire risk, and noxious weeds…)

Management Recommendations - Wildlife

- Ensure habitats support healthy, productive, and diverse populations and communities of native plants and animals
- Balance wildlife populations, recreation, and private land management
- Land management- Protection of key habitat components (identification and mapping needed) in the face of increasing pressure on public lands (particularly recreation activities) and increasing private land development residential, partitioning, etc.)

- Terrestrial taxa in need of special management attention: amphibians; reptiles susceptible to ground disturbing activities; birds and mammals associated with scare or declining habitats including native grasslands and late-seral low and mid elevation forests

Priority Management Objectives

This final section of the Crooked River Watershed Assessment provides management recommendations, organized by topic in the same order as the remainder of the document. The management recommendations provided below are the results of an interagency planning process that occurred in the winter of 2000. The Crooked River Watershed Council will use this information, as well as that obtained in the watershed assessment process, in the refinement of the Council's Action Plan. While not an integral part of the council's assessment process, the inter-agency planning process did provide valuable information on the priorities and objectives of the key natural resource entities in the Crooked River Basin. Instead of providing an overview on environmental conditions, as the remainder of the assessment does, this section provides an overview of the organizational focus related to watershed conditions. This information helps illustrate the varying roles and interests of the many entities working on resource management issues in the basin. It can also be used to define potential future roles and partners as specific projects or management activities are planned by the watershed council or other users of the Crooked River Watershed Assessment.

Planning Process

In a basin-wide planning process conducted with State agencies, federal land management agencies, the Crook County Soil and Water Conservation District and the Crooked River Watershed Council in the winter of 2000, priority management objectives were identified for the Crooked River Watershed. Each participating entity developed a top ten list of priority objectives, shared these with the group, and worked to summarize information on management priorities for the basin. Individual priorities and the agency or organization they are linked to are described in Table 10-1. Participating agencies and organizations included: Oregon Department of Agriculture, Oregon Department of Environmental Quality, Oregon Department of Forestry, Oregon Department of Fish and Wildlife, Division of State Lands, Oregon Water Resources Department, Ochoco National Forest, Prineville District Bureau of Land Management, Crook County Soil and Water Conservation District and the Crooked River Watershed Council. The session was facilitated by the Oregon Watershed Enhancement Board.

Once each participant had shared their entities top ten resource priorities for the Crooked River Basin, the group compiled a list of ten overall management priorities, based on areas of overlap. The list included the following:

- Á Fish Presence
- Á Fish Passage
- Á Education
- Á Erosion, Sedimentation, Vegetation Management
- Á Invasive Species
- Á Allocation of Uncontracted Water at Prineville Reservoir
- Á Monitoring
- Á Non-point Source Pollution
- Á Assessment, Analysis, Plans, Data
- Á Collaboration (landowners, organizations, agencies)

Crooked River Watershed Council. 2000

The group then discussed each shared priority, working to list opportunities, barriers and potential projects under each of the ten priorities.

Fish Presence

More information on fish habitat and population is needed for: private, non-industrial timberlands, South Maury mountain region, Southeast corner of basin, Upper Crooked River mainstem, private lands in general and BLM lands in general.

Current priority areas for redband trout include the Lower Crooked River and the South Fork Crooked River.

Fish Passage

Ochoco National Forest has a goal of inventorying and prioritizing all culverts in 2000. The ODOT inventory is complete. A survey of push-up dams and their likelihood of being barriers to fish passage is needed. ODFW has a pretty good idea of the locations of fish passage barriers but funding and coordination is needed to replace them. Education on passage problems and solutions is needed. Target area for fixing fish barriers is the Lower Crooked River sub-basin, particularly the lower Crooked River Mainstem below Bowman Dam. The North Fork Crooked River Watershed is another key area of concern.

Education

Projects suggested for collaborative support included: fish passage education, continuation of Fishfest, support of the Crooked River Ecosystem Education Council, demonstration projects and an annual watershed forum. The significance of local media in the role of public education related to resource issues was also noted.

Erosion, Sedimentation and Vegetation Management

Information needs related to this priority management item included: road assessments, riparian condition assessments, and the need for long-term monitoring (and sharing of information) on upland management techniques. Ideas for specific projects included hosting a bioengineering workshop, using demonstration projects to showcase science based management examples, and expanded juniper control efforts, particularly on private lands. The need for interdisciplinary technical expertise in the identification of projects and sites was noted.

Invasive Species

The invasive species discussion focused primarily on noxious weeds, although the presence of feral pigs in the watershed was noted. The potential for introduced disease and other issues related to impacts on native wildlife and livestock related to game farms was also discussed. Discussions on invasive species centered on the need for improved funds for control efforts and collaboration among agencies and organizations to improve overall education, inventory and management.

Allocation of Water at Prineville Reservoir

Information, outreach and expanded involvement are needed.

Monitoring

Priority areas and topics for monitoring included:

- The south fork crooked river (water quality, riparian and channel conditions and fish populations;
- Project monitoring and sharing of lessons learned;
- Snow monitoring and more instream flow gages above reservoirs to support better management of water in the reservoirs;
- Information needed on actual water use;
- More information needed on water quality (particularly long term trends and lower elevation reaches); and
- Effectiveness of the forest practices act.

The need for common standards and shared information was also noted, as was the fact that data confidentiality issues exist on private lands.

Non-point Source Pollution

Information needs related to non-point source pollution included:

- Site potential;
- Potential natural communities;
- Sedimentation;
- Soils;

- Current plant communities; and
- Use and monitoring of long-term, large scale demonstration projects.

Assessment, Analysis, Plans, Data

Major data needs to improve assessment and planning processes include information on: roads, riparian areas, fish passage barriers, and fish presence. Capacity issues included: need for current aerial photos of private and public lands, need for geographic information systems mapping of the basin (Crook County is just beginning to get things mapped, USFS and BLM both do this but have incompatible systems). A variety of Geographic Information Systems (GIS) expertise is available (USFS, BLM, OWRD high expertise ODF, CC, FSA just getting started). Funds are needed to provide for more detailed assessment and analysis work. Data confidentiality issues exist on private lands.

Collaboration

Specific collaborative projects that were identified as priorities for continuation or expansion included: regional database and website, regional technical team, watershed and sub-watershed working groups and the OWEB restoration project database. The need to expand and improve relationships between agencies and organizations was noted; the Wyden Amendment and the watershed council were identified as successful venues to continue these relationships.

Table 10-1: Priority Management Objectives for the Crooked River Basin

Priority Management Objectives - Oregon Department of Environmental Quality
Work collaboratively to collect sufficient water quality data to identify problems and their sources
Complete Total maximum Daily yields for appropriate priorities by 2004
Encourage landowners to manage lands to minimize impacts to water quality
Evaluate 401 certification for the round butte hydroelectric complex
Work with watershed council
Ensure that City of Prineville and Ochoco West sewerage facilities are sufficiently sized and operated to allow growth and protect water quality and public health
Ensure that failing on-site sewage disposal systems are identified and corrected
Review all permitted sources and renew or modify them so they are on a uniform 5-year schedule
Identify unpermitted sources of wastewater discharges
Work with local governments and ODOT to ensure stormwater is managed to protect surface and groundwater resources
Priority Fish Management Objectives- Oregon Department of Fish and Wildlife
Fisheries protection and enhancement downstream of Prineville and Ochoco Reservoirs: passage and screening at all passage barriers or diversions within 7 years; participate in Prineville Reservoir reallocation; participate in Pelton-Round Butte relicensing
Adapt hatchery supplementation to compliment wild fish objectives: develop hatchery stock based on Crooked River redband trout
Fish inventory: continue efforts to monitor fish populations throughout the basin. Priority areas for inventory include the North Fork Crooked River and the lower Crooked River
South Fork Crooked River: work cooperatively with BLM, council, and landowners to implement long-term monitoring program of fish populations and habitat conditions
Stream enhancement: work cooperatively with private landowners to encourage, facilitate and provide input on enhancement projects throughout the basin
Priority Wildlife Management Objectives- Oregon Department of Fish and Wildlife
Sage grouse: potential listing and management implications to workload, landowners and federal land management
Wildlife damage issues: continue close working relationships with private landowners to balance wildlife populations, recreation and private land management
Land management issues: Protection of key wildlife habitat components in the face of increasing pressures on public lands (recreation) and increasing private land development (residential, developments)
Species management plans for elk, deer and turkey
Feral pigs: eliminate feral pig populations where possible, concerns over destruction of sensitive habitats

Crooked River Watershed Council. 2000

Table 10-1: Priority Management Objectives for the Crooked River Basin

Priority Management Objectives- Crook County Soil & Water Conservation District
Streambank stabilization on Ochoco Creek
Promote improved watershed health, priority areas include: Ochoco Creek, Camp Creek, Beaver Creek, North Fork Crooked River and the Lower Crooked River
Noxious weed education and control: continue to act as County Weed Board, support cooperative weed management
Information and Education, key projects include: Fishfest, conservation poster contest, small acreage management workshops, soil stewardship week, and agriculture in the classroom programs.
Monitoring: monitor district sponsored projects, encourage and assist in the collection of reliable monitoring data
Participate in regional conservation efforts: Deschutes Basin Work Group (SWCD and NRCS), Oregon Association of Conservation Districts, RC&D, watershed council board, weed management area board, Crooked River Ecosystem Education Council
Range management: encourage resource planning for farms and ranches
Reduce soil erosion: encourage resource planning for farms and ranches
Priority Management Objectives- Oregon Department of Water Resources
Improve measurements of water use: devices on People's diversion, Rice-Baldwin diversion and the Crooked River canal
Fish passage at Rice-Baldwin dam
More snow water content sensors in upper basin to improve management of flows at reservoirs
Participate in Prineville Reservoir water reallocation
Set of scaled and rectified color aerial photos of the entire basin
Sediment control structures on Camp Creek
Replace push-up dams with fish friendly diversions
Install remote controlled discharge gates at Prineville Reservoir
Priority Management Objectives- Oregon Department of Forestry
Maintain forest health: forest practices, reduce wildfire risk
Landowner assessments: technical assistance for road, riparian, fish assessments
Forest practices monitoring: monitor compliance with and effectiveness of forest practice rules
Fish passage: provide technical assistance to landowners for design of culverts and bridges
Assistance to family forest landowners: stewardship programs
Riparian protection requirements: ensure vegetation requirements are met during harvest
Active placement of large woody debris: encourage forest landowners and operators to take advantage of incentives to provide structure to streams during active operations
Forest road improvement/relocation: assist landowners with design improvements
Education and outreach: provide forest landowners and operators with educational opportunities related to best management practices to protect water quality and habitat
Coordination: coordinate with other agencies and organizations to act on opportunities to improve resource conditions

Crooked River Watershed Council. 2000

Table 10-1: Priority Management Objectives for the Crooked River Basin

Priority Management Objectives- Ochoco National Forest
Support the Crooked River Ecosystem Education Council
Stream restoration through Challenge Cost-share
Road decommissioning based on watershed analysis
Complete top three road repair projects: road slumps in Mill Creek Watershed, culvert replacements in Deep Creek Watershed and bridge replacement in the Marks Creek Watershed
Watershed assessment and analysis: planned analysis for the next five years include: Maury mountain watersheds, Beaver Creek and McKay Creek
Write water quality restoration plans as watershed analysis are completed
Develop and maintain collaborative relationships
Develop and implement watershed restoration program
Continue development of ecological site potential classifications for riparian areas in the basin
Implement noxious weed management and control
Forest monitoring: water quality (temperature, sediment and base flows), timber sale implementation, range resource, stream surveys and riparian habitat inventory for future watershed analysis
Priority Management Objectives- Bureau of Land Management
Upland watershed function
Riparian/wetland function
Ecological processes
Water Quality
Native, protected status and locally important species and associated habitats
Community sustainability
Recommended Actions to achieve objectives: riparian exclosures, riparian planting, forest health management, weed management, prescribed fire, juniper cutting, seeding, livestock grazing management, aspen stand treatment, road obliteration and rehabilitation, off-road vehicle management, wild horse management, big game population coordination with ODFW, snag creation, water development, land exchanges, culvert replacement, stream complexity improvement, control/removal of feral pigs, rock hound management, and debris removal.
Priority Management Objectives- Oregon Department of Agriculture
Minimize agriculture's contribution to water quality problems: develop practical agricultural water quality management plans, advance interests of soil and water conservation districts, keep livestock waste from polluting streams while allowing producers to remain economically viable, apply pesticides as required by State law.
Promote watershed health: conserve Oregon's native plant species on state-owned and managed lands, protect against the invasion and proliferation of noxious weeds

Crooked River Watershed Council. 2000

Table 10-1: Priority Management Objectives for the Crooked River Basin

Priority Management Objectives- Crooked River Watershed Council
Complete the watershed assessment
Education: host a watershed forum, conduct a workshop for teachers, implement an education project/campaign that addresses the difference in rural/urban perception of resource issues
Watershed Working Groups: facilitate the initiation of watershed or sub-watershed groups
Fish habitat: priority area is the Mill, Marks, McKay and Ochoco Watersheds
Demonstration project
Secure council capacity, including coordinator position and technical staff support
Funding: work to provide financial assistance to private landowners for project implementation
Regional processes: continue to participate in regional projects and processes
Riparian protection and enhancement: support implementation of riparian improvement projects
Priority Management Objectives- Oregon Division of State Lands
Obtain permits or jurisdiction for all waterway and wetland projects that require State approval
Coordinate all fill/removal activities with adjacent landowners
Help bring together necessary technical assistance
Monitor projects for compliance
Education to improve permit compliance rates
Use enforcement where necessary to obtain permit compliance
Promote protection of wetlands
Inform agencies, organizations and individuals about scenic waterways and protected status species
Promote the Oregon Plan for Salmon and Watersheds
Promote healthy streams, riparian zones and wetlands on State-owned lands through proper land management

Crooked River Watershed Council. 2000

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APPENDICES

Appendix 1-A: Temperature and Precipitation Data

Crooked River Basin Temperature (1961-1990 averages)

Lower Crooked River Sub-basin Sites: Brothers, Redmond AP, Grizzly, Ochoco Ranch
Upper Crooked River Sub-basin Sites: Barnes
Beaver-South Fork Sub-basin Sites: Paulina

Variable	Brothers elev. 4640ft	Redmond Airport elev. 3060ft	Grizzly elev. 3640ft	Ochoco Ranch elev. 3980ft	Barnes STN elev. 3970ft	Paulina elev. 3680ft
Mean Temperature F	Brothers	Redmond Airport	Grizzly	Ochoco Ranch	Barnes STN	Paulina
Jan	27.2	31.3	31	25.2	28.1	27.9
Feb	32	36	34.7	30.1	33.6	33.8
Mar	35.3	39.5	37.5	35.4	37.6	38.7
Apr	40.4	44.1	41.5	41.1	42.7	43.7
May	47.5	51	48	47.6	50.1	51.2
Jun	55.4	59.4	56.2	55.1	58	58.5
Jul	61.9	65.7	62	60.6	64.7	64.9
Aug	60.9	65.1	62.1	60.8	63.6	63.8
Sept	53.4	56.8	54.7	53.6	55.7	56.2
Oct	45.2	48.3	46.9	44.9	46.9	46.3
Nov	34.4	38.1	37.3	33.6	36.2	36.2
Dec	27.8	31.8	31.4	26.6	29	28.6
Year	43.5	47.2	45.1	43.2	45.6	45.8

Median Frost Dates	Brothers	Redmond Airport	Grizzly	Ochoco Ranch	Barnes STN	Paulina
24 F	25-Jun	8-May	20-May	30-Apr	14-May	21-May
28 F	11-Jul	29-May	8-Jun	21-May	4-Jun	8-Jun
32 F	21-Jul	28-Jun	9-Jul	10-Jun	28-Jul	3-Jul
36 F	25-Jul	10-Jul	22-Jul	28-Jun	16-Jul	22-Jul
24 F	8-Sep	13-Oct	4-Oct	4-Oct	30-Sep	17-Sep
28 F	16-Aug	24-Sep	15-Sep	21-Sep	11-Sep	8-Sep
32 F	8-Aug	9-Sep	28-Aug	10-Sep	2-Sep	23-Aug
36 F	4-Aug	19-Aug	6-Aug	29-Aug	15-Aug	9-Aug

Growing Season	Brothers	Redmond Airport	Grizzly	Ochoco Ranch	Barnes STN	Paulina
24 F	83	155	141	155	136	122
28 F	46	117	105	120	96	89
32 F	23	77	58	88	65	51
36 F	13	45	32	63	34	23

Appendix 1-A: Temperature and Precipitation Data

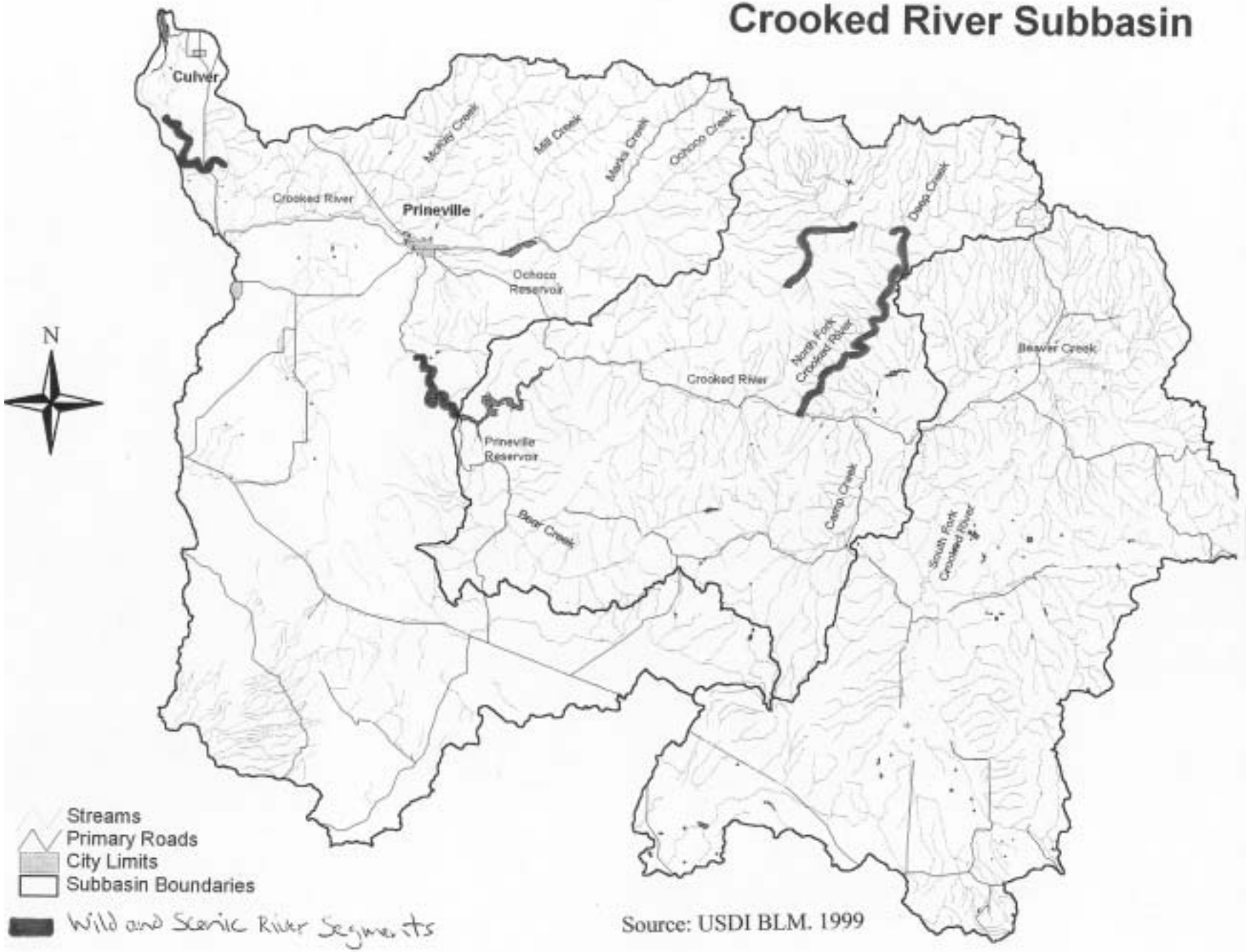
Crooked River Basin Precipitation (1961-1990 averages)

Source: State of Oregon Climate Service Center. 1999

Lower Crooked River Sub-basin Sites: Brothers, Redmond Airport, Grizzly, Ochoco Ranch
Upper Crooked River Sub-basin Sites: Barnes
Beaver-South Fork Sub-basin Sites: Paulina

Variable	Brothers elev. 4640ft	Redmond Airport elev. 3060ft	Grizzly elev. 3640ft	Ochoco Ranch elev. 3980ft	Barnes STN elev. 3970ft	Paulina elev. 3680ft
Monthly and Annual Precipitation (inches) 1961-1990	Brothers	Redmond Airport	Grizzly	Ochoco Ranch	Barnes STN	Paulina
Jan	1.06	1.06	1.54	2.13	1.22	1.33
Feb	0.49	0.6	1	1.55	0.88	0.88
Mar	0.64	0.69	1.09	1.37	0.97	1.03
Apr	0.64	0.58	0.97	1.13	0.79	0.81
May	1.05	0.71	1.23	1.24	1.11	1.08
Jun	0.95	0.73	1.04	1.29	1.06	1.08
Jul	0.52	0.45	0.42	0.7	0.71	0.61
Aug	0.72	0.54	0.77	0.88	0.89	0.67
Sept	0.49	0.41	0.71	0.94	0.6	0.53
Oct	0.67	0.54	0.88	1.25	0.79	0.83
Nov	1.21	1.16	1.79	2.49	1.62	1.44
Dec	1.1	1.09	1.36	2.38	1.52	1.39
Average Annual Precipitation 1961-1990	Brothers	Redmond Airport	Grizzly	Ochoco Ranch	Barnes STN	Paulina
	9.31	8.62	12.4	17.1	12.19	12.49
Average Annual Precipitation 1974-1998	Brothers	Redmond Airport	Grizzly	Ochoco Ranch	Barnes STN	Paulina
	9.43	8.61	13.86	incomplete data	14.86	13.47
Monthly Mean Snowfall (inches)	Brothers	Redmond Airport	Grizzly	Ochoco Ranch	Barnes STN	Paulina
Jan	7.27	5.43	7.97	5.03	10.18	7.4
Feb	2.53	2.74	4.06	2.44	6.6	3.3
Mar	2.48	1.91	4.25	2.27	4.32	2.1
Apr	2.15	1.13	2.62	0.45	1.19	0.8
May	0.92	0.07	0.55	0.11	0.62	0.1
Jun	0	0.08	0	0	0.05	0
Jul	0	0.02	0	0	0	0
Aug	0	0	0	0	0	0
Sept	0.03	0	0	0	0.15	0
Oct	0.74	0.15	0.49	0.35	1.24	2
Nov	3.99	3.28	4.81	1.14	7.18	2.9
Dec	8.42	5.02	7.63	5.42	12.43	7.7

Crooked River Subbasin



Source: USDI BLM. 1999

Appendix 3-A: Historic Fish Weir Sites of the Upper Deschutes Basin

Upper Deschutes River Basin

Source: Nehlsen, 1995

Appendix 4-A: Lower Crooked River Sub-basin Surface Water Rights

Water Rights Summary Information | Surface water: streams (cfs) and reservoirs (acre-feet)

Location	Primary cfs	Supplemental cfs	Total Surface Rights	Primary Acre-feet	Supplemental Acre-feet	Total Reservoir Rights
Allen Creek & Tribs.	17.96	0	7	364.3	4014.3	2
Crooked River	3158.34	0	118	582.09	0	5
Crooked River & Tribs.	2.26	0	7	24.1	0	3
Dry Creek & Tribs.	9.31	0	6	379	0	0
Dry River & Tribs.	20.2	2.3	20	851.55	0	9
Dry River & Tribs.	5.83	4.45	4	0	0	0
Johnson Creek & Tribs.	3.2	0	7	930.8	0	5
Lytle Creek & Tribs.	2.29	0.5	11	161.07	405	4
Marks Creek & Tribs.	5.13	0	15	71	0	5
McKay Creek & Tribs.	14.28	0.65	39	7.26	0	3
Mill Creek & Tribs.	16.64	0.72	36	5	0	1
Ochoco Creek	287.7	0.35	53	48219.9	0	2
Ochoco Creek & Tribs.	12.71	1.95	27	263.24	600	11
	Primary cfs	Supplemental cfs	Total Surface Rights	Primary Acre-feet	Supplemental Acre-feet	Total Reservoir Rights
Lower Crooked River Sub-basin Totals	3555.85	10.92	350	51859.31	5019.3	50

Source: Oregon Water Resource Department, 1999

Appendix 4-A: Upper Crooked River Sub-basin Surface Water Rights

Water Rights Summary Information | Surface water: streams (cfs) and reservoirs (acre-feet)

Location	Primary cfs	Supplemental cfs	Total Surface Rights (#)	Primary Acre-feet	Supplemental Acre-feet	Total Reservoir Rights (#)
Bear Creek	19.5	0	17	2402.7	1495.7	4
Bear Creek & Tribs.	2.02	0.34	20	140.4	36.2	11
Little Bear Creek	4.32	0	11	0	0	0
Camp Creek & Tribs.	56	0	26	1850.05	0	31
Crooked River	53.62	0	53	155,166.39	0	3
Crooked River & Tribs.	29.04	0	59	4185.97	0	31
Horse Heaven Creek	8.17	2.66	9	257.8	498.6	3
Johnson Creek & Tribs.	301.19	0	15	1533.5	0	22
Lost & Sheep Creek	8.19	0	12	7.37	139.4	3
Lucky Creek & Tribs.	2.4	0	13	0	0	0
Peterson Creek & Tribs.	9.82	0	4	93.5	16.5	2

	Primary cfs	Supplemental cfs	Total Surface Rights (#)	Primary Acre-feet	Supplemental Acre-feet	Total Reservoir Rights (#)
Upper Crooked River Sub-basin Totals	494.27	3	239	165637.68	2186.4	110

Source: Oregon Water Resource Department, 1999

Appendix 4-A: Beaver South Fork Sub-basin Surface Water Rights

Water Rights Summary Information | Surface water: streams (cfs) and reservoirs (acre-feet)

Location	Primary cfs	Supplemental cfs	Total Surface Rights	Primary Acre-feet	Supplemental Acre-feet	Total Reservoir Rights
Beaver Creek	52.95	0	26	115.92	0	6
Beaver Creek & Tribs.	5.82	0	5	60.9	0	10
Bulger Creek	1.5	0	3	2.9	0	5
Crooked River	18.91	0	16	166.3	0	1
Crooked River and Tribs.	3.26	0	3	11.9	0	8
Grindstone Creek & Tribs.	24.17	0	10	746	0	18
N. Fork Beaver Creek	12.93	0	8	32.15	0	22
S. Fork Beaver Creek	14	0	23	321.92	0	6
Swamp Creek	7.88	0	3	51.92	0	4
Twelvemile Creek	26.72	2.8	17	1221.2	99.5	8
Wolf Creek	11.72	0	8	1.5	0	1
Paulina Creek & Tribs.	30.2	0	11	36.46	0	17
South Fork Crooked River	44.52	0	18	291.34	0	56

	Primary cfs	Supplemental cfs	Total Surface Rights	Primary Acre-feet	Supplemental Acre-feet	Total Reservoir Rights
Beaver South Fork Sub-basin Totals	254.58	2.8	151	3060.41	99.5	162

Source: Oregon Water Resource Department, 1999

Appendix 4-B: Instream Water Rights by Sub-basin, Lower Crooked

Location of In-Stream Rights	Average Annual cfs of In-Stream Rights	Peak cfs and Month of In-Stream Rights	Purpose of In-Stream Rights
Allen Creek & Tribs.	5.82	15, Apr-May	Resident Fish Rearing
Crooked River, Bowman Dam to Lake Billy Chinook	129.4	255, Mar-May	Resident Fish Rearing
Marks Creek & Tribs.	14.6	53.1, Apr	Resident Fish Rearing
McKay Creek & Tribs.	21.57	61.5, Apr	Resident Fish Rearing
Mill Creek and Tribs.	30.48	76.5, Apr-May	Resident Fish Rearing
Ochoco Creek & Tribs.	81.96	175, Mar-May	Resident Fish Rearing
Lower Crooked River Sub-basin Totals	283.83	636.1, Apr	

Source: Oregon Water Resources Department. 1998

Appendix 4-B: Instream Water Rights by Sub-basin, Upper Crooked

Location of In-Stream Rights	Average Annual cfs of In-Stream Rights	Peak cfs and Month of In-Stream Rights	Purpose of In-Stream Rights
Bear Creek	14.6	25, Mar-May	Resident Fish Rearing
Crooked River, SF to NF	36.25	70, Mar-May	Resident Fish Rearing
Crooked River, NF to Prineville Reservoir	68.87	113, Mar-May	Resident Fish Rearing
Horse Heaven Creek	2.88	11.3, Apr	Resident Fish Rearing
Johnson Creek & Tribs.	17.45	41, Apr	Resident Fish Rearing
N Fork Crooked River	155.17	247, Apr	Anadromous and Resident Fish Rearing
Peterson Creek & Tribs.	4.01	10, Mar-May	Resident Fish Rearing
Upper Crooked River Sub-basin Totals	299.23	517, Apr	

Source: Oregon Water Resources Department. 1998

Appendix 4-B: Instream Water Rights by Sub-basin, Beaver South Fork

Location of In-Stream Rights	Average Annual cfs of In-Stream Rights	Peak cfs and Month of In-Stream Rights	Purpose of In-Stream Rights
Beaver Creek & Tribs.	54.73	110.9, Mar	Anadromous and Resident Fish Rearing
N. Fork Beaver Creek	11.18	33, Mar 16-Apr 1	Anadromous and Resident Fish Rearing
S. Fork Beaver Creek	15.5	33, Mar-May	Resident Fish Rearing
S. Fork Crooked River	9.75	21, Mar-May	Resident Fish Rearing
Wolf Creek	8.42	26, Mar	Anadromous and Resident Fish Rearing
Beaver South Fork Sub-Basin Totals	99.58	223.9, Mar	

Source: Oregon Water Resources Department. 1998

Appendix 4-C: Lower Crooked River Sub-basin Consumptive Use Summary

Lower Crooked River Sub-basin
Consumptive Use as a Percentage of 80% Exceedance Streamflow
(80% exceedance streamflow=amount of water in the channel for a given month at least 80% of the time)

Location (water availability basin)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crooked River (below Osborne can.)	134%	118%	122%	83%	76%	141%	464%	970%	747%	306%	89%	111%
Dry River												
Crooked River (below Dry Creek)	115%	114%	122%	76%	58%	105%	339%	705%	538%	230%	51%	85%
McKay Creek	0.21%	0.09%	0.06%	9.30%	42%	170%	824%	2171%	1894%	911%	1.60%	0.30%
Allen Creek	0.19%	0.08%	0.05%	6.60%	29%	120%	580%	1547%	1350%	620%	1.40%	0.27%
McKay Creek (C.R. to Allen crk)	0.10%	0.04%	0.03%	6.30%	28%	114%	548%	1495%	1303%	626%	1%	0.15%
Little McKay Creek	0	0	0	0	0	0	0	0	0	0	0	0
Ochoco Creek	719%	756%	721%	420%	170%	240%	1015%	1643%	698%	1056%	615%	650%

Source: Oregon Water Resources Department. 1998

Appendix 4-C: Upper Crooked River Sub-basin Consumptive Use Summary

Upper Crooked River Sub-basin
Consumptive Use as a Percentage of 80% Exceedance Streamflow
(80% exceedance streamflow=amount of water in the channel for a given month at least 80% of the time)

Location (water availability basin)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bear Creek	264%	249%	271%	256%	440%	398%	385%	418%	414%	451%	142%	213%
Crooked River (below Sand Creek)	13%	11%	25%	32%	91%	113%	106%	112%	99%	48%	5.70%	7.20%
North Fork C.R. (above Deep Creek)	3.20%	3.30%	17%	21%	60%	81%	79%	87%	82%	58%	1.90%	2.40%
Deep Creek	0	0	0	0	0	0	0	0	0	0	0	0
North Fork C.R. (below Deep Creek)	6.30%	6.40%	31%	34%	97%	130%	127%	142%	137%	109%	4.10%	4.80%
Peterson Creek	11%	7.20%	15%	17%	48%	57%	55%	63%	63%	57%	5.90%	9.30%
Johnson Creek	13%	11%	49%	55%	140%	171%	167%	191%	188%	170%	8.00%	12%
North Fork C.R. (below Johnson crk)	0.44%	0.22%	16%	20%	98%	282%	287%	240%	180%	76%	0.66%	0.36%
Camp Creek	28%	28%	35%	48%	233%	352%	270%	222%	149%	47%	20%	23%

Source: Oregon Water Resources Department. 1998

Appendix 4-D: Lower Crooked River Sub-basin Water Availability Summary

Lower Crooked River Sub-basin
Monthly Net Water Availability cfs (water available= net streamflow at 80% exceedance level- consumptive use- instream rights)

Location (water availability basin)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crooked River (below Osborne can.)	-113	-198	-365	-126	-134	-280	-423	-454	-404	-181	-67	-85
Dry River	-1.2	-1.3	-1.2	-3.3	-5.5	-6.5	-6.6	-6.6	-5.9	-2.7	-1.3	-1.2
Crooked River (below Dry Creek)	-16	-37	-104	178	207	-15	-229	-275	-229	-67	32	14
McKay Creek	-7.21	-18.71	-20.01	-15.8	-15.7	-8.3	-5.42	-4.94	-4.34	-1.67	-1.1	-3.51
Allen Creek	-1.9	-5.3	-5.3	-4.46	-4.14	-1.95	-1.09	-0.97	-0.85	-0.35	-0.3	-0.96
McKay Creek (C.R. to Allen crk)	-3.6	-10.2	-9.7	7.63	-7.7	-3.5	-1.89	-1.68	-1.48	-0.63	-0.56	-1.8
Little McKay Creek	-1.04	-2.7	-2.8	-2.2	-1.8	-0.53	-0.09	-0.02	-0.02	-0.05	-0.23	-0.51
Ochoco Creek	-94	-233	-441	-308	-44	-61	-117	-89.2	-36.1	-31.7	-25.1	-61

Source: Oregon Water Resources Department. 1998

Appendix 4-D: Upper Crooked River Sub-basin Water Availability Summary

Upper Crooked River Sub-basin
Monthly Net Water Availability cfs (water available= net streamflow at 80% exceedance level- consumptive use- instream rights)

Location (water availability basin)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bear Creek	-5.48	-11.7	-28.7	-29.1	-26.7	-16.9	-5	-2.4	-2.51	-1.96	-1.1	-3.09
Crooked River (below Sand Creek)	19	81	140	294	-79	-109	-55	-52	-50	-26	7.6	21.5
North Fork C.R. (above Deep Creek)	-6.6	-28.4	2	164	9	-41	-16	-21	-21	-13.7	-9.21	-10.36
Deep Creek	-15.7	-27	-51	-3	-26	-7	0	-0.9	-0.5	-1.5	-3.2	-8
North Fork C.R. (below Deep Creek)	-11.47	-34.4	-33	48	-71	-83	-27	-18	-19	-10.7	-5.48	-13.53
Peterson Creek	-2.22	-3.2	-6.26	0.7	-4.3	-0.8	-1.2	-0.64	-0.73	-0.48	-0.39	-0.95
Johnson Creek	-2.32	3.8	8	35	-45	-47	-15	-10.6	-13.2	-8.4	-3.04	-4.15
North Fork C.R. (below Johnson Crk)	-1.61	-5.21	-4.2	19.9	-16	-24.8	-7.4	-3.6	-3.6	-2.2	-1.11	-0.81
Camp Creek	4.4	9.3	12.5	11.1	-10.3	-9.9	-2.7	-1.3	2.1	2.1	5	5.5

Source: Oregon Water Resources Department. 1998

Appendix 5-A: ICBEMP Range Condition Summary

Range Clusters/Variables	Crooked River Basin
Primary Characteristics	▪ Highest level of juniper woodlands ▪ High road densities ▪ Low forest, range, and composite integrity ▪ Moderate aquatic and hydrologic integrity ▪ Fire regimes are more severe
Primary Risks to Ecological Integrity	▪ Juniper encroachment into shrubland ▪ Forage for ungulates (wild/domestic) reduced through woodland encroachment ▪ Noxious weed expansion
Primary Opportunities to Address Risks to Integrity	▪ Reduction of forest stocking could improve forage/cover relationships for livestock and big game ▪ Curtailment of juniper expansion ▪ Curtailment of noxious weed expansion ▪ Mgt. of riparian areas to enhance stream bank stability and riparian vegetation

Source: ICBEMP. 1997

Appendix 5-B: ICBEMP Forest Condition Summary

Forest Clusters	Upper Crooked River Sub-basin	Lower Crooked River Sub-basin
Primary Characteristics	▪ Dry forest types ▪ Low to moderate aquatic integrity ▪ Low forest integrity ▪ Low composite integrity ▪ Sensitive watersheds to disturbance ▪ Highly roaded	▪ Dry forest types ▪ Low hydrologic, forest, and composite integrity ▪ Moderately roaded
Primary Risks to Ecological Integrity	▪ Fish strongholds from sediment/erosion potential ▪ Forest composition and structure, especially old/late ▪ Hydrologic integrity due to fire severity and intensity	▪ Forest composition and structure, especially old/late ▪ Old/late primarily present at finer resolutions
Primary Opportunities to Address Risks to Integrity	▪ Restoration of forest integrity through forest mgt. ▪ Maintenance of scattered aquatic strongholds that exist ▪ Restoration of old/late forest structure ▪ Restoration of aquatic and hydrologic integrity by reducing the risk of fire, insect, and disease and road mgt.	▪ Restoration of forest structures ▪ Reduction of risk of fire, insect, and disease

Source: ICBEMP. 1997

Appendix 6-A: Riparian Zone Plant Associations of the Ochoco Mountains

Sagebrush/Cusick Bluegrass Association: Common in Ochoco Mountain physiographic area and basin and range physiographic areas. Occurs in broad, low gradient floodplains at low to moderate elevations on dry terraces and inactive floodplains and the dry margins of mid elevation meadows.

Mountain Alder Associations: Common in Ochoco mountain physiographic area. low to moderate elevations (2400-5600 feet), sites are young, seral, active channel shelves between active and flood stage streambanks along second order and large streams in moderately graded valleys.

Mountain Alder/Common Snowberry Association: Common in Ochoco Mountain physiographic area. Low to moderate elevations (2400-5600 feet), sites are well developed banks, overflow channels, and channel shelves, along second order and large streams in moderately graded valleys.

Willow/Aquatic Sedge: Common at higher elevations on the Ochoco National Forest but has largely been degraded to the Kentucky Bluegrass community type. Narrow, low to moderate floodplain s in upper elevational reaches.

Willow/Wooly Sedge Association: Found in Ochoco Mountain and basin and range physiographic areas. More common farther south. Occurs on low gradient floodplains at moderate elevation (4400-5500) on active overflow channels and floodplains.

Tufted Hairgrass Association: One of the most common throughout all of Central Oregon. Broad elevational and geographic distribution.

Aquatic Sedge: Fairly common at high elevations in Ochoco Mountain physiographic area. Found on moist to wet, flat or concave meadows, also along beaver ponds and lakes. Normally 6000-6800 feet elevation.

Inflated Sedge Association: Wide geographic and elevational distribution, in most low gradient landforms. Saturated soils.

Beaked Sedge Association: Wide geographic and elevational distribution, in most low gradient landforms on wet fluvial surfaces (streambanks, floodplains, overflow channels, marshes, fens) low to moderately high elevation (4000-6000 ft).

Creeping Spikerush Association: Found throughout central Oregon in wide range of elevations (3000-6800ft), riparian landforms, and physiographic areas. Low valley gradient and standing water characteristics.

Mountain Alder (queencup beadlily): Common in narrow banks of 1st order streams in moderate to steeply graded, mesic, v-shaped valley landforms. Elevations low to moderate (3200-5800ft), narrow riparian zone.

Source: Kovalchik. 1987

Appendix 6-A: Riparian Zone Plant Associations of the Ochoco Mountains

Abundant Riparian Plant Associations and Communities

Pondersoa Pine/Common Snowberry Community: Floodplain habitat, low to moderate elevation (2700-4700ft) in moderately broad, moderate gradient floodplain channels. Abundant association. Abundant in Ochoco Mountain physiographic area.

Willow/Kentucky Bluegrass Community: Occurs on sites of various potential that have been altered by grazing and/or lowering of the water table. Major community type in Ochoco Mountain and basin and range physiographic areas.

Kentucky Bluegrass Community Type: Abundant in Ochoco Mountain physiographic area occupies sites of various potential formerly occupied by: willow/wooly sedge, willow/aquatic sedge, and ponderosa pine common snowberry. 3000-5000 feet. Gently sloped floodplain habitats.

Wooly Sedge Association: Abundant in Ochoco Mountain physiographic area. Most common on active fluvial surfaces within low gradient low to moderate elevation (4400-5500 feet) floodplains.

Nebraska Sedge: Abundant throughout CO east of Cascade Mountains. Low to moderate elevation (4000-5500). Occurs on a wide variety of landforms once occupied by other sedge communities (beaked, inflated, widefruit, wooly and tufted hairgrass associations).

Common Riparian Plant Associations and Communities

Lodgepole Pine/Kentucky Bluegrass Community: Common association in the Ochoco Physiographic area, abundant in pumice-mantled basin and range areas. Occurs on a variety of sites where the ecological potential has been altered (grazing, lowering of water table, etc.).

Lodgepole Pine/Aqautic Sedge Community: Locally common at higher elevations in the Ochoco Mountain physiographic area. Elevation from 4600-6800 feet. Association found in landforms supporting ponds and lakes, forested basins and active floodplains.

White Fir/ Quenncup Beadlily Community: Common in the Ochoco Mountain physiographic area. Occurs in inactive floodplains, toeslopes. Relatively low elevation, warmer sites. Transitional association.

Quaking Aspen/Common Snowberry/Wild Rye: Association common in Ochoco Mountain physiographic area. Elevation low to moderate 3600-5800 feet.

Quaking Aspen/Blue Wildrye: Common Ochoco Mountain physiographic area. 4400-4900 feet elevation.

Source: Kovalchik. 1987

Appendix 6-A: Riparian Zone Plant Associations of the Ochoco Mountains

Uncommon Riparian Plant Associations and Communities

Willow/Beaked Sedge: Minor association on the Ochoco Mountain physiographic area

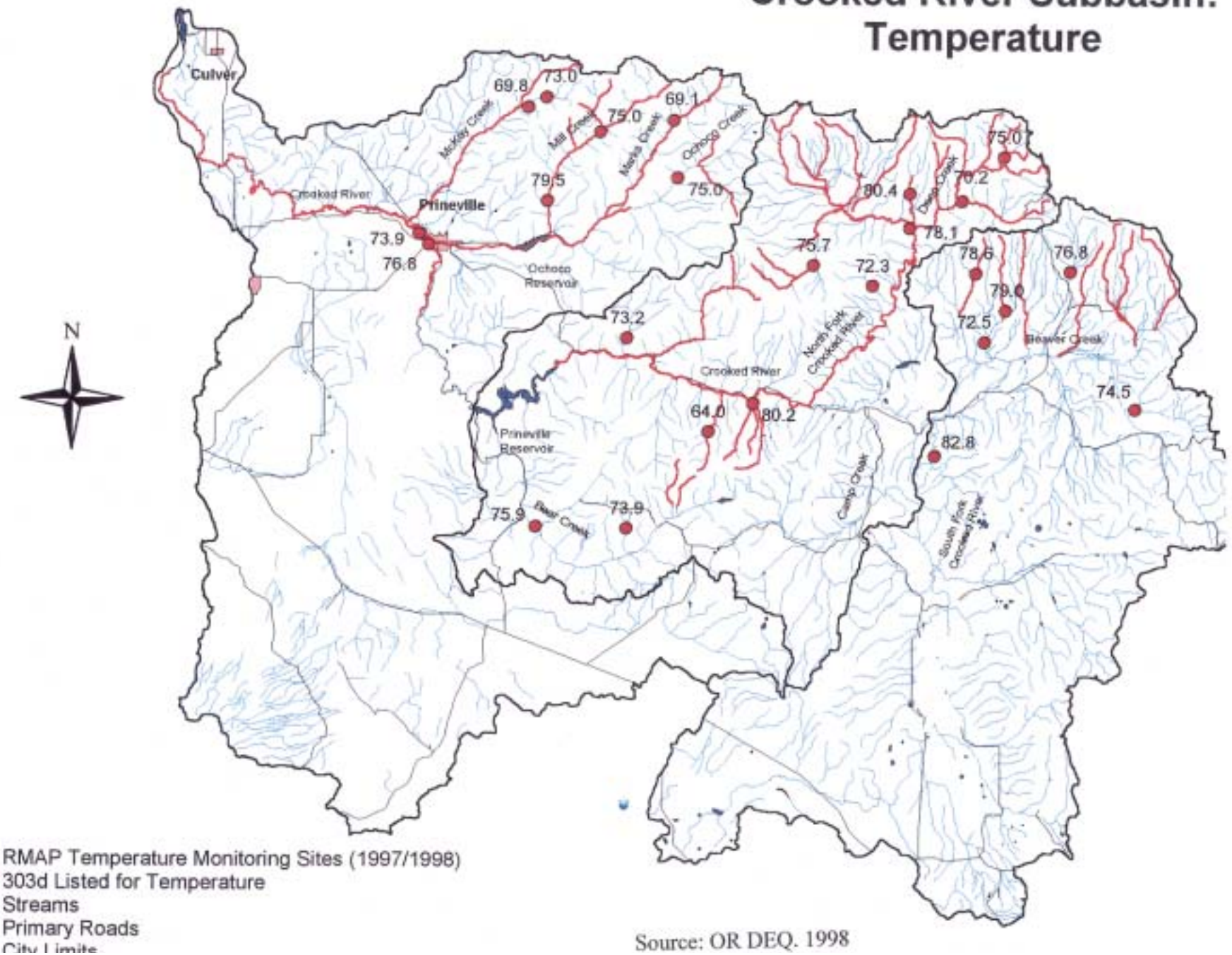
Short Beaked Sedge: Not common but scattered throughout central Oregon. Flat to gently sloping bog-like meadows (requires high groundwater, cold temperatures). Toeslopes or edges of meadows.

Bigleaf Sedge (small fruit bullrush): Infrequent in Ochoco Mountain physiographic area. Low to moderate elevation (2500-5700 feet). Active channels, floodplains, wet meadows.

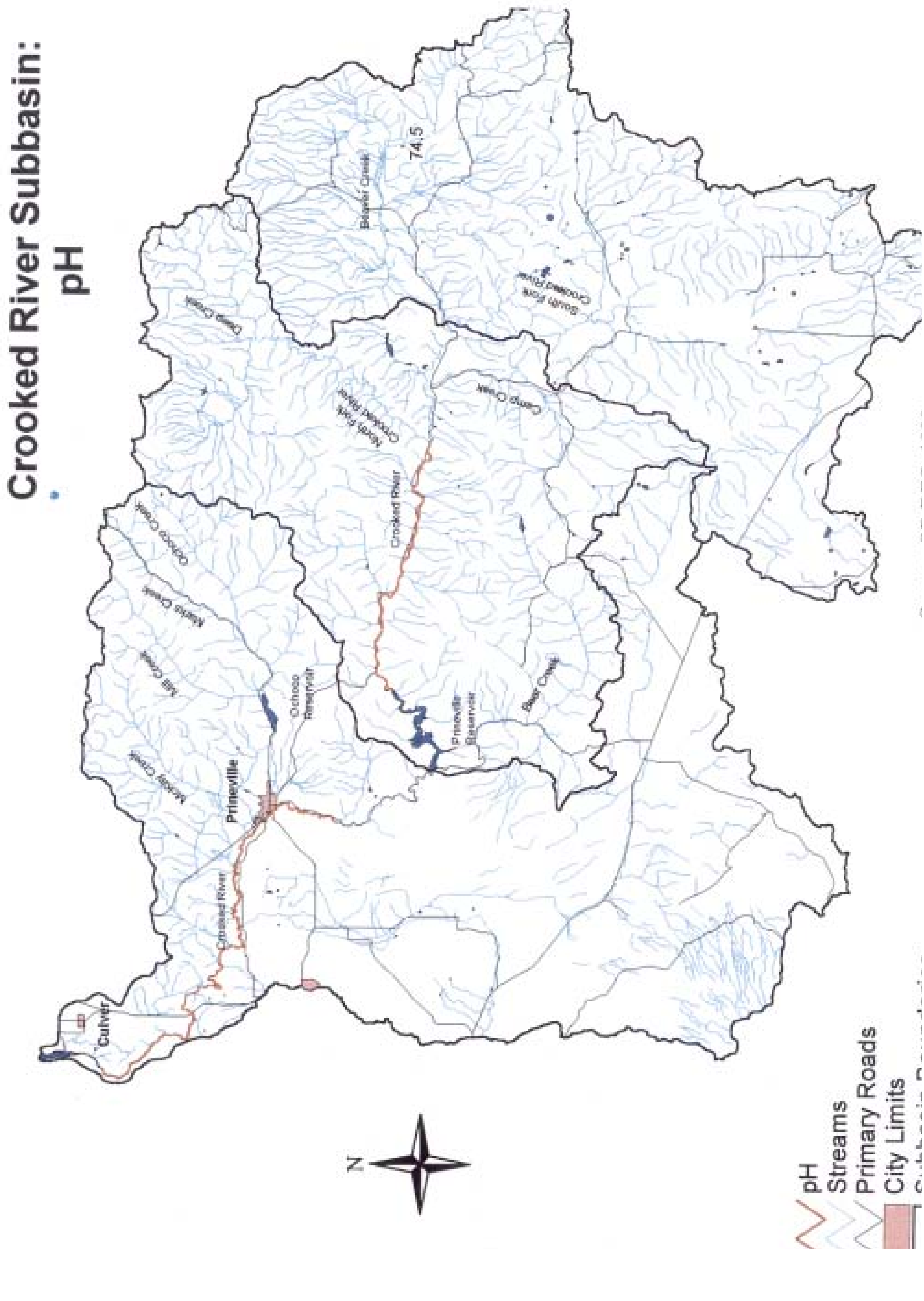
Arrowleaf Grounsel: Very rare within the Ochoco Mountain physiographic area. Occurs in narrow banks of 1st order streams in moderate to steeply graded, mesic, v-shaped valley landforms. Elevations moderate to high (5300-6400), narrow riparian zone.

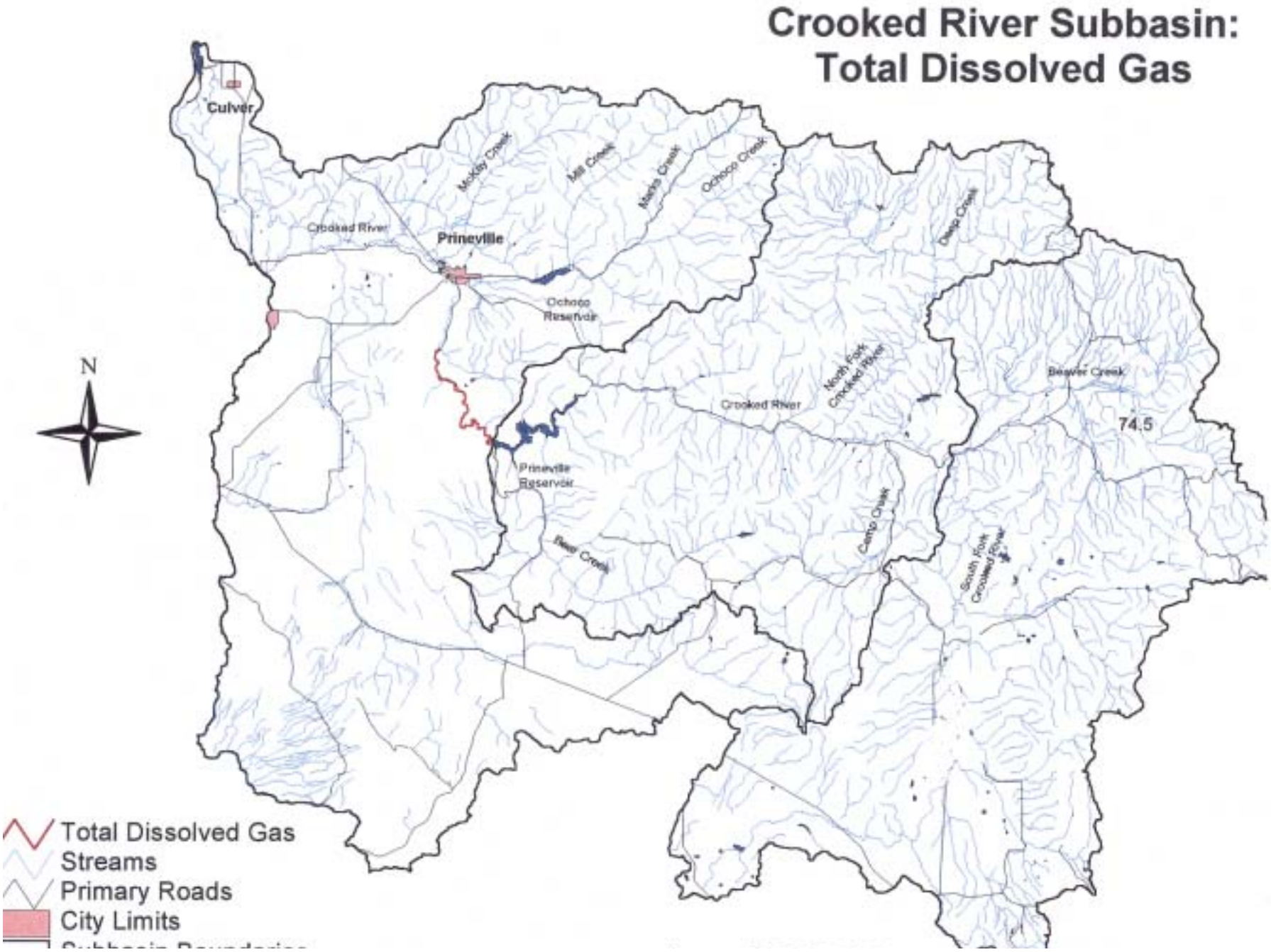
Source: Kovalchik. 1987

Crooked River Subbasin: Temperature

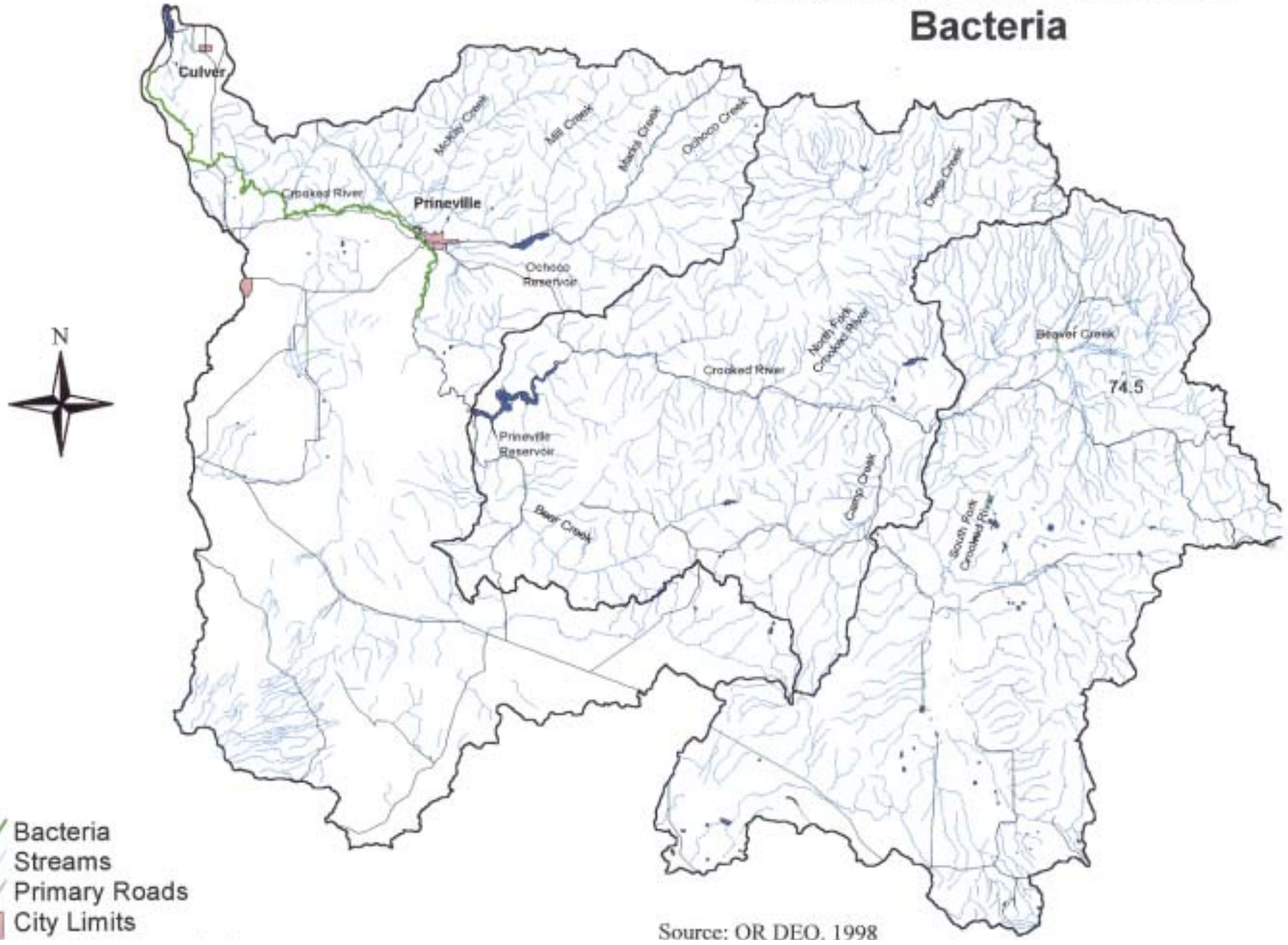


Source: OR DEQ. 1998


Crooked River Subbasin:
pH
74.5
Beaver Creek
South Fork Crooked River
Deep Creek
North Fork Crooked River
Camp Creek
Crooked River
Ochoco Creek
Marks Creek
Mill Creek
Ochoco Reservoir
Prineville Reservoir
Bear Creek
McKay Creek
Prineville
Crooked River
Culver
N
pH
Streams
Primary Roads
City Limits


Crooked River Subbasin:
Total Dissolved Gas
Culver
Prineville
Ochoco Reservoir
Prineville Reservoir
Crooked River
North Fork Crooked River
South Fork Crooked River
Beaver Creek
Deep Creek
Camp Creek
Mill Creek
Ochoco Creek
74.5
N
Total Dissolved Gas
Streams
Primary Roads
City Limits

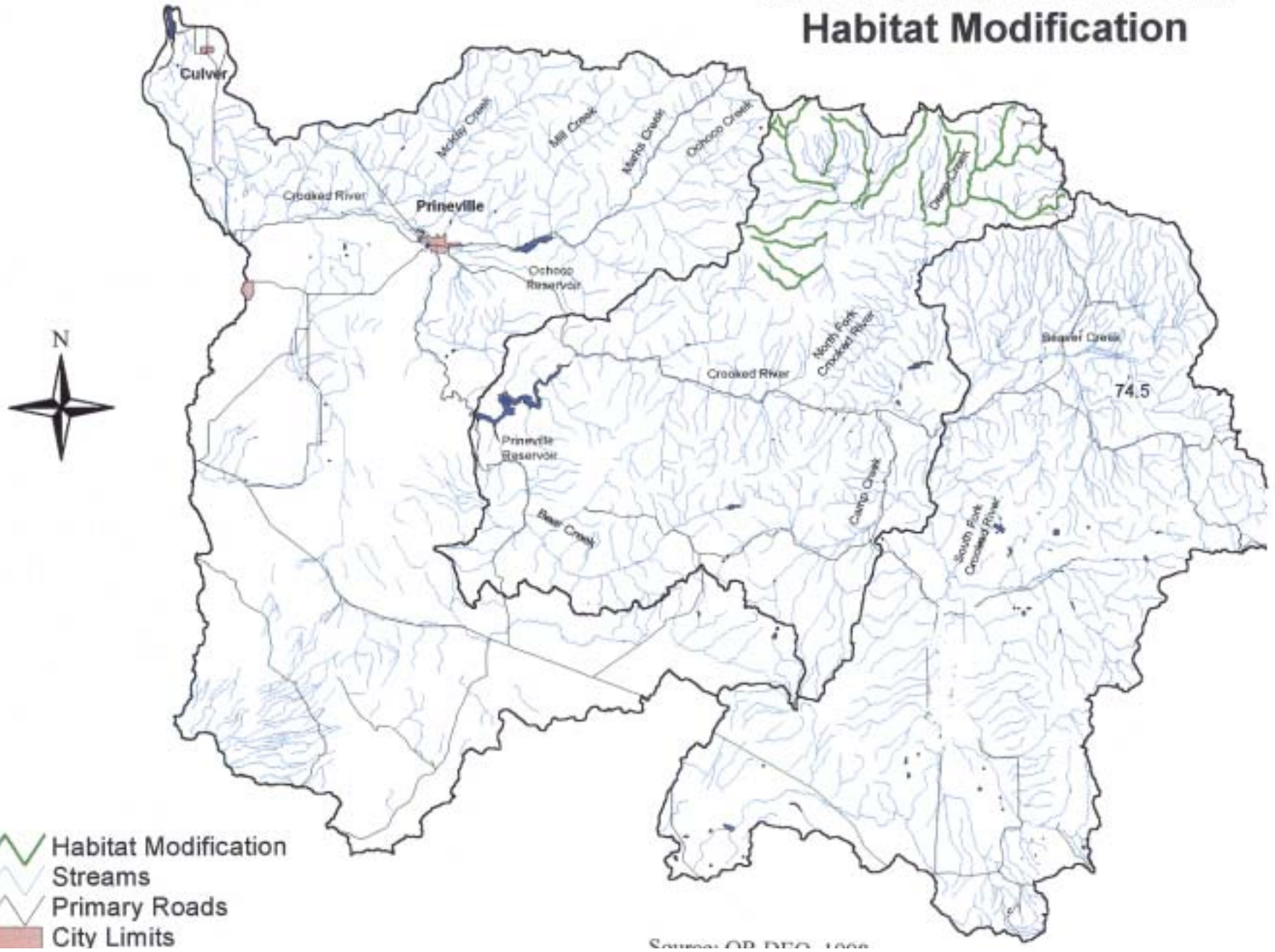
Crooked River Subbasin: Bacteria



Source: OR DEQ. 1998

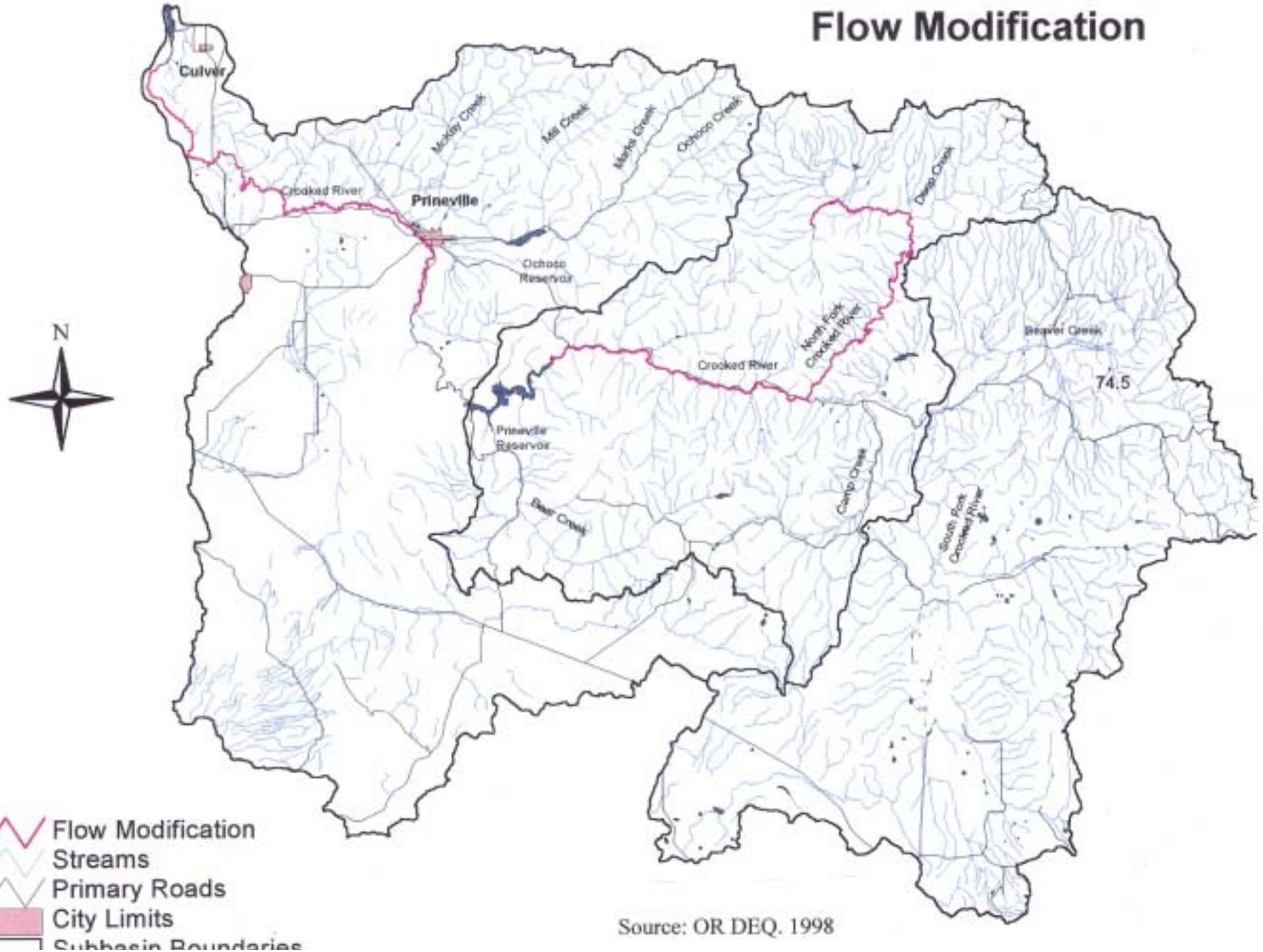
Appendix 7-A: Water Quality Limited Streams

Crooked River Subbasin: Habitat Modification



Source: OR DEQ, 1998

Crooked River Subbasin: Flow Modification



Source: OR DEQ. 1998

Appendix 7-B: Lower Crooked River Sub-basin Water Chemistry

Site Name	Crooked River	Crooked River revisited	McKay Creek	Little McKay Creek	Marks Creek	Mill Creek	Mill Creek	Ochoco Creek
Rivermile	47.2	47.2	14.3	1.3	13.3	11.9	3	32.3
REMAP #	97-28	97-28	98-40	97-20	97-26	98-39	98-36	98-38
Date	9/8/97	9/22/97	9/14/98	7/14/97	7/29/97	7/28/98	7/28/98	9/16/98
Time	1545	1430	1323	1220	1120	1600	915	830
Temp (C)	18.4	18.4	14.7	15.7	16	19.7	16.6	13.2
DO (mg/l)	12.6	12.9	8.7	9.5	9.2	7.4	9.1	8.1
DO (%Sat)	147	150	97	108	107	91	103	87
BOD-5 (mg/l)	1.7	.4	3.9	1	1.3	.05	.6	.7
PH	8.8	8.8	8	8.3	8.1	8	8	7.8
T. Solids (mg/l)	78	200	150	130	200	120	120	180
Ammonia (mg/l)	.04	.03	.01	.04	.02	.02	.02	.01
Nitrate (mg/l)	.03	.06	.03	.03	.02	.02	.01	.02
T. Phosphorus (mg/l)	.08	.09	.06	.09	.02	.04	.05	.03
Water Quality Index*	78	75	77	87	90	90	94	92
Turbidity	10	12	2	2	2	2	2	1

*Water Quality Index:
0-59= very poor, 60-79= poor, 80-84= fair, 85-89= good, 90-100= excellent

Source: OR DEQ. 1999

Appendix 7-B: Upper Crooked River Sub-basin Water Chemistry

Site Name	Bear Creek	Bear Creek Revisited	Bear Creek Revisited	Bear Creek	L. Bear Creek	L. Bear Creek	L. Bear Creek revisited	Cow Creek	Cow Creek revisited
Rivermile	15.4	15.4	15.4	17	8	1.5	1.5	2.4	2.4
REMAP #	97-17	97-17	97-17	98-22	97-59	97-65	97-65	97-03	97-03
Date	7/15/97	9/17/97	8/17/97	7/7/98	9/23/97	9/17/97	10/1/97	7/16/97	9/24/97
Time	1413	1500	1510	930	1300	1105	1010	1335	1240
Temp (C)	26.1	14	18.2	16.8	12	10.3	11.3	20.9	14
DO (mg/l)	9.9	8.5	10.2	8.6	8.9	9.3	8.9	8.5	9.4
DO (%Sat)	136	110	121	101	96	95	91	110	106
BOD-5 (mg/l)	1.3	.6	.1	.6	.2	.3	.2	.1	.1
PH	8.8	8.5	8.6	8.4	8.3	8.4	8.4	8.5	8.3
T. Solids (mg/l)	420	520	460	460	280	380	400	350	390
Ammonia (mg/l)	.04	.03	.01	.03	.03	.04	.05	.02	.08
Nitrate (mg/l)	.02	.07	.01	.03	.02	.02	.02	.02	.02
Total Phosphorus (mg/l)	.03	.13	.03	.1	.06	.09	.05	.01	.02
Water Quality Index*	**62**	**75**	**80**	**80**	**89**	**84**	**85**	**84**	**87**
Turbidity	2	28	2	24.7	2	27	1	2	3

*Water Quality Index:
0-59= very poor, 60-79= poor, 80-84= fair, 85-89= good, 90-100= excellent

Source: OR DEQ. 1999

Appendix 7-B: Upper Crooked River Sub-basin Water Chemistry

Site Name	Wildcat Creek	Wickiup Creek	L. Summit Creek	Jackson Creek	Fox Creek	Porter Creek	Grey Creek	Fox Canyon Creek
Rivermile	.6	1.6	.4	6	2.6	3.4	.01	2.6
REMAP #	98-09	97-30	97-01	98-.1	98-31	98-34	98-33	97-23
Date	7/23/98	8/27/97	7/30/97	8/4/98	8/4/98	8/5/98	9/15/98	8/26/97
Time	846	955	1245	920	1716	840	913	925
Temp (C)	16.7	15.2	18.2	14.5	19.9	13.6	9.9	13.4
DO (mg/l)	7.5	9	8.5	8.1	7.2	8.6	9.5	3
DO (%Sat)	86	98	106	95	93	96	100	33
BOD-5 (mg/l)	.9	.8	.4	.3	.5	05	.02	.7
PH	8.3	8.4	8.4	7.8	7.9	7.6	8.2	7.2
T. Solids (mg/l)	250	290	120	110	100	90	130	140
Ammonia (mg/l)	.02	.01	.02	.01	.01	.01	.01	.04
Nitrate (mg/l)	.01	.02	.02	.01	.04	.01	.01	.02
T. Phosphorus (mg/l)	.04	.04	.02	.02	.02	.03	.02	.02
Water Quality Index*	**86**	**87**	**91**	**95**	**90**	**97**	**96**	**26**
Turbidity	4	3	2	2.5	2	1	4	1

Source: OR DEQ. 1999

*Water Quality Index:
0-59= very poor, 60-79= poor, 80-84= fair, 85-89= good, 90-100= excellent

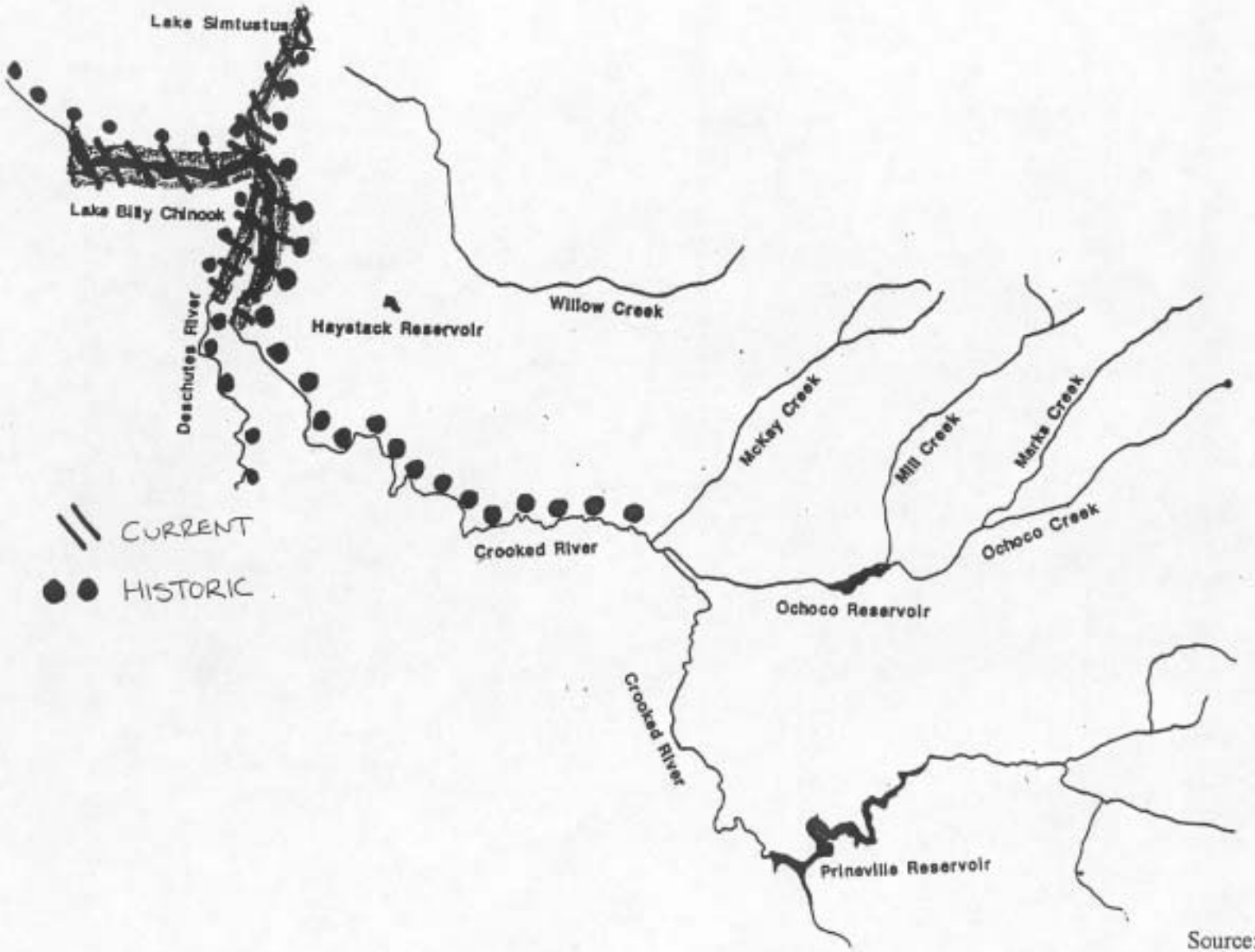
Appendix 7-B: Beaver South Fork Sub-basin Water Chemistry

Site Name	Dry Paulina Creek	Dry Paulina Creek	S.F. Beaver Creek	S.F. Crooked River	Wolf Creek	Roba Creek
Rivermile	2.6	3.9	6.5	6.1	11.7	3.9
REMAP #	97-63	97-12	98-12	98-10	98-14	97-10
Date	7/22/97	7/22/97	7/15/98	8/18/98	7/14/98	7/28/97
Time	1420	910	1835	1710	1738	1710
Temp (C)	23.8	18.1	23.1	23.1	22.7	21
DO (mg/l)	9.9	3.9	7.1	10.3	7.3	-
DO (%Sat)	132	47	94	135	96	-
BOD-5 (mg/l)	1.9	3	.7	.7	.6	-
PH	8.3	7.5	8.4	9.9	8.3	8.4
T. Solids (mg/l)	150	150	300	310	120	170
Ammonia (mg/l)	.03	.04	.01	.02	.01	.03
Nitrate (mg/l)	.02	.04	.01	.01	.01	.02
T. Phosphorus (mg/l)	.04	.06	.03	.05	.03	.04
Water Quality Index*	**75**	**49**	**79**	**63**	**83**	**85**
Turbidity	4	5	4.3	2	.43	1

Source: OR DEQ. 1999

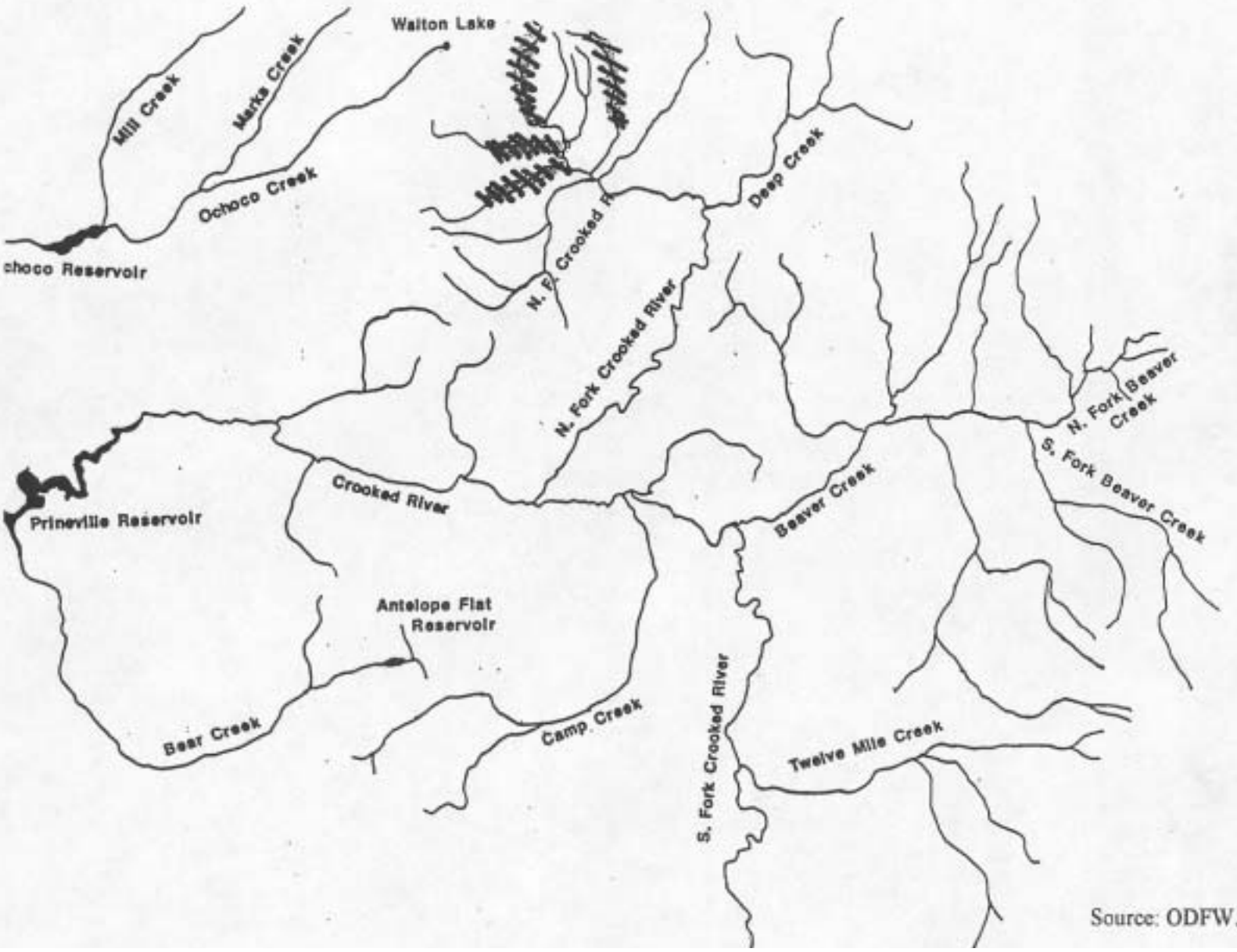
*Water Quality Index:
0-59= very poor, 60-79= poor, 80-84= fair, 85-89= good, 90-100= excellent

Appendix 8-A: Historic and Current Bull Trout Distribution



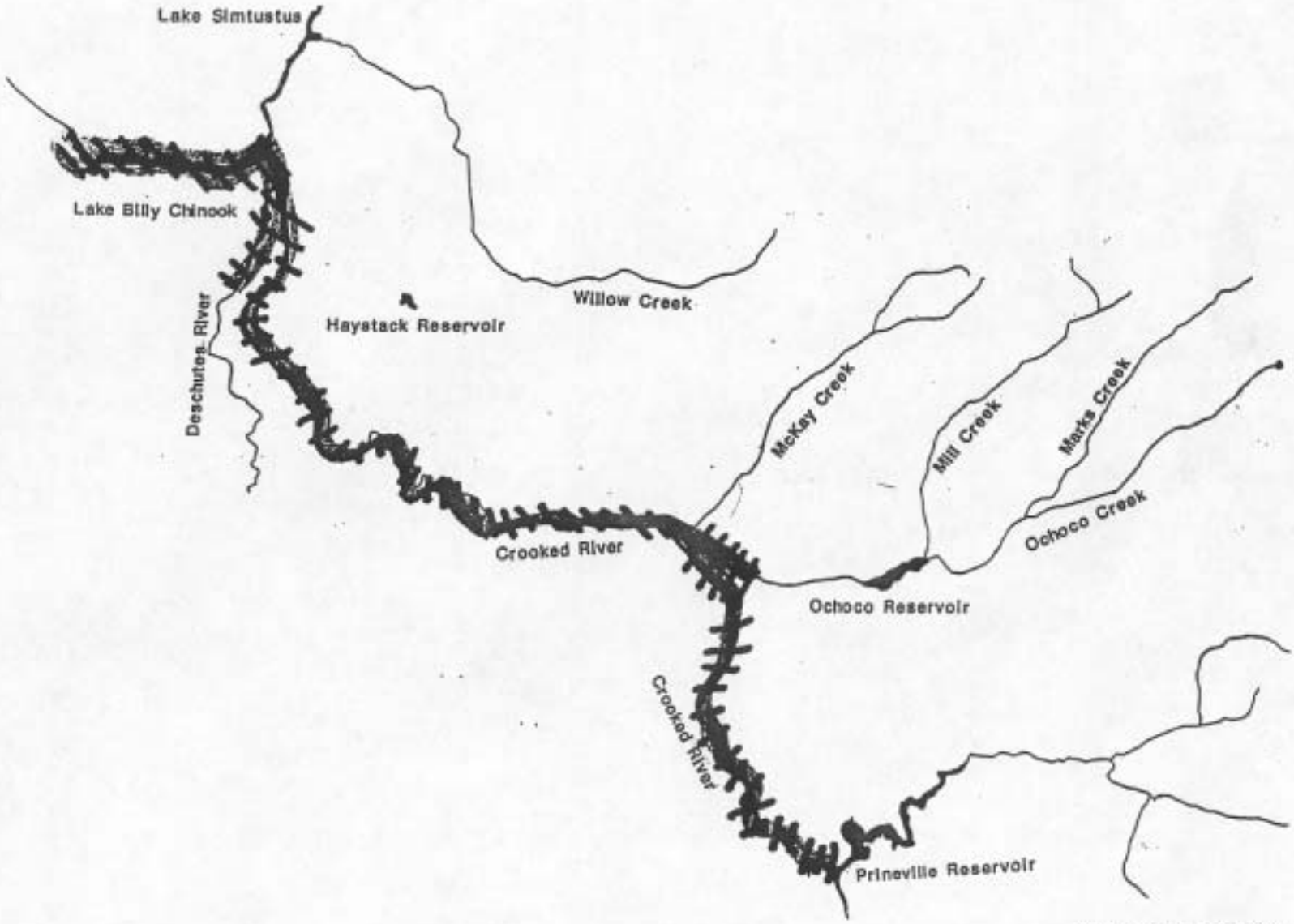
Source: ODFW. 1990

Appendix 8-B: Current Brook Trout Distribution



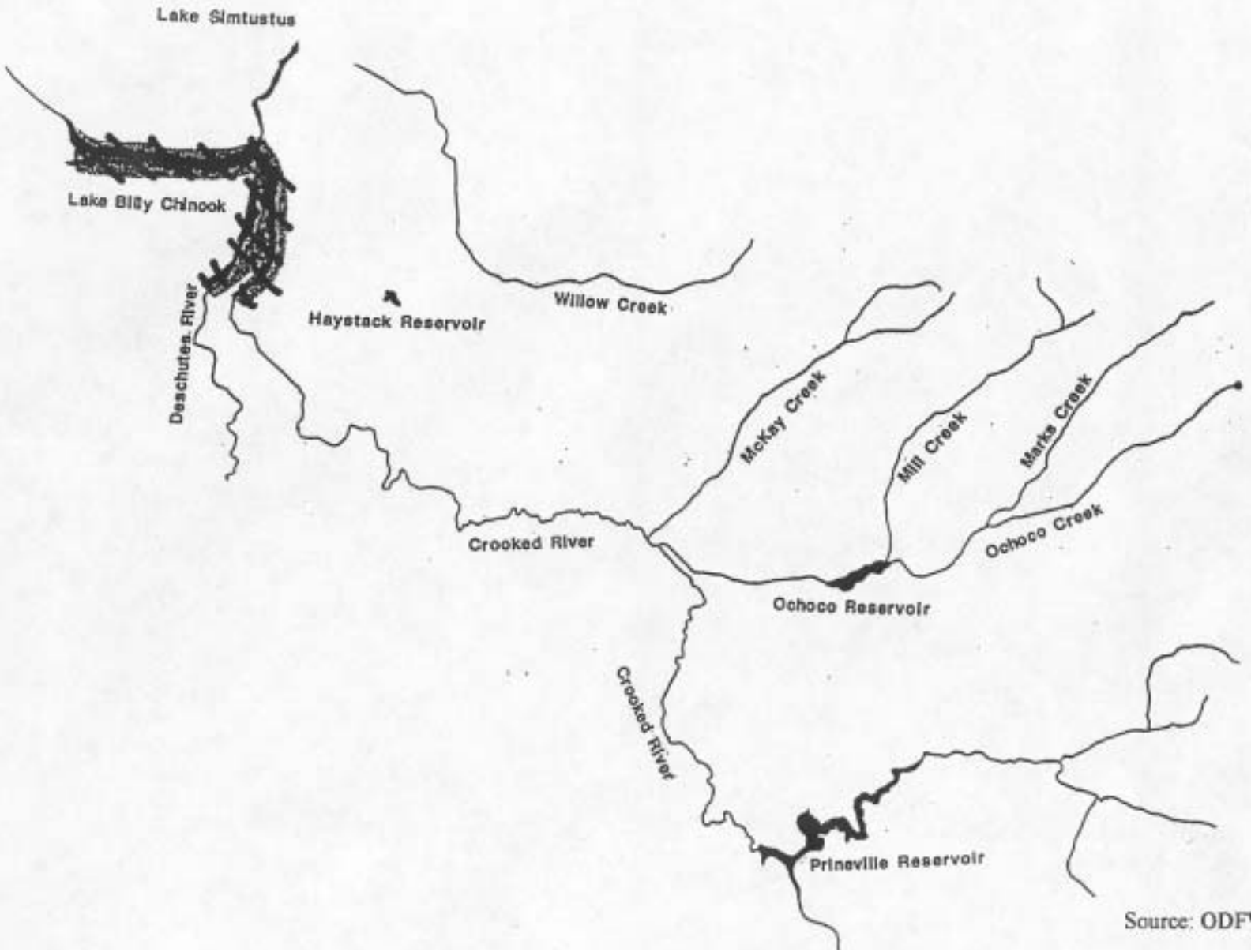
Source: ODFW, 1990

Appendix 8-C: Current Mountain Whitefish Distribution



Source: ODFW, 1990

Appendix 8-D: 1990 Chinook Salmon Distribution



Source: ODFW, 1990

Appendix 8-E Wild Redband Trout Populations

Location/Population	Compliance with Wild Fish Management Policy	
	< 10% Hatchery Spawners	> 300 Spawners
Crooked River below Bowman Dam	no	yes
Willow Creek above Madras	yes	unknown
Willow Creek below Madras	unknown	unknown
Ochoco Creek above Ochoco Dam	unknown	yes
Ochoco Creek below Ochoco Dam	unknown	unknown
Marks Creek	unknown	unknown
Bingham Springs/Desolation Creek	yes	unknown
Bear Creek below Antelope Flat Reservoir	unknown	unknown
Bear Creek above Antelope Flat Reservoir	unknown	unknown
Crooked River above Bowman Dam	unknown	unknown
N.F. Crooked River below Lower Falls	Yes	unknown
N.F. Crooked River between Lower Falls and Upper Falls	yes	unknown
N.F. Crooked River above Upper Falls	yes	yes
Deep Creek	yes	yes
Peterson Creek	yes	yes
Allen Creek	yes	yes
Big Summit Prairie tributaries	yes	yes
Horseheaven/Buck creeks	yes	yes
Sheeprock Creek	yes	unknown
Pine Creek	yes	unknown
Drake Creek	yes	unknown
Camp Creek	yes	unknown
S.F. Crooked River	unknown	no
Beaver Creek and tributaries	yes	yes
Rager Creek	yes	unknown
Dry Paulina Creek	yes	unknown

Source: ODFW, 1996