Little Deschutes River Subbasin Assessment

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Prepared for

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Little Deschutes River Subbasin Assessment
Summary

The purpose of the assessment is to use existing information to characterize historical and current watershed conditions for the Little Deschutes River Subbasin. The assessment findings will help the Upper Deschutes Watershed Council (UDWC) and others identify opportunities for voluntary actions to improve fish and wildlife habitat and water quality.

Many of the impacts to fish and wildlife habitat and water quality in the Little Deschutes River Subbasin are concentrated in the areas of housing, roads, and other human development. Most of the human population in the subbasin is concentrated around the community centers of La Pine, Gilchrist, Crescent, and Crescent Lake. There is significant dispersed development along the lower reaches of the Little Deschutes River between the communities of Sunriver and La Pine – an area characterized by gentle topography and depressions with forested wetlands, marshes and shallow lakes. Streams in this area, as illustrated by the Little Deschutes River, are low gradient and originate in the high elevation areas in the southwest portion of the watershed where there is higher precipitation. This ownership pattern has significant implications for natural resource management, as lower gradient floodplain areas tend to provide important wetland, fish, and wildlife habitat.

Key Findings

Fuel Loading: Having homes safe from wildfires is a concern for many residents. Fire suppression has increased the amount of dry wood in the area, creating a ready source for major wildfires.

Riparian Areas and Wetlands: Loss of wetland and riparian areas, especially in the lower areas along the Little Deschutes River, has affected a number of resources. Water quality has been affected by the reduced wetlands that act as filters of nitrogen; the loss of streamside trees and other vegetation reduces shade that helps to cool water temperatures. Finally, loss of wetlands and riparian vegetation has reduced important fish and wildlife habitats.

Wildlife: The growth and development have altered wildlife habitats. Loss of wetlands, streamside vegetation, and other changes in the watershed have reduced important wildlife habitat. Roads and development have impacted migrating mule deer, increasing collisions between deer and cars and altering their migration pathways.

Fish: There has been a significant loss of native trout and an increase in introduced brook and brown trout in the Little Deschutes River and tributaries. Loss of native trout is from competition with introduced species and changes in aquatic habitat and water temperatures.

Water Quality: A major concern about the water in the river is unusually high temperatures in the summer and the abnormal growth of algae. Other studies indicated that there are problems with groundwater loading of nitrogen. The high water table and porous pumice soils contribute to increased nitrates, a by-product of septic systems and an indicator of human pathogens.

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1.0 INTRODUCTION

The purpose of the assessment is to characterize historical and current watershed conditions in the Little Deschutes River Subbasin and to assess the opportunities for improvements in wildlife and fish habitat and water quality. Funds to complete the assessment were provided to the Upper Deschutes Watershed Council (UDWC) by the Oregon Watershed Enhancement Board (OWEB). Watershed Professionals Network, LLC was awarded the contract to complete the assessment in April 2001.

Due to the limited budget the assessment was designed as a screening level technical assessment of the current status of the watershed. This assessment uses existing information, reports, and studies to draw conclusions about the status of the Little Deschutes River Subbasin. No additional new data, reports, or studies were completed as part of this effort. The objective was to clearly summarize what is known about the subbasin and its watersheds, what is not known, and what additional data are necessary to aid in identifying opportunities and priorities for watershed restoration projects. This assessment is a summary of all information that was made available to the contractors during the course of the assessment. In some cases, there was not enough information to address all of the identified critical questions. In these cases, the lack of detail is representative of the lack of available information.

1.1 Project Assumptions

The assessment, while providing an overview of the entire area, focused on the private land portions of the watershed, including unincorporated communities and rural residential areas. Most of these areas are concentrated in the lower portions of the watershed between LaPine and Sunriver. There were several reasons for emphasizing these areas: (1) most of the UDWC's conservation opportunities will be with small private landowners; and 2) while most upland areas are managed by public landowners where detailed analyses have been completed, there has not been an assessment of watershed resources for the scattered private lands. To provide a context for the private land analyses an overview of broader subbasin conditions was provided.

Additional assumptions include:

1. This is a screening-level assessment, with no new data collection or modeling efforts.
2. The assessment relied on existing data, aerial photography, and previously published reports.
3. There was no fieldwork.
4. The UDWC's coordinator was the primary contact to the contractor throughout the duration of the contract. This person was responsible for:

    - Communicating UDWC assessment priorities and other issues to the consulting team.
    - Facilitating the transfer of exiting information, including information, reports, GIS layers, describing watershed conditions, and resource status to the consulting team.
    - Assisting the contractors with gaining access to private lands for field reconnaissance.
    - Obtaining all metadata for GIS layers.

2.0 WATERSHED OVERVIEW

2.1 Physical Description

The Little Deschutes River Subbasin encompasses approximately 669,202 acres along the eastern edge of the Cascade Mountains in Central Oregon. Elevations in the subbasin range from 8,665 feet in the Cascade Mountains above Crescent Lake to 4,166 feet where the river joins the main Deschutes River approximately one mile south of Sunriver Resort. The Little Deschutes River Subbasin contains the following 5th field watersheds: 1) Newberry, 2) Little Deschutes, 3) Long Prairie, 4) Sellers, 5) Walker Mountain, 6) Upper Little Deschutes and 7) Crescent (Map 2-1).

The Little Deschutes River headwaters are within Klamath County and the river flows north into Deschutes County; a portion of the eastern edge of the subbasin is in Lake County. Major tributaries include Crescent and Paulina Creeks, and headwater tributaries Clover, Hemlock, Rabbit and Big Marsh Creeks (Map 2-2).

2.2 Geology

Large areas of deposited volcanic ash, pumice, and other sediments, characterize the Little Deschutes River Subbasin geology. The volcanic eruption from Mt. Mazama (Crater Lake) approximately 6,800 years ago contributed most of the sediments deposited in the basin. In addition, lava flows from the Cascade Mountains from the west and Newberry Crater from the east periodically dammed and shifted the course of the Deschutes River. These lava flows also created the La Pine Basin where volcanic material has been deposited, resulting in the relatively flat topography characteristic of the area. The deposited volcanic materials are highly permeable which creates coarse, rapidly draining soils and high groundwater tables (Deschutes County, 1998).

2.3 Ecoregions

Ecoregions are areas with similar landscape and physical features, climate, geology, soils, natural vegetation, and biotic communities. By identifying the ecoregions within a watershed, areas with unique geologic or vegetation characteristics are identified. This helps in understanding the range of variability in physical features occurring in the watershed (WPN, 1999).

The Little Deschutes River Subbasin contains five distinct ecoregions: 1) Pumice Plateau Forest, 2) Cold Wet Pumice Plateau Basins, 3) Cascade Crest Montane Forest, 4) High Southern Cascades Montane Forest, and 5) Cascade Crest Subalpine / Alpine. Table 2-1 describes the physical and biological characteristics of the ecoregions represented in the Little Deschutes River Watershed, and the distribution of the ecoregions is depicted in Map 2-3. The locations of ecoregions are largely influenced by elevation.

Approximately 86% of the watershed is within the Pumice Plateau Forest ecoregion and the Cold Wet Pumice Plateau ecoregion. The Cold Wet Pumice Plateau ecoregion is in the lower elevation areas adjacent to the Little Deschutes River. The Pumice Plateau Forest ecoregion is in the adjacent higher elevation areas.

Most of the private lands and development in the watershed are located in the Cold Wet Pumice ecoregion, which has gentle topography and depressions with forested wetlands, marshes, and shallow lakes. Streams in this ecoregion, as illustrated by the Little Deschutes River, are low gradient and originate in the high elevation areas in the southwest portion of the watershed where there is higher precipitation.

Ash deposits creating high undulating volcanic plateaus with isolated buttes dominate the Pumice Plateau Forest ecoregion. These areas have very low stream densities due to the porous nature of the soils.

The mountainous portions of the watershed along the Cascade Crest and the Paulina Crater are represented by the Cascade ecoregions, which occupy approximately 14% of the subbasin. These landscapes were formed by lava flows and glaciation. Precipitation in these ecoregions is double the precipitation in the lower elevation ecoregions; hence they contain higher densities of streams.

2.4 Federally Protected Areas

Sections of the upper Little Deschutes River and tributary streams are protected under the Federal Wild and Scenic Rivers Act (Act). In 1988 congress designated a 12-mile section (RM 84 to RM 97) at the headwaters of the Little Deschutes and a 10-mile section of Crescent Creek (from Crescent Lake dam downstream to County Road 61 crossing) as Wild and Scenic Rivers (Map 2-2). Big Marsh Creek from its headwaters to the confluence with Crescent Creek is designated as a recreation stream under the Act. The Forest Service has developed management plans for these streams that outline measures to protect and enhance key resource values cited in the Act's designation (Deschutes National Forest, 2001). The Wild and Scenic River plan includes resource management goals for scenery, vegetation, geology and hydrology, wildlife, fish habitat, recreation, roads and access, and water quality.

Table 2-1: Ecoregion descriptions for the Little Deschutes River Subbasin (WPN, 1999).

	Pumice Plateau Forest (9e)	Cold Wet Pumice Plateau Basins (9f)	Cascade Crest Montane Forest (4c)	High Southern Cascades Montane Forest (4e)	Cascade Crest Subalpine / Alpine (4d)
Percent of Watershed	52%	34% (Most private lands are in this ecoregion.)	10%	3%	1%
Geology	Geology dominated by Mount Mazama ash and pumice. Ash is underlain by basalt and andesite lava flows.	Geology consists of Mount Mazama ash underlain by river and lake deposits.	Geology consists of lava flows and pyroclastic deposits. Some glacial deposits.	Geology consists of andesite and basalt. Highly glaciated.	Geology consists of basalt and andesite, deposited as flows and as pyroclastic deposits. Highly glaciated.
Soils	Soils range from well-drained coarse loam to loamy course sand derived from ash and pumice.	Soils range widely from mucky silt loam to sandy loam.	Soils range widely from sandy loam to very cobbly loam.	Soils range from deep, very gravelly and stony loam to gravelly loamy coarse sand.	Soils are bare rock and rubble.
Erosion	Erosion Rate is low due to very high infiltration rates and low precipitation.	Erosion rate is low due to very high infiltration rates and low precipitation. These are depositional areas.	Erosion rate is low due to competent geology and gentle slopes on the plateaus. Shallow landslides occur on the slopes of steep buttes and cones.	Erosion rate is low due to competent geology and gentle slope on the plateaus.	Erosion rates are moderate and occur mostly in the form of ravel and avalanches.
Mean annual precipitation	16 to 30 inches	20 to 25 inches.	55 to 80 inches.	45 to 70 inches.	70 to 90 inches.
Dominant Upland Vegetation	Forests: Lodepole pine on flats and in the depressions and ponderosa pine on the slopes.	Lodgepole pine, forested wetlands (willow and lodgepole pine), wetland and meadow vegetation (such as tules, sedges and tufted hairgrass).	Mountain hemlock, Pacific silver fir, Engelmann spruce, and lodgepole pine forests.	Mountain hemlock, Pacific silver fir, white fire, and lodgepole pine forests	Mountain hemlock, subalpine fir forests, subalpine meadows and rock.
Natural Disturbances	Frequent, low-intensity fires were common in ponderosa pine forests in the past, but fire suppression has reduced fire frequency.	Bark beetles periodically kill a majority of the lodgepole pine near streams and marshes.	Infrequent fires.	Infrequent fires.	Avalanches and fires comprise the major disturbances. Infrequent fires are also a disturbance agent.

3.0 HISTORIC CONDITIONS ASSESSMENT

3.1 Critical Questions

The goal of this section is to describe and summarize information on early development of the watershed and resource management activities. The following critical questions are answered in this section:

1. What are historical trends and locations of land use and other management impacts within the subbasin?

2. What are historical accounts of fish and wildlife populations and distributions in the subbasin?

3. Where are the locations of historic floodplain, riparian area, channel, and wetland modifications and what were the types of disturbance?

3.2 Historical Conditions and Trends

This section provides an overview of historical conditions in the Little Deschutes River Subbasin. The historical record is summarized here to provide insights into what the area looked like at the time of Euro-American exploration and settlement, and to gain an understanding of how human uses have modified the watershed through time.

For the purpose of this description, the history of the Little Deschutes River Subbasin is divided into four time periods: The Native American landscape, settlement, timber communities, and the transition to modern times (Table 3-1). Watershed conditions during each of these historical periods are described based on evidence from written and verbal first-hand accounts and summaries of explorers and watershed residents, resource inventories, maps, drawings, and photographs.

Table 3-1: Little Deschutes River Subbasin assessment historical time periods

Dates	Period
Pre-Columbian to 1870	Native American landscape
1870 to 1930	Settlement
1931 to 1950	Timber communities
1951 to 1980	Transition to modern times

The four historical periods set the context for understanding current conditions and land use patterns in the subbasin. By the 1980's many of the existing land use activities and other trends in the Little Deschutes River Subbasin were established.

3.2.1 *The Native American Landscape: Pre-Columbian to 1870*

Indigenous people have occupied the area surrounding the Little Deschutes River for approximately 9000 years (Robbins, 1997). At the time of Euro-American exploration, the native people of the area were primarily comprised of the Paiute band, which occupied a large area from southeastern Oregon into Nevada, Idaho, and western Utah. The lifestyle of the Paiutes was considerably different from many of the other bands in the Pacific Northwest who occupied areas for long periods with a stable supply of salmon. The Paiute's high-plains existence required that they migrate further and more frequently for game, and fish was not an important part of their diet. Deer were a principal economic resource, and productive habitat was maintained through intentional burning, a practice which also improved the productivity of huckleberries and certain root crops (Robbins, 1997). These burning practices and lightning-caused fires helped maintain open stands of ponderosa pine and other trees.

The open stands of large trees were noted by early explorers. In 1843 Lieutenant John Fremont's expedition crossed through the Little Deschutes River Subbasin near the present community of Crescent. He wrote in his journal: "The great beauty of the country in summer constantly suggested itself to our imaginations… the rich soil and excellent water surrounded by noble forests made a picture that would delight…these [ponderosa] pines are remarkable for the red color of their boles…all day we traveled over pumice stone; beautiful firs but no grass here" (Gray, 1986, p. 2).

Another traveler through the area observed in 1865: "Upon the sides and generally upon the tops of these buttes and over the surrounding county of the Deschutes and to the east and north, the timber is generally black pine [lodgepole]. There is very little undergrowth in this or the yellow [ponderosa] pine forests…" (Gray, 1986, p. 2).

Due to a series of falls, the upper Deschutes River, including the Little Deschutes River, was not accessible to anadromous salmonids, such as chinook salmon and steelhead. Thus fish species in the Little Deschutes River during the time of early exploration were resident species of trout and sculpin, including redband trout, bull trout, mountain whitefish, and reticulate sculpin (Fies *et al.*, 1996). There are also historical accounts of bull trout occurring in Crescent Creek and Crescent Lake (Fies *et al.*, 1996). The last record of a bull trout in Crescent Lake was in 1979 (USFS, 1997).

In addition to fires, the landscape and vegetation of the Little Deschutes River Subbasin was subject to periodic floods and volcanic eruptions. The enormous volcanic eruption of Mt. Mazama (Crater Lake) approximately 6,800 years ago left its deep ash and pumice deposits which are prominent features of the sub-watershed's landforms, soils, hydrology, and vegetation patterns. The largest flood in recorded history was probably the enormous regional flood of 1861, though there are very few recorded accounts of the impacts (Minear, 1999).

3.2.2 *Settlement: 1870 to 1930*

The Oregon Central Military Road (OCMR) was developed in the 1860s to provide military and public access from western Oregon into the eastern parts of the state (Friends of the La Pine Public Library, 2000). The road, which went over Willamette Pass, passed through the upper Little Deschutes River area near the town of Crescent and facilitated early settlement of the watershed. Traveling over much of the same route as today's Highway 58, the road was used by trappers, miners, and cattlemen and was the general route for horse and wagon going from Eugene to Klamath Falls or Prineville (Gray, 1986). Thomas Condon, while traveling on the OCMR in 1877 stated: "We had a fine view of Diamond Peak behind us…Summit Lake and Crescent Lake are very pretty bodies of water. I could see no life on their margins though I am told that fine trout abound in the latter lake" (Gray, 1986, p. 4).

By the latter part of the 1800s a number of families were living in the subbasin. Cattle grazing was a common activity. One individual observed: "There are several thousand acres of good meadow and good grazing lands along the Deschutes" (Gray, 1986, p. 4). In 1898 a number of families came to the area around present day Crescent to establish 160-acre homesteads along the Little Deschutes River (Gray, 1986). By 1911 La Pine had a population of 600, with 100 children in school (Deschutes County Historical Society, 1985). In 1912 one author noted that near La Pine "all of the good places along the river were taken up, and nothing but jack pine flats were left" (Ridgley, 1993, p. 59).

Supplies of water were important for continued operation of the homesteads. The limited waters supply led to the establishment of water rights from the river and tributary streams. In 1899, for example, Caldwell's Ranch on Paulina Prairie established "the right to use the waters now, or to be stored in Paulina Lake, to a height of about 8 feet above the normal lake outlet to supplement the regular flow of Paulina Creek, so as to deliver water for irrigation" (Friends of La Pine Public Library, 2000, p. 53). In 1910 or 1911, a dam was constructed at the outlet of Paulina Lake to supply irrigation water (Ridgley, 1993). In 1922, a small earth and wooden dam was constructed across the outlet of Crescent Lake to store irrigation water (USFS, 1997). In 1956, the Bureau of Reclamation further elevated the lake surface by constructing a 40-foot earth and concrete dam. This dam currently controls the lake levels and flow regime of Crescent Creek. There are extreme fluctuations in both systems, especially the creek (USFS, 1997).

Timber cutting in the upper Deschutes River Basin began around the turn of the century with the opening of mills around Bend in 1902. The mills were created to process timber from the "sole remaining virgin forest in the United States (The Deschutes Echo, Dec. 6, 1902, as reported in Minear, 1999). It was difficult to get the logs to the mills since water transport on the upper Deschutes River was limited by rapids, bends, and falls (Farnell, 1981). Despite these obstacles, the largest log drive occurred in May 1939 when 26 million board feet of timber were rafted on the Deschutes River from the vicinity of Wickiup Reservoir site to a mill near Bend, somewhat unsuccessfully (Farnell, 1981). This period was the beginning of timber cutting in and near the lower portions of the subbasin, though there are no records of large log drives on the Little Deschutes River.

3.2.3 *Timber Communities: 1931 to 1950*

Despite the stands of large ponderosa pine that were noted by early explorers and settlers, before 1934 most of the forests in the upper Little Deschutes River area were uncut. The 1923 construction of the railroad along the route of the Oregon Central Military Road and the beginning of construction of Highway 58 in 1934 provided a means for supply and shipping and sparked an interest in harvesting the uncut stands (Gray, 1986). In 1934, Deschutes Lumber Company began harvesting trees in the headwaters of the Little Deschutes River. The mill was located along the Little Deschutes River, which provided an ideal location, with water for the log pond, steam power for the mill, and water supplies for domestic use (Gray, 1986).

Timber cutting was not the only activity in the upper Little Deschutes River system. Cattle and sheep grazed throughout the area. One author noted that the summer of 1939 "brought sheepherders to the banks of the Little Deschutes River. The sheepmen came from as far Shaniko and Prineville. Sheepherders with their dogs would herd as many as 1,000 sheep up the meadows of the Deschutes to its headwaters around Clover Creek" (Gray, 1986, p. 30). Big Marsh was grazed by cattle from 1890 to 1917 and by sheep from 1917 to 1945 (USFS, 1997). In 1946, the owner installed six miles of diversion ditches to drain Big Marsh in order to provide better cattle grazing (USFS, 1997). One individual noted: "La Pine was a pretty wild place when all the loggers and sheepherders were in the area in the 1920's, 30's and 40's" (Friends of La Pine Public Library, 2000, p. 50).

Like most of the river systems of the west, non-native fish were introduced to the streams and lakes of the Little Deschutes River Subbasin. It is not known precisely when brown and brook trout were introduced into the Little Deschutes River system, but the timing was probably similar to the Deschutes River – in the early part of the century, certainly before the 1920's (Fies, *et al.*, 1996). The first fish stocking in Crescent Lake occurred in 1915 with the release of brook trout; lake trout were first released into the lake in 1917 (USFS, 1997). Brook trout continued to be stocked in the lake until 1939. Tui chub were introduced at an unknown time to Big Marsh Creek (Fies, *et al.*, 1996). Stocking of non-native fish species continued through the 1970s (Table 3-2).

Table 3-2: Fish species stocked in the Little Deschutes River by the Oregon Department of Fish and Wildlife, 1950 to 1974 (Fies et al., 1996).

Year	Species	Number
1950	*brook trout*	26,240
1954	*brook trout*	1,000
1969	*kokanee*	25,600
1970	*brown trout*	462
1974	*brown trout*	13,327

3.2.4 *Transition to Modern Times: 1951 to 1980*

Rapid population growth in Deschutes County and inexpensive lots fueled the development of the areas near the lower Little Deschutes River. Deschutes County's population nearly tripled between 1950 and 1980, from 21,812 to over 60,000, which contributed to residential and other development in the Little Deschutes River Subbasin (Table 3-3). For most of the century, Klamath County's population exceeded Deschutes County. By 1980, this pattern had shifted with a larger and more rapidly growing population in Deschutes County. Most of the growth in the Little Deschutes River Subbasin focused in areas outside of incorporated communities. In 1951, small 1 to 2-acre parcels of land near La Pine were offered for $100 as possible sites for summer cabins (Friends of La Pine Public Library, 2000).

A key factor in the area's population growth was the development of Sunriver Resort at the northern edge of the subbasin. The Sunriver area went from a cattle ranch to an army base during World War II. Development of the resort began in the 1960s and grew slowly, with a population of about 109 residents in 1971 (Deschutes County Historical Society, 1985). The Sunriver resort became an important tourist draw and contributed to residents locating in the area. The Sunriver community currently contains 3,900 homes and condominiums.

In the 1960's and early 1970's, before Oregon statewide planning regulated growth and development, over 15,000 lots were created in subdivisions platted in the northern portion of the subbasin (Deschutes County, 1998). Most of these parcels are less than two acres in size and use on-site septic systems to dispose of sewage. Beginning in the 1960's, septic tank permits were required before construction could begin, and many property owners were caught by surprise when they discovered that they could not build because of soil conditions (Friends of La Pine Public Library, 2000).

Table 3-3: Deschutes and Klamath County populations, 1900 to 2000 (US Census Bureau, 2001).

Census Year	Deschutes County	Klamath County
1900	--	3,970
1910	--	8,554
1920	9,622	11,413
1930	14,749	32,407
1940	18,631	40,497
1950	21,812	42,150
1960	23,100	47,475
1970	30,442	50,021
1980	62,142	59,117
1990	74,958	57,702
2000	115,367	63,775

3.2.5 *Time Line of Historical Conditions*

The information compiled for the historic conditions assessment was used to create the timeline in Table 3-4. This timeline provides an overview of locations and timing of key historic events impacting the Little Deschutes River Subbasin.

Table 3-4: Historic Conditions Timeline for the Little Deschutes River Subbasin.

Year	Event	Location of Observation / Modification
1843	Fremont expedition describes the environment of the area	Near the current community of Crescent
1860s	Construction of the Oregon Central Military Road	Along the current route of Highway 58
1911	La Pine's population is 600; Dam at the outlet of Paulina Lake completed	La Pine Area; Paulina Lake
1917	Brook trout released into Crescent Lake	Crescent Lake
1920	9,622 residents in Deschutes County and 11,413 residents in Klamath County	Little Deschutes River
1922	Earth and wooden dam constructed across the outlet of Crescent Lake	Crescent Lake
1934	Deschutes Lumber Company begins logging old-growth ponderosa pine	Headwaters of the Little Deschutes River
1939	1,000 sheep graze the meadows of the upper Little Deschutes River	Headwaters of the Little Deschutes River
1946	Landowner installs six miles of diversion ditches to drain Big Marsh	Big Marsh Creek
1950	21,812 residents in Deschutes County and 42,150 residents in Klamath County	Little Deschutes River
1950s	1 to 2-acre parcels of land offered near La Pine for $100	La Pine Area
1960s	Sunriver Resort established; over 15,000 lots were platted in the lower river area.	Lower Areas of the Watershed
1980	62,142 residents in Deschutes County and 59,117 residents in Klamath County	Little Deschutes River – private property along lower river
1990's	Deschutes County's Regional Problem Solving Project identifies watershed concerns	Lower Portions of the Watershed / La Pine Area
2000	115,367 residents in Deschutes County and 63,775 residents in Klamath County	Little Deschutes River

4.0 FUTURE PROJECTIONS

This section presents information on the nature of growth in the area and potential impacts. The assessment of the current status and potential impacts of growth on watershed resources has been incorporated into the individual assessment sections.

The goal of this section is to provide the background information needed to link projected population growth to potential impacts on the watershed over the coming 20 years. The individual resource reports following this section use this information to attempt to identify the types and locations of potential impacts in the watershed.

4.1 Critical Questions

1. What are the general impacts from future watershed development and land uses on fish and wildlife habitat and populations?

2. How do future population growth projections influence conservation options?

3. What effects might regulations have on growth and quality of life in the sub-basin?

4. How will future watershed use trends affect the local economy?

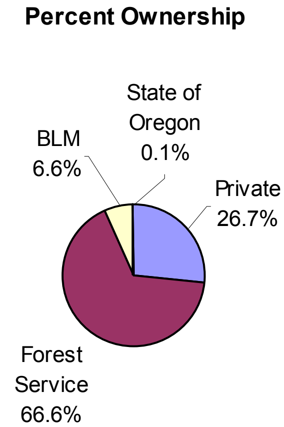
4.2 Land Ownership

Most of the land, almost 73%, in the watershed is federally owned by the Forest Service, and to a lesser extent the Bureau of Land management (Table 4-1). However, the federal lands tend to be in the upper portions of the watershed and a significant portion of the subbasin, 27%, is in private ownership, primarily concentrated in the lower portions of the landscape adjacent to the Little Deschutes River and Crescent Creek (Map 4-1). Most of the human population in the subbasin is concentrated in the community centers of La Pine, Gilchrist, Crescent, and Crescent Lake (Map 4-2).

This ownership pattern has significant implications for natural resource management, as lower gradient floodplain areas tend to provide important wetland, fish and wildlife habitat. The implications of this ownership pattern are analyzed in the individual resource reports following this section.

Table 4-1: Land ownership in the Little Deschutes River Subbasin.

Ownership	Acres
Private	178,671
Forest Service	445,393
BLM	44,410
State of Oregon	728
Total:	***669,202***



4.3 Population Growth

The rural character of the Little Deschutes Subbasin, the attractive location of private property on the Little Deschutes River, and relatively inexpensive land prices have contributed to a rapidly growing population. Since 1989, Deschutes County has been the fastest growing county in Oregon on a percentage basis (Deschutes County, 1998). The county's population growth rate dramatically increased between 1990 and 2000, with the county growing by over 40,000 residents (Figure 4-1). There are an estimated 16,000 residents in the unincorporated area around La Pine in the lower portions of watershed which would make this area the second largest city in Oregon east of the Cascades (after Bend) were it incorporated (Deschutes County, 1998). Most of the developed lands and undeveloped lots are along the Little Deschutes River and Crescent Creek (Map 4-3).

This dramatic population growth is expected to continue into the foreseeable future. Figure 4-1 depicts the projected growth in the unincorporated sections of Deschutes County over the next 20 years (Deschutes County, 2000). Although the greatest growth in Deschutes County is expected to occur in the Bend area, the unincorporated areas, including the lower portions of the Little Deschutes River, are projected to experience an increase of as much as 56% over the 2000 population in the next 20 years.

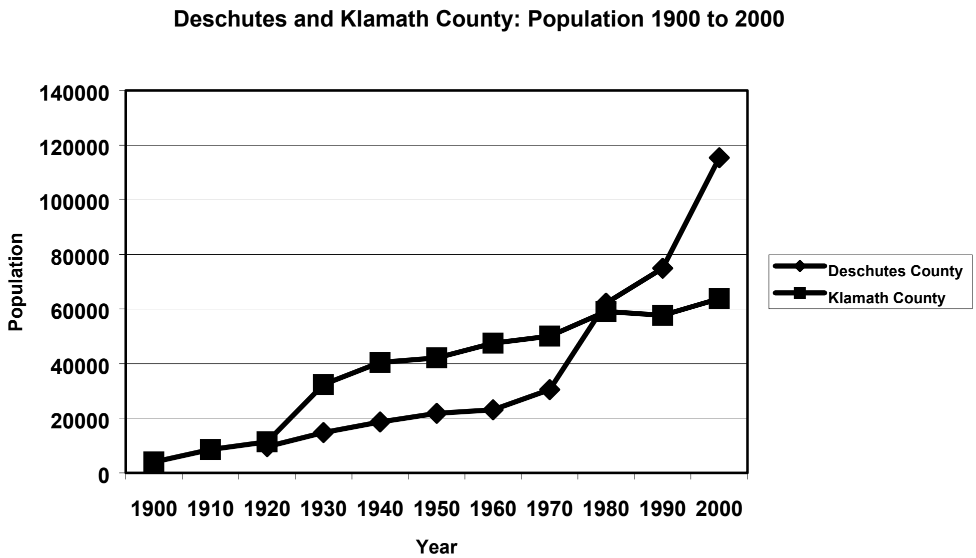


Figure 4-1 : Deschutes and Klamath County population trends, 1900 to 2000 (US Census Bureau, 2001).

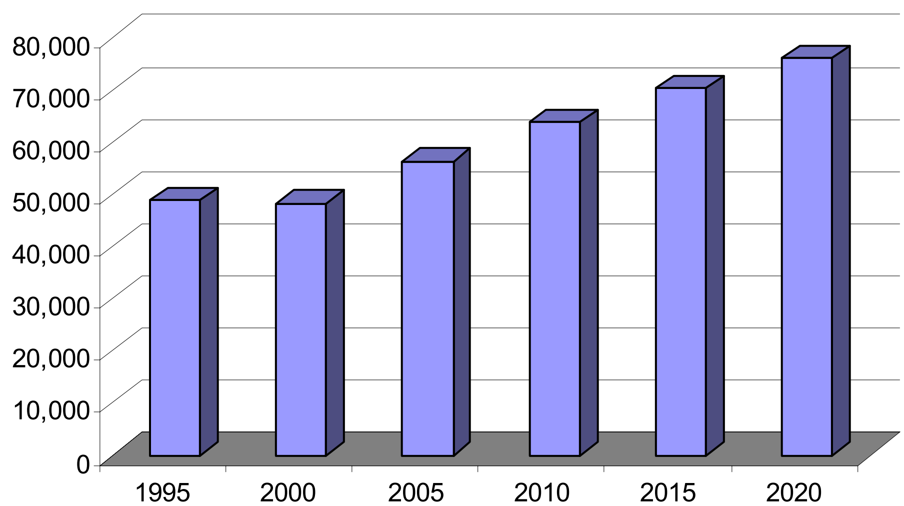


Figure 4-2: Projected Population Growth in Unincorporated Deschutes County, 1995-2020 (Deschutes County, 2000)

This calculation is based in part on the fact that some of these rural areas were subdivided prior to the passage of land use laws in Oregon. In the lower portions of the Little Deschutes River Subbasin, there were 200 subdivisions and 13,000 lots created, and many were purchased sight-unseen (Deschutes County, 2000). At this time, in the La Pine area alone, there are more than 11,000 lots, of which only about 4,000 have been developed. If all of these lots were built out, the population density in the La Pine/Gilchrist/Crescent area would nearly triple (Deschutes County, 2000). According to county tax records there are a total of 14,110-platted tax lots within the watershed, only 7,097 of these lots are developed, and 2,763 of these lots are within one half mile of the river (Table 4-2).

Table 4-2: Distribution of county tax lots listed as developed and undeveloped in the Little Deschutes River Subbasin (Source: Deschutes and Klamath Counties).

County	Developed lots	Undeveloped lots	Total Lots	Developed lots w/in 1/2 mile of River	Undeveloped lots w/in 1/2 mile of River	Total Lots within 1/2 mile of River
Deschutes	4931	3630	8561	1312	1465	2777
Klamath	2166	3383	5549	735	1298	2033
Total	***7097***	***7013***	***14110***	***2047***	***2763***	***4810***

It is important to note many of these lots are not developable as home sites. The high water table and lot size prevent the use of individual septic systems. There are also inadequate roads for emergency access in many of these subdivisions, and inadequate fire service options (Deschutes County, 2000). At this point in time, the number and locations of undeveloped lots has not been identified.

In addition, incomes for residents of the Little Deschutes River Subbasin tend to be lower than regional levels. According to the La Pine Community Action Team 1998 population and income study, 49.7% of families on La Pine have incomes below the low-moderate threshold and 37.8 % have incomes below the poverty level (Jill Phillips-McLane La Pine Community Action Team, 11/01 email). The unemployment rate in La Pine is about 24% and the unemployment rate for the county is about 6.4% (Jill Phillips-McLane La Pine Community Action Team, 11/01 email).

To try to address the concerns about combining sound development planning in a low income area, Deschutes County requested and obtained a Regional Problem Solving Grant from the Oregon State Legislature. Meetings with stakeholders throughout the county have resulted in a comprehensive understanding of the options available and the relative popularity of each (Deschutes County, 2000). The La Pine Sewer District, Oregon Department of Fish & Wildlife, La Pine Water District, Oregon Parks& Recreation, La Pine School District, Oregon Department of Environmental Quality, Oregon Water Wonderland II Sewer District, Deschutes National Forest, La Pine Rural Fire Protection District, Oregon Economic and Community Development Department, Oregon Department of Forestry, Oregon Housing and Community Services Department, Oregon Department of Land Conservation & Development, Oregon Department of Transportation and the Baldwin-Herndon Trust have all entered into memorandums of understanding with the Regional Problem Solving effort.

Key goals of that Regional Problem Solving Project are to protect the water quality, maintain the rural character of the area, recognize private property rights of existing lot owners, and to accommodate anticipated growth without taxpayer expense (Deschutes County, 2000). The Regional Problem Solving project has identified key concerns that relate to the health of the Little Deschutes River system (Deschutes County, 1998). Those that relate to the purpose of this report are listed below.

- **Groundwater quality:** The area's highly permeable, rapidly draining soils and high water table with relatively cold water temperatures are not suitable for large numbers of septic systems. Nitrates, a by-product of septic systems and an indicator of human pathogens, are poorly retained in the fast draining soils and do not easily break down with the cool water temperatures.

- **Mule deer migration corridor:** The area, especially between La Pine and Sunriver, contains the largest mule deer migration corridor in the state. The pattern of continued development and the associated roads and traffic all threaten the mule deer migrating through the area.

- **Riparian and wetland habitat:** Many of the lots and subdivisions are in sensitive areas near the Little Deschutes River, impacting riparian and wetland habitats that are important for fish and wildlife habitat and water quality.

- **Wildfire hazards:** High fuel loads, dense forest stands, developed and undeveloped lots that were not thinned, lots with absent landowners, and private lands contiguous with public ownership, all contribute to the areas extreme wildfire risk. Continued dispersed development makes it difficult to plan and manage the risks and to fight wildfires.

Detailed analysis of these concerns, potential impacts, and possible approaches are covered in the following sections of this document.

5.0 UPLAND VEGETATION & FIRE

The purpose of the Upland Vegetation and Fire assessment is to summarize what is known about vegetation patterns, the influence of fire in the ecosystem, and how these factors have been modified through human use. Most of the information for the assessment comes from existing information.

5.1 Critical Questions

1. What are the dominant vegetation cover types and extent?
2. What is the condition and trend of the terrestrial vegetation?
3. Are there habitat patches, dynamics, and fragmentation issues?
4. Are some cover types expanding their historic range?
5. Are there any plant communities of special concern? (Wetland and Riparian communities are addressed separately in Section 6.0)
6. What are the noxious weed species and extent?

5.2 Findings

The native vegetation patterns of the Little Deschutes River Subbasin can most easily be described in terms of elevation zones. At the highest elevations, above the tree line, there are alpine snowfields and high subalpine meadows. Below this is the subalpine forest zone, comprised of subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*) and mountain hemlock (*Tsuga mertensiana*) forest types. At the next lower elevation zone are fir forests, made up of true fir (*Abies sp.*) and other conifers. The Douglas fir (*Pseudotsuga menziesii*) mixed conifer forests inhabit the next lower zone. This area is more moist than the ponderosa pine zone, but too dry for subalpine fir or true fir. Below these forests in elevation are the ponderosa pine (*Pinus ponderosa*) forests and lodgepole pine forests. Interspersed among all these forest types are occasional meadows, and riparian and wetland areas (Johnson *et al.*, 1994) (Franklin and Dyrness, 1988).

Fire suppression, livestock grazing, timber harvest practices, and urban development have major influences on vegetation patterns in the watershed. Fire suppression has altered disturbance patterns, creating the potential for severe fires. Timber harvest practices have a dramatic effect, by completely altering forest age and structure. Livestock influence vegetation patterns by their selective forage habits. They can completely remove some plant species (the most palatable ones), and spread noxious weeds. Deschutes County is the fastest growing county in Oregon. With numerous undeveloped lots the potential for urban growth on private lands bordering the Little Deschutes River is high. This kind of development can have a huge impact on riparian vegetation and water quality.

5.2.1 *Vegetation Cover Types*

There are a variety of ways to define and map vegetation types. Plant ecologists generally look at the plant species composition, frequency, and density, while wildlife biologists may be interested in forage species and habitat structure. A fuel load manager may examine insect and disease distribution, downed trees, and other characteristics not considered by the other resource professionals.

The following vegetation maps were located for this project area:

1. Oregon Gap Analysis Project (GAP)
2. Deschutes National Forest Plant Association Groups (PAG)

These maps are presented in order to describe the dominant vegetation cover types and their extent. Both maps are included here because they each illustrate the available information differently (Maps 5-1 & 5-2).

5.2.2 *The Oregon Gap Analysis Project*

The Gap Program is designed to identify the degree to which native animal species and natural communities are represented in the current mix of conserved land areas so that "gaps" in these lands and habitat types can be identified. Its ultimate goal is to provide broad geographic information on the status of ordinary species (those not threatened with extinction or naturally rare) and their habitats in order to provide land managers, planners, scientists, and policy makers with the information they need to make better-informed decisions.

Maps of existing vegetation have been prepared from satellite imagery (LANDSAT) and other sources and entered into a geographic information system (GIS). These maps are verified through field checks and examination of aerial photographs. The Oregon Gap Analysis Project was updated and released in 1998 and is part of a national mapping effort by the US Geological Survey, Biological Resources Division. The data for this report was obtained from the Oregon Geospatial Data Clearinghouse (http://www.sscgis.state.or.us).

There are 17 different cover types identified and mapped by the Gap Program in the study area (Map 5-1, Table 5-1). Full descriptions of the GAP cover types are in Appendix B. Eight of the identified cover types can be classified more generally as "Forest and Woodland" types. These occupy 81 % of the land area in the watershed. If the cover type "Regenerating Young Forest" were included in this calculation, almost 90% of the watershed would be described as forestland. The largest single cover type, in terms of area, is the Ponderosa-Lodgepole Pine on Pumice comprising nearly half of the watershed. This roughly corresponds to the location of the Pumice Plateau Forest Ecoregion Boundaries (Map 2-2). Wetland cover types make up 7.7 % of the land area and generally occur adjacent to the streams. Vegetation types increase in diversity with increased elevation in the western third of the watershed within the boundaries of the "Cascade" ecoregions.

The distribution of cover types between landowners in the Little Deschutes River Subbasin shows some clear patterns. For example, private lands contain the highest percentage of wetland cover types (Figure 5-1). The State of Oregon owns very little acreage in the watershed and it is almost entirely Forest and Woodland cover types (Figure 5-1). The Forest Service has the greatest diversity of cover types with 16 types (lacking only the Agricultural category) while private, BLM, and State lands have 15 types, 6 types, and 3 types, respectively (Table 5-1).

Table 5-1 Cover Types on the 1998 Oregon Gap Analysis Project Map in the Little Deschutes River Subbasin.

	GAP COVER TYPE	BLM	Private	State Lands	USFS	Total Acreage by GAP Cover Type	Percent Acreage by GAP Cover Type
Forest and Woodland	033 - Mountain Hemlock Montane Forest		4		29,894	**29,899**	**4.5%**
	034 - True Fir-Hemlock Montane Forest		23		37,081	**37,104**	**5.5%**
	040 - Ponderosa Pine Dominant Mixed Conifer Forest		1,564		27,525	**29,089**	**4.3%**
	044 - Lodgepole Pine Forest and Woodland	10,479	19,966	8	28,563	**59,016**	**8.8%**
	045 - Subalpine Fir-Lodgepole Pine Montane Conifer		3,973		17,816	**21,788**	**3.3%**
	054 - Ponderosa Pine Forest and Woodland		1,255		3,908	**5,163**	**0.8%**
	056 - Douglas Fir Dominant-Mixed Conifer Forest		1,881		31,591	**33,471**	**5.0%**
	056 - Ponderosa-Lodgepole Pine on Pumice	19,537	97,566	711	208,654	**326,469**	**48.8%**
						Total	***81%***
Shrub-land & Grass-land	105 - Subalpine Grassland				96	**96**	**0.01%**
	110 - Subalpine Parkland	27	569		1,201	**1,797**	**0.3%**
	121 - Grass-shrub-sapling or Regenerating Young Forest	10,893	15,758	9	31,862	**58,523**	**8.7%**
	125 - Agriculture	924	395			**1,318**	**0.2%**
						Total	***9.21%***
Other	127 - Lava Flow		251		5,834	**6,085**	**0.9%**
	129 - Alpine Fell-Snowfields				201	**201**	**0.03%**
	130 - Open Water		6,690		772	**7,463**	**1.1%**
						Total	***2.03%***
Wet-land	137 - NWI Estuarine Emergent		3,507		4,703	**8,210**	**1.2%**
	138 - NWI Palustrine Emergent	2,550	25,270		15,691	**43,511**	**6.5%**
						Total	***7.7%***
	Total Acreage by Ownership	**44,410**	**178,672**	**728**	**445,393**	**669,203**	
	Percent Acreage by Ownership	**6.6%**	**26.7%**	**0.1%**	**66.6%**		

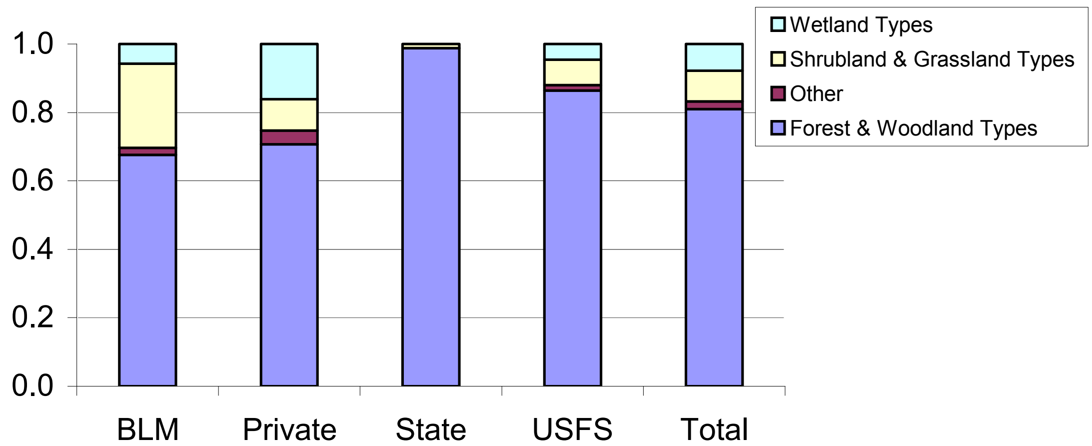


Figure 5-1: Cover Types as a Fraction of Total Acreage Owned

5.2.3 *Deschutes National Forest Plant Association Groups (PAG)*

The Deschutes National Forest developed a vegetation cover type map from the 1988 ISAT image data interpreted by Pacific Meridian Resources. These data are classified by size, stand structure, and crown cover classes. The Forest GIS staff and silviculturist combined these classes to allow for a more manageable data set to support their Landscape Assessment Plan (LAP) (Map 5-2 and Table 5-2). This classification is termed Plant Association Group (PAG) and identifies 12 vegetation cover types within the 599,426 acres of the Little Deschutes Watershed.

Both the GAP and the PAG data sets show similar broad patterns. For example, the PAG map shows over 90% of the watershed are classified as forest cover types (Map 5-2). The GAP analysis shows 89.7 % of the watershed is comprised of forest cover types (if the regenerating young forest type is included). As with the GAP delineation, PAG dry forest types are shown to occur in the eastern half of the watershed. However, the PAG classification splits the lodgepole pine from the Ponderosa pine and this better illustrates the landscape patterns of these two forest types.

Table 5-2: Plant Association Groups (PAG) in the Little Deschutes River Subbasin.

	PAG Description	BLM	Private	State	USFS	Total by PAG Description	% by PAG Description
		Ownership (Acres)					
	Alpine Dry		0		400	400	0.1%
	Cinder		17		323	340	0.1%
	Lava		476		4,893	5,369	0.9%
	Meadow	39	1,888		225	2,152	0.4%
						Total	***1.50%***
FOREST COVER	Mixed Conifer Dry		6,711		77,963	84,673	14.1%
	Mixed Conifer Wet		48		1,019	1,067	0.2%
	Mountain Hemlock Dry		24		42,675	42,699	7.1%
	Ponderosa Pine Dry	349	59,774	253	87,023	147,399	24.6%
	Ponderosa Pine Wet	5	9,083		7,883	16,971	2.8%
	Lodgepole Pine Dry	42,189	73,313	476	157,070	273,048	45.6%
	Lodgepole Pine Wet	383	2,638		2,511	5,532	0.9%
						Total Forest	***95.3%***
	Riparian	135	6,062		4,467	10,665	1.8%
	Rock	107	336		1,693	2,137	0.4%
	Water		6,477		498	6,975	1.2%
						Total	***2.4%***
	Ownership -- Total Acres	43,208	166,848	728	388,642	599,426	
	Ownership -- Percent of Total	7.2%	27.8%	0.1%	64.8%		

5.3 Condition and Trend of Terrestrial Vegetation

The vegetation of eastside Oregon has a long history of disturbance. These eastside ecosystems are considered stable when the period between disturbance events is decades. The vegetation is made up of plants with mechanisms capable of withstanding relatively frequent, severe disturbances (Johnson, *et al.*, 1994). One of the most striking and significant trends is the change in forest disturbance regimes and consequent effects on forest composition and structure. This change in the fire disturbance regime has affected wildlife habitat, susceptibility to insects and disease, and, created forest that are susceptible to unusually severe fire (Hemstrom, *et al.*, 1998).

A broad scale assessment by Hemstrom, *et al.* (1988) indicates major shifts in disturbance regimes across eastside forests. According to Quigley and Cole (1997), the acreage with lethal fire regimes has more than doubled in recent times. "Before Euro-American settlement, most fires in low and mid elevation forests were nonlethal. Forests and rangelands benefited from these frequent, surface fires, which thinned vegetation and favored growth of fire-tolerant species. Lethal, or stand replacing fires, played a lesser role on the landscape. Lethal or stand-replacing fires currently predominate. Lethal fire regimes now exceed nonlethal fire regimes in forested areas. Fire exclusion, livestock grazing, timber harvest, and exotic plant introduction have contributed to these changes" (Quigley and Cole 1997).

5.3.1 *Habitat Patch Dynamics and Fragmentation*

Within the Deschutes River Basin, the landscape pattern has become more diverse and fragmented over time (Lehmkuhl, *et al.*, 1994). Current forest patch sizes are smaller while edge and patch densities are greater than they were 50 years ago. Connectivity of ponderosa pine has decreased significantly; patch density rose from 5.8 to 10.9 patches per 10,000 hectares, and mean patch size declined (Hessburg, *et al.*, 1999). Increased fragmentation and loss of connectivity within and between blocks of habitat isolates some habitats and populations and reduces the ability of wildlife populations to move across the landscape, resulting in long-term loss of genetic interchange.

Expansion of Cover Types From Their Historic Range

Increased forest cover in the watershed suggests that the exclusion of fire has resulted in forest establishment on areas that were previously bare ground or shrubland, or grassland areas that were previously maintained by fire (Hessburg, *et al.*, 1999). Conifer encroachment on wet meadows and riparian areas can be attributed to a secondary result of overgrazing. Overgrazing causes the incising of stream channels to greater depths, which reduces the available moisture in meadows and permits invasion of xeric (dry land) plants such as conifers and sagebrush (*Artemesia spp.*) (Johnson, *et al.*, 1994).

Historic Vegetation Information

The Oregon Natural Heritage Program (ONHP, 2001) has made an effort to determine what the vegetative cover was like in Oregon at the time of the pioneers, circa 1850 (Map 5-3). A general comparison of the current and historical maps shows that the percent of land covered by forest is nearly the same today as it was in 1850. Forest cover has increased by 8% in the past 50 years in the Deschutes basin (Lehmkuhl, *et al.*, 1994). However, currently fewer of the low and middle elevation forest stands have a park like structure because the exclusion of fire has allowed these stands to grow with higher densities. This makes these forests more susceptible to stand-replacing insect, disease, and fire disturbances (Johnson, 1994).

In the past 70 years forested wetlands increased 5-12% while non-forested wetland cover stayed the same (Lehmkuhl, *et al.*, 1994). Ponderosa pine and Douglas fir/True fir forest types increased slightly in cover as well. Other forest types stayed about the same in amounts of cover. The amount of bare ground decreased by 45%, which is attributed to fire suppression allowing a thick understory to develop in previously open forest stands. Increase in forest area and decrease in non-forest/non-range types has been associated with forest regrowth from extensive tractor logging of ponderosa pine conducted before the 1930's (Hessburg, *et al.*, 1999).

Table 5-3: Historic Vegetative Cover Types in the Little Deschutes River Subbasin (OHNP, 2001).

Cover Type	Acres	Percent
Subalpine fir	15,937	*2.4%*
Ponderosa pine	301,117	*45.0%*
Lodgepole pine	288,335	*43.1%*
Shasta fir-white fir	26,510	*4.0%*
Mixed conifer	7,272	*1.1%*
Grand fir	5,931	*0.9%*
Douglas fir	4,882	*0.7%*
	Total Forest	***97.20%***
Alpine tundra-barren	1,929	*0.3%*
Open water	7,047	*1.1%*
Bitterbrush	6,370	*1.0%*
Bare rock	3,873	*0.6%*

5.3.2 *Plant Communities of Special Concern*

No Federally listed threatened or endangered species are known from the Little Deschutes watershed. The following table indicates plant species listed as species of concern with the US Fish and Wildlife Service, and species listed as threatened and candidates for listing by Oregon Department of Agriculture. These plants are found in Deschutes and Klamath counties in the ecoregions that overlap with the Little Deschutes watershed.

Table 5-4: Rare Plants from Deschutes and Klamath Counties, Oregon (OHNP, 2001).

Scientific Name	Common Name	Ecoregion	OR Counties	Fed Status	State Status
Astragalus peckii	Peck's milkvetch	EC	Desc, Klam	SOC	LT
Botrychium pumicola	pumice grape fern	WC, EC	Desc, Klam		LT
Calochortus greeneii	Green's mariposa lily	EC, KM	Klamath	SOC	C
Eriogonum prociduum	prostrate buckwheat	EC,BR	Klamath	SOC	C
Perideridia erythrorhiza	red-root yampa	CR,WC,EC, KM	Klamath	SOC	C
Phacelia inundata	playa phacelia	BR,EC	Klamath	SOC	
Rorripa columbiae	columbia cress	WC,EC,BR	Klamath		C

Ecoregions:	Status:
EC = East Cascade Range	SOC = Species of Concern
WC = West Cascade Range and Crest	LT = Listed Threatened
KM = Klamath Mountains	C = Candidate for listing
BR = Basin & Range	
CR = Coast Range	

5.3.3 *Noxious Weeds*

The presence and extent of noxious weeds in the watershed was identified as a concern to be addressed in this analysis. Noxious weeds are plant species that are not native to a particular area, and have the aggressive tendency to invade habitats to the exclusion of native plants and wildlife. These plant species often are accidentally or intentionally introduced from some other part of the world. They have no predators locally and can often out-compete native plants using different survival strategies to their advantage. The result is a habitat that is completely overgrown with the invasive species, to the exclusion of all other plants (and the wildlife that depend upon them). This habitat is less diverse, less productive, and typically considered to be less aesthetic than native communities.

Three sources of information, the Deschutes County Weed Control Board, Oregon Department of Transportation and the Deschutes National Forest were used as resources for this portion of the analysis.

Oregon Department of Transportation

The Oregon Department of Transportation (ODOT) works to reduce noxious weeds along roadways. According to Dave Culver of the ODOT, most of the right-of-way within the Little Deschutes Watershed is on a monitoring program with little or no treatment required. The Department uses herbicide as the primary control agent, but some mechanical treatment and reseeding with native species and nonnative grass species has been done. Mare's tail (*Hippuris sp*.), storksbill (*Erodium cicutarium*), mullein (*Verbascum thapsis)*, whitetop (*Cardaria draba*) and perennial pepperweed (*Lepidium sp*.) are relatively new additions to the list the highway district uses for weed control.

Forest Service

The Deschutes National Forest (DNF) also has a program to develop and implement noxious weed prevention and control measures. Their goal is to eradicate or gain control over the establishment and spread of selected noxious weeds. The majority of weed infestations in the DNF are along areas that have been disturbed such as road right-of-ways, old timber sale units, administrative sites, and recreation areas. Some of the herbicides that the ODOT uses cannot be used on DNF land because the results of an Environmental Assessment prohibit the use of herbicides (Grenier, USFS, 2001, Personal communication).

The Forest Service has identified additional weed species of concern. No systematic surveys have been conducted within the watershed. Some weed population and species data are available for the Deschutes National Forest (Table 5-4) (Grenier, USFS, 2001, Personal communication). The Deschutes National Forest provided information on the weed species and treatment types in use for the current noxious weed program (Table 5-5).

Nearly 3,000 acres of noxious weeds have been identified on the DNF. The Crescent watershed has the highest number of acres identified and the most number of different weed species identified for treatment. This reflects the relative amount of ground disturbances within this 5th field watershed compared to the other 5th field watersheds within the Little Deschutes Watershed analysis area. (Please note that total acres within each 5th field watershed in Table 5-5 are greater than the total for the 5th field watershed in Table 5-4 because more than one species is noted at each treatment location.).

Spotted knapweed (*Centaurea maculosa*) and diffuse knapweed (*Centaurea diffusa*) are clearly the most widespread of all weed species identified. Knapweeds have been introduced from Eurasia and now represent a threat to pastures and rangelands (Whitson, 1992). They infest roadsides, waste areas, and dry rangelands and threaten to exclude many desirable plant species. There is some evidence that knapweeds release chemical substances that inhibit the growth of surrounding vegetation.

Table 5-5: Number Of Acres Of Each Weed Species By 5th Field Watershed. (Deschutes National Forest, 2001).

Scientific Name	Code	Common Name	Noxious Weed Category	Crescent	Little Des.	Long Prairie	Newberry	Upper Little Des.	Walker Mt.
Euphorbia esula	EUPESU	leafy spurge	A	0	0	0	41	0	0
Isatis tinctoria	ISATIN	Dyer's woad	A	3	0	0	0	0	0
Senecio jacobaea	SENJAC	tansy ragwort	A	6	0	0	0	0	0
Centaurea diffusa	CENDIF	diffuse knapweed	B	915	206	30	208	147	138
Centaurea maculosa	CENMAC	spotted knapweed	B	1062	267	233	263	208	138
Cirsium arvense	CIRARV	Canada thistle	B	376		0	41	13	139
Linaria dalmatica	LINDAL	dalmation toadflax	B	48	1	0	3	55	0
Linaria vulgaris	LINVUL	yellow toadflax or butter & eggs	B	1	0	0	0	48	0
Hypericum perforatum	HYPPER	St. Johnswort	C	379	0	0	0	56	21
Bromus tectorum	BROTEC	cheatgrass	FS	0	0	3	0	0	0
Chrysanthemum leucanthemum	CHRLEU	oxeye daisy	FS	1	0	0	0	0	0
Cirsium vulgare	CIRVUL	bull thistle	FS	595	67	5	45	11	169
Chrysanthemum leucanthemum	HYLEU	oxeye daisy (possible duplicate to CHRLEU)	FS	10	0	0	0	0	0
Lepidium	LEPID	pepperweed	FS	1	0	0	0	0	0
Linaria sp.	LIN	toadflax	FS	16	0	0	0	0	0
Marrubium vulgare	MARVUL	white horehound	FS	0	0	3	0	0	0
Phalaris arundinacea	PHAARU	reed canary grass	FS	906	0	0	19	0	0
Verbascum thapsis	VERTHA	mullein	FS	221	0	0	22	2	60

List A – Weed that occurs in small enough infestations to make eradication/containment possible. These are high priority sites.

List B – Weed that is abundant and of great concern because it causes loss. They are a high priority for strategic treatment and control to prevent further spread.

List C – A weed that is abundant. It may be desirable to treat localized populations.

List FS – Forest Service weed species.

Table 5-6: Acres of weed treatment types within each 5th field watershed within the Little Deschutes River Subbasin (Deschutes National Forest, 2001).

Watershed	Manual (pulled or clipped)	No Treatment	Herbicide	Prescribed Burn	Biological Control	Acres
Crescent	71	221	329	906	7	1,534
Little Deschutes	44	234	56	0	0	334
Long Prairie	151	91	0	0	0	242
Newberry	21	107	205	0	0	333
Upper Little Deschutes	14	173	3	45	0	235
Walker Mountain	78	74	124	0	1	277
					Total Acres	2,955

Weed Control Coordination

In late 1999, Deschutes County established the Deschutes County Weed Board (DCWB) to help coordinate the weed identification and control efforts by the various interested agencies and private organizations. The following groups have participated in this effort:

Government Groups: Bureau of Land Management (BLM), Deschutes National Forest (DNF), Oregon Department of Agriculture (ODA), Oregon Department of Transportation (ODOT), Deschutes County Road Department (DCRD), Deschutes County Soil and Water Conservation District (SWCD), Bend Metro Parks & Recreation, City of Bend.

Private Organizations: Upper Deschutes Watershed Council (UDWC), Sunriver Owner's Association, Native Plant Society (NPS), Deschutes Basin Land Trust (DBLT).

The DCWB has adopted a noxious weed list (Table 5-6). Adopting the system used by the Oregon Department of Agriculture, weeds are categorized into the following lists based on the degree of infestation. The DCWB had no specific information available on noxious weed distribution in the Little Deschutes Watershed.

Table 5-7: Deschutes County Noxious Weed List

List A: A weed **that <u>occurs in small enough infestations</u>** to make eradication containment possible; or is not known to occur, but its presence in neighboring counties make future occurrence in Deschutes County seem imminent. List A also includes weeds that are actively managed by neighboring counties due to agricultural concerns (e.g. Jefferson County produces carrots and wild carrot poses a threat to agricultural carrot crops). List A weeds are **<u>high priority sites for treatment</u>**

Management Goal: eradicate or contain populations; prevent List A weeds from becoming more abundant and moving onto the B List.

Species Name	Common Name
Cardaria spp.	whitetop, hoary cress
Carduus nutans	musk thistle
Centaurea pratensis	meadow knapweed
Centaurea repens	Russian knapweed
Centaurea solstitialis	yellow starthistle
Centaurea virgata	squarrose knapweed
Chondrilla juncea	rush skeletonweed
Cynoglossum officinale	common houndstongue
Daucus carota	wild carrot
Euphorbia esula	leafy spurge
Hydrilla verticiliata	Hydrilla
Isatis tinctoria	Dyer's woad
Lepidium latifolium	perennial pepperweed
Lythrum salicaria	purple loosestrife
Onopordum acanthium	Scotch thistle
Peganum harma1a	African rue
Potentilla recta	sulfur cinquefoil
Salvia aethiopis	Mediterranean sage
Senecio jacobaea	tansy ragwort
Solanum rostratum	Buffaloburr
Taeniatherum caput-medusae	medusahead rye
Tamarix ramosissima	Tamarisk, Salt cedar
Tribulus terrestris	Puncturevine

<u>List</u> B: A weed that is **<u>abundant</u>** in Deschutes County and **<u>of area of concern</u>** because it causes economic and ecological losses. Eradication of List B weeds in the county may not be realistic; however, they are still **<u>high priority species for strategic treatment and control top prevent further spread.</u>**

Management Goal: Control List B weeds to prevent their spread into new areas. Management strategies should focus on outlying populations to protect native ecosystems, as well as high public use areas.

Species Name	Common Name
Centaurea diffusa	diffuse knapweed
Centaurea maculosa	spotted knapweed
Cirsium arvense	Canada thistle
Conium maculatum	poison hemlock
Cytisus scoparius	Scotch broom
Kochia scoparia	Kochia
Linaria dalmatica	Dalmation toadflax
Linaria vulgaris	yellow toadflax or butter and eggs"
Ranunculus testiculatus	bur buttercup
Salsola iberica (= S. kali)	Russian thistle

<u>List</u> C: A weed that is abundant. These are **<u>not</u> high priority** species to control. However, it **<u>may be desirable to treat localized populations</u>** to prevent their spread into new areas, and/or to protect from economic and ecological losses.

Management Goal; Treat List C species as 'incidental' and control on a case-by-case basis.

Species Name	Common Name
Agropyron repens	Quackgrass
Cicuta maculata	water hemlock
Cirsium vulgare	bull thistle
Convolvulus arvensis	field bindweed
Conyza canadensis	Horseweed
Cuscuta spp.	Dodder
Elodea densa	South American waterweed
Hypericum perforatum	St Johnswort
Iva axillaris	poverty stump weed
Melilotus alba	white sweetclover
Melilotus officinalis	yellow sweetclover
Melilotus indica	Indian sweetclover
Verbascum thapsis	common mullein
Xanthium spinosum	spiny cocklebur

5.4 Fire/Fuel Load Issues

The purpose of this section is to examine the role of fire in the Little Deschutes Subbasin and discuss how increased forest fuel loads have affected the watershed.

Fires ignited by people or through natural causes have interacted over evolutionary time with ecosystems, influencing many ecosystem functions (Pyne, 1982). Fire recycles nutrients, reduces biomass, influences insect and disease populations, and is the principal disturbance agent affecting vegetative structure, composition, and biological diversity. As humans change fire frequency and intensity through fire suppression, many plant and animal communities are experiencing a loss of species diversity, site degradation, and increases in the size and severity of wildfires due to the buildup of fuel loads. (Ferry, *et al.*, 1995).

Staff at the Deschutes National Forest (DNF), Oregon Department of Forestry (ODF), the Bureau of Land Management (BLM), and Deschutes County were interviewed for this section. One thing every agency person agreed on and quickly volunteered when questioned about the fire issues in the watershed, is that the "area is a tinder box". The combination of the fire dependent lodgepole pine and rural residential development throughout much of the watershed is a source of high fire risk.

5.4.1 *Critical Questions*

1. What are the natural fire frequencies and is this different from current fire frequency?
2. What are the extent and causes of fire?
3. What are the forest fuel load issues?
4. What are the insect and disease issues?
5. What are the urban/wildland interface issues related to fire?

5.4.2 *Fire Frequency*

Historically, fires in the watershed were naturally caused by lightening. As discussed in the Historical Conditions and Trends section of this document, the Paiutes used intentional fires as a tool to retain open areas for food plants and deer habitat. These fires added to the lightening-caused fires to produce the open ponderosa and lodgepole forests that existed historically.

The five ecoregions identified in the watershed have different natural fire frequencies and are best addressed separately. In the Cascade Crest Montane Forest, High Southern Cascades Montane Forest, Cascade Crest Subalpine/Alpine ecoregions fires are infrequent even without human intervention (Table 5-7). However, these ecoregions comprise only 14% of the Little Deschutes River Subbasin.

Table 5-8: Fire Frequency Characteristics by Ecoregions in the Little Deschutes watershed (WPN, 1999).

Ecoregion	% Of Water-shed	Fire Characteristics	Location in Watershed
Pumice Plateau Forest	52%	Frequent, low-intensity fires common in ponderosa pine forest in the past, current fire suppression efforts have reduced frequency.	Upland areas, away from Little Deschutes River.
Cold Wet Pumice Plateau Basins	34%	Fire suppression reduces fire frequency.	Little Deschutes River basin. Highest density of private lands.
Cascade Crest Montane Forest	10%	Infrequent fires.	Crescent Lake area and Paulina Lake area.
High Southern Cascades Montane Forest	3%	White fir and Shasta red fir have higher fire frequency than mountain hemlock forests.	Central southwestern boundary area
Cascade Crest Subalpine / Alpine	1%	Infrequent fires result in low survival of dominant tree species. Fire intensity depends on weather conditions.	Small areas on southwestern border.

Fifty-two percent of the Little Deschutes River Subbasin is within the Pumice Plateau Forest ecoregion. This ecoregion's historic crown closure was dependent on fire cycle. Lodgepole pine forests located on flats and in depressions typically have a 40 to 50 year fire cycle that creates newly burned, open areas. Young forests that regenerate are very dense and as they mature these forests thin out and then burn again. Infestation of the crown by mountain pine beetle kills limbs and trees, providing more fire fuel loads. Ponderosa pine forests located on slopes typically have less than 30% of the fire frequency in lodgepole forests, occurring every 8 to 20 years. The Forest Service owns the majority of the land in this ecoregion. Fire suppression is used as a timber management tool.

In the Cold Wet Pumice Plateau Basin ecoregion, lodgepole pine and willow dominate along with meadow vegetation such as sedges, tules, and tufted hair grass. Fires are largely confined to forested areas. Fire frequency is dependent on the fire suppression effort as this area is largely privately owned and has the largest number of residents. Periodic infestations by bark beetles kill a majority of the lodgepole pine near streams and marshes, adding substantially to the fire fuel loads. Fire fuel loads are increasing and are a concern for area residents.

There are several editions of fuel plans by the various land management agencies and new versions are expected within a year. All contacts indicated that data was sorely lacking on private lands. The Forest Service has mapped the results of a Fuels Model, however, this data is not included in the assessment because the metadata describing the mapped features was not provided, this lack of data did not allow for an adequate interpretation of the map.

5.4.3 *Fuels Loads*

Fire suppression, commercial logging, livestock grazing, and insect and disease infestations are primary causes of fuel loading in forests. Research conducted over the past 30 years has documented the importance of fire disturbance to forest ecosystems and also determined the detrimental effects of fire suppression. The results include a general deterioration in forest ecosystem integrity and an increased probability of large, high-severity wildfires (Stephens, 2000). Interconnected, fuel-laden stands may now link areas that historically burned less frequently into large, homogeneous areas that are vulnerable to high-intensity, stand replacing events (Agee, 1993).

Fuels and fire management planning is ongoing at BLM, ODF, DNF and within county agencies. The federal land managers have several natural fuels management documents completed, and a new Fire Management Plan is being drafted. Bill Johnson, with the U.S. Forest Service, and Sue Stewart with the BLM in Prineville are the leads on this Fire Management Plan. However, representatives from each group all mentioned the need for an assessment of fire risk on private lands. The May 1998 Integrated Natural Fuels Management Strategy for the DNF, provides guidance for prescribed fire, mechanical brush mowing, and small diameter tree thinning and release. A fuels map of the watershed was provided by the DNF, however, neither data or annotation on the categories was available. The BLM and DNF both have fire potential mapped. In addition, within the DNF, 100 years of fire history is mapped. Risk assessment is on hold until the Fire Management Plan is updated. Insect, disease, and rural residential development make this area troublesome for fire managers. The fire risk map for the watershed has only one risk level, *high*.

Deschutes County adopted an ordinance for wildfire hazard: County Ordinance 2001-024 Map of New Wildfire Hazard Zone Implemented OR Revised State Statute 93 270(4). Mapping Criteria was provided by the ODF.

John Jackson, Fire Management Officer for the ODF, indicates that all fire chiefs have risk maps for fire-fighting efforts He states that there is high hazard throughout the basin. ODF is working with private landowners to reduce fuel load by thinning. But there is little consistency in fuel load management because of the private land ownership. New buildings tend to pose less fire hazard because they must use the building code for high fire risk areas, such as a prohibition on shake roofs.

5.4.4 *Urban /Wildland Interface*

At the request of the County leaders, D&H Enterprises delivered a report titled "Fire Management Recommendations for Southern Deschutes County" in April 1997. This document presented recommendations for specific treatments and strategies for fire protection in the rural/forest interface. Their work concentrated on the effect of fire on residents of the county and did not address the issue of Forest Service management of timberland. They stated that fire suppression in southern Deschutes County has led to increased fuel load near homes. Fire suppression efforts increased in the watershed as land use changed from timberland to rural/residential. In some cases this has occurred rapidly, as when a new subdivision was developed. It has also occurred over time as forestland is divided and partitioned off for various reasons. Homeowner expectations with regard to fire and fire suppression changes as an area becomes less isolated and more residential. The resulting fuel loading in developed areas tends to exceed its natural characteristics.

The county is now experiencing the predictable problems associated with large numbers of homes being built in heavily forested areas that are 1) subject to major lightning storms during periods of extreme fire danger and 2) dominated by lodgepole pine that has periodically experienced major insect infestations resulting in heavy dead fuel loading. The document includes detailed information and recommendations on addressing this problem from the standpoint of resident safety.

6.0 WETLANDS/ RIPARIAN VEGETATION

The purpose of the Wetlands / Riparian Vegetation assessment is to summarize the known wetland and riparian areas in the watershed, the condition of these habitats, and actions that can be taken to enhance or restore these key habitats. The information comes primarily from existing reports and studies. Aerial photography and limited field verification was used to characterize wetland and riparian conditions. There was very limited data available on wetland types and locations in the subbasin, hence none of the critical questions are addressed. Where feasible, this chapter identifies opportunities for voluntary actions that can be taken to protect and restore wetland and riparian habitats.

6.1 Critical Questions

1. What is the current condition of the riparian vegetation?

2. What is the extent of riparian vegetation within the 100-year floodplain?

3. What is the estimated rate (years to 50 percent canopy coverage) of riparian vegetation recovery by major soil type (e.g. loamy, sand, gravel, rock) within the Upper Deschutes Watershed?

4. How do current conditions compare to those potentially present for the environmental conditions (e.g., soils and climate conditions) represented in the watershed?

5. What types and distribution of wetlands occur within the watershed?

6. What is the general condition of the wetlands within the watershed?

7. What are the types and extent or distribution of the impacts to the riparian and wetlands communities?

8. What are the limitations to restoration or riparian communities and wetlands within the watershed?

9. What is the planning and zoning or development impacts on riparian vegetation and wetlands?

6.2 The Role of Wetlands and Riparian Vegetation

Both wetland and riparian vegetation types comprise a small portion of the landscape, however both are disproportionately important to wildlife and water quality. Riparian areas are highly diverse and productive due to periodic flooding and influx of nutrients from upstream (and in the case of salmon streams, an influx of nutrients from downstream as well). Their high water table is due to proximity to rivers and streams, and they are unique in their linear form (Mitsch and Gosselink, 1986). Riparian wetlands differ from still water wetlands due to their proximity to moving water. They are subjected to periodic flooding and drought, and are adapted to the physics of moving water. Riparian plants also have fibrous root systems adapted to hold soil in place during high water events.

Wetlands provide significant functions within a watershed and are an important hydrologic component. Logging operations, livestock grazing, development, and other human activities can impair wetland functions within a watershed.

Wetland functions have been divided into three major classes:

- Hydrologic functions include flood peak reduction, storm abatement, shoreline stabilization, and groundwater recharge.
- Water quality improvement includes trapping sediment and nutrient uptake.
- Food-chain support and nutrient cycling provide habitat diversity for plants and animals.

On a landscape level, wetlands function as sponges and filters. They collect rainwater and slowly release it. This sponge quality is important for flood mitigation, groundwater recharge, and also creates a productive habitat. Wetlands also act as filters, thereby improving water quality. They reduce the velocity of water flow, causing sediments and toxins to drop into the wetland. Wetlands have natural processes that remove toxins and minerals from water. They accumulate peat that buries these deposits (Mitsch and Gosselink, 1986). Wetlands are also able to withstand and utilize high levels of nutrients such as nitrates (Kadlec and Knight, 1996).

6.3 Riparian Vegetation

In the Forest Service Publication, *Riparian Zone Associations – Deschutes, Ochoco, Fremont, and Winema National Forests*, Bernard Kovalchik defines or classifies two distinct ecosystems in the riparian zone: riparian and transitional. The riparian ecosystem is defined as the land, adjacent to water, that supports plants that are dependent on a continual source of water. Riparian sites include fluvial surfaces such as stream banks, active stream channel shelves, active floodplains, and overflow channels.

The transitional ecosystem occurs on sub-irrigated sites that lie between the riparian zone and upland. This ecosystem does not have true riparian vegetation such as sedges and willows, but is uniquely different from uplands. Transition sites include inactive floodplains, terraces, toe-slopes, and meadows, which have seasonally high water that recedes below the rooting zone in mid to late summer (Kovalchik, 1987). These transitional sites, mesic (moist) meadows in particular, provide important forage areas for livestock and wildlife.

Both of these ecosystems are found along the interface between aquatic and terrestrial ecosystems. These zones are well defined and are surrounded by much drier upslope ecosystems. Riparian Zone Associations have been defined for the Deschutes National Forest (Kovalchik, 1987). The Little Deschutes River Subbasin includes approximately 27 riparian plant associations including forest, shrub, and grass-like vegetation types. These plant associations are summarized in Table 6-1. A plant association is a group of plants found together with enough frequency to identify it as a distinct unit, such as a pine forest, a prairie, or a marsh. Plant associations tend to repeat across the landscape and over time. See Appendix C for a detailed list of specific plant associations.

Table 6-1: Numbers of Riparian Zone Associations by Dominant Plant Type (Kovalchik, 1987).

Dominant Plant Type	Number of Associations
Lodgepole pine	7
Quaking aspen	2
Mountain alder	3
Willow	3
Grass and Grass-like	12

A cursory examination of aerial photography provides some general information on the riparian areas. At higher elevations in the upper watershed, riparian areas in the Little Deschutes River Subbasin have more shrub and tree canopy cover. The lower elevation areas of the watershed have more herbaceous plant cover, showing cut banks and increased erosion. This erosion appears to increase in areas with grazed meadows. These riparian types and their canopy closure can be further identified using the riparian zone associations and aerial photography. Field sampling to verify the mapping is a very important part of the process, and will lend concrete information to remote sensing data.

Private landowners hold the majority of the Riparian and Water cover types (Figure 6-1). Education programs that teach private landowners the value of these habitat types and best management practices may be useful, helping ensure healthy, functioning riparian condition.

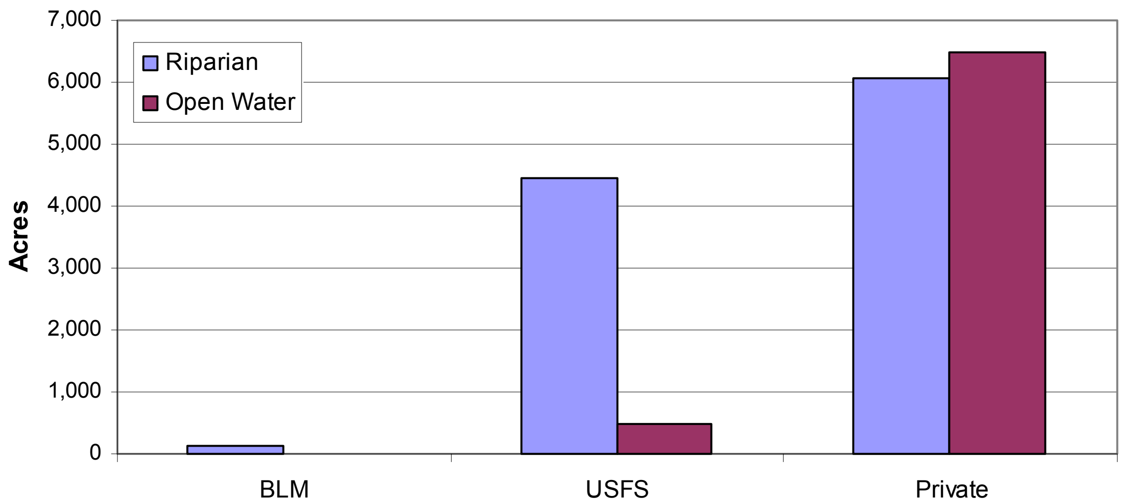


Figure 6-1: Ownership of Riparian and Open Water Habitat Types (Source: USFS PAG data).

6.4 Wetlands

The National Wetland Inventory (NWI) program is a U. S. Fish and Wildlife Service wetland mapping program. NWI maps provide a basic level of information regarding location, type and size of wetlands for the whole United States. The NWI data includes attribute information on wetland system, sub-system, class, water-regime, and special modifiers indicating the general length of time water may be expected to exist in a wetland. Other special modifiers include water chemistry, soils, and manmade features and disturbances (Cowardin, *et al.*, 1979).

The limitations of using NWI maps is that their mapping is incomplete; of the 35 quadrangle maps that comprise the study area only eight have been digitized by NWI. The data are also limited by the accuracy of the aerial photography interpretation and mapping. Frequently wetland areas are missed by interpreters and not mapped as wetlands, and sometimes non-wetland areas are identified as wetlands on the maps. Most NWI data have not been verified in the field. When identifying data gaps with NWI maps, inaccuracies should be relayed to the NWI so that the data can be corrected.

On a landscape level, wetland patterns in the Little Deschutes River Subbasin follow the ecoregions. Within the three mountainous ecoregions (Cascade Crest Montane Forest, High Southern Cascades Montane Forest, and the Cascade Crest Subalpine/Alpine), wetlands tend to be more shrub and tree dominated. High mountain shrub communities include those dominated by bog blueberry, willow, and Douglas spiraea. Due to the high elevations, these wetlands have a short growing season and occur in cold conditions. Bog blueberry wetlands are true bogs or peatlands (wetlands with a high water table that support acid-loving vegetation and create peat deposits). The cold conditions inhibit processes that allow decay, which in turn promotes the formation of peat.

In the lower elevation ecoregions (Pumice Plateau Forest and Cold Wet Pumice Plateau Basins), wetlands are characterized as marshes which are dominated by herbaceous plants. There are some shrub wetlands (dominated by willows), but in general, wetlands are more open in character. The Cold Wet Pumice Plateau Basins are a particularly significant ecoregion in terms of wetlands. This ecoregion describes the LaPine, Sycan, and Klamath basins of Oregon, which are unique because of their riparian and wetland habitats. Streams are low gradient making these depositional areas with abundant wetlands. The LaPine basin includes forested lodgepole pine wetlands along the Little Deschutes River. It is also significant to note that this area is predominantly privately owned. See Figure 6-2 derived from GAP data.

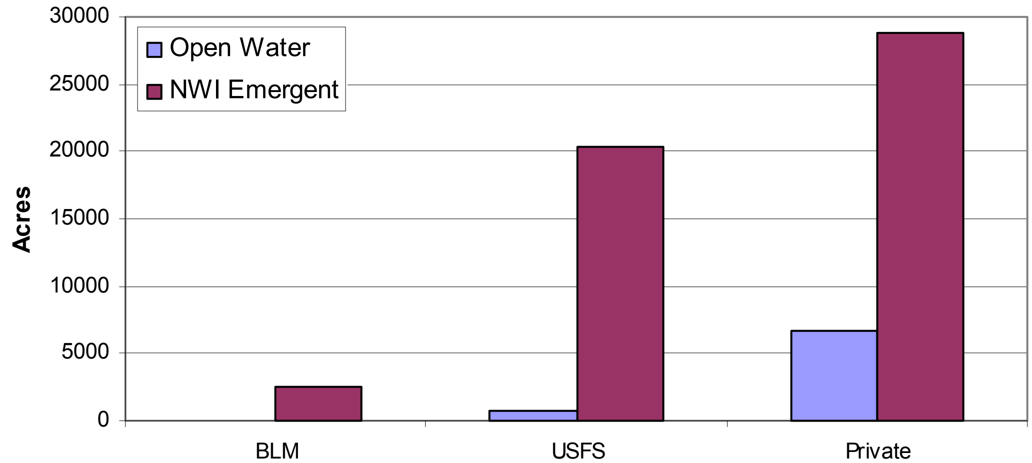


Figure 6-2: Ownership of Emergent Wetland and Open Water Cover Types (USFS GAP data).

6.4.1 *Wetland Habitat Types*

The following general wetland habitat types are found in the Little Deschutes River Subbasin:

Palustrine Forested Wetlands

Palustrine is another word for freshwater wetland. This type of wetland is a forested freshwater wetland, sometimes referred to as forested swamps. Having a high water table, or standing surface water for all or part of a year characterizes this type of wetland. The major plant species in the Little Deschutes River Subbasin is mountain alder (*Alnus incana*) (Franklin and Dyrness, 1988).

Palustrine Scrub-Shrub Wetlands

This type of wetland is a freshwater wetland where the main vegetation component is comprised of shrubs. Typical shrub species in the Little Deschutes River Subbasin are willows (*Salix spp.*), Douglas spiraea (*Spiraea douglasii*), bog birch (*Betula glandulosa*), and bog blueberry (*Vaccinium uliginosum ssp. occidentale*).

Palustrine Emergent Wetlands

Emergent freshwater wetlands contain plants which are water loving. Virtually all wetland plants have specialized adaptations that allow them to survive with their roots submerged in water (Mitsch and Gosselink, 1986). One common strategy is ‘breathing tubes’ or air spaces in the stems that allow air to reach the plant’s roots. Typical plant species in emergent wetlands are cattails (*Typha latifolia*), bulrushes (*Scirpus spp.*), sedges (*Carex spp.*), and rushes (*Juncus spp.*). In the Little Deschutes River Subbasin, sedges are the dominant emergent wetland species.

Palustrine Aquatic Bed Wetlands

Palustrine aquatic bed wetlands are freshwater ponds with plants growing on or below the water surface. Typical plant species in these wetlands in the Little Deschutes River Subbasin are common bladderwort (*Utricularia macrorhiza*), floating leaved pondweed (*Potomogeton natans*) and yellow pond-lily (*Nuphar luteum ssp. polysepalum*).

Lacustrine Aquatic Bed Wetlands

Lacustrine aquatic bed wetlands are found in shallow lakes or shallow margins of lakes with floating or submerged aquatic vegetation. Typical plant species in these wetlands are common bladderwort (*Utricularia macrorhiza*), floating leaved pondweed (*Potomogeton natans*) and yellow pond-lily (*Nuphar luteum ssp. polysepalum*).

One highly significant wetland is located in the watershed. Big Marsh is a unique wetland that is included in the National Wild and Scenic River System. It is designated as a Tier 1 Watershed in the Northwest Forest Plan, and is in the Oregon Cascade Recreation Area. Big Marsh, located in Klamath County, is an 8 km^2 (3 mi^2) perennial sedge marsh. The marsh is surrounded by pine and spruce forests and mesic (moist) meadows. The marsh itself is dominated by sedge fens (a type of non-acidic peatland), sedge marshes, willow shrublands and blueberry/birch shrublands (Titus and Christy, 1997).

6.5 Impacts to Wetland/Riparian Habitats

Impacts to wetlands and riparian areas have been occurring since before settlement times. Historically, widespread beaver trapping initiated changes in the hydrological functioning of riparian areas and streams. Beaver ponds once expanded floodplains, dissipated the erosive power of floods, and provided deposition areas for sediment and nutrient-rich organic matter. When beavers were trapped, their dams were not maintained and eventually failed. As dams gave way, stream energy became confined to discrete channels, causing erosion and incised channels (Elmore and Beschta, 1995). Homesteaders and ranchers followed the trappers. Grazing practices on the rangelands of eastern Oregon were similar to those throughout much of the West and relied on year round or season-long use. These practices allowed livestock to concentrate their foraging in riparian areas. As a result, many of the riparian areas in eastern Oregon are in a state of disrepair and degradation. Channels that once easily handled spring runoff and summer storms are now unstable and eroding.

In addition to livestock grazing, destruction of riparian ecosystems is largely caused by clearing for agriculture, stream-channel modifications, water impoundments, diversion for irrigation, and urbanization. Because riparian zones often follow the gradual elevation changes of a watershed, road and pipeline construction often impact riparian ecosystems. Recreational development (e.g., trails, campgrounds, etc.) can also destroy natural plant diversity and structure, lead to soil compaction and erosion, and disturb wildlife (Manci, 1989). In the Pacific Northwest, stream corridors are major sources of erosion (Carlson, 1979). Human activities such as logging, urban development, grazing, cropping, and recreational activity have increased surface runoff, removed protective riparian vegetation, and altered flows, often with catastrophic effects.

6.6 Current Conditions of Wetland/Riparian Habitats

Riparian and wetland condition can be measured in a number of ways. The Bureau of Land Management has developed a condition assessment for riparian areas called Proper Functioning Condition (BLM, 1993). This method takes into account the many factors that influence riparian health: soils, geomorphology, bank stability and water quality. The Riparian and Wetland Research Program (RWRP) is a research arm within the School of Forestry at the University of Montana, Missoula. RWPR also has a condition assessment methodology that private landowners can use to assess condition on their lands. There are other riparian and wetland assessment methods as well. Most focus on field survey and inventory methods for obtaining accurate condition information.

Field inventory methods are necessary to obtain accurate and detailed information regarding riparian and wetland conditions and trends in the watershed. Additional information could also be gained by reviewing maps with the Deschutes National Forest and Bureau of Land Management staff that may have additional field data on riparian and wetland vegetation condition. This information could also be used to identify priority areas for restoration.

6.7 Wetland/Riparian Restoration

Riparian and wetland restoration can be an active or a passive process depending on the type and extent of original impact to the site and the site conditions. Passive restoration can take place by excluding livestock, or importing beavers to a site to help raise the water table. Active restoration typically involves planting native vegetation, installing check dams to raise the water table, manipulating the landform of the creek, and using other bioengineering techniques.

Rates of riparian vegetation recovery vary depending on many factors. A minimum of 8 years of excluding livestock from riparian vegetation on Big Creek, Rich County, Utah, was necessary to restore the habitat for productive fish and wildlife uses, as well as water-quality maintenance (Duff, 1979). Where a channel is currently beginning a cycle of erosion, seed sources for native riparian species are absent, channels have steep gradients, or silt loads are low, recovery may require decades or longer (Elmore and Beschta, 1995). Simply excluding livestock may not greatly improve the riparian habitat, in which case active restoration efforts may be required to restore the habitat to a functional condition (Manci, 1989). Where the potential vegetation type is grass or grass-like plants, restoration will probably proceed faster than in areas where the potential vegetation is shrubs or trees. Restoration goals should include not only vegetation cover but functional condition as well. See the summary table in Appendix C for additional information on site conditions, wildlife use, fire effects, and restoration pathways for the riparian plant associations of the Little Deschutes River Subbasin.

Limits to restoration of riparian and wetland areas generally occur on a site-specific basis. It is possible for a site to be degraded past the point where it can be restored to its original potential (Johnson, *et al.*, 1994). Continued livestock grazing limits riparian restoration efforts. Where streams have incised and the water table has lowered, active in-stream restoration methods are usually required which is more costly than re-vegetation and passive restoration methods. In areas of the watershed that are privately owned, a large coordination effort must be conducted to involve private landowners in the restoration process and get their cooperation.

7.0 WILDLIFE

The Little Deschutes River Subbasin supports a variety of resident and migratory wildlife species, including songbirds, waterfowl, reptiles, amphibians and mammals. The purpose of the Wildlife assessment is to summarize what is known about wildlife populations, the condition of their habitats, and actions that can be taken to enhance or restore those habitats. The assessment focuses primarily on species of special concern and mule deer migration patterns. Where feasible, this chapter identifies opportunities for voluntary actions that can be taken to restore and protect wildlife populations and habitat.

7.1 Critical Questions

Species of Special Concern

1. What are the wildlife Species of Special Concern?
2. What critical habitat or special habitat designations are in this area?
3. What are the restrictions or limiting factors in population growth or stability?

Wildlife Species

1. What are the primary bird, mammal, reptiles and amphibians of interest in the watershed?
2. Is the population growth or stability of these species being impacted by increased human development?

7.2 Species of Special Concern

Species of Special Concern include Threatened and Endangered species listed under the federal Endangered Species Act (ESA) as well as those considered or under review for listing. These species are regulated through the U.S. Fish and Wildlife Service. Species of Special Concern also include those listed by the State of Oregon, the BLM, and the Deschutes National Forest (DNF). State listed species are regulated through the Oregon Fish and Wildlife Commission. Specific habitat and location data are available to land management agencies from Oregon State University's Oregon National Heritage Program (ONHP). ONHP has established a series of databases to tracks rare plants, animals, and plant communities throughout Oregon. General information on species is available through their web site, but specific location data are not provided to the public to avoid harm to the species. Two primary sources were used for specific information: 1) The *Joint Aquatic and Terrestrial Programmatic Biological Assessment Apri1 2001- April 2003* was conducted on federal lands including BLM lands and 2) the Big Marsh Watershed Analysis (Deschutes National Forest, 1997). The species with Federal or State status documented as occurring in the Little Deschutes River Subbasin are listed in Table 7-1.

Table 7-1: Proposed, Endangered, Threatened or Sensitive wildlife species known or potentially occurring in the Little Deschutes River Subbasin (ONHP, 2001).

Species	Status Federal, State*	Presence in Subbasin
Canada Lynx	LT, -	Not Documented, Habitat Available
Pacific Fisher	Soc, SC	Present
California Wolverine	Soc, CT	Present
Marten	-,SV	Present
Bald Eagle	LT, LT	Present
Northern Spotted Owl	LT,LT	Present
Northern Goshawk	Soc, SC	Habitat Available, Presence uncertain?
Long-billed Curlew	-, SV	Not Documented, Habitat Available
American White Pelican	-, SV	Present
Black-backed woodpecker	-, SC	Present
Flammulated Owl	-, SC	Not Documented, Habitat Available
Great Gray Owl	-, SV	Present
Greater Sandhill Crane	-, SV	Present
Pileated Woodpecker	-, SV	Present
White-headed woodpecker	SoC, SC	Present
Yellow Rail	SoC, SC	Present
Sage Grouse	SoC, SC	?
Mountain Quail	SoC, SV	?
Oregon Spotted Frog	C, SC	Present
Columbia Spotted Frog	C, SU	Present

***Federal Listing Categories:**
LE = Listed Endangered. Taxa listed by the U.S. Fish and Wildlife Service (USFWS) as Endangered under the Endangered Species Act (ESA).
LT = Listed Threatened. Taxa listed by the USFWS, NMFS, ODA, or ODFW as Threatened.
C = Candidate taxa for which NMFS or USFWS have sufficient information to support a proposal to list under the ESA.
SoC = Species of Concern. Former C2 candidates which need additional information in order to propose as Threatened or Endangered under the ESA.
Oregon Sensitive Species Categories:
CRITICAL (SC) - Species for which listing as threatened or endangered is pending; or those for which listing as threatened or endangered may be appropriate if immediate conservation actions are not taken.
VULNERABLE (SV) - Species for which listing as threatened or endangered is not believed to be imminent and can be avoided through continued or expanded use of adequate protective measures and monitoring.
UNDETERMINED STATUS (SU) - Animals in this category are species for which status is unclear.

Northern Bald Eagle

Northern bald eagle (*Haliaeetus leucocephalus*) is listed as a Threatened species under the ESA. In the watershed, threats to bald eagles include recreation and other human disturbance, logging, shooting, pesticides, and land development. Bald eagle mid-winter survey data is available for 1988 to present. Nesting season data has been collected since the mid-1970s from the Oregon Eagle Foundation, Inc. Annual reports summarizing these data were discussed by Recovery Zones as established by the Bald Eagle Recovery Plan. To support the Recovery Plan the DNF identified Bald Eagle Management Areas (BEMAs) that have specific requirements for maintenance and protection of eagle habitats. The Crescent Ranger District has 12 BEMAs and

5 identified eagle nest sites outside of the allocation. No BEMAs have been identified to protect roost sites on the DNF. All of the BEMAs include existing or historic nest sites and are closely associated with lakes and streams in the southern or upper part of the watershed.

According to the Big Marsh Watershed analysis, bald eagles historically nested and foraged on Crescent Lake where they fed on bull trout, rainbow trout, whitefish, and waterfowl (Deschutes National Forest, 1997). Bald eagles probably winter in the dense, non-fragmented stands adjacent to Crescent Lake. The habitat use around Crescent Lake is similar to other nest locations within the watershed where fish form a primary prey base.

Bald eagle nests are protected under the ESA on both public and private lands. There are no known nest sites on private lands within the subbasin. Development on private lands can impact bald eagle dispersed foraging activities. The disturbance is through direct human impact from recreational activities and through a loss of fish prey species resulting from dewatering. In addition, fluctuating lake levels and recreational use have impacted lakeside riparian habitat reducing eagle habitat quality in the Crescent Lake area (Deschutes National Forest, 1997). Bald eagles prey on fish and carrion, including roadkill. Road kill numbers are higher in the southern part of the watershed along Highway 97 (see section below). Traffic use and likely road kill events increase with increased vehicle trips. Because bald eagles can forage 10-15 miles from a nest location these road kills may be utilized (Shane Jefferies, wildlife biologist, DNF, personal communications, 2002).

Northern Spotted Owl

Northern spotted owls (*Strix occidentalis caurina*) require mature or old-growth coniferous forests with complex structure such as multiple layers. This bird is listed as Threatened under the ESA. The population size is a function of the amount and distribution of suitable habitat. Nesting, roosting and foraging habitat is available on the DNF. This area is reported as the eastern extent of the owl's range. Spotted owl pairs are generally located within the mature/old growth conifer Plant Association Groups (PAGs) associated with the buttes or high elevation mountains (Deschutes National Forest, 1997).

The Crescent Ranger District has a total of nine pairs of owls with one resident male that has not bred (Deschutes National Forest, 1997). There are five pairs of owls within the Crescent fifth field watershed. Critical habitat was only designated on federally managed lands and these areas are legally protected under the Late Successional Reserves (LSRs) or Congressionally Reserved Areas. There are two LSRs in the Crescent fifth field-watershed; Crescent Lake and Upper Big Marsh LSRs. Upper Big Marsh has had minimal impacts from humans with the exception of wildfire suppression. The Crescent LSR has 73 summer homes along the north shore of Crescent Lake (Deschutes National Forest, 1997). Although protected there are still some impacts to owl habitat from insect, disease, wildfire, and timber harvest.

Owl habitat is found in the southern and southwestern portion of the watershed. Dispersal habitat across the DNF is heavily fragmented by roads, timber harvest units, or by areas that have been burned or defoliated by insects and disease. Connectivity is lacking or widely dispersed on this and other dry eastside forests. However, the historic range of the northern spotted owl was probably similar to the current range (Deschutes National Forest, 1997). In the ponderosa pine and mixed conifer dry PAGs, historic harvest of ponderosa pine stands and fire suppression activities have resulted in the growth of a dense understory of white fir. These activities have created better quality spotted owl habitat in the ponderosa pine and mixed conifer dry plant association groups. This habitat is susceptible to wildfires and is not stable over time (Deschutes National Forest, 1997).

Canada Lynx

Canada Lynx (*Lynx canadensis*) is listed as Threatened under the ESA. To date, historical records from a lynx specimen collected in1916 indicated an occurrence roughly 35 miles west of Bend near Lava Lake. Surveys have been conducted for Canada lynx on the DNF but no recent confirmed sightings or hair samples have been collected in Oregon. There are no current standards or guidelines, designated Management Areas, or other specific requirements related to historic or potential lynx habitat. Lynx Analysis Units (LAUs) were developed by the Forest Service for analysis of proposed projects on the Forest lands and one LMU was identified on the Deschutes National Forest encompassing the Three Sisters area.

Wolverine, Fisher, Marten

The distribution of wolverine, marten and fisher in Oregon have been dramatically reduced over the past 40-50 years and is most likely attributable to loss of late successional forest habitat (Deschutes National Forest, 1997). In the Crescent fifth-field watershed a fisher was sighted in 1996 and two records of wolverines one in 1995 and one in 1994 were recorded (Deschutes National Forest, 1997). Numerous marten have been observed throughout the watershed.

Within the Little Deschutes River Subbasin historic wolverine habitat was likely similar to current conditions since they occur in higher elevation areas where land management activities and development have been minimal (Deschutes National Forest, 1997).

Marten and fisher habitat is located throughout mixed conifer, lodgepole and hemlock plant associations. Timber harvest activities have fragmented the mixed conifer and lodgepole pine stands reducing the canopy cover and downed woody debris subsequently reducing the quality of marten and fisher habitat. It is likely private development has caused fragmentation of connective habitat for fisher (Deschutes National Forest, 1997). Martens use a variety of plant association groups as travel corridors; this habitat is not likely a limiting factor for this species (Deschutes National Forest, 1997).

Black-backed Woodpecker

Numerous sightings of black-backed woodpeckers (*Picoides arcticus*) have been recorded throughout the Crescent fifth-field watershed (Deschutes National Forest, 1997). Habitat is located in the lodgepole and mixed conifer plant association groups. Some of the habitat in the Crescent fifth-field watershed has been fragmented due to natural mortality and timber harvesting (Deschutes National Forest, 1997).

Flammulated and Great Gray Owls

There are no documented sightings of flammulated owls (*Otus flammeolus*) in the watershed, but they are suspected to be present around Crescent Lake (Deschutes National Forest, 1997). The lack of low intensity fires due to aggressive fire suppression has reduced most of the suitable habitat for the flammulated owl within the ponderosa pine and mixed conifer PAGs which have historically provided habitat (Deschutes National Forest, 1997).

Two sightings of great gray owls (*Strix nebulosa*) have occurred in the Crescent fifth-field watershed (1995 and 1997) (Deschutes National Forest, 1997). There is suitable nesting and foraging habitat around Big Marsh, Whitefish and Crescent Creeks. The amount and distribution of habitat around riparian areas, meadows, and lodgepole wet stands is similar to historic habitat (Deschutes National Forest, 1997).

Greater Sandhill Crane

During the spring and summer, sandhill cranes (*Grus canadensis*) can be heard and observed at Big Marsh. Two confirmed nests were located at the marsh in 1996 and 1997; one nesting pair was located on Big Marsh Creek near the confluence with Crescent Creek (Deschutes National Forest, 1997). Based on the observed activity it is suspected six or more nesting pairs use the area.

Sandhill crane nests and young are susceptible to coyote, raven, raccoon, and skunk predation as well as predation by uncontrolled domestic dogs. Disturbance from humans and development in wet meadows, shallow marshes, and wetlands reduces habitat quality (Deschutes National Forest, 1997).

Pileated Woodpecker

Pileated woodpeckers (*Dryocopus pileatus*) occur in the subbasin primarily in mid-elevation mature and old growth mixed conifer forests. Foraging habitat includes large diameter dead and downed woody debris. Timber harvest, personal firewood collection,0 and increased distribution of white fir have fragmented habitat and reduced the number of large diameter dead trees (Deschutes National Forest, 1997).

White-headed Woodpecker

White-headed woodpeckers (*Picoides albolarvatus*) use open canopy ponderosa pine and mixed conifer stands. Loss of many of the large ponderosa pines due to timber harvest and development of the white pine understory creates a risk of losing additional habitat.

Yellow Rail

Breeding bird surveys at Big Marsh identified one male yellow rail (*Coturnicops noveboracensis*) in 1996 and four in 1997 (Deschutes National Forest, 1997). This is one of few nesting four yellow rail populations in Oregon (Deschutes National Forest, 1997). Yellow rails use shallow freshwater marshes and wet meadows for nesting (Terres, 1991). Big Marsh provided optimal habitat prior to draining in the 1940's and sheep and cattle grazing.

Amphibian Species

Oregon spotted frog (*Rana pretiosa)* and the Columbia spotted frog (*R. luteiventris*) are under review and as yet do not have an ESA status. The spotted frogs have communal egg laying sites which are apparently used repeatedly. They also prefer warmer waters which overlap with preferred habitats of introduced predatory warm water fish, and they over winter in springs. These factors make the frogs susceptible to impacts because there are a limited number of warm water reaches in the Pacific Northwest, and alterations to egg laying sites or springs used for overwintering will impact the local populations.

Some amphibian surveys have been conducted in the watershed. Rick Demmer, wildlife biologist, BLM, Prineville, provided a map and some population data on four species. He does not submit his data into the ONHP because it is not tracked in useful a format or is incomplete to support his needs. Surveyed species include: Long-toed salamander (*Ambystoma macrodactylum*), western toad (Bufo *boreas),* pacific tree frog (*Hyla regilla)* and bullfrogs *(Rana catesbelana).* In addition, surveys have been completed by the DNF. Big Marsh contains a large population of spotted frogs and is the largest area of suitable habitat in which an extant population has been found (Hayes 1995).

The introduction and continued stocking of fish in lakes that did not historically contain a fishery is probably directly responsible for reductions in aquatic amphibian populations. A local survey documented that a stocked trout had consumed ten long-toed salamanders in one feeding (Deschutes National Forest, 1997). Declines in amphibian population levels have been documented in the DNF where non-native fish stocking occurs and where recreational use and cattle grazing impact riparian areas (Deschutes National Forest, 1997).

7.3 Mule Deer Migration

The Deschutes County Regional Problem Solving Project (Deschutes County, 1998) identified the area, between La Pine and Sunriver, as containing the largest mule deer migration corridor in the state. There were concerns that the pattern of continued development and the associated roads and traffic would impact mule deer migrating through the area.

Mule deer and elk populations within the watershed have increased over time as a result of past timber harvest which creates forage in close proximity to cover (Deschutes National Forest, 1997). There has also been an increase in the effective deer and elk cover where fire suppression has resulted in dense under stories of white fir (Deschutes National Forest, 1997). Elk in the region are considered "non-migratory" by the ODFW (Steve George, 2000, personal communication). They move from east to west across the Cascades during the summer. They don't travel east across Highway 97. Elk were not indicated as an issue under scoping for this project.

There are six populations of mule deer in the region (i.e., Metolius, Tumalo, North Polina, South Polina, Silver Lake and Fork Rock). They migrate through the watershed from east to west to summer range on the east side of the Cascades in the spring, from the end of April through June. In the fall, from the end of November through December, the deer migrate to winter ranges in the Fort Rock, Christmas, and Silver Lake Basins on the east side of Highway 97. The migration corridor extends roughly from Bend to Klamath Falls. The movement patterns are best described as a "sheet" rather than a "corridor" because of the width (approximately 130 miles) of the area they travel across (Steve George ODFW, 2002 pers. comm.). Migration is defined as a "sheet" in this area because there are no defined corridors or east-west oriented watersheds to 'funnel' deer, creating dispersed movement patterns. However, deer will stay in dense vegetation that provide screens/cover and avoid human developments (Steve George ODFW, 2002 personal comm.).

The quality of habitat during migration is also important for herd health. Migration habitat, including cover and forage requirements, has not been mapped in this watershed. No specific data on the migration patterns or timing are available. There is track count data available from ODFW that provides some insight into gross areas of higher use versus presence of dogs, but does not identify any specific corridors of use (Steve George ODFW, 2000 personal communication). Although the ODFW recognizes primary mule deer summer and winter ranges as being located outside the watershed, mule deer do use the upper reaches of the watershed during the summer (Shane Jefferies, 2002, personal communications).

Road kill data collected in 2000 by the Oregon Department of Transportation provides some insight into the number of animals crossing Highway 97 (Figure 7-1). These data are not collected in a systematic manner and do not include all animals killed, only those reported. However, despite the limitations, the data appear to show more animals are killed in the southern portion of the watershed, south of Crescent, than in the area between La Pine and Sunriver. This is consistent with the assumption that the deer avoid the densest areas of human development. The gender and ages of animals was only noted for 67 of the 83 animals reported with the distribution as follows: 12% or 18% of the road-kill deer were fawns, 37% or 55% were does, and 18% or 27% were bucks.

In addition to deer reported as road kill along Highway 97 there were 4 elk, 1 dog, and 1 buzzard. Data from other highways in the watershed were less specific. Along Highway 31 between mileposts 0 to 25, there were 38 deer, and 1 porcupine reported. Highway 58 between mileposts 51 to 73, 26 deer and 2 elk were reported.

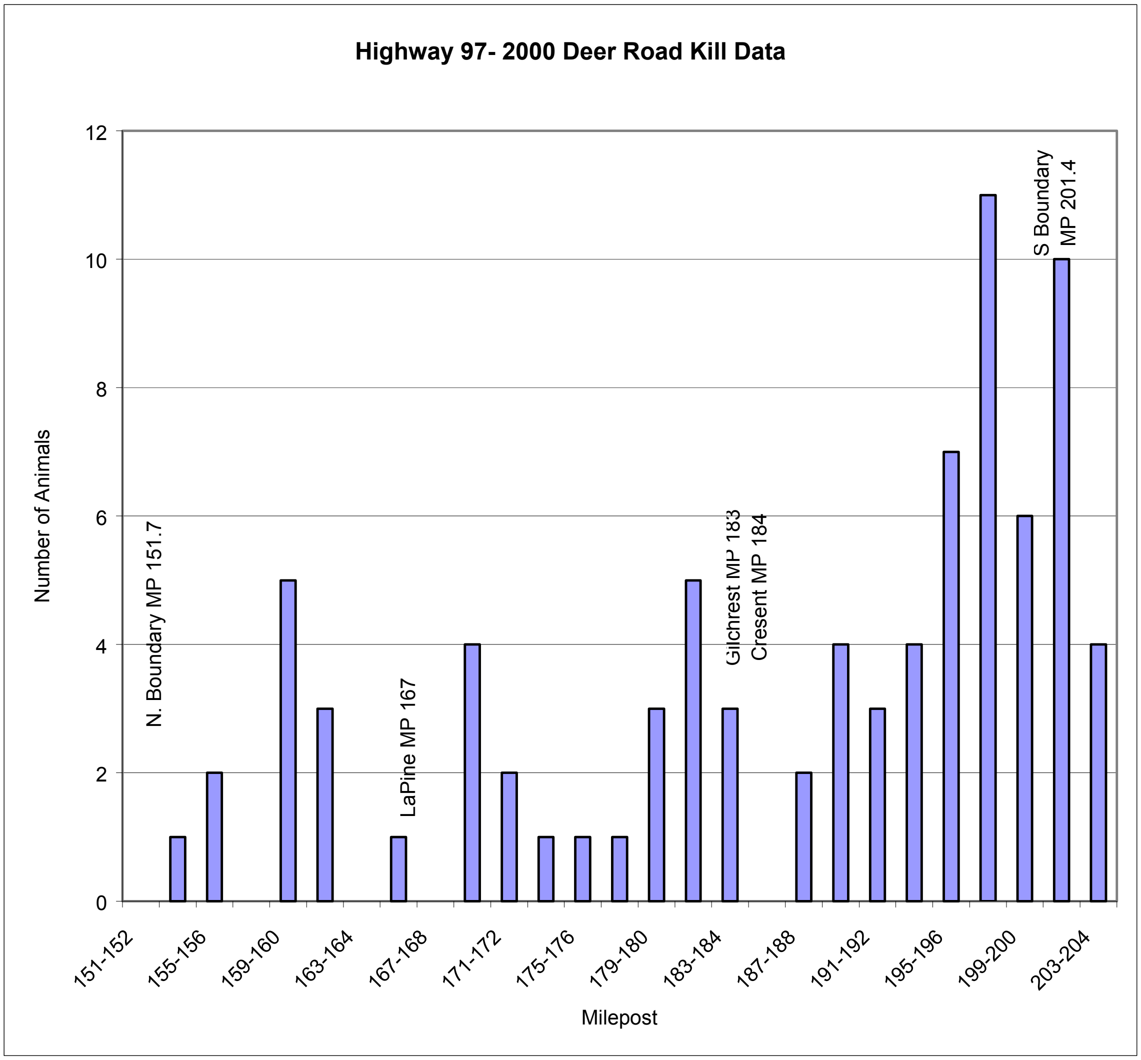


Figure 7-1 : Roadkill Deer along Highway 97 in the Little Deschutes River Subbasin (2000 Oregon Department of Transportation data).

8.0 FISHERIES AND AQUATIC HABITAT

The purpose of the Fisheries and Aquatic Habitat assessment is to summarize what is known about fish and other aquatic species populations, the condition of their habitats, and actions that can be taken to enhance or restore those habitats. The information comes primarily from Oregon Department Fish and Wildlife (ODFW) and USFS fisheries surveys and management plans. Where feasible, this report identifies opportunities for voluntary actions that can be taken in specific reaches of the Little Deschutes River and its tributaries.

8.1 Critical Questions

1. What fish species occur in the watershed? What is their abundance and distribution?
2. What other aquatic species, especially those of special interest, are found in the watershed? What is their distribution?
3. What are the aquatic habitat conditions in the watershed?
4. What are the locations and relative magnitude of channel modifications as identified in existing reports?
5. What portions of the channel network are likely sites for restoration?

8.2 Methods

Available reports on fisheries and aquatic habitats were obtained from the ODFW and the Deschutes National Forest (DNF). Primary contacts were Nate Dachtler with the Crescent Ranger Station, DNF, and Steve Marx, with ODFW in Bend.

The Upper Deschutes Subbasin Fish Management Plan (Wise *et al.*, 1996) provides a good overview of the fish species present in the watershed and aquatic habitat conditions at a broad scale. More detailed information on fish presence, habitat limitations, and restoration opportunities is summarized in habitat survey reports completed by the DNF and ODFW. The DNF surveys were conducted from 1989 to 2000 and cover the upper Little Deschutes River and tributaries. The ODFW fish habitat survey addresses the lower 75 miles of the Little Deschutes River from the mouth to the Forest Service boundary. Between the two agencies, the habitat surveys provide good spatial coverage of the river and main tributaries.

8.3 Findings

8.3.1 *Fish Species and Management*

As described in the historic conditions section, the Little Deschutes River was not accessible to anadromous salmonids due to a series of falls on the Deschutes River. Thus, fish species in the Little Deschutes River were historically native species of resident trout and sculpin, including redband trout, bull trout, mountain whitefish, and reticulate sculpin (Wise *et al.*, 1996). There are historical accounts of bull trout occurring in Crescent Creek and Crescent Lake (Wise *et al.*, 1996), with the last record of a bull trout in Crescent Lake in 1979.

Like most of the river systems of the west, non-native fish were introduced to the streams and lakes of the Little Deschutes River Subbasin. It is not known precisely when brown and brook trout were introduced into the Little Deschutes River system, but the timing was probably similar to the Deschutes River – in the early part of the century, certainly before the 1920's (Wise *et al.*, 1996). The first fish stocking in Crescent Lake occurred in 1915 with the release of brook trout; lake trout were first released into the lake in 1917. Brook trout continued to be stocked in the lake until 1939. Tui chub were introduced at an unknown time to Big Marsh Creek (Wise *et al.*, 1996). Stocking of non-native fish species (brook trout, kokanee, and brown trout) continued through the 1970's. Current status and pertinent life history information for species of management interest are listed in Table 8-1.

Table 8-1: Game fish in the Little Deschutes River Subbasin.

Species	Status	Description and Management Implications
Brook Trout (*Salvelinus fontinalis*)	Introduced	Brook trout is a charr, a trout family that includes lake trout and bull trout. Brook trout, native to the eastern United States, were introduced widely across the country. Brook trout readily hybridize with and out-compete bull trout. Consequently, ODFW manages brook trout to reduce their impact on native trout populations. Brook trout are no longer stocked, and are not protected by harvest regulations.
Brown Trout (*Salmo trutta*)	Introduced	Brown trout, native of Europe, are predators on fish, and effective competitors with other trout species in altered habitats with warm temperatures such as occur in the Little Deschutes River. Brown trout spawn mid-September to mid-November in the Little Deschutes.
Redband Trout Rainbow Trout (*Oncorhynchus mykiss*)	Native (State sensitive species) Introduced	This species includes the rainbow, redband, and steelhead subgroups. Redband trout are inland resident fish, native to the Little Deschutes River. Steelhead are the anadromous form that do not occur in the Little Deschutes River due to downstream falls. Hatchery Rainbow trout, of unknown hatchery origin, were stocked in the river to improve fisheries. Fish management objectives are now directed toward enhancing the native redband populations.
Bull Trout (*Salvelinus confluentus*)	Native Federal - Threatened species (USFWS) State – Sensitive Species	Bull trout are inland native charr that require cold water to successfully reproduce. Bull trout were historically distributed throughout the upper Deschutes River, but were extirpated in the L. Deschutes through hatchery introductions and changes in habitat. A limited population of natural adfluvial bull trout occurs in Odell Lake, in the nearby upper Deschutes River basin.
Mountain Whitefish (*Prosopium williamsoni*)	Native	Mountain whitefish is a member of the salmonid family native to streams and lakes in Oregon. Whitefish feed primarily on bottom dwelling insects in streams. Unlike salmon and trout, whitefish do not dig a redd (nest) to bury their eggs, but broadcast spawn instead. Whitefish are not listed as threatened and endangered species.

Fisheries management

Game fish management in the Little Deschutes River Subbasin is primarily directed toward brown trout, redband trout, brook trout, and mountain whitefish. Rainbow trout were stocked for many years in the Little Deschutes River, but this practice was discontinued in 1978. Existing river habitat is considered better habitat for brown trout than rainbow trout, due to warm water temperatures and aquatic plant growth favored by brown trout. Brown trout generally out compete rainbow trout because they occupy the best habitat and are a longer-lived fish. Current policies are to manage mountain whitefish and redband trout for natural production under the Wild Fish Alternative for trout; manage brown and brook trout for natural production under the Basic Yield Management Alternative; and state that hatchery trout will not be stocked in the Little Deschutes River and tributaries.

The Upper Deschutes River Subbasin Fish Management Plan identified five fisheries management issues (Wise *et al.*, 1996):

1. Introduced brown and brook trout have extirpated native rainbow and bull trout from much of the upper Little Deschutes; bull trout have been completely eliminated, and rainbow trout are found only in a small portion of their former range.
2. Reintroduction of bull trout and expansion of rainbow trout to their former range is considered technically infeasible at this time.
3. None of the irrigation diversions in the Little Deschutes River Subbasin are screened. The most significant unscreened diversion is the Walker Basin canal. The extent of trout loss to these diversions is unknown. The diversion locations were not specified in the report.
4. Fluctuations in streamflow in Crescent Creek and the Little Deschutes downstream from Crescent Creek due to irrigation withdrawals from Crescent Lake impact survival of trout in those streams.
5. Much of the Little Deschutes River system is in private ownership, and not accessible to the public.

The Fish Management Plan recommended a number of actions for addressing these issues. Actions that potentially can be taken by the UDWC and local landowners are identified in the Recommendations Section below.

8.3.2 *Fish Stocking*

Current fish stocking records for the Little Deschutes River date back to 1945 when fingerling rainbow trout of unknown stock were planted in the river. Legal-size rainbow were first stocked in 1948, and each year from 1954-1975 and from 1977-1978. There has been no stocking of hatchery rainbow trout since 1978. Numbers stocked ranged from 800 to 14,000 rainbow trout annually. Brook trout, brown trout, and kokanee were also stocked in the river. Table 8-2 summarizes these fish stocking records.

Table 8-2: Fish stocking records for Little Deschutes River (Wise et al., 1996).

Year	Species	Number	Size
1945	Rainbow trout	52,000	Fingerlings
1954-1975	Rainbow	800 - 14,000	Legal-size
1977-1978	Rainbow	800 - 14,000	Legal-size
1950	Brook trout	26,240	Fingerlings
1954	Brook trout	1,000	Legal-size
1969	Kokanee	25,600	Fry
1970	Brown trout	462	Legal-size
1974	Brown trout	13,327	Legal-size

Current stocking records show Crescent Creek was stocked only once in 1950 with 4-6 inch rainbow trout. However, Crescent Lake was stocked with brook and lake trout at the turn of century. Brown trout in Crescent Creek most likely moved downstream from Crescent Lake or upstream from the Little Deschutes River.

Current records show Big Marsh Creek was stocked in 1968-1969 with four to five thousand legal-size rainbow trout, reared at Klamath hatchery. Brown trout in Big Marsh Creek likely migrated from Crescent Creek. The origin of brook trout in Big Marsh Creek is unknown.

8.3.3 *Fish Distribution and Relative Abundance*

Information on fish distribution comes from Deschutes National Forest habitat surveys on the upper segment, primarily above Highway 58, and from ODFW surveys on the lower reach. The National Forest surveys were completed over several years using different protocols. The surveys completed in the 1990's and later generally included electrofishing or snorkeling, and therefore provide more reliable information.

Observation of fish species occurrence from the Forest Service surveys is summarized in Table 8-3. In general, these surveys show that brook trout are the dominant species in the tributaries and a section of the Little Deschutes River above Highway 58, and brown trout are the dominant species below Highway 58. These surveys also generally indicate that the population has shifted from native redband trout (and possibly bull trout) in these headwater streams to the non-native species. Brook trout now make up 95% of the population in the upper Mount Thiesen Wilderness.

Table 8-3: Distribution of fish species in the Little Deschutes River Subbasin.

Stream/Segment	Location	Species Occurence	Source
Cold Creek	Trib. to Crescent Creek	Brook, Redband (*Noted ideal habitat for bull trout)	Dachtler, 1999
Whitefish Creek	Trib. to Crescent Lake	Brook; 2-9 inches Rainbow (stocked) Brown	Meyer & Foster, 1991a
Refrigerator Creek	Trib. to Big Marsh Creek	Brook, Brown	Branum, 1996a
Upper Refrigerator Creek	Trib. to Big Marsh Creek	No fish observed Long-toed Salamander	Dachtler, 1997a
Big Marsh Creek	Trib. to Crescent Creek	Brook – 95%, redband –3%, brown – 2%	Dachtler, 1997b
Clover Creek	Trib to L. Deschutes	Brook, Brown	Hollister & Houslet, 1990a
Rabbit Creek	Trib. to Spruce Cr.	Small trout observed	Meyer & Foster, 1991b
Spruce Creek	Trib. to Hemlock Creek (to LDR)	Brook – dominant Brown - scarce	Dachtler, 1998
L. Deschutes River *River mile 95 - 93*	Clover Cr. to Burn Cr.	Brook - dominant Brown - scarce	Houslet, 2001
L. Deschutes River *River mile 86 - 93*	From Clover Creek downstream	Brown – dominant Brook - scarce	Houslet, 2001
Paulina Creek	Trib. to L. Deschutes	Brook – 6-7 inch size Rainbow	DNF, 1989

Relative abundance of fish species in the Little Deschutes River was evaluated by ODFW in 1974 and again in 1990/1992. ODFW surveys focused on the lower section of river below the national forest boundary. The most abundant species in the 1974 study (Lorz, 1974 cited in Wise *et al.*, 1996) were brown trout, mountain whitefish, brown bullhead, and Tui chub (Table 8-4). In the 1990's survey only 10 rainbow trout (3 to 9 inches) were captured in the reach extending from the mouth of Little Deschutes River to Cow Camp. Brook trout up to 7 inches long were abundant in the upper reach, but were scarce below Highway 58. Brown trout were the most abundant trout species, increasing in numbers from the headwaters to Highway 58, and then declining in abundance toward the mouth of the Little Deschutes River. Declining habitat conditions are believed to have allowed the brown and brook trout to out-compete the historically dominant rainbow trout.

Table 8-4: Relative abundance of fish species in the Little Deschutes River, 1974 (Wise et al., 1996).

Species	Relative Abundance	Status
Brown trout	Abundant	Non-native
Mountain whitefish	Abundant	Native
Brown bullhead	Abundant	Non-native
Tui chub	Abundant	Non-native
Brook trout	Common	Non-native
Reticulate sculpin	Common	Non-native
Rainbow trout (redband)	Scarce	Native

Fisheries in Paulina Creek are minimal due to habitat limitations. Only a few brook trout, 6-7 inches in length, were noted in a habitat survey (Deschutes National Forest, 1989). Although rainbow trout were stocked into the creek, no live fish were observed during the survey.

ODFW surveys from 1992 (below Highway 58) found rainbow trout to be the most abundant trout species in Crescent Creek with fewer species being captured downstream. The high proportion of rainbow trout in the sample in comparison to brown trout was attributed to the greater stream gradient in the canyon section below Highway 58. As gradient decreased the fish community shifted toward brown trout. The report noted low fish densities in Crescent Creek, and speculated that the stream should support a greater population.

Summary of Fish Distribution

The distribution of salmonid species is summarized in the attached maps (Maps 8-1, 8-2, and 8-3). In the upper Little Deschutes River fifth field watershed (in comparison to the Crescent Creek fifth field) brook trout are the dominant species in the tributary streams (Map 8-1). Below approximately Hemlock Creek, the fish community shifts to brown trout (Map 8-2), and further downstream, below Highway 58, brown trout become the dominant species. Thus, it appears that the non-native brook trout have displaced the native bull trout in the upper cooler tributaries, and non-native brown trout have displaced the native redband trout (Map 8-3). It should be noted that the ODFW Fish Management Plan (Wise *et al.*, 1996) identified the occurrence of a nematode parasite in the brown trout, and speculated if the decline in the brown trout population from 1960-1970 might be attributed in part to the effect of this parasite.

8.3.4 *Aquatic Habitat Conditions*

Habitat conditions and potential actions for restoration (where needed) are summarized in Table 8-5. The source of information is listed in the last column of the table.

Table 8-5: Aquatic habitat conditions and restoration opportunities.

Stream	Habitat Conditions	Opportunities	Source of Information
Cold Creek	Riparian zone, streambanks, LWD, and spawning gravel in good condition. Water source – cold-water springs. Pools provided by old beaver dams are declining.	Survey indicates a high quality habitat with springs that maintain cold water temperatures. The report suggests high quality habitat for bull trout.	Dachtler, 1999
Whitefish Creek	Wilderness designation in upper reach limits enhancement. Lower reach has unstabilized banks and lacks cover.	Riparian plantings to stabilize banks and provide cover.	Meyer & Foster, 1991a
Refrigerator Creek	Spring-fed, providing cold temperatures. Falls in upper section limits fish distribution. Habitat impacted by RR and road crossings.	The report indicated presence of oil barrels at RR crossing at time of survey. Road crossing may need to be evaluated further as source of sediments.	Branum, 1996a
Upper Refrigerator Creek	Spring fed, dense undisturbed riparian canopy.	Protected by Oregon Cascade Recreation Area. No management indicated.	Dachtler, 1997a
Big Marsh Creek	Past grazing and dewatering in Big Marsh restoration project in 1997.	Continued protection of marsh needed during recovery.	Dachtler, 1997b
Clover Creek	Clover Cr. is in the designated wilderness area. Grazing at time of survey caused limited bank damage.	Survey indicated some minor changes to season of use, but the survey is 10 years old	Hollister & Houslet, 1990a
Rabbit Creek	Small high quality stream provides cold water to Spruce Cr.	No enhancement indicated other than continued protection.	Meyer & Foster, 1991b
Spruce Creek	Low gradient stream, sand substrate. Past grazing practices caused downcutting and entrenchment.	Current streamside management practices will assist stream recovery. No stream enhancement needs indicated.	Dachtler, 1998
L. Deschutes River **River mile 95 - 86**	Low gradient, meandering, with sand substrate. Temperatures exceed water quality criteria.	Temperatures increase until criteria of 14C exceeded starting at Highway 58. Potential for riparian enhancements to increase shade and cover.	Houslet, 2001
L. Deschutes River, ***River mile 80 - 63*** ***Highway 58 to Gilchrist Mill Pond.***	Insufficient information.		Wise *et al.*, 1996
L. Deschutes River, ***River mile 63 - 00*** ***Gilchrist Mill Pond to mouth.***	Altered flow regime, high temperatures, degraded riparian conditions.	Riparian enhancement to restore sedge/willow streambank community, examination of minimum streamflows.	Wise *et al.*, 1996
Paulina Creek	Lacks pool habitat, cover & spawning gravel, Falls as migratory barriers.	Opportunities may be limited by natural conditions – falls and bedrock channels.	DNF, 1989

9.0 SURFACE WATER QUALITY

The purpose of the surface water quality section is to summarize existing information sources and identify the key data gaps that may require further study. The primary source of information on water quality is from the Oregon Department of Environmental Quality (ODEQ), Deschutes National Forest (DNF), and local governments. Where feasible, the report will identify specific actions that can be taken by the UDWC to address data gaps and improve water quality.

A common source of confusion regarding water quality assessment is the unique jargon used to describe water quality goals and measures. The terms – *beneficial uses, water quality standards, water quality criteria, water quality limited*, etc. have a distinct meaning derived from the federal Clean Water Act and incorporated into Oregon water quality regulations. We will bring these terms into context, and then describe the application to the Little Deschutes River Subbasin.

9.1 Critical Questions

1. What are the designated beneficial uses for streams in the watershed?
2. What are the water quality criteria that apply to streams in the watershed?
3. Are there stream reaches identified as water quality limited on the State's 303(d) list?
4. What do water quality studies or other summary documents indicate about water quality conditions?
5. What are the key data/information gaps in water quality information?

9.2 Methods

Information on beneficial uses, applicable water quality criteria, and 303(d) listed streams were identified from the Oregon Water Quality Standards, and approved 303(d) list provided by ODEQ. Existing water quality data available were obtained by checking the ODEQ, Environmental Protection Agency, and U.S. Geological Survey online databases and agency websites. Information on planned water quality studies, clarification of the 303(d) listing, and non-published reports were obtained directly from Bonnie Lamb, ODEQ Bend office. This information was reviewed for descriptions of existing water quality conditions and potential data gaps.

9.3 Water Quality Regulations

In a broad sense, the term water quality includes the water column, the stream channel, and the associated riparian areas that influence the stream. The goal of the federal Clean Water Act, "*to protect and maintain the chemical, physical, and biological integrity of the nation's waters*", identifies the importance of assessing both water chemistry and the habitat required for maintaining fish and other aquatic organisms. In Oregon, this goal is incorporated into the state Water Quality Standards and the associated regulations.

Water Quality Standards include the list of beneficial uses of the stream, the criteria designed to protect those uses, and policies to implement the standards. *Beneficial uses* refer to a list of specific uses for which water is to be protected, such as drinking water supplies, fisheries, and recreation. *Water quality criteria* are defined to protect these beneficial uses of water. Water quality criteria are comprised of narrative statements and numeric criteria. Numeric criteria are established when it is feasible to identify specific limits that protect these uses across the basin. Narrative criteria are used when it is infeasible to set specific targets at a regional or statewide level. Information from the scientific literature is then used on a case-by-case basis to interpret the narrative criteria and apply it to the specific watershed. For example, water quality criteria are specified that limit the suspended solids and bacteria that can be present in drinking water. To protect trout, the criteria provide specific numeric limits for stream temperature, dissolved oxygen, and toxic agents. However, nutrients and sedimentation are covered only by narrative statements.

The beneficial uses and criteria identified in the Water Quality Standards provide the basis for a TMDL, the Total Maximum Daily Load, for a stream segment. The federal Clean Water Act requires states to maintain a list of streams, called "*water quality limited streams,* " that do not meet water quality standards. The 303(d) list of water quality limited segments refers to the section of the Clean Water Act that identifies the requirement. Streams on the list may be studied further to determine if the listing was appropriate in the first place; if not, the stream segment can be removed from the list. If the 303(d) listing is warranted, data are collected to calculate the TMDL. The TMDL is based on identifying the maximum pollutant load that can be supported and still meet water quality criteria. Pollutant loads, above the level that meet water quality criteria, are required to be reduced over time using pollution control technology for point sources, such as wastewater treatment plants, and using BMPs, best management practices, for non-point sources.

The beneficial uses of water, water quality criteria, and 303(d) listed streams in the Little Deschutes River are identified in the next section.

9.4 Findings

9.4.1 *Beneficial Uses and Water Quality Standards*

Beneficial uses in the Little Deschutes River Subbasin and water quality criteria applicable to the Deschutes Basin are listed in Table 9-1 and Table 9-2.

Table 9-1: Beneficial uses of water protected in the Deschutes Basin.

Beneficial Uses: Deschutes River Basin (OAR 340-41-562)	
Public Domestic Water Supply*	Salmonid Fish Spawning
Private Domestic Water Supply*	Resident Fish & Aquatic Life
Industrial Water Supply	Wildlife & Hunting
Irrigation	Fishing
Livestock Watering	Boating
Anadromous Fish Passage	Water Contact Recreation
Salmonid Fish Rearing	Aesthetic Quality

* With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards. (ODEQ, 2001a).

Table 9-2: Summary of applicable water quality criteria.

Parameter (Beneficial Use)	Criteria Type/ Measurement	Criteria *
Aquatic Weeds or Algae (Water contact recreation, aesthetics, fishing)	Narrative Criteria (biological monitoring)	Growth of fungi or other growths having a deleterious effect on aquatic life or which are injurious to public health, recreation, or industry are not allowed. See also Nutrients.
Bacteria (Water contact recreation)	NumericCriteria *Escherichia coli*	126/100 ml. (30 day log mean) 406/100 ml. (Single sample)
Biological Criteria (Resident fish and aquatic life)	Narrative Criteria (measured using macroinvertebrates)	Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
Dissolved Oxygen (Resident fish and aquatic life, salmonid spawning and rearing)	Numeric Criteria Dissolved oxygen (mg/L)	Salmonid Spawning: Greater than 11 mg/L Cold Water Aquatic Life: Greater than 8.0 mg/L. (Several conditions apply, see standards for details.)
Habitat & Flow Modification (Resident fish and aquatic life, salmonid spawning and rearing)	Narrative Criteria (Habitat measurements, flow assessment)	Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
Nutrients (Aesthetics)	Narrative Criteria (phosphorus, nitrates, ammonia)	No criteria for the Deschutes Basin. Suggested screening criteria from OWEB Manual (WPN 1999). Total Phosphorus 0.05 mg/L Total Nitrate 0.30 mg/L
pH (Resident fish and aquatic life, water contact recreation)	Numeric Criteria (pH)	pH: 6.5 – 8.5
Sedimentation (Resident fish and aquatic life, salmonid spawning and rearing)	Narrative Criteria	Formation of bottom deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry are not allowed
Temperature (Resident fish and aquatic life, salmonid spawning and rearing)	Numeric Criteria (temperature)	Salmonid fish rearing: 64 ° F. Salmonid spawning: 55 ° F.
Toxics (Resident fish and aquatic life)	Numeric Criteria	Numeric criteria are identified for 120 organic and inorganic toxic substances in Table 20 in the Oregon Water Quality Standards (ODEQ 2001).
Turbidity (Resident fish and aquatic life, water supply, aesthetics)	Narrative Criteria (turbidity (NTU))	Not greater than 10% increase over natural stream turbidity. Suggested screening criteria – 50 NTU (WPN 1999)

* The criteria are abbreviated in this table. Most criteria have associated conditions and exceptions that apply. Obtain the full text of the regulations (ODEQ, 2001a) for specific applications.

The water quality standards become meaningful when applied to specific issues in the Little Deschutes River Subbasin. The 303(d) listing (described below) and the Regional Problem Solving document (Deschutes County, 1998) address several water quality problems. Currently, stream segments are listed on the 303(d) list for temperature. The application of the temperature standards to these segments are important since ODEQ is required to develop a TMDL and subsequent water quality management plan for the listed segments. The Regional Problem Solving document highlights a concern with the impact of continued residential development and the effect of septic systems on water quality. Although the issue has been primarily directed to groundwater contamination, this development may have an effect on surface waters as well. Specific criteria that may be of concern from sewage disposal are nutrients, bacteria, and associated pathogens. The concern with nutrients is the stimulation of excess aquatic plant growth, which then can cause other deleterious effects on the aquatic ecosystem such as shifts in pH and dissolved oxygen. Narrative criteria that apply to aquatic weeds or algae and numeric criteria for dissolved oxygen and pH may then apply.

9.4.2 *Water Quality Limited Streams – 303(d) listing*

The Little Deschutes River has four segments listed on the 1998 303(d) list (ODEQ, 1998) for temperature, shown in Table 9-3 and shown on Map 9-1. The listing is based on ODFW and USFS continuous temperature data collected over several years. In addition, the Little Deschutes River, from the mouth to Crescent Creek, is on the 303(d) list as needing data for bacteria, flow modification, habitat modification, nutrients, and sediments. The basis for this listing is the statewide non-point source assessment (ODEQ, 1988). The non-point source assessment was based on a questionnaire procedure, and therefore needs validation through data collection.

Table 9-3: 303(d) listed waters in Little Deschutes River Subbasin.

Stream Segment (Description)	Parameter/ Criteria	Supporting Data or Information
Crescent Creek (mouth to Crescent Lake)	Temperature Rearing (64° F) 303 (d) List	USFS Data , 2 Sites: Above and Below Big Marsh Cr: 7 day average of daily maximums of 68.3/68.5 with 56/60 days respectively exceeding standard in 1989; ODFW Data (RM 18.5): 7 day average of daily maximum of 73.6 with 102 days exceeding 64 in 1994.
Little Deschutes River (mouth to Crescent Creek)	Temperature Rearing (64° F) 303 (d) List	ODFW Data (4 Sites between RM 62 - 80): 7 day average of daily maximums exceeded standard (64) with values ranging from approximately 68 to over 73 in 1994.
Little Deschutes River (Crescent Creek to Hemlock Creek)	Temperature Rearing (64° F) 303 (d) List	(Same as row above)
Paulina Creek (mouth to Paulina Lake)	Temperature Rearing (64° F) 303 (d) List	USGS Data (Site 14063300; below Paulina Lake outlet): 7 day average of daily maximums of 70.9/64.9/71.9 with 69/8/65 days exceeding standard (64) in 1992/1993/1994 respectively.
Little Deschutes River (mouth to Crescent Creek)	303 (d) Listing Status: Needs Data	Needs Data for bacteria, flow modification, habitat modification, nutrients, sedimentation. Based on Oregon Nonpoint Source Assessment (ODEQ 1988).

9.4.3 *Water Quality Information*

The primary emphasis on water quality in the Little Deschutes River has been on the effect of septic systems on nitrates in groundwater. Therefore, surface water quality data are fairly limited. ODEQ initiated a comprehensive water quality study in 2001 to collect data for the development of TMDLs in the Little Deschutes watershed. This study will provide much needed objective information to understand water quality conditions in this watershed for which little current data is available. Available water quality information for the watershed is provided in the following sources, which will be summarized briefly below.

1. A 1997-1998 ODEQ study, the Upper Deschutes River Basin, Regional Environmental Assessment Program (REMAP). Study results are summarized in three reports: temperature (Mochan, 1998), water chemistry (Hubler, 1999), and fisheries (Hubler, 2000).

2. Data in the ODEQ water quality database, Laboratory Analytical Storage and Retrieval Database (ODEQ, 2001b).

3. Oregon Water Quality Index station located at Little Deschutes River at Highway 42(#10696).

Upper Deschutes River Basin, REMAP study.

The study's objective was to evaluate the Deschutes River at a basin scale. The study design approach used randomly selected monitoring sites within the basin, so few monitoring stations were located within the Little Deschutes River Subbasin. As a result, the study provides little useable information relative to water quality issues in the Little Deschutes River. The information does provide some context for understanding how the Little Deschutes River compares to other rivers in the basin.

In general, water quality in the Upper Deschutes Basin was good to excellent using the ODEQ water quality index scores as an indicator. It was noted that the Little Deschutes River site exhibited some potential dissolved oxygen problems; fluctuations in dissolved oxygen characteristic of a river with high algal/aquatic plant productivity (Hubler, 1999). An inspection of the ortho-phosphorus and nitrate data in the report shows an increase in these nutrients from the tributaries (Hemlock and Crescent Creek) to the lower Little Deschutes River. The temperature summary (Mochan, 1998) provides no data interpretation useful for the Little Deschutes River Subbasin.

Water Quality Stations

There are 14 water quality stations in the ODEQ water quality database. Many of these stations were associated with the 1997-1998 REMAP study. Other stations are located to monitor the effects of the Gilchrist millpond and the Gilchrist sludge lagoons. The data available at these stations is summarized in Table 9-4.

Table 9-4: ODEQ water quality monitoring stations in Little Deschutes River Subbasin.

Station Number	Station Description	Begin Date	End Date	Representative Number of samples*
Little Deschutes River Basin				
12883	Hemlock Cr. 75ft. downstream of Road 5830	8/5/97	8/5/97	1
12884	L. Deschutes R., 0.5 mi downstream USFS Rd. 100	8/7/97	9/2/98	5
10703	L. Deschutes R., upstream Gilchrist Mill Pond.	4/29/69	1/24/96	22
10702	L. Deschutes R., downstream Gilchrist Mill Pond.	4/29/69	5/7/75	15
10701	L. Deschutes R., downstream 1st sludge lagoon	4/29/69	3/31/70	3
10700	L. Deschutes R., downstream 2nd sludge lagoon	3/31/70	8/4/70	2
10699	L. Deschutes R. at Road 2320	3/31/70	1/23/96	15
10698	L. Deschutes R. at Masten Rd	3/31/70	1/23/96	5
10922	Long Prairie Slough	11/17/70	11/14/72	5
10697	L. Deschutes R. at Burgess	8/1/95	1/24/96	4
12560	L. Deschutes R., State Park Road.	8/1/95	1/24/96	5
10696**	L. Deschutes R. at Hiway 42	8/1/95	3/13/01	40
10595	L. Deschutes R. downstream Vandervert Ranch	3/31/70	11/14/72	8
10921	Paulina Cr. at Highway 97	11/14/72	11/14/72	1
Crescent Creek Basin				
10713	Crescent Cr. @ RR Crossing	9/1/98	9/1/98	1
12564	Crescent Cr. @ Crescent Cr. cutoff	8/1/95	1/24/96	4
12565	Crescent Cr. @ Little River	8/1/95	8/2/95	2
10704	Crescent Cr. @ Roads 2027/2320 (Gilchrist)			

* Sample frequency and parameters varies by station. To provide an indication of the amount of data available, the table shows the number of samples for nitrates as a representative parameter.
** Little Deschutes River trend station. Source is ODEQ, 2001b.

Sample periods, frequency, and parameters vary at these stations. As a result, data interpretation using these existing data sets is not particularly useful. The trend station and the TMDL study results described below will provide more useable information.

Trend Station

The monitoring station, Little Deschutes River at Highway 42 (#10696), was added to the statewide ambient water quality monitoring network in 1995. The ODEQ maintains a network of ambient water quality monitoring sites to monitor trends over time using consistent methods across the state. Overall conditions and trends are evaluated using a water quality index. The Oregon Water Quality Index (OWQI) analyzes a defined set of water quality variables and produces a score describing general water quality. The water quality variables included in the OWQI are temperature, dissolved oxygen (percent saturation and concentration), biochemical oxygen demand, pH, total solids, ammonia and nitrate nitrogens, total phosphorus, and fecal coliforms. OWQI scores range from 10 (worst case) to 100 (ideal water quality).

The Little Deschutes River trend station was included in the latest summary report (Cude, 2000) in which sites were grouped into categories by score: 90-100 excellent, 85-89 good, 80-84 fair, and 60-79 poor. In this analysis the Little Deschutes site scored a summer average score of 91, falling into the excellent category. The analysis provides some general comparison to water quality on a statewide basis, but does not address local water quality conditions that can be explored in a concentrated study. The TMDL study described below will be helpful in evaluating the local water quality issues.

TMDL Study

The Upper/Little Deschutes TMDL Water Quality Monitoring Plan (Lamb, *et al.*, 2001) was initiated in the 2001 field season. This is an ongoing project, but the information is useful to summarize here to understand what data gaps might exist. The Little Deschutes River Subbasin study has two objectives: assessing temperature and the effects of excessive plant productivity.

The temperature study includes several components designed to assess the existing temperature condition, evaluate sources, and provide sufficient information to run the ODEQ temperature model. Temperature data will be collected at sixteen locations in the Little Deschutes River Subbasin using continuous temperature recorders from May through October. A Forward-Looking Infrared Radiometry (FLIR) flight will be completed during the summer. The FLIR flight provides an infrared map of surface water temperature to help delineate heating and cooling sources throughout the length of the river. In conjunction with collection of FLIR data, streamflow, physical stream measurements, and riparian vegetation data will be collected. These data are used to provide inputs into a temperature model, *Heat Source*, used by ODEQ to simulate processes that influence temperature, evaluate predictions of restoration strategies, and allocate heat loading for TMDLs.

To evaluate the effect of plant productivity (both algae and aquatic plants) on pH and dissolved oxygen, ODEQ plans to collect data over two one-week intensive periods during July and October 2001. Timing of the intensive surveys is designed to target the critical period during the summer for pH and during the fall for dissolved oxygen. The fall survey will assess dissolved oxygen during the critical period for salmonid spawning, such as brook and brown trout, when the water quality standards require the highest dissolved oxygen concentrations. Dissolved oxygen, temperature, pH, and conductivity will be collected continuously using Hydrolab meters, and water chemistry samples for nutrients and associated parameters will be collected on a daily basis.

Together these data sets should be useful for evaluating water quality issues that have been raised as concerns in agency and local planning documents. One potential issue that is not being addressed with these studies is bacterial contamination of surface waters from septic systems. Bacteria data are not being collected since it has not been indicated as a surface water problem in previous data sets. This may be a data gap that can be addressed at the local level, as it specifically relates to private and community waste disposal systems.

10.0 SURFACE WATER QUANTITY, GROUNDWATER QUANTITY & QUALITY

Surface water refers to the water flowing in streams and in lakes. Groundwater is water moving below ground. It is important for land managers to have an understanding of how much water is available in their watershed, where it comes from, and how it moves through the watershed. This information is key to determining how land management activities, water use, and development may be impacting the quality and quantity of water.

This portion of the assessment summarizes the available groundwater and surface water data to identify and quantify the components of the hydrologic budget in the basin and identify data gaps and potential watershed enhancement options. The information comes primarily from United States Geological Survey (USGS) reports and data from the Oregon Water Resources Department (OWRD).

10.1 Critical Questions

Surface Water

1. What are the streamflow characteristics?

2. How has the natural hydrologic pattern/cycle been altered?

3. What are the sources and amount of surface water use in the subbasin?

Groundwater

1. What is the hydrogeologic setting of the basin and how does it influence groundwater flow in the region?

2. What are the components and quantities of water identified by the USGS in their water budget calculations?

3. What are the sources and estimated amounts of groundwater recharge to the basin?

4. What are the sources and estimated amounts of groundwater withdrawals in the basin?

5. What fluctuations in groundwater levels have been identified and what are some of the possible causes?

6. What are the groundwater/surface water interactions in the basin?

7. What are some of the potential impacts of growth on groundwater and surface water supplies?

10.2 Methods

Available reports on groundwater hydrology were obtained from the USGS. Reports included "*Ground-Water Hydrology of the Upper Deschutes Basin, Oregon"*, Water Resources Investigation Report 00-4162 (Gannett *et al.* 2001) and *"Chemical Study of Regional Ground-Water Flow and Ground-Water/Surface-Water Interaction in the Upper Deschutes Basin, Oregon"* Water Resources Investigation Report 97-4233 (Caldwell, 1997). Surface flow data was obtained from USGS web sites containing data from gauging stations on the Little Deschutes and Deschutes Rivers. Water rights data was obtained from the OWRD web site and Kyle Gorman, OWRD Water Master.

The *Ground-Water Hydrology of the Upper Deschutes Basin* report (Gannett *et al.* 2001) gave a good overview of the hydrologic regime in the Upper Deschutes River and quantified components of the water budget. The report described geology, topography, soils, vegetation and precipitation typical for the entire Upper Deschutes. While the quantities given in the report are specific to the Upper Deschutes River, a comparable range of values can be expected in the Little Deschutes River Subbasin. Specific data, where available, are presented for the Little Deschutes River Subbasin.

10.3 Surface Water

Surface water sources in the Little Deschutes River Subbasin include the Little Deschutes River, Paulina, Crescent, Big Marsh, Whitefish, Cold, Refrigerator, Clover, Rabbit, and Spruce Creeks and a number of unnamed tributaries. Surface water withdrawals are closed to any additional appropriation of surface water. Hence, future water development needs in the area will have to rely on groundwater as a water source.

10.3.1 *Streamflow Characteristics*

Streamflow data for the Little Deschutes River near La Pine, Oregon gauging station was obtained from the USGS. Data were compiled for the period of record (1923-1995) and minimum, maximum, and mean data were computed for each day of the irrigation year (Figure 10-1). For example, on October 1 for the period of record, the lowest flow recorded was 9 cubic feet per second (cfs), the highest flow was 332 cfs and the mean flow was 84.7 cfs. The very high value for December 25 represents the 24-hour average flow at La Pine during the 1964 flood event when a flow 3240 cfs was recorded.

The figure illustrates a typical spring runoff pattern with increasing flows in the months of March, April, and May from melting snow pack and decreasing flows by the end of June. The hydrograph illustrates the river is dominated by surface flow. A groundwater component to the flow is present, however, as shown by the percent of the minimum flow relative to the mean.

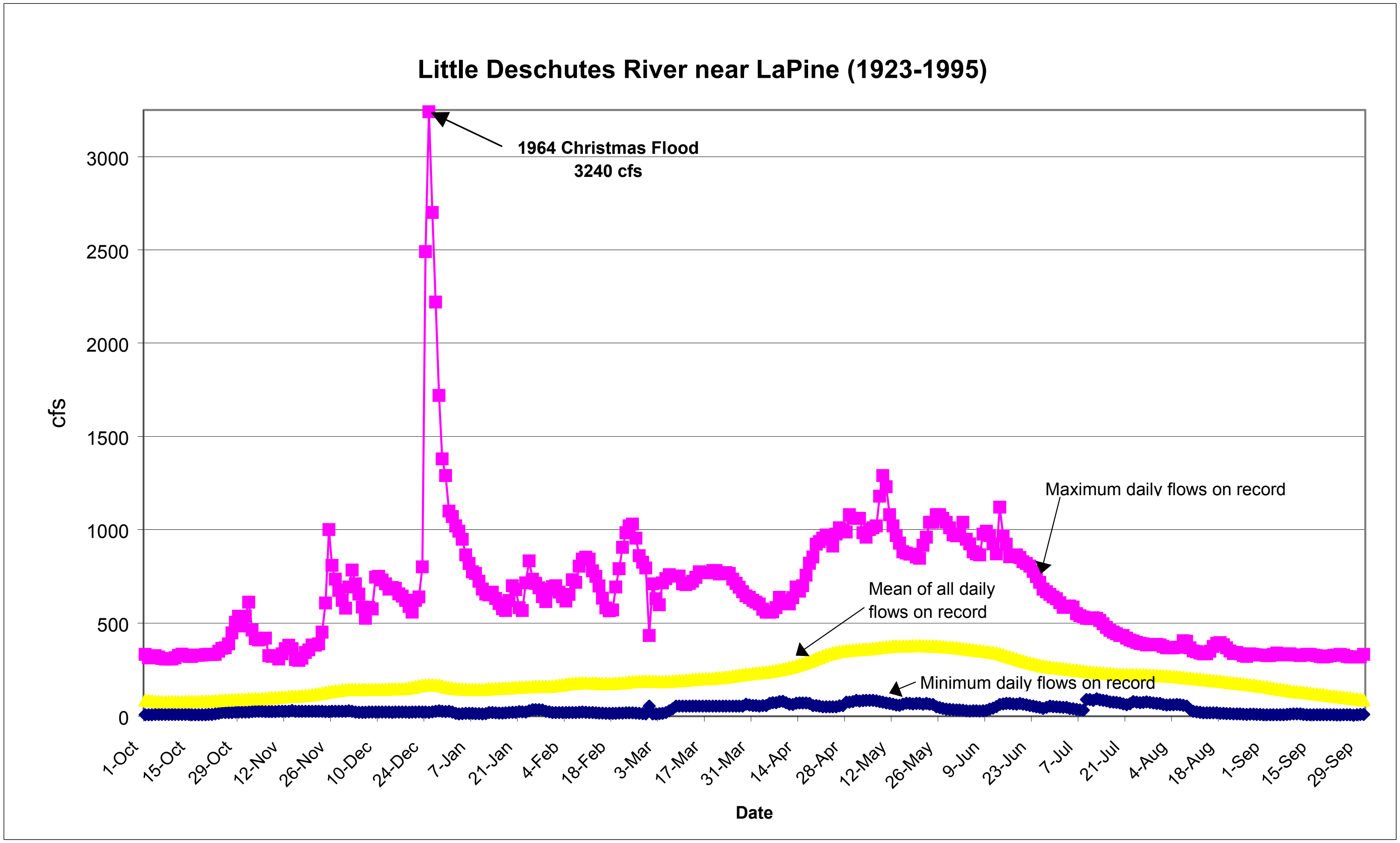


Figure 10-1: Mean, Minimum and Maximum daily flows on the Little Deschutes River, Oregon for period of record 1923-1995. Data compiled from the United States Department of the Interior, Bureau of Reclamation historical data from HYDROMET.

10.3.2 *Alteration of Natural Hydrologic Pattern*

The natural hydrologic cycle of a watershed can generally be described as inflow to the system in the form of rainfall or snowmelt and outflow in the forms of streamflow (or runoff) and evapotranspiration (Figure 10-2). Any change to this pattern results in an alteration of the natural hydrologic pattern. Examples of alterations include dams, stream diversions, pumping, and storm drains.

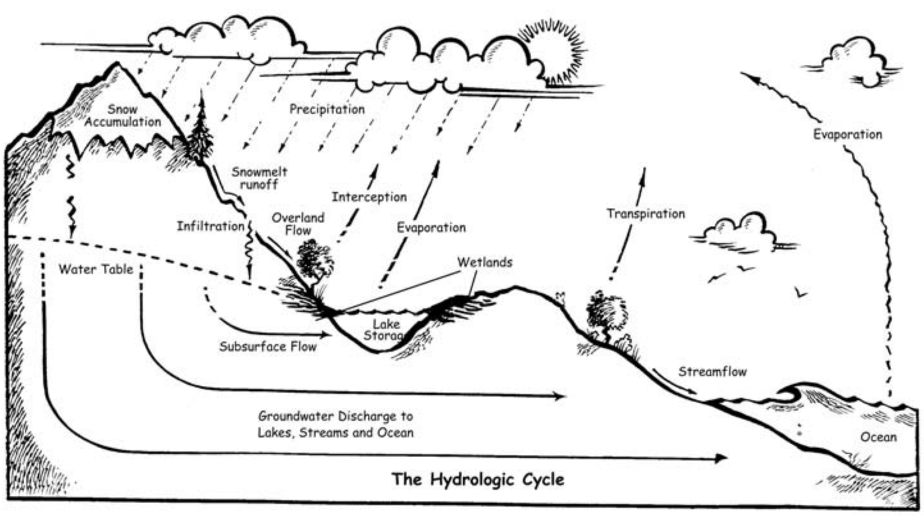


Figure 10-2: Illustration of a generalized hydrologic cycle (WPN, 1999).

Crescent Lake and Paulina Lake are natural lakes with man-made outlet structures to store water and control outflow for irrigation. Some irrigation diversions are present in the basin, but the number and amount of water rights on the Little Deschutes River does not significantly alter flow in the river. Similarly, groundwater pumping in the Little Deschutes River Subbasin does not comprise a significant component of groundwater discharge in the basin. This will be discussed in greater detail in the Hydrologic Budget section.

10.3.3 *Surface Water Use*

A portion of the Surface water use in the Little Deschutes River Subbasin is for irrigation. Total use was calculated using water right information from the OWRD. Valid water rights were totaled for each tributary to the Little Deschutes River. Rights no longer considered valid were not included in the summary. Table 10-1 summarizes the total flow rights on each stream. Mr. Kyle Gorman of OWRD and water master for the Deschutes River indicated that diversions on the smaller creeks and the Little Deschutes River do not have measuring devices so actual diversion measurements are unavailable. Consequently, the total amount diverted annually was computed by assuming each diversion took their full right every day for the irrigation period May 1 through September 30 – which is likely to overestimate the actual water used.

Table 10-1: Summary of Surface Water Rights on Little Deschutes River and Tributary Creeks (ODWR water rights data).

Stream	Water Rights (cfs)	Total Acre-Feet
Crescent Lake		86,050
Paulina Lake		249,850
Cold Creek	0.1	30
Whitefish Creek	No rights	0
Refrigerator Creek	No rights	0
Big Marsh Creek	0.44	133
Clover Creek	No rights	0
Crescent Creek	5.92	1,796
Rabbit Creek	No rights	0
Spruce Creek	No rights	0
Little Deschutes River	16.75	5,083
Paulina Creek	8.3	2,519

Mr. Gorman indicated the only creek that goes dry at any time during the year is Paulina Creek but stated it is not due only to irrigation demand. The total water rights on Paulina Creek are not so large as to cause the creek to run dry during the year. The flow in the creek is controlled at Paulina Lake and the amount of water released into Paulina Creek is based on the elevation of the water in the lake and/or the amount of water needed for irrigation. Consequently, as happens in the winter months, if the inflow into the lake is relatively low, there will be very little water released from the lake and the creek will run dry. Also, the reach immediately downstream of Paulina Lake is a losing stream reach, which will also result in the creek going dry at low flows. This will be discussed in the section on stream leakage.

10.4 Groundwater

10.4.1 *Hydrogeologic Setting*

The storage and flow of groundwater is controlled to a large extent by geology. The principle geologic factors that influence groundwater flow are the porosity and permeability of the rock or sediment through which it flows. Porosity is the proportion of a rock or deposit that consists of open space. Permeability is a measure of the ability of water to move through the soil or rock. Deposits with large interconnected open spaces, such as gravel, have little resistance to groundwater flow and are considered highly permeable. Rocks with few, very small or poorly connected open spaces offer considerable resistance to groundwater flow and have low permeability.

The Little Deschutes River Subbasin is dominated by deposits of volcanic ash and pumice as the result of lava flows from the Cascade Mountains from the west and Newberry Crater from the east. This highly permeable volcanic material has created coarse, rapidly draining soils and high groundwater tables. As a result, precipitation to the subbasin in the form of rainfall and snowmelt infiltrates quickly and migrates downward to the underlying aquifer.

The principal aquifer underlying the Little Deschutes River Subbasin is the Deschutes Formation that consists of a variety of materials which are highly permeable: lava flows, vent deposits, and sand and gravel layers. The aquifer ranges in thickness from zero to over 2,000 feet at its westernmost exposure in the Cascade Range.

Regional groundwater flow in the Little Deschutes River Subbasin is primarily controlled by the distribution of recharge areas, the geology, and the location and elevation of streams. Groundwater flow in the Little Deschutes River Subbasin is from recharge areas in the Cascade Range and Newberry Crater to the north, parallel to flow in the Little Deschutes River. Map 10-1 illustrates regional groundwater flow in the entire Upper Deschutes River basin. The Little Deschutes River Subbasin is located in the southern portion of this figure.

Groundwater underlying the La Pine subbasin forms a relatively flat surface, with an elevation of about 4,200 feet and a slight gradient generally toward the north-northeast. In this area the water table is shallow, often within several feet of land surface.

10.5 Hydrologic Budget Components and Estimates

The USGS report *Ground-Water Hydrology of the Upper Deschutes Basin, Oregon* (Gannett, *et al.*, 2001), provides a quantitative assessment (hydrologic budget) of the regional groundwater system. A hydrologic budget identifies the components and amounts of recharge and discharge in a basin. Recharge is defined as infiltration of water that moves downward into the underlying aquifer. Discharge is defined as groundwater flowing toward the surface where it may escape as a spring, seep, well, or base flow in a stream. Groundwater may also discharge as evapotranspiration, which is groundwater used by plants.

The report identified the following sources of recharge to the Little Deschutes River Subbasin: infiltration of precipitation, canal leakage, on-farm losses, stream leakage, drainage wells, and interbasin flow. Sources of discharge include: groundwater discharge to streams, groundwater discharge to wells, and groundwater discharge by evapotranspiration. Figure 10-3 illustrates the elements and relative contributions of each element to the overall Little Deschutes River Subbasin groundwater budget. Each component of the budget is discussed below.

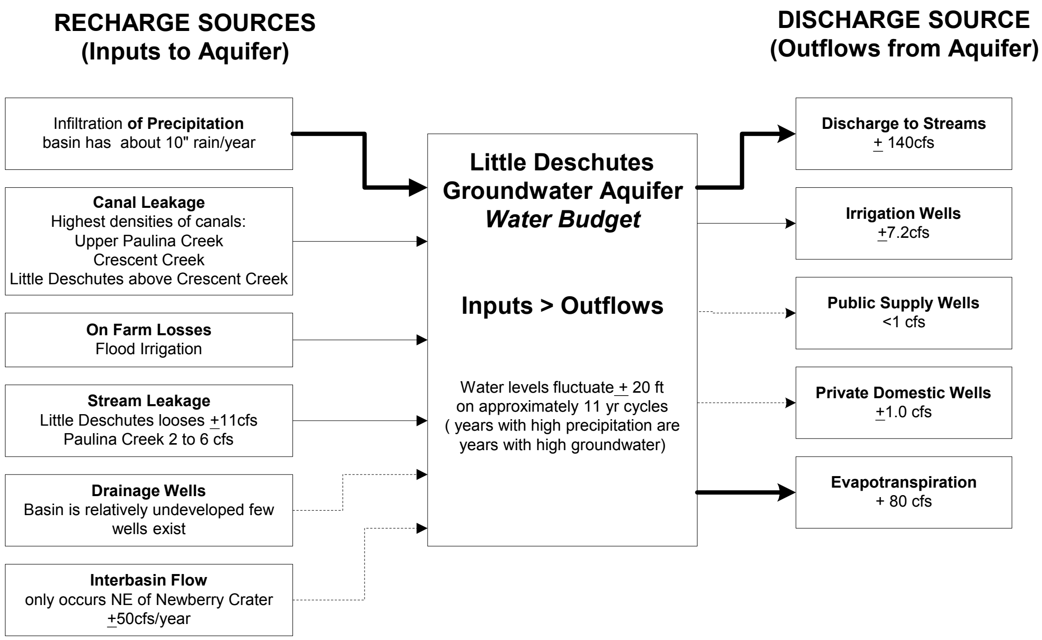


Figure 10-3: Flowchart of Little Deschutes River Subbasin groundwater budget components (Summary of data in Gannett, et al. 2001).

10.5.1 *Groundwater Recharge*

Infiltration of Precipitation

Recharge from precipitation occurs where rainfall or snowmelt infiltrates and percolates through the soil and reaches the saturated part of the groundwater flow system. Recharge is the quantity of water remaining after runoff and evapotranspiration take place.

The USGS study used a deep percolation model to estimate mean monthly and annual recharge from precipitation to the aquifer. The model uses precipitation, temperature and solar radiation data to estimate the amount of recharge to the aquifer. The model estimated recharge between 1962-1997. Estimated recharge ranged from less than 3 inches in the drought years of 1977 and 1994 to nearly 23 inches in 1982. The mean for this period was 11.4 inches/year; this converts to an annual rate of about 3,800 cfs or 7,540 acre-feet.

Approximately 84 percent of recharge from precipitation occurs between November and April. Recharge peaks in December and again in March and April. The December peak results from percolation of precipitation after fall rains and early winter snowfall and melt have saturated the soils. After January, precipitation is reduced, but snowmelt sustains recharge at the higher elevations through April. By May, increasing evapotranspiration begins to deplete soil moisture storage and reduce recharge rates to nearly zero.

At the regional scale the geographic distribution of recharge mimics that of precipitation. The Cascade Range, which constitutes the western boundary, locally receives in excess of 200 inches per year, mostly as snow. The thin soils allow rapid infiltration of much of the rain and snowmelt making the Cascade Range the source for most of the groundwater recharge in the basin. The central part of the basin typically receives less than 10 inches per year and is not an area of significant recharge relative to recharge in the Cascade Range to the east.

Canal Leakage

The largest canal diverting from the Little Deschutes River is the Walker Basin Irrigation Canal with approximately 30 miles of canals and 30 miles of laterals that carry water. Canal leakage rates vary greatly depending on the geology of the canal bottom and the extent to which the cracks and voids have been filled or sealed by sediment. Canal leakage rates for the Little Deschutes River Subbasin are not available. In areas where streams lose water in canals, water is also being lost through seepage to groundwater. Mr. Gorman indicated that the seepage studies he completed determined that canals in areas where there are losing stream reaches also leak into the subsurface and recharge the aquifer. Consequently, canals in the vicinity of upper Paulina Creek, Crescent Creek above the confluence with the Little Deschutes River, and the Little Deschutes River above the confluence with Crescent Creek will have some leakage into the subsurface. This will be discussed in greater detail in the section ***Stream Leakage***.

On-Farm Losses

On-Farm losses include water lost to evaporation, wind drift, runoff, and deep percolation. Deep percolation is water that migrates through the unsaturated zone of the soil profile and enters the saturated zone (or aquifer). The amount of on-farm losses depends on the type of irrigation system in use. In the Little Deschutes River Subbasin, flood irrigation is the predominant method of irrigation. These areas receive up to 10 inches/year of recharge from surface water.

Stream Leakage

Losing streams are defined as those where the elevation of a stream is above that of the underlying water table and water can leak from the stream to recharge the groundwater system, decreasing streamflow. Conversely, in areas where the stream elevation is below that of adjacent aquifers, groundwater can discharge to streams, increasing streamflow. Such streams are termed gaining streams.

In the Little Deschutes River Subbasin, losing streams are much less common than gaining streams (Map 10-2). Seepage runs indicate some losses along the Little Deschutes River as it flows through the La Pine subbasin. Most of the measured losses are small, 1 to 3cfs, and are within measurement error of the streamflow rates. Measured losses along the Little Deschutes between Gilchrist and Crescent Creek range from 11 to 14.4 cfs (21.8 to 28.6 acre-feet). The river crosses lava flows along this reach and it is likely that water is being lost into permeable lava. Mr. Gorman indicated this water immediately recharges groundwater in the area.

Paulina Creek had measured net losses of approximately 2 to 6 cfs (3.96 to 11.9 acre-feet). This loss accounts for roughly 20 to 40 percent of the flow at the times the measurements were made.

Drainage Wells

Drainage wells include drilled disposal wells and hand-dug shallower drywells used to dispose of storm runoff in urban areas. Runoff disposed of in drainage wells is routed directly to permeable rock beneath the land surface, bypassing the soil zone from which a certain amount of water would normally be returned to the atmosphere through evaporation or transpiration by plants. Once routed to permeable rock beneath the soil, the runoff percolates downward to recharge the groundwater system. This source of groundwater recharge is very small relative to other sources of recharge and is estimated to be approximately 2.3 cfs (4.6 acre-feet) in Bend and 0.28 (0.55 acre-feet) cfs in Redmond. Runoff calculations are not available for the Little Deschutes Basin but it is unlikely this is a significant component of groundwater recharge.

Interbasin Flow

The final source of recharge is subsurface flow from adjoining basins. In general, the lateral boundaries of the Little Deschutes Basin study area are considered to be no-flow boundaries. That is, the rocks are relatively impermeable and no flow passes into the basin. There are two areas where flow from an adjacent area is probable: northeast of Newberry Crater and to the south from the Fort Rock and Christmas Lake Basins. The estimated inflow from these areas are about 50 cfs and 14 cfs, respectively (99.1 and 27.7 acre-feet).

10.5.2 *Groundwater Discharge*

Groundwater discharges from the aquifer to streams, wells (both public and private), and by evapotranspiration. Discharge to streams is the principal mechanism by which water leaves the groundwater system. Each component is discussed below.

Groundwater Discharge to Streams

Groundwater discharges to streams in areas where the stream elevation is lower than the elevation of the water table in adjacent aquifers. The amount of groundwater discharging to streams or leaking from streams varies geographically and with time. Estimates of groundwater discharge to major streams in the Little Deschutes River Subbasin are provided in Table 10-2**.** These values represent approximate long-term average conditions.

Table 10-2: Estimated Stream Gains and Losses Due to Groundwater Exchange, Upper Little Deschutes River Subbasin.

Stream Name	Reach (river mile)	Estimated gain (+) or loss (-) (in cfs)	Data Source
Little Deschutes	Entire drainage above Hwy 58	31.5	OWRD 10/95
Little Deschutes	Hwy 58 to above Crescent Ck	-15.6	OWRD 10/95
Little Deschutes	Above Crescent Ck to Crosswater	9.3	OWRD 10/95
Big Marsh Creek	Drainage above gage near Mouth	21	USGS statistical summary
Crescent Creek	Crescent Lake outlet to Hwy 58	18.7	OWRD 10/95
Crescent Creek	Hwy 58 to above mouth	-1.5	OWRD 10/95
Paulina Creek	Paulina Lake outlet to Road 21	-1.7 to –6.1	USGS Water Resources Inv.
Odell Lake	Above gage at lake outlet	41	USGS statistical summary
Odell Creek	Odell Lake outlet to OWRD gage	41	USGS & OWRD gage data

As shown by the blue lines in Map 10-2, groundwater constitutes a portion of the flow in many streams in and along the margin of the Cascade Range in the southern part of the Little Deschutes River Basin. Stream reaches not recharged by groundwater are in pink and include the upper parts of Paulina Creek, Crescent Creek before the confluence with the Little Deschutes, and the Little Deschutes River below Highway 58 before the confluence with Crescent Creek. Under average flow conditions, groundwater discharge to streams in the Little Deschutes River subbasin is approximately 140 cfs (278 acre-feet).

Groundwater Discharge to Wells

Groundwater is pumped from wells for a variety of uses in the Little Deschutes Basin, including irrigation, public supply, and private domestic use. Irrigation is primarily agricultural, but can include watering of golf courses and parks. Public supply systems include publicly and privately owned water utilities, which are typically located in urban and suburban areas. Public supply use includes not only drinking water but also commercial, industrial, and municipal uses. Private domestic use generally refers to pumping by individual wells that typically supply a single residence. Each of these is discussed below.

Irrigation Wells

Pumping of groundwater for irrigation was estimated using water rights information from the State of Oregon and crop-water requirement estimates. Pumping of groundwater for irrigation in the Little Deschutes Basin was estimated to be 520 acre-feet/year (an average annual rate of 7.2 cfs) during 1994. The geographic distribution of annual groundwater pumping for irrigation from 1993 to 1995 is shown in Map 10-3. As illustrated in this figure, irrigation pumping in the Little Deschutes River Subbasin is low relative to other parts of the Deschutes River Subbasin.

Public Supply Wells

Public water supply pumping has increased in recent years in response to population growth but is still very limited. Currently public supply wells exist for Sunriver, the La Pine School District, the La Pine incorporated well, and a well at the Oregon Water Wonderland south of Sunriver. It is estimated that these wells account for less than one cfs.

Private Domestic Wells

It is estimated that 24 percent of the population in Deschutes County obtains water from private domestic wells or small water systems. If an average per capita pumping of 100 gal/day is used, groundwater pumping by private domestic wells (assuming 7,000 individuals in the Little Deschutes Basin) is an average annual rate of 1.0 cfs. Virtually all of the homes on private domestic wells also use on-site septic systems so most water is returned to the groundwater system. Actual consumptive use of groundwater by private domestic wells in the Little Deschutes Basin is likely less than one cfs.

Groundwater Discharge to Evapotranspiration

The majority of evapotranspiration within the basin occurs from consumption of water from the soil profile or unsaturated zone. Plant roots intercept and utilize some of the available soil water prior to reaching the groundwater table or saturated zone. This type of evapotranspiration is not considered groundwater discharge. Under certain circumstances, plant roots of sufficient depth can interface with shallow groundwater resulting in the utilization and evapotranspiration loss of groundwater. This rooting groundwater interface can occur within or near the capillary fringe. Evapotranspiration of water in this manner is considered groundwater discharge. The La Pine subbasin is the only significantly large region in the study area where conditions exist for groundwater discharge to occur from evapotranspiration. In general, these zones of groundwater loss occur where deeper rooted plants interface with groundwater within 10 ft of the land surface. Based on land area size estimates and rates of evapotranspiration, the average annual rate of loss is 80 cfs (158 acre-feet) (Gannett et al, 2001). This value is considered a rough estimate.

10.6 Groundwater Fluctuations

The elevation of the water table is not static and fluctuates with time in response to a number of factors including recharge from precipitation in the form of rainfall and snowmelt, canal operations, and pumping.

10.6.1 *Large Scale Water-Table Fluctuations*

The most substantial groundwater level fluctuations in the Little Deschutes River Subbasin occur in parts of the La Pine subbasin. These fluctuations are illustrated in the hydrograph of well 21S/11E-19 CCC near La Pine (Figure 10-4). The La Pine well is shown in the middle of the hydrograph as a dotted line; the cumulative departure from mean annual precipitation at Crater Lake is shown at the top of the graph as a solid line. The graph plots the depth to water (in feet) in the La Pine well when the well is not pumping (i.e. static water level) and compares the depth to water in the well to the precipitation at Crater Lake. For example, in 1965 the depth to water in the well was slightly greater than 40 feet and precipitation at Crater Lake was approximately 8 inches less than average for the period 1962 through 1998. In 1965 the depth to water in the well was 20 feet while precipitation at Crater Lake was approximately 9 inches more than the average for the period 1962 through 1998.

The water level in the well near La Pine fluctuates up to 20 feet with a cycle averaging roughly 11 years. A comparison of this fluctuation with precipitation in the Cascade Range indicates that a period of high groundwater levels generally correspond to periods of high precipitation and low water level elevations correspond to periods of low precipitation. This relationship is to be expected.

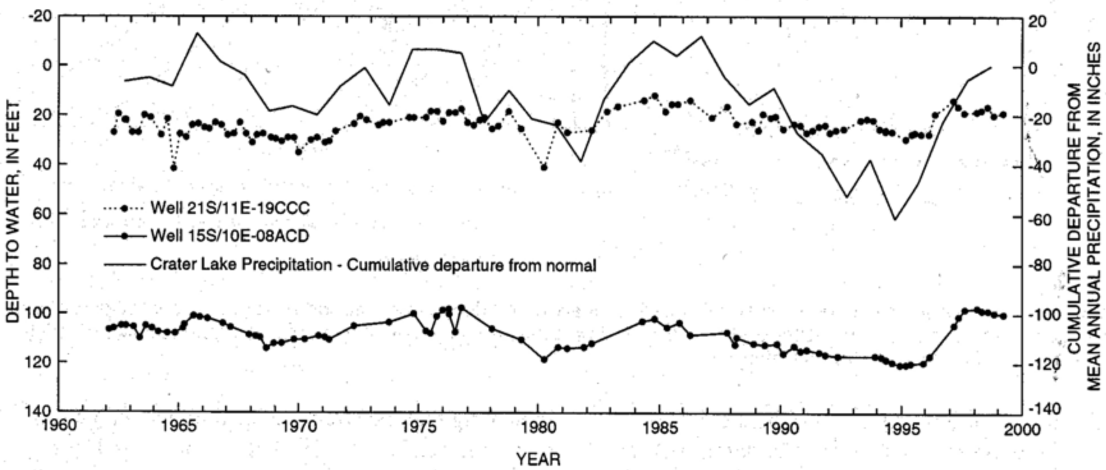


Figure 10-4: Static water levels in well 21S/11E-19CCC in the Little Deschutes Basin, Oregon and cumulative departure from normal annual precipitation at Crater Lake, Oregon (Gannett, et. al 2001).

During periods of high precipitation the rate of groundwater recharge exceeds, at least temporarily, the rate of discharge. When groundwater recharge exceeds discharge, the amount of groundwater in storage must increase, causing the water table to rise. During dry periods the rate of discharge may exceed the rate of recharge and groundwater levels drop as a result.

Fluctuations in the water table elevation in response to variations in recharge are most prominent in the Cascade Range, the recharge area. Hydrographs of wells in the area show that as the distance from the recharge area increases, the magnitude of fluctuations decreases, and the timing of the response is delayed.

During the period 1993 through early 1999, water levels in wells near the Cascade Range rose over 20 feet due to the change from drought to wetter-than-normal conditions. Wells several miles to the east exhibited only a slight rise in water level, less than 2 feet, in response to the end of the drought. The wells also exhibited an apparent delay in response.

Water level fluctuations are attenuated with increasing depth as well as with increasing horizontal distance from the recharge area. Hydrographs of two wells in the La Pine area are illustrated in Figure 10-5. Well 21S/11E-19 CCC is 100 feet deep and well 22S/10E-14 CCA is 550 feet deep. The water level in the shallow well was declining due to drought conditions until early 1995 when it started to rise in response to increased precipitation. The water level rose over 15 feet by early 1997. The water level in the deep well, however, declined until early 1996 and by 1999 had risen only 7 feet in response to the end of drought conditions.

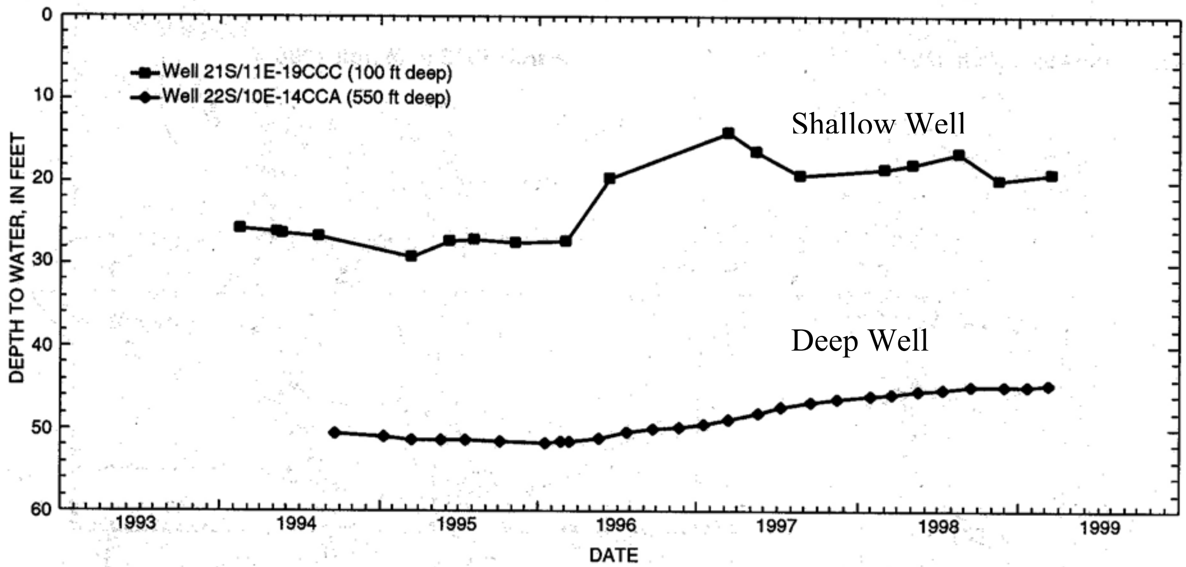


Figure 10-5 Static water-level variations in a shallow well and a deep well in the La Pine subbasin, Oregon (Gannett, et al 2001).

10.6.2 *Local Scale Water Table Fluctuations*

In addition to basin-wide groundwater elevation fluctuations, smaller-scale, localized water-table fluctuations occur. These more isolated fluctuations are due to varying rates of recharge from local sources such as leaking streams and canals, and by groundwater pumping. Fluctuations due to irrigation canal leakage occur in many wells throughout the irrigated areas with water levels rising during the irrigation season and dropping when canals are dry. The magnitude of the fluctuations varies depending on the proximity of the well to the canal, the depth of the well, and the local geology.

10.7 Groundwater-Surface Water Interactions

Groundwater levels in the Little Deschutes River Subbasin ranges from at ground surface to 70 feet below ground surface. The interaction between groundwater and surface water is controlled largely by the relative elevations of the water table and adjacent streams. In the La Pine subbasin, south of Benham Falls, the water table elevation is near land surface. Stream gains and losses along most of the Little Deschutes River in this area are small, indicating relatively little net exchange between groundwater and surface water. Other groundwater and surface water interactions are shown in Map 10-2 illustrating the location of losing and gaining stream reaches in the subbasin.

10.8 Groundwater Quality

The groundwater quality in the subbasin has been impacted by development of thousands of small lots served by on-site sewage disposal systems (septic systems), including standard drain fields, cap and fill systems, and sand-filter systems. The construction of these systems upon highly permeable, rapidly draining soils and a high groundwater table with relatively cold-water temperatures results in elevated levels of nitrates. The nitrates are a by-product of septic systems and an indicator of human pathogens. These are poorly retained in the septic systems because of the fast draining soils and do not easily break down due to the cool groundwater temperatures. There has been measurable loading of nitrates in the shallow groundwater aquifer that is also the source of drinking water for the residents in the area (Deschutes County, 1998).

The USGS study of groundwater in Central Oregon concludes that groundwater in the Little Deschutes River is connected to nearby surface waters. Due to the existing pattern and density of development ODEQ is predicting that nitrate levels will continue to increase over time, even if measures were taken now to alter the development pattern. Mr. Rodney Weike of the ODEQ has been working on a groundwater quality study in the La Pine area in the Little Deschutes River Subbasin for the past three years. Final data and a report will be published in cooperation with the USGS in the spring of 2002. Data were to be made available on the internet this fall but were delayed due to a computer virus.

Discussions with Mr. Weike indicate that nitrogen in the form of nitrate-nitrogen is the constituent of concern relative to groundwater. The primary sources of nitrogen are from human and animal wastes, primarily septic systems. Due to the nature of the soils in the La Pine area, sewage can flow quickly through the porous soil and into the underlying aquifer without decomposing. Preliminary loading data provided by Mr. Weike are given in Table 10-3 below.

Table 10-3: Nitrogen Loading to Groundwater in the Little Deschutes River Subbasin.

Year	1960	1970	1980	1990	1999
kg/year nitrogen loaded to groundwater	2,900	10,020	30,900	38,000	53,200

11.0 CONCLUSIONS AND ACTION OPPORTUNITIES

The purpose of the assessment is to characterize historical and current watershed conditions for the Little Deschutes River Subbasin and identify opportunities for voluntary UDWC actions to improve fish and wildlife habitat and water quality. This section provides a summary of the assessment's key finding and recommendations.

Many of the causes of the impacts to fish and wildlife habitat and water quality in the Little Deschutes River Subbasin are concentrated in the areas of housing, roads, and other human development. Most of the human population in the subbasin is concentrated around the community centers of La Pine, Gilchrist, Crescent, and Crescent Lake. There is significant dispersed development along the lower reaches of the Little Deschutes River between the communities of La Pine and Sunriver – an area characterized by gentle topography and depressions with forested wetlands, marshes, and shallow lakes. Streams in this area, as illustrated by the Little Deschutes River, are low gradient and originate in the high elevation areas in the southwest portion of the watershed where there is higher precipitation. This ownership pattern has significant implications for natural resource management, as lower gradient floodplain areas tend to provide important wetland, fish and wildlife habitat.

The following provides an overview of key findings and recommendations for:

- Upland vegetation;
- Wetlands and riparian areas;
- Wildlife;
- Fisheries and aquatic habitat;
- Surface water quality; and
- Groundwater quantity and quality.

11.1 Upland Vegetation

11.1.1 *Upland Vegetation Key Findings*

- Fire suppression, livestock grazing, timber harvest practices, noxious weeds, and urban development have had major impacts on vegetation patterns in the watershed. Fire suppression may be the most important factor influencing vegetation.
- Fuel loads are high in the watershed, on both private and public lands. In general, past land management practices have not focused on maintaining ecosystem health and sustainability.

11.1.2 *Upland Vegetation Action Opportunities*

1. Conduct, in cooperation with the Oregon Department of Forestry, fuel load surveys, especially on private lands.

2. Create a partnership between homeowners and land management agencies that create strategic fuel reduction zones, using mechanical fuel reduction treatments. Through education, workshops, and other mechanisms, encourage private landowners to create defensible space around structures and remove fine fuels and needles annually from roofs and around houses to reduce the chance of spot fire ignition during wildfires.

3. Educate the public about noxious weeds, how they threaten habitats, how to identify them, how they spread, and how to remove them.

11.2 Wetlands and Riparian Areas

11.2.1 *Wetlands and Riparian Areas Key Findings*

- Wetland/riparian areas are critical for water quality, water quantity, wildlife habitat, and flood abatement. Wetland/riparian areas in the Little Deschutes River Subbasin have been impacted over time by human activity, resulting in impaired function in some areas.

- The majority of riparian/wetland habitat in the Little Deschutes River Subbasin is privately owned.

- The LaPine Basin is part of a unique ecoregion in Oregon dominated by wetland habitats.

- Continued growth and development, especially in the lower portions of the watershed, will continue to impact wetland and riparian vegetation.

11.2.2 *Wetlands and Riparian Areas Key Findings Action Opportunities*

1. Identify the impact of planning and zoning issues on wetland and riparian areas, by collecting more information on the specific type, extent, and condition of the wetlands and riparian types. Conduct a riparian and wetland inventory using aerial photography and systematic field checks throughout the watershed. Obtain permission from cooperative landowners and agencies for land access. Use this inventory to identify type, extent, and condition of wetlands/riparian areas in the watershed.

2. In order to determine with any accuracy the extent of riparian vegetation within the 100-year floodplain, use Federal Emergency Management Agency (FEMA) and National Wetland Inventory (NWI) maps to create a composite map. The NWI

digitization process limits this mapping, but the inventory recommended above would add valuable information to this process as well.

3. Educate landowners about the importance of wetlands and riparian areas to water quality, fish habitat, and wildlife. Offer workshops and technical advice to landowners to assist them in pursuing voluntary riparian restoration actions.

11.3 Wildlife

11.3.1 *Wildlife Key Findings*

- Bald Eagles nest and feed at Crescent Lake and other lakes and reservoirs in the Little Deschutes River Subbasin. Vacation cabins, recreation use, and fluctuating lake levels impact habitat quality. Bald Eagle use along the lower portions of the river has the potential to be impacted. Dispersed foraging is likely to be impacted through increased development.

- Spotted owls and wolverines tend to use higher elevation habitat. These species are not likely to be impacted by increasing development on private lands, which are primarily at lower elevations

- Fisher use riparian zones as travel corridors. These corridors are fragmented by private development along the river and are likely to become more disturbed by future development.

- Sandhill cranes and yellow rail use marsh and wetland habitats. Big Marsh provides optimal habitat; use of other wetland habitats in the subbasin has not been documented.

- Amphibian species, especially the Oregon spotted frog, are dependent on wetland habitats. Wetland draining, fish stocking, and developments affecting riparian and wetland habitats have impacted their populations in the subbasin. However, the distribution of usable wetland habitat on private lands has not been surveyed.

- Migrating mule deer move across the subbasin from the east to west side in spring and west to east in fall. There are no known areas of concentrated migration. There appears to be multiple migration paths. However, increased housing development will likely reduce the available migration pathways. The number of road-kill deer is higher in less developed portions of the subbasin, indicating deer avoid developed areas.

11.3.2 *Wildlife Action Opportunities*

1. Analyze Bald Eagle habitat and use patterns further to identify if there are areas of likely use where development is likely to occur.

2. Map wetland types and distribution on private lands. This will provide information on potential amphibian and bird habitat on private lands that may potentially be impacted by development.

3. Analyze current development and potential trends to identify if an undeveloped corridor along the east-west axis of the Little Deschutes River Subbasin can be identified and maintained.

4. Educate landowners about the importance of habitats in the watershed for wildlife species. Offer workshops and technical advice to landowners to assist them in pursuing voluntary wildlife habitat protection and restoration actions.

11.4 Fisheries and Aquatic Habitat

11.4.1 *Fisheries and Aquatic Habitat Key Findings*

- Non-native brook and brown trout are the dominant game fish species in the Little Deschutes River and tributaries. The native redband trout is limited in distribution, and native bull trout have been extirpated in the Little Deschutes River Subbasin.

- Fisheries management policy directs that game fish species (mountain whitefish, redband trout, brown trout, and brook trout) be managed for natural reproduction. Hatchery stocking is no longer used as a management tool in the Little Deschutes River. Managing trout species for natural production places an emphasis on enhancing and restoring aquatic habitats.

- Cumulative effects of land management have altered aquatic habitats over time. Grazing was most often mentioned in regards to streambank alteration, but timber harvest, roads, and flow alteration are also likely causes. The altered aquatic habitats in the Little Deschutes River favor the non-native trout species, especially brown trout.

- Less is known about aquatic habitat conditions downstream from the Forest Service boundary adjacent to private lands. More information on site-specific conditions would be useful in identifying potential protection or restoration needs.

- The Upper Deschutes River Subbasin Fish Management Plan describes enhancement/restoration actions that would appropriately be addressed in partnership with non-governmental agencies such as the UDWC. These include development of habitat improvement plans (aquatic and uplands), enhancing instream flows, fixing unscreened diversions, addressing fish passage, and water quality monitoring. These actions are listed in the action opportunities.

11.4.2 *Fisheries and Aquatic Habitat Action Opportunities*

1. Site-specific information is needed to direct aquatic habitat and riparian area improvement projects, especially within private land holdings. Agency habitat surveys tend to focus on assessing condition, and less on identifying specific habitat improvement opportunities. The UDWC should provide the leadership and community involvement needed to develop a useable habitat assessment and habitat improvement inventory. UDWC volunteers should conduct the survey with landowners to facilitate ready transfer of information and develop communication and trust with the local community. The survey could take the form of an informative audit for landowners in streamside zones similar the approach used to inform homeowners about conservation through energy audit. Agency specialists (ODFW, USFS) could provide the necessary technical expertise and quality control over the process.

2. The UDWC can work with ODFW to develop a Habitat Improvement Plan for private lands in the Little Deschutes. The plan would identify needs based on the habitat surveys, volunteer capability, and programs to implement resulting projects. The UDWC can act as a clearinghouse for information on habitat improvement programs, such as ODFW's Access and Habitat Program, develop information packages, and provide information to landowners on issues such as permitting and working with contractors.

3. The Upper Deschutes River Subbasin Fish Management Plan identifies the need for maintaining and improving flows for fish production and screening irrigation water diversions. There are opportunities for the UDWC to participate in evaluating instream flow needs (in cooperation with ODFW), conducting an inventory of fish screens, and in providing information and education to landowners on ditch screening alternatives, water conservation, and cost-share programs for installing fish screens.

4. Voluntary protection and enhancement of the riparian zones may be better achieved through long term planning and protection rather than through restoration actions. The UDWC may consider working with local, county, and state agencies to pursue efforts at a broader scale to protect riparian areas through voluntary measures such as conservation easements.

5. Educate landowners about the status of fisheries resources and habitat. Offer workshops and technical advice to landowners to assist them in pursuing voluntary aquatic habitat restoration actions.

11.5 Surface Water Quality

11.5.1 *Surface Water Quality Key Findings*

- The primary beneficial uses that are potentially limited by water quality in the Little Deschutes River Subbasin are salmonid fish spawning and rearing, aquatic life, and fishing. At this point in time, temperature is the only parameter listed on the 303(d) list in the Little Deschutes River and is currently the subject of intensive water quality investigations by ODEQ. Otherwise, water quality is generally rated good to excellent when compared to other rivers in Oregon.

- The other primary water quality parameter under investigation is dissolved oxygen in the lower Little Deschutes River. Excessive algal and aquatic plant growth may be contributing to swings in dissolved oxygen and pH with potential detrimental effects on aquatic life. An ODEQ water quality study is underway in the Upper Deschutes River Basin to investigate these potential alterations.

- There is little objective information on linkages between water quality and land use in the basin. There is general supposition that past forest management, livestock grazing practices, and suburban development have diminished water quality. But, there is little specific information to confirm cause-and-effect relationships.

- There is limited information on surface water quality data in the subbasin. The current water quality data are not comparable over time or by type of pollutant, and cannot be used effectively to evaluate water quality. This information gap is currently being addressed by the intensive study initiated by ODEQ in the 2001 field season.

11.5.2 *Surface Water Quality Action Opportunities*

1. The UDWC can fill a critical function in disseminating information to the public about water quality goals, study results, and implementation plans. This is especially important with development of the TMDL and the associated implementation plan. Aside from point source permitting, ODEQ has little direct influence on changing land management practices (such as riparian zone management) and implementing voluntary best management practices. The UDWC can assist the local communities in assuring that there are open public forums during development of the TMDL, in getting the stakeholders involved, in assisting ODEQ in developing a meaningful implementation plan, and providing the community leadership in implementing restoration actions as they are identified.

2. The UDWC can encourage state and local agencies to implement follow-up studies on water quality and linkages to pollution sources. Specifically, there may be a need to investigate further the linkage if any between individual septic systems and surface water quality. The Habitat Surveys mentioned in the Fisheries and Aquatic Habitat sections can incorporate water quality issues such as canopy cover, streambank erosion, and

monitoring riparian buffer strip widths. The ODEQ intensive study will address information gaps relevant to temperature, dissolved oxygen, and nutrients. Other data gaps should be identifies as a follow-up to completion of this study.

3. The ODEQ study is not addressing bacterial concentrations in the Little Deschutes River. Although the primary concern with septic systems is leaching of bacteria, pathogens, and nutrients to groundwater, there is a potential for contamination of surface waters with nonfunctional systems. The UDWC could consider monitoring fecal bacteria indicators in surface waters along the urban/suburban boundary. Volunteers can readily conduct a study of bacterial contamination with assistance by qualified professionals from ODEQ or the local public health agencies.

4. The UDWC could consider developing and implementing a long-term water quality monitoring program focused on major contaminants identified by the ODEQ study. At this point in time, these parameters may conceivably include temperature, nutrients, and bacteria.

11.6 Groundwater Quality and Quantity

11.6.1 *Groundwater Quality and Quantity Key Findings*

- Surface streams are administratively closed to additional appropriation of water so future development in the area will rely on the use of groundwater. Water budget calculations indicate recharge to the Little Deschutes River basin exceeds discharge. At this time, groundwater quantity is not a problem.

- Groundwater levels in the basin are very shallow in the vicinity of the Little Deschutes River and increase in depth from the land surface as one moves away from the river to the higher elevations. Therefore locations with shallow groundwater are generally in the vicinity of private lands and should be identified.

- Groundwater loading of nitrogen has increased nearly 20 times from 1960 through 1999. However, the extent of contamination and potential for surface water contamination has not been documented.

- An estimated 4,000 to 5,000 lots are available for building in the La Pine subbasin which would further increase nitrogen loading to groundwater in the basin.

11.6.2 *Groundwater Quality and Quantity Action Opportunities*

1. Review the ODEQ water quality data report currently being prepared by Mr. Rodney Weike when it becomes available in the spring of 2002. The extent of contamination and potential for surface water contamination should be addressed. This should identify specific areas of concern, sources of contaminant and high priority areas for actions. Potential options include:

a) Developing a groundwater remediation plan for the impacted areas.

b) Considering experimental on-site sewage disposal options that can be applied to new and possibly existing systems.

c) Identifying undeveloped properties near creeks, rivers, and wetlands where groundwater has been impacted and explore options for voluntary purchase or transfer of development rights.

2. Develop a groundwater/surface water model to characterize the flow regime and determine what impacts additional groundwater development will have on groundwater and surface water flow in the subbasin. At this time, groundwater quantity is not a problem. However, development of a groundwater/surface water model would be an excellent tool to assist in long- and short-term planning in the area.

3. Educate landowners about the importance of ground water quality and how their actions can affect this resource. Offer workshops, and technical advice to landowners to assist them in efforts to protect ground water quality. Examine the potential to developing and implementing the Home*A*Syst and Lake*A*Syst Programs. These are programs designed to teach homeowners and lake front property owners how to conduct an inventory of their property to determine how their activities may be impacting surface and groundwater.

4. Refer to the Water Quality information gaps and monitoring needs section above.

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Kelley Candala, Secretary, Deschutes County Weed Board, and Public Works, 541-322-7104

Salem Office, Region 4, OR Department of Transportation. Bess Tickman 503-986-4251. Region 4 includes Districts 9, 10 and 11. The Little Deschutes Watershed includes District 10.

Appendix A: Maps

Map 2-1: Fifth Field Watershed Boundaries
Map 2-2: Major Tributaries & Federally Designated River Reaches
Map 2-3: Ecoregions

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Map 4-2: 1995 Population Densities
Map 4-3: Landuse

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Map 9-1: Oregon DEQ 1998 303(d) Listed Waters

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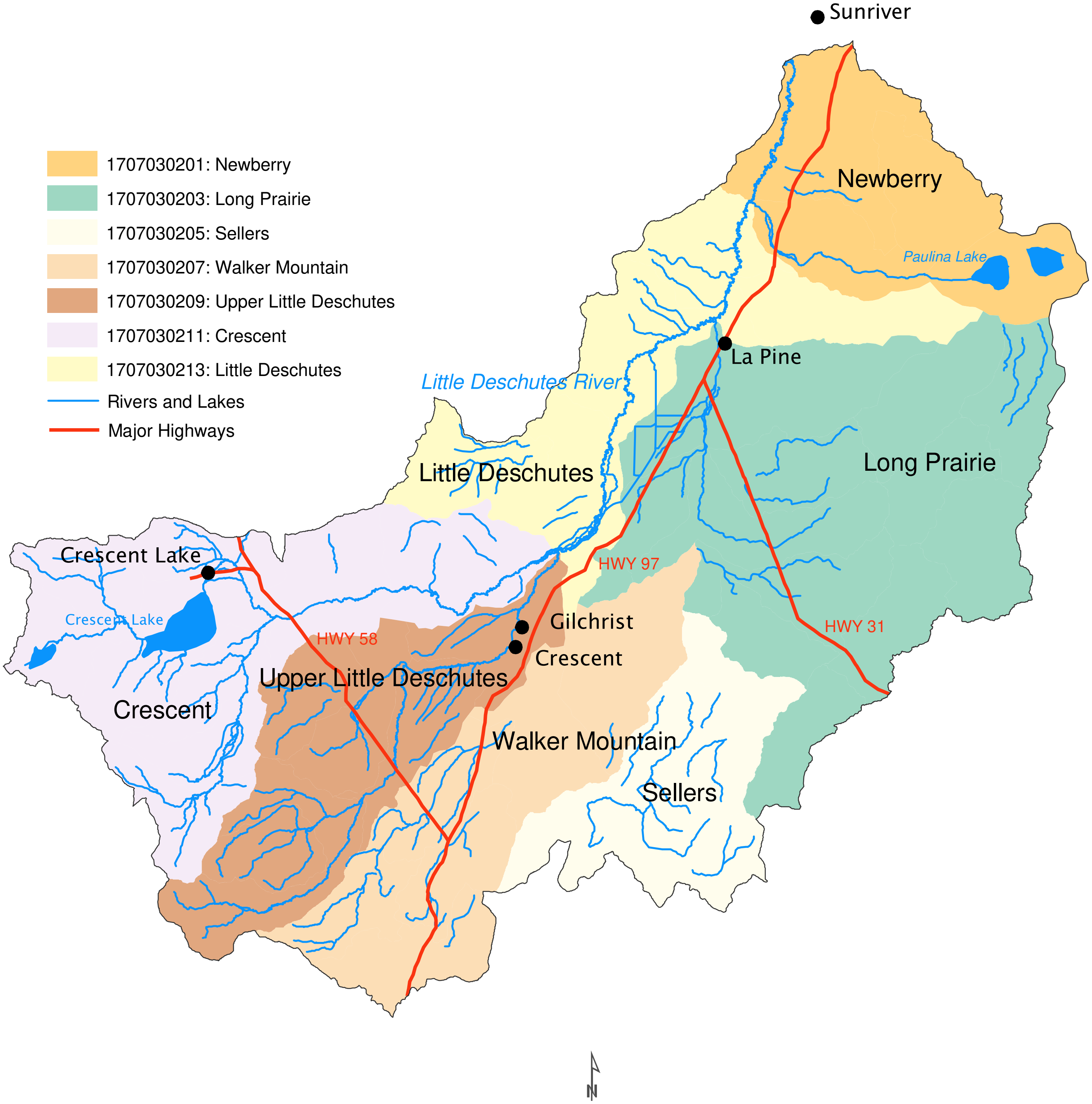
Map 10-2: Estimated Gains and Losses in the Little Deschutes Basin.
Map 10-3: Estimated average annual ground water pumping for irrigation in the Little Deschutes Basin, Oregon.

Map 2-1: Fifth Field Watershed Boundaries

Little Deschutes Subbasin Watershed Assessment



Data Source: USFS Deschutes National Forest

/proj/deschutes/maps/fifthfield August 6, 2001

Map 2-2: Major Tributaries & Federally Designated River Reaches

Data Source: USFS, Oregon Department of Fish and Wildlife
/proj/deschutes/maps/basemap September 7, 2001

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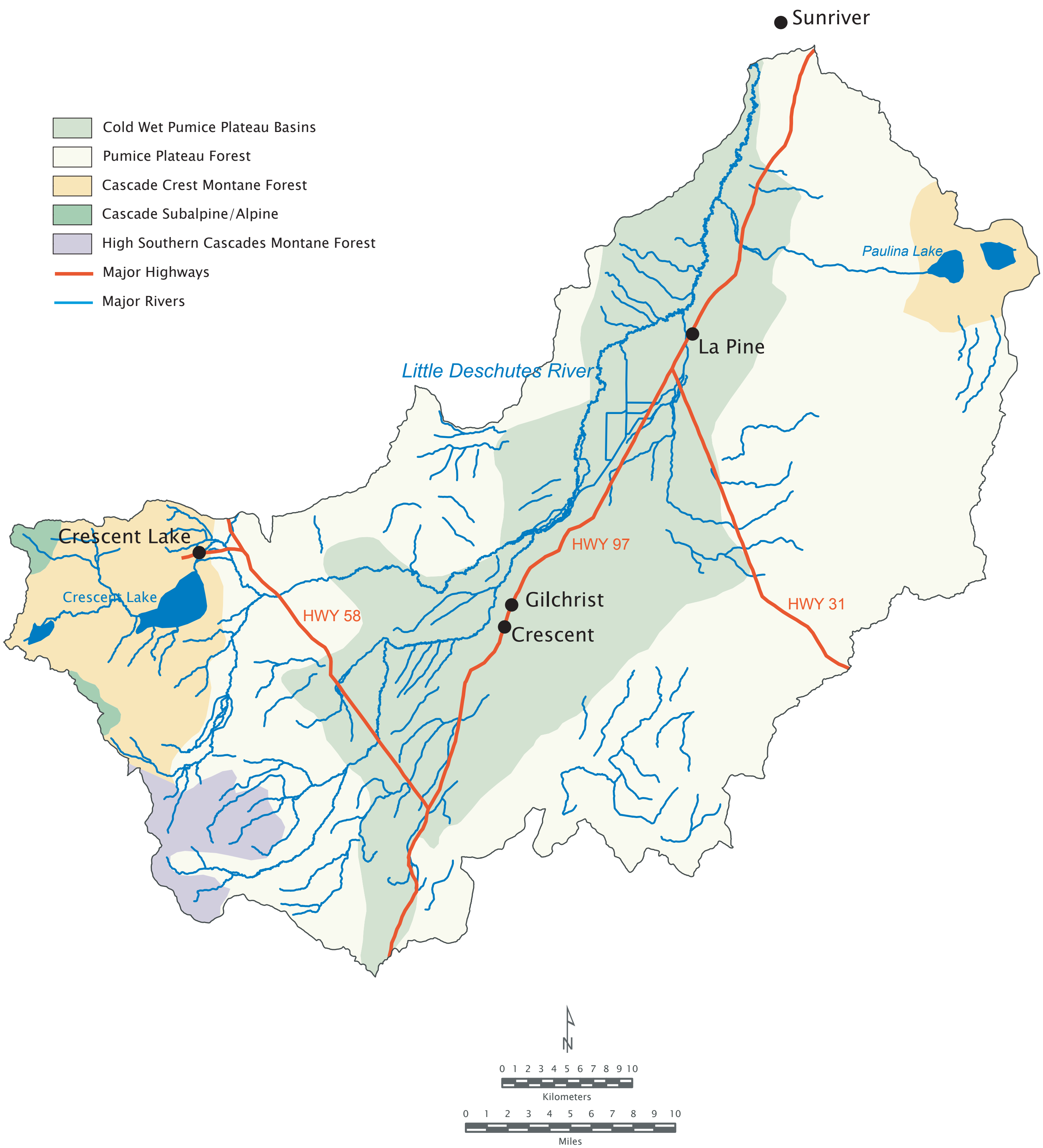
Map 2-3: Ecoregions
Little Deschutes Subbasin Watershed Assessment



Data Source: Oregon Geospatial Data Clearinghouse
/proj/deschutes/maps/ecoregions July 26, 2001

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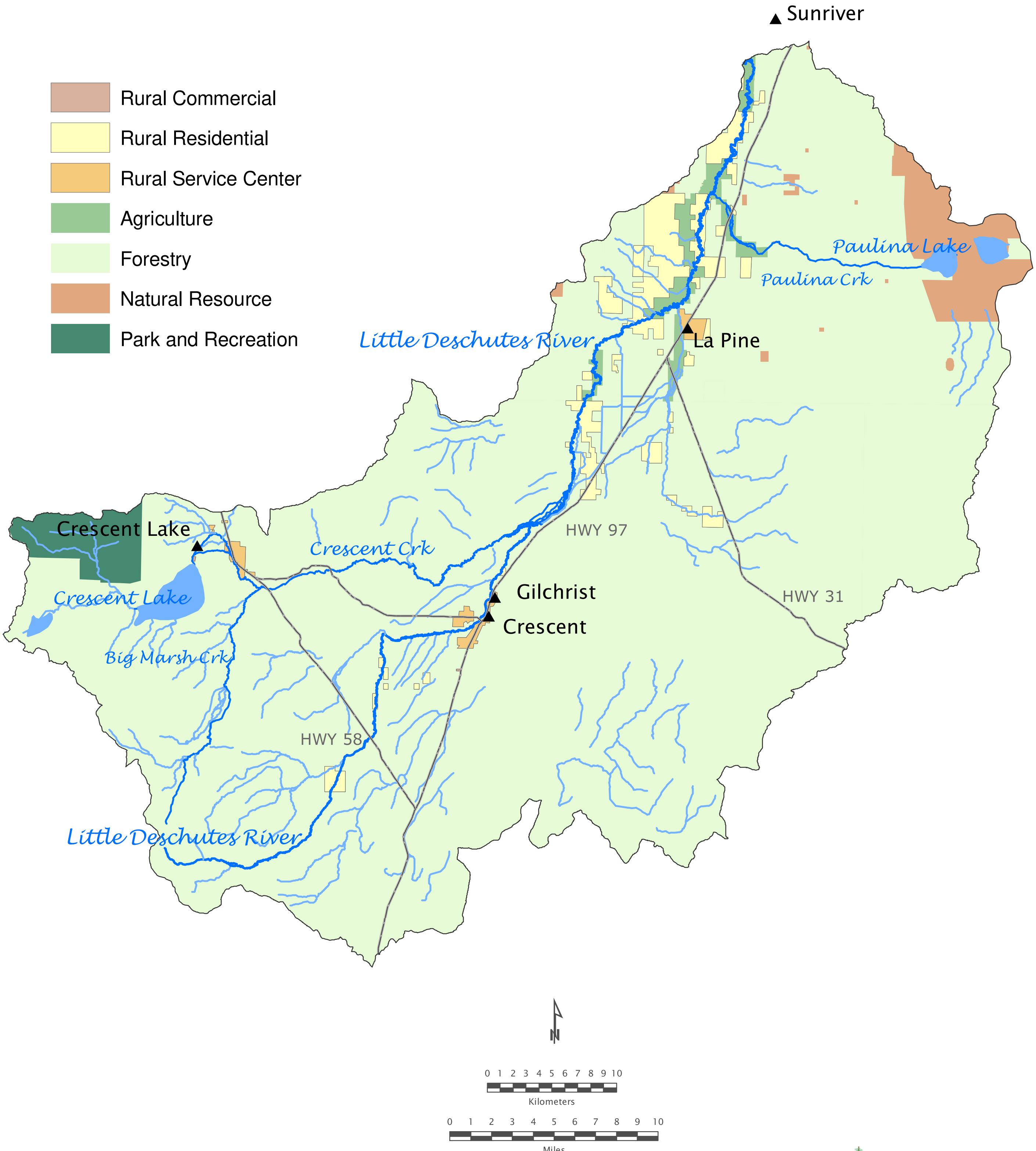
Map 4-1: Landuse
Little Deschutes Subbasin Watershed Assessment



Data Source: Deschutes and Klamath Counties
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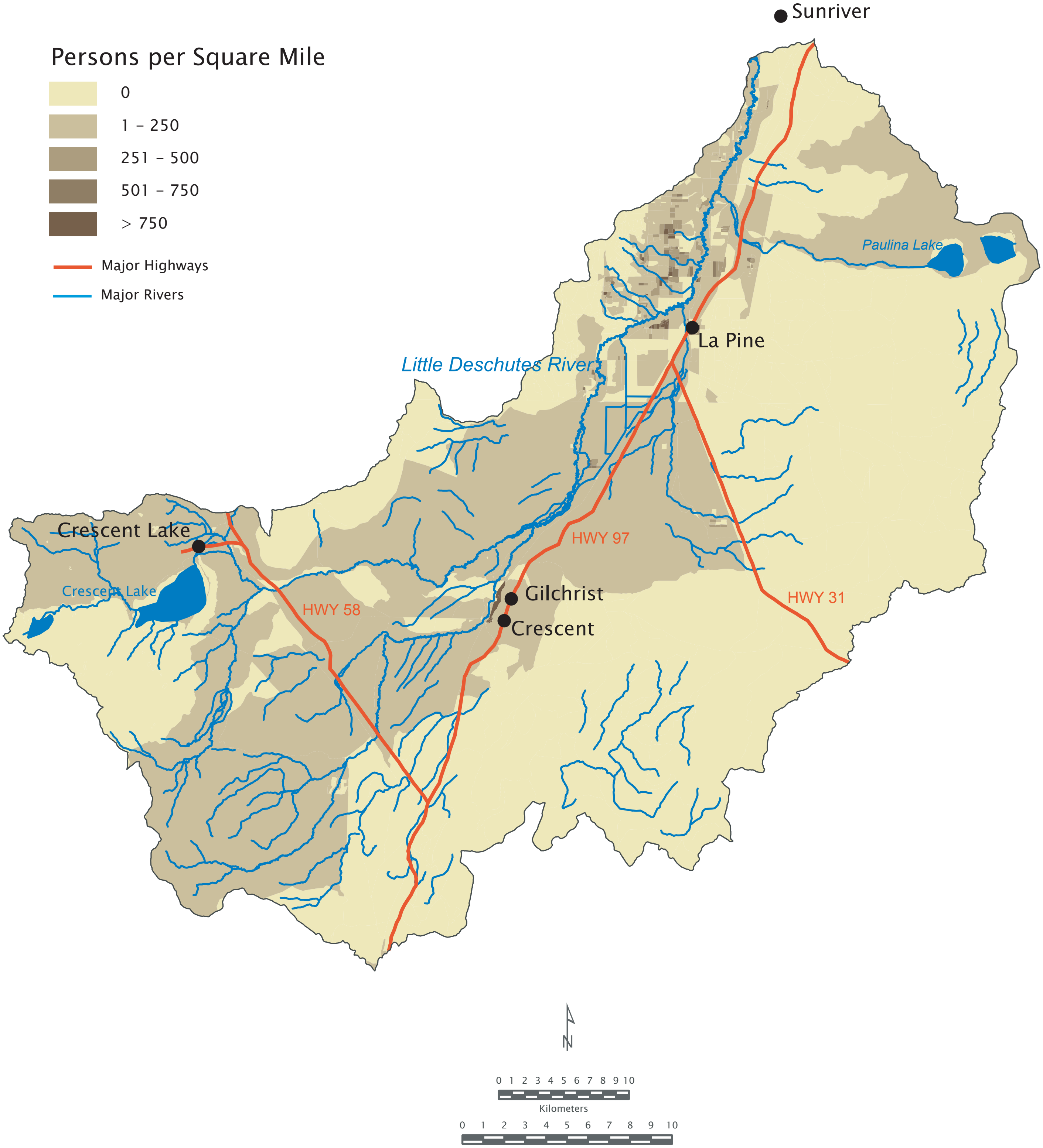
Map 4-2: 1995 Population Density
Little Deschutes Subbasin Watershed Assessment



Data Source: Oregon Geospatial Data Clearinghouse
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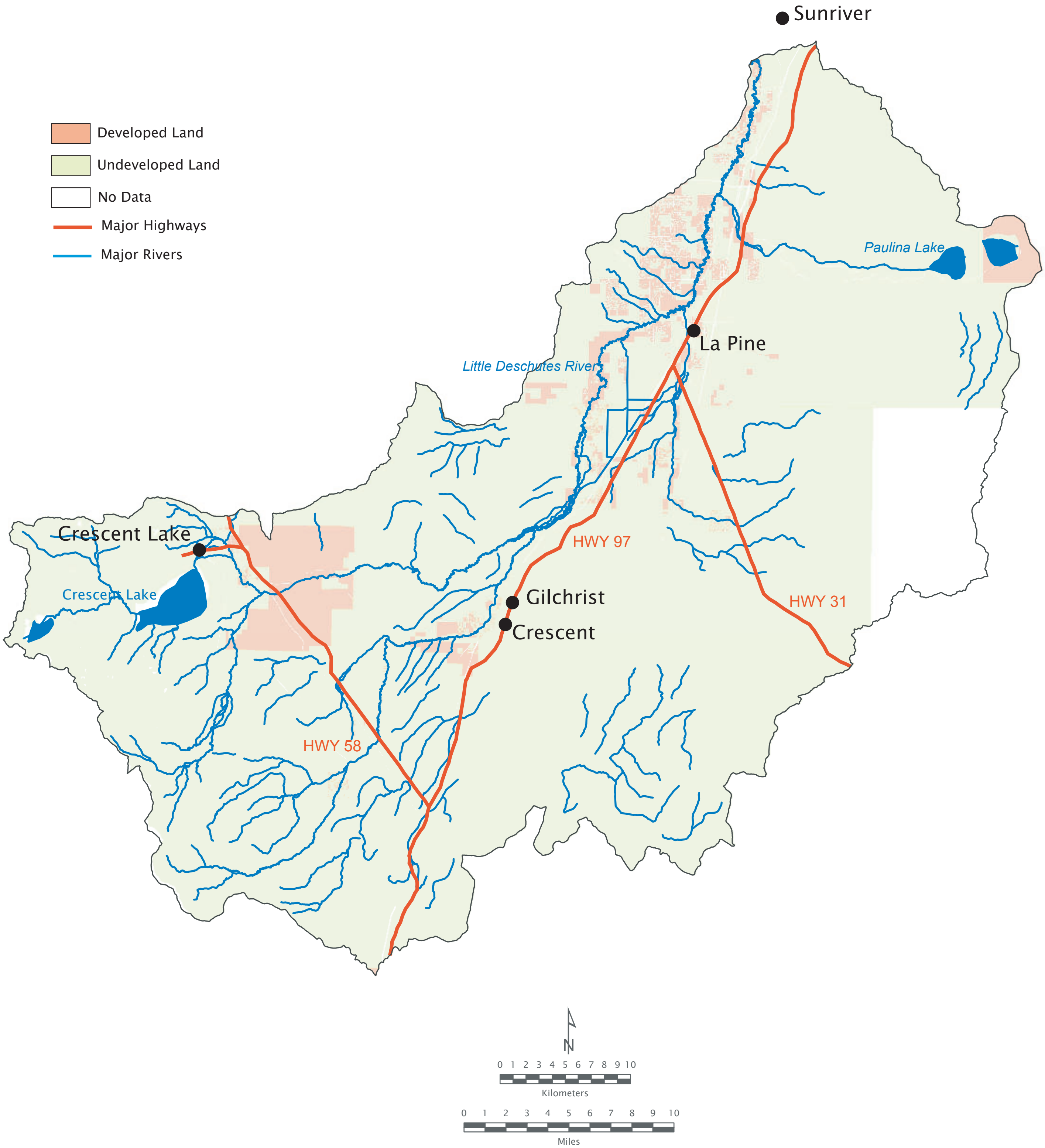
Map 4-3: Landuse
Little Deschutes Subbasin Watershed Assessment



Data Source: Deschutes and Klamath Counties
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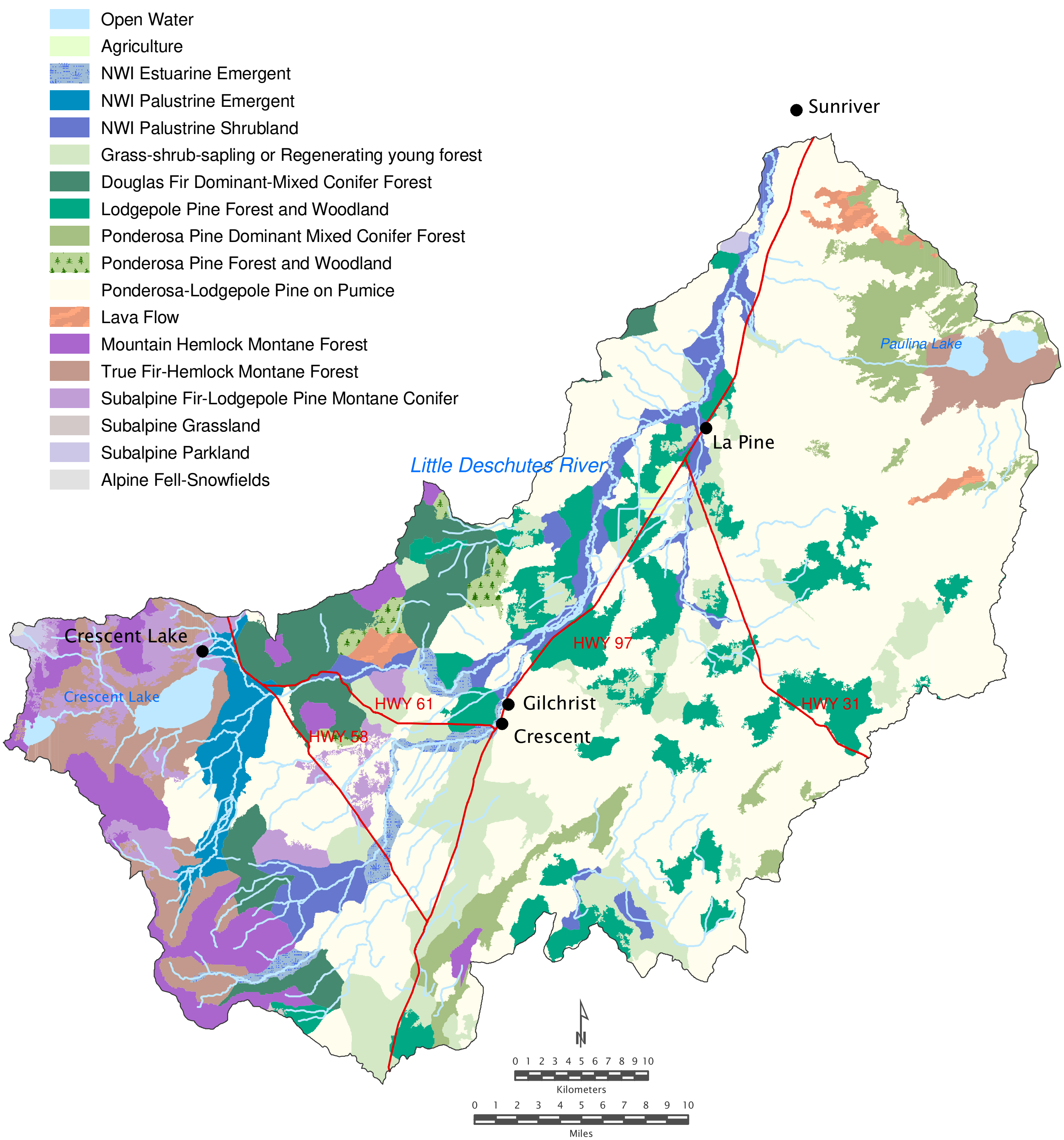
Map 5-1:

Oregon GAP Vegetation, 1998

Little Deschutes Subbasin Watershed Assessment



Data Source: Oregon Geospatial Data Clearinghouse, ONHP

/proj/deschutes/maps/currentveg July 26, 2001

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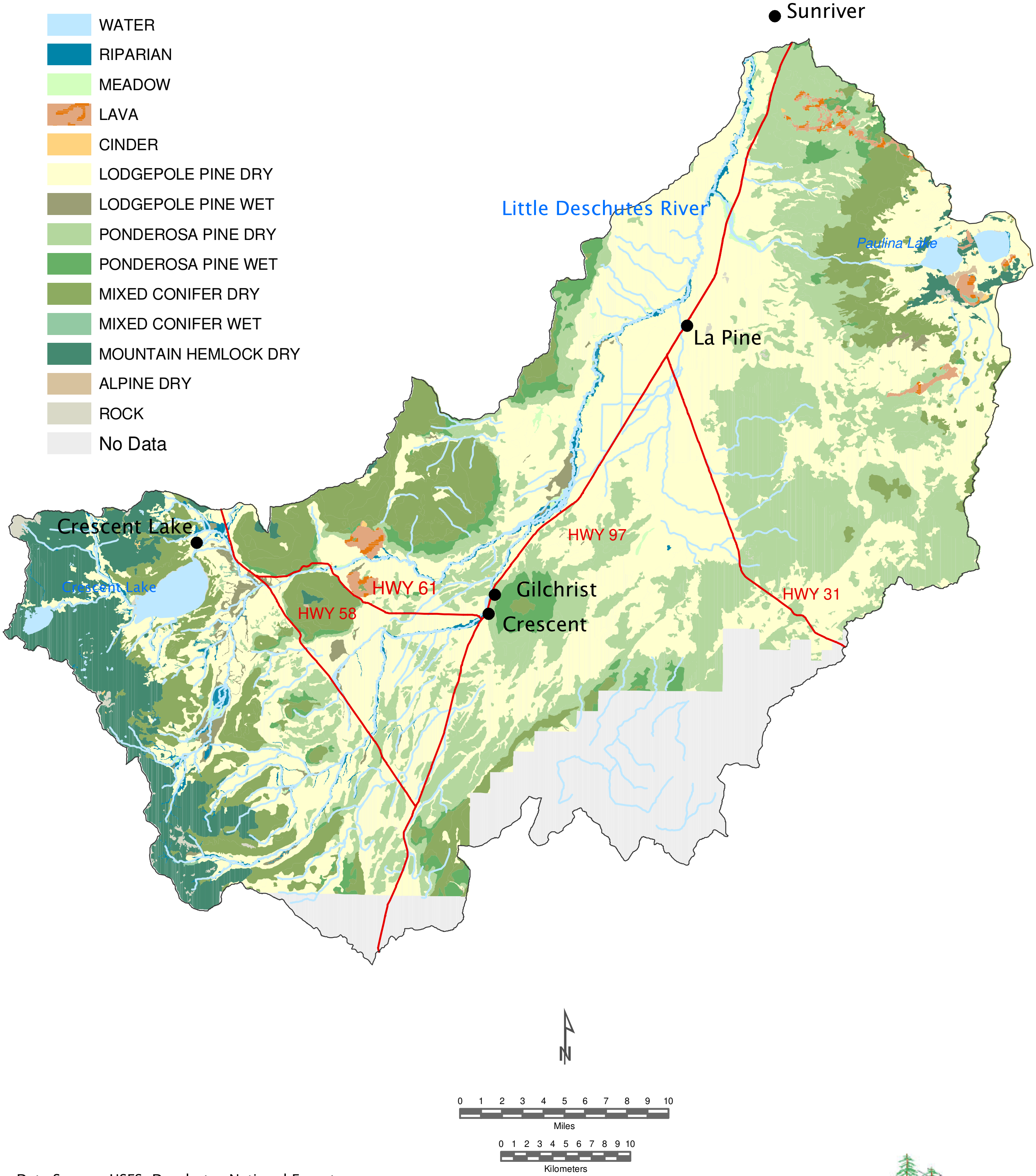
Map 5-1:
Plant Association Groups
Little Deschutes Subbasin Watershed Assessment



Data Source: USFS, Deschutes National Forest
/proj/deschutes/maps/pag July 26, 2001

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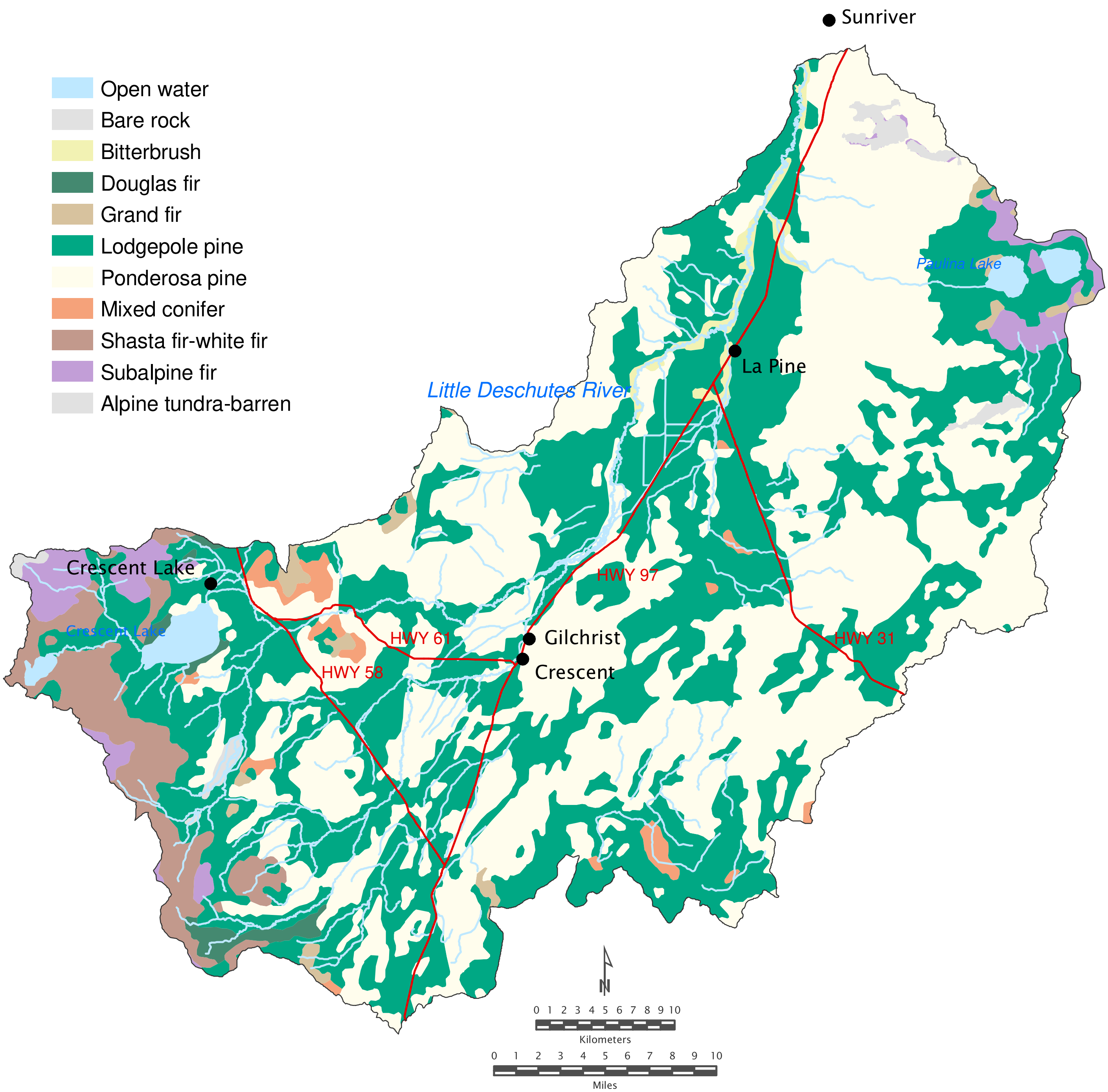
Map 5-1:

Historic Vegetation, c. 1850

Little Deschutes Subbasin Watershed Assessment



Data Source: ONHP, 2001

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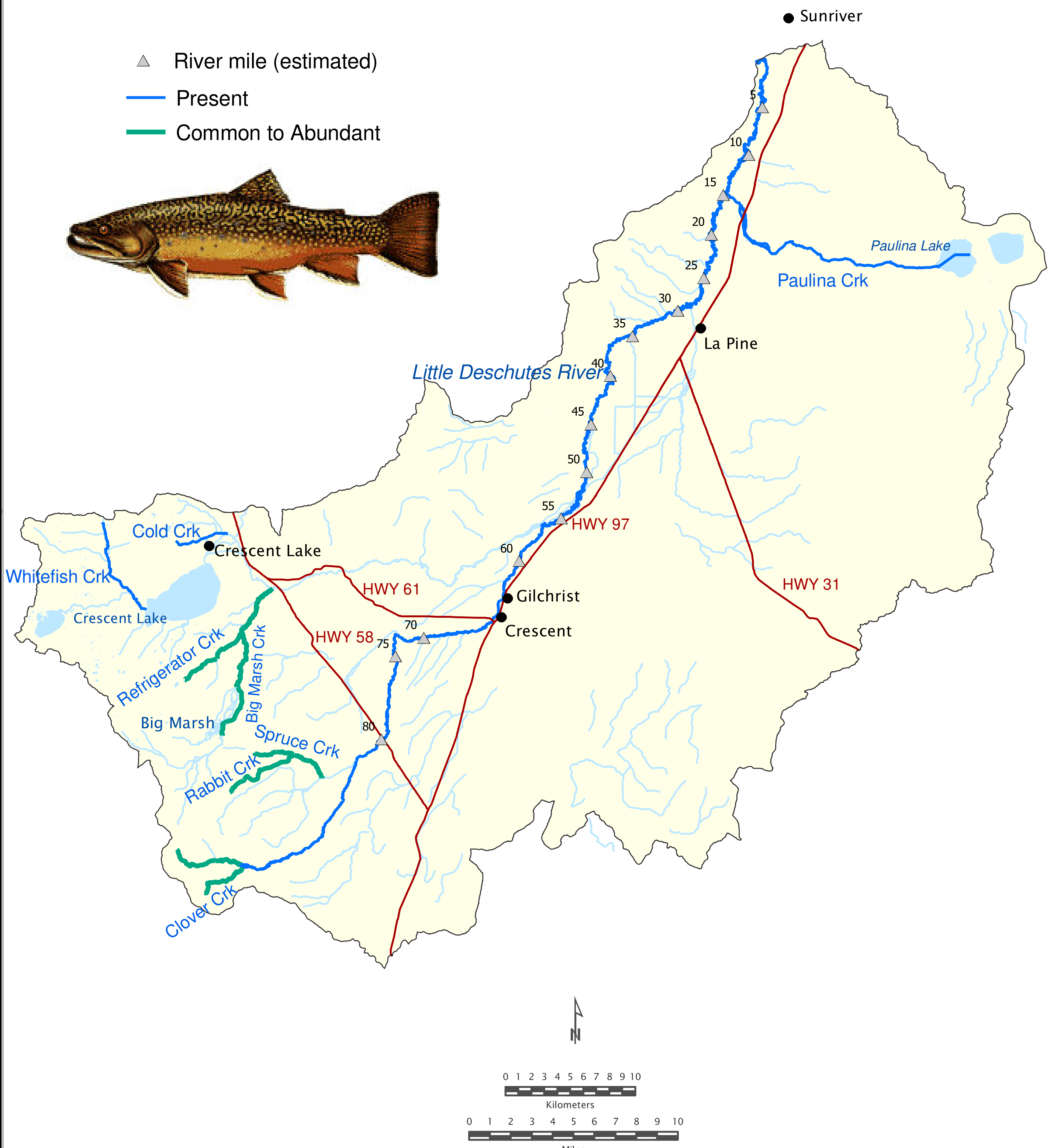
Map 5-1:
Brook Trout Distribution
Little Deschutes Subbasin Watershed Assessment



Data Source: Steve Bauer, Watershed Professionals Network
/proj/deschutes/maps/fish_brook September 7, 2001

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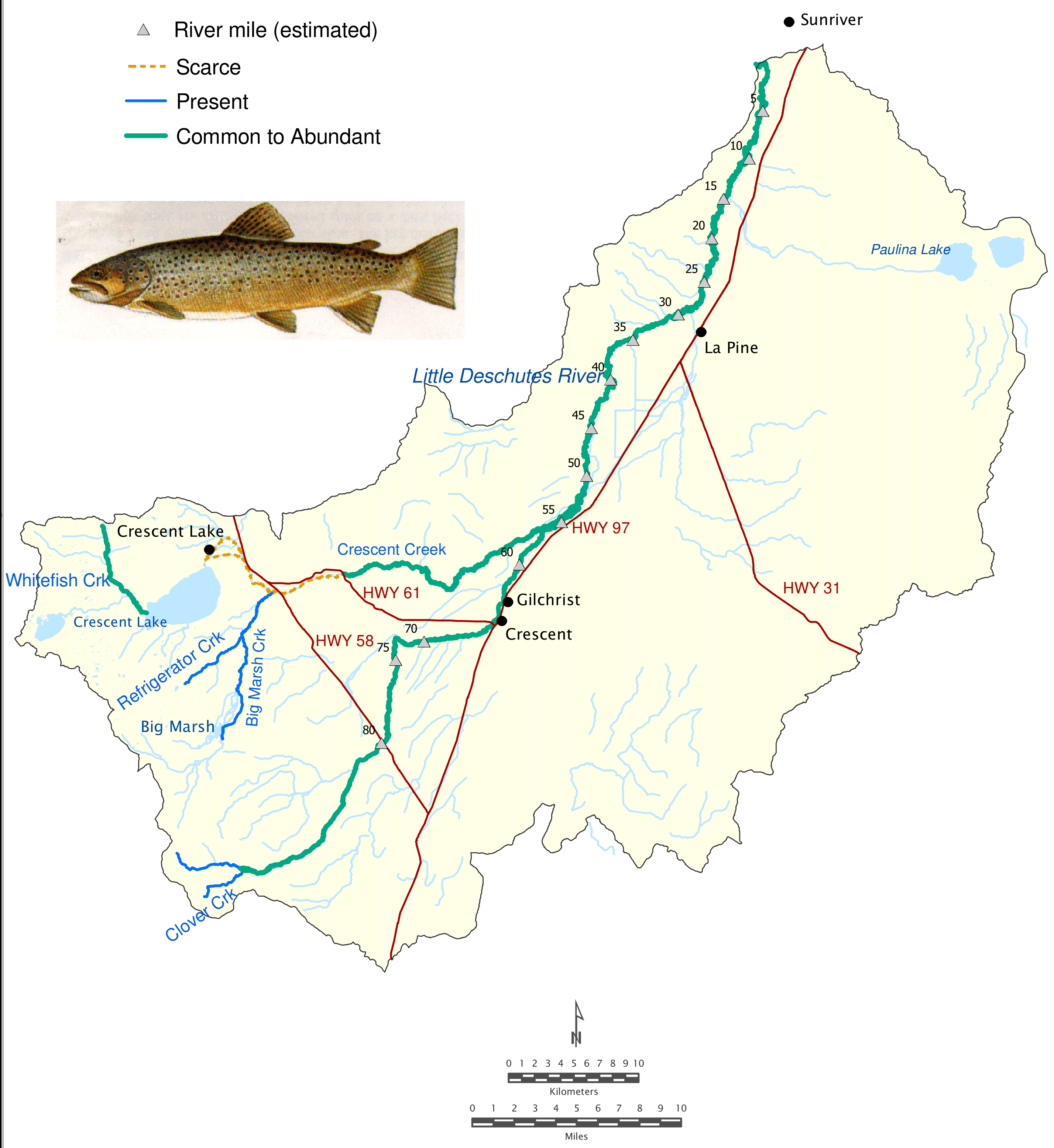
Map 8-2:
Brown Trout Distribution
Little Deschutes Subbasin Watershed Assessment



Data Source: Steve Bauer, Watershed Professionals Network
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Alsea Geospatial, Inc.
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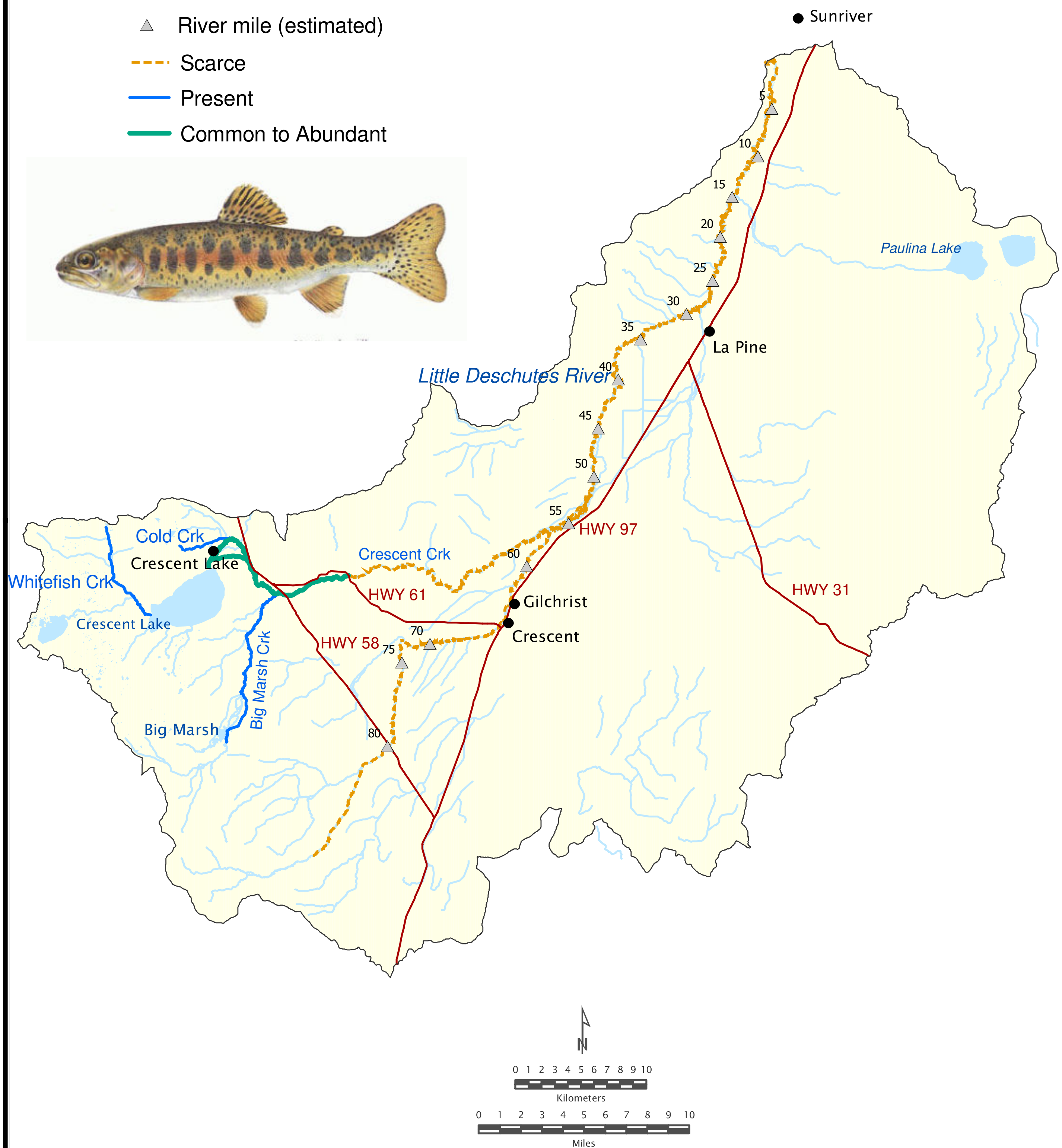
Map 5-1:
Redband Trout Distribution
Little Deschutes Subbasin Watershed Assessment



Data Source: Steve Bauer, Watershed Professionals Network
/proj/deschutes/maps/fish_redband September 7, 2001

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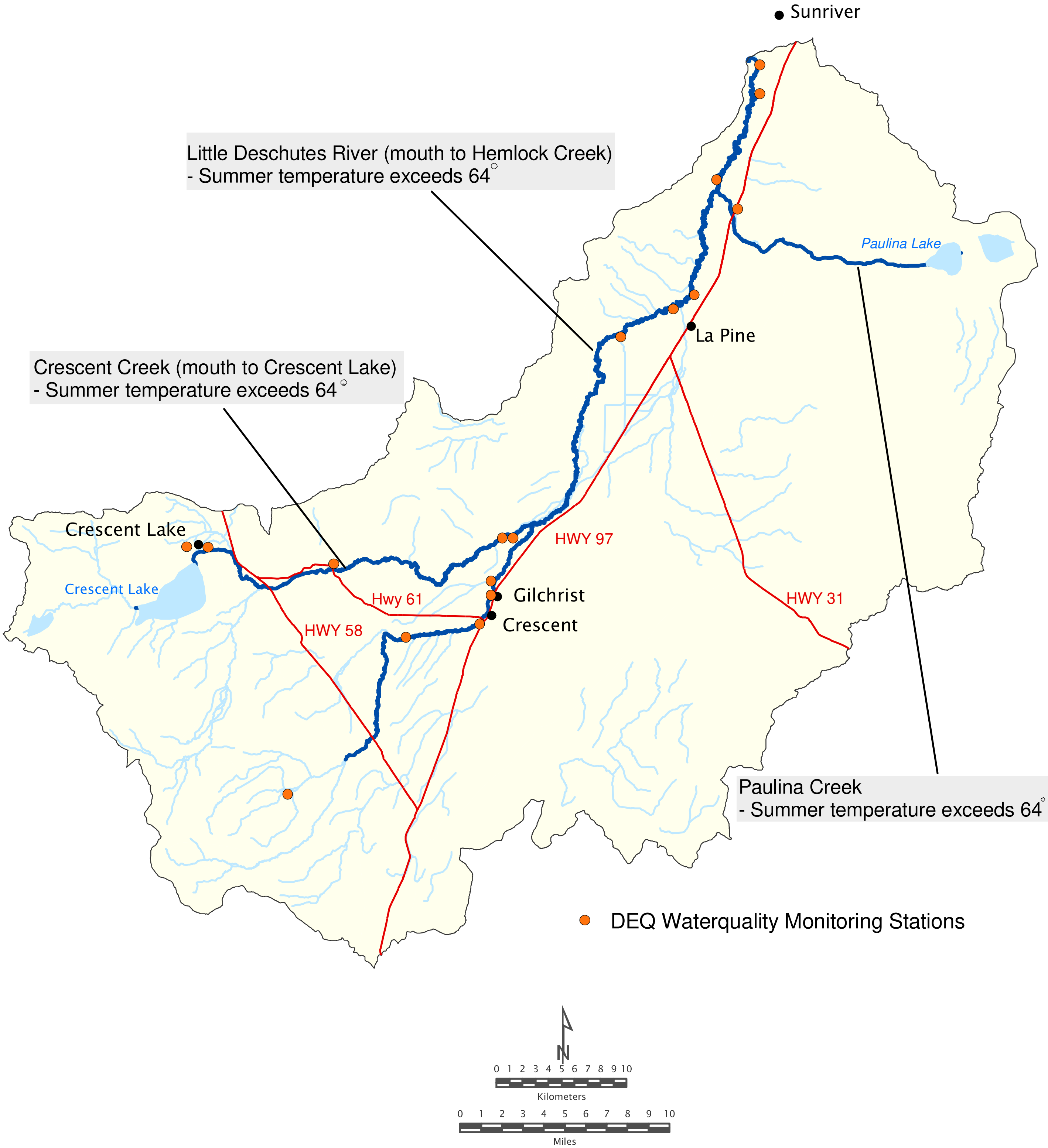
Map 9-1:

Oregon DEQ 1998 303 (d) Listed Waters

Little Deschutes Subbasin Watershed Assessment



Data Source: Oregon Department of Environmental Quality

/proj/deschutes/maps/deqwater August 21, 2001

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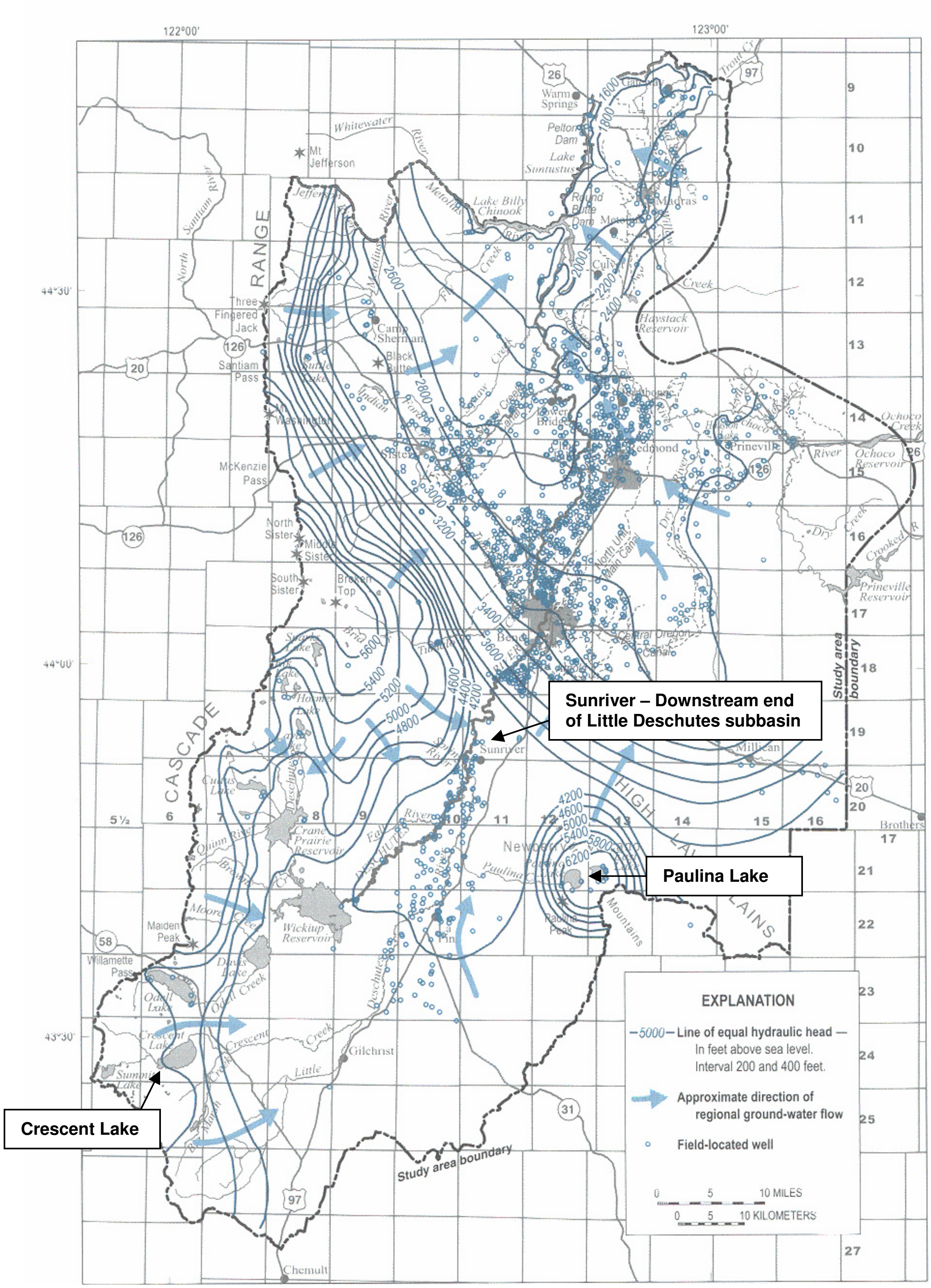
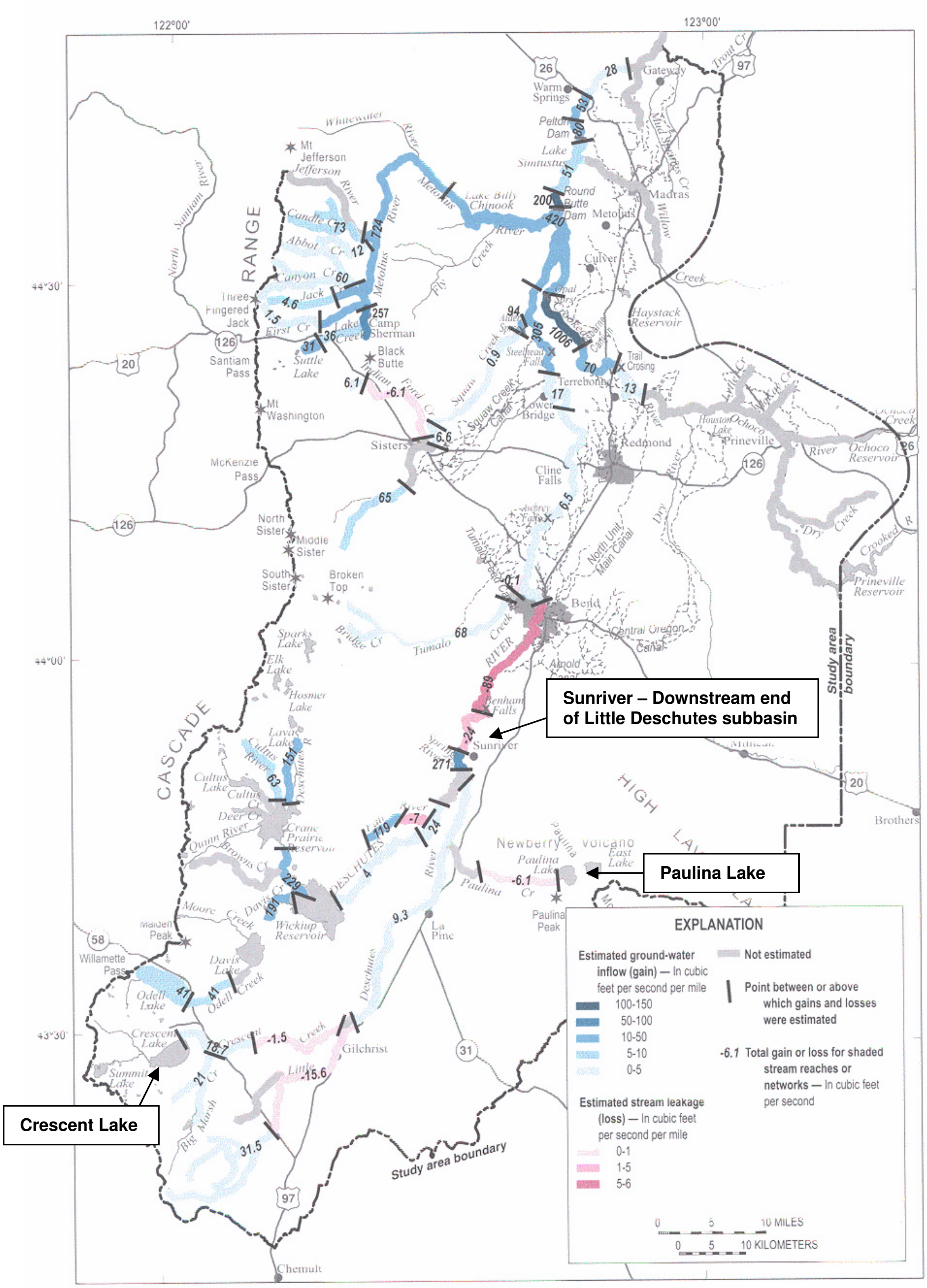
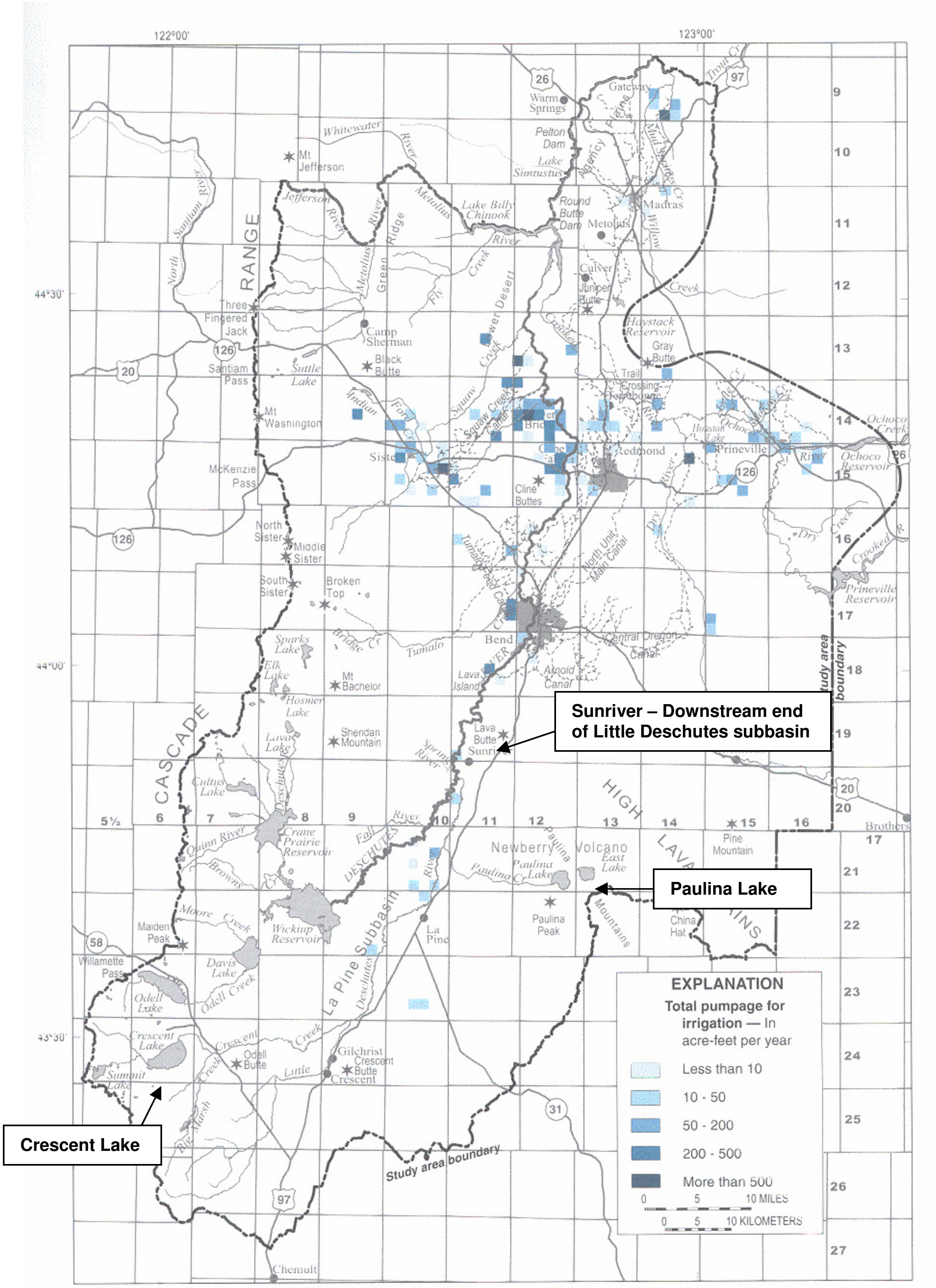


Map 10-1: Approximate Direction of Groundwater Flow in the Little Deschutes Basin, Oregon (source: Gannett et al. 2000).



Map 10-2: Estimated Gains and Losses in the Little Deschutes River Subbasin (source: Gannett et al. 2000).



Map 10-3: Estimated average annual ground water pumping for irrigation in the Little Deschutes Basin, Oregon (source: Gannett et al. 2000)

Appendix B: GAP Vegetation Cover Type Descriptions

FOREST AND WOODLAND COVER TYPES

Mountain Hemlock Subalpine Forest (33)

Geographic Distribution. Mountain hemlock (*Tsuga mertensiana*) ranges throughout the Cascades at higher elevations (generally above 4500 ft). In the southern Cascades and Siskiyou Mountain ranges the mountain hemlock cover type grades into the Shasta red fir (*Abies magnifica* var. *shastensis*)/mountain hemlock forest cover type. Mountain hemlock is also found in the Wallowa Mountains of northeastern Oregon. In both the Siskiyous and Wallowas, mountains hemlock is not as common, nor as extensive, as in the Cascades.

Structure and Appearance. At the lower elevation range of mountain hemlock this cover type is a forest that can have a multi-storied canopy, although it typically tends to single story. In these conifer dominant forests tree size is considerably smaller and regeneration difficult than lower elevation conifer cover types due to persistent snowpack and short growing season. Mountain hemlock, at its upper elevation range, grades into alpine parkland. Parkland settings are considered as a mosaic of treeless openings with clumps of closed canopy trees.

Composition. Mountain hemlock typically dominates the overstory in this upper elevation conifer forest. Pacific silver fir (*Abies amabilis*), lodgepole pine (*Pinus contorta*), western white pine (*Pinus monticola*), western hemlock (*Tsuga heterophylla*), and Douglas fir (*Pseudotsuga menziesii*) may be present in the overstory. In parkland mosaics mountain hemlock may appear in pure clumps, or mixed with subalpine fir (*Abies lasiocarpa*) or whitebark pine (*Pinus albicaulis*).

Shrubs and forb layer are typically sparse and species poor. Several of the Vaccinium genus are the most commonly found shrubs, big huckleberry, (*V. membranaceum*), grouse whortleberry (*V. scoparium*), and Alaska huckleberry (*V. alaskaense*). Dwarf bramble (*Rubus lasiococcus*), and prince's pine (*Chimaphila umbellata*) also occurs commonly in this type.

Beargrass (*Xerophyllum tenax*) is the dominant herb in most places. Other associated herbs are: sidebells pyrola (*Pyrola picta*), beadlily (*Clintonia uniflora*), and sickletop pedicularis (*Pedicularis racemosa*).

Landscape Setting. In the Cascade Range mountain hemlock occupies the elevation zone between the true fir dominant montane forests, and the alpine parkland forest types. Mountain hemlock also occurs as high elevation savanna in pure clumps or mixed with whitebark pine in the volcanic soils of the southern Cascades.

References. Atzet *et al.* 1996, Hemstrom *et al. 1987,* Volland *1985,* Crawford *et al.* 1999, Johnson and Simon 1987.

True Fir/Hemlock Montane Forest (34)

Geographic Distribution. Found throughout the northern and central Cascade Range at middle to higher elevations, especially west of the Cascade crest. The true fir/hemlock type reaches its southern limit in the upper Rogue River drainage, east of Prospect. This type is also found in disjunct populations in the Coast Range.

Structure and Appearance. Multi-story closed canopy forests. Trees can grow to large stature barring disturbance in these fertile, mid-elevation forests. Snags and large woody debris are commonly found. Understory vegetation is rich in species with a diversity of forms.

Composition. Canopy co-dominance of pacific silver fir (*Abies amabilis*), and/or noble fir (*A. procera*) along with both western and mountain hemlock characterize this conifer forest type. Other canopy trees found in this type include: Douglas fir (*Pseudotsuga menziesii*), western white pine (*Pinus monticola*), subalpine fir (*Abies lasiocarpa*), Alaska yellow cedar (*Chamaecyparis nootkatensis*) and grand fir (*Abies grandis*).

The shrub layer in this cover type is dense and diverse with a number of deciduous and evergreen shrubs commonly found. Shrubs associated with this cover type are: pacific rhododendron (*Rhododendron macrophyllum*), Cascade azalea (*R. albiflorum*), salal (*Gaultheria shallon*), fools huckleberry (*Menziesia ferruginea*), big huckleberry (*Vaccinium membranaceum*), Alaska huckleberry (*V. alaskaense*), dwarf Oregongrape (*Mahonia nervosa*), and vine maple (*Acer circinatum).*

The forb layer in these forests is also rich in species and abundance. Indicator species of wet and mesic sites include: skunk cabbage (*Lysichitum americanum*) devils club (*Oplopanax horridum*), beadlily (*Clintonia uniflora*), foamflower (*Tiarella unifoliata*) wild ginger (*Asarum caudatum)* Oregon oxalis (*Oxalis oregana*), vanillaleaf (*Achlys triphylla*), bunchberry (*Cornus canadensis*) and beargrass (*Xerophyllum tenax*).

Landscape Setting. This cover type is adjacent to Douglas fir/western hemlock/western red cedar at its lower elevation range and subalpine forest types at its upper limits. These are cool site, fertile soil forests with winter snowpack and moist soils during the growing season. The long droughty summers of southern Oregon are likely the limiting factor in its southern distribution.

References. Hemstrom *et al.* (1982, 1987), Atzet and Wheeler 1984, Atzet *et al.* 1996, Halvorson *et al.* 1986, Crawford *et al.* 1999.

Ponderosa Pine Dominant – Mixed Conifer Forest (40)

Geographic Distribution. The ponderosa pine dominant-mixed conifer forest is found primarily in the southern half of the eastern Cascades, ranging from the California border to Bend.

Structure and Appearance. This type is typically a two story conifer forest with the predominance of the overstory canopy (greater than 60%) being ponderosa pine (*Pinus ponderosa*). White fir (*Abies grandis* and *A. concolor*), is the other common overstory tree with occasional incense cedar (*Calocedrus decurrens*), and sugar pine *(Pinus lambertiana*). Understory regeneration can be dense, or sparse, based on intensity of cattle grazing, fire frequency, and ecological site conditions.

Composition. Overstory conifers are ponderosa pine, white fir, with lesser contribution from incense cedar and sugar pine. Understory trees are similar in composition to overstory although generally white fir predominates over ponderosa and lodgepole pine (*Pinus contorta*) is a common understory occupant.

The shrub and herb layers form a diverse and prominent ground cover component in this forest type especially when compared to adjacent cover types. Commonly associated shrubs include snowberry (*Symphoricarpos albus*), creeping snowberry (*S. mollis*), dwarf Oregongrape *(Mahonia nervosa*), wax currant (*Ribes cereum*), and serviceberry (*Amelanchier alnifolia*).

Indicator cover type herbs are: heartleaf arnica (*Arnica cordifolia*), long stolon sedge (*Carex pensylvanica*), squirreltail bottlebrush (*Sitanion hystrix*), starwort (*Stellaria jamesiana*), white hawkweed (*Hieracium albiflorum*), and broadleaf strawberry (*Fragaria virginiana*).

Landscape Setting. This mid elevation cover type occupies the zone between the drier low elevation types, primarily ponderosa-western juniper cover type, and higher elevation mixed conifer or sub-alpine types. This type, with its mesic site conditions, is transitional in its ecological setting bridging the gap between drier, low elevation types and the colder, wetter higher elevation types. This type also warrants distinction because of its lack of Douglas fir (*Pseudotsuga menziesii*) in its stands and the consistent presence, but lack of co-dominance by associated conifers.

References. Hopkins, 1979, Volland, 1988, Kovalchik, 1987.

Lodgepole Pine Forest and Woodland (44)

Geographic Distribution. A common forest cover type found throughout the central and southern Cascades, east of the crest; and in smaller, scattered mosaics throughout the mountains of northeastern Oregon, and along the crest of the Cascades.

This cover type is most extensive in the same geographic area as the ponderosa-lodgepole pine on pumice type; but warrants distinction because it occurs on mid-slopes and ridges and is a forest type responding from wild fires, not soil conditions.

Structure and Appearance. Single layer, open to closed canopies, dominated by lodgepole pine (*Pinus contorta*). A typical post-fire successional path for this cover type is to have dense reproduction of short stature lodgepole. As the stand matures lodgepole cover thins to scattered overstory lodgepole with regeneration layers of other conifers. These other conifers, regionally important replacement trees would be: Douglas-fir (*Pseudotsuga menziesii*), grand fir *(Abies grandis*), white fir (*A. concolor*), incense cedar (*Calocedrus decurrens*), and western white pine (*Pinus monticola*) will eventually form the overstory and eliminate lodgepole from the stand entirely.

Composition. Lodgepole dominates the overstory in early to mid successional stands. Western larch (*Larix occidentalis*), another post-fire colonizing conifer, can be co-dominant in this cover type, especially in the northeastern Oregon mountains. Regeneration layers are composed of conifers listed in the structure and appearance section.

Shrubs are common and diverse in this cover type: common snowberry (*Symphoricarpos albus*), mountain snowberry (*S. mollis*), serviceberry (*Amelanchier alnifolia*), ninebark (*Physocarpus* *malvaceus*), shiny-leaf spirea (*Spiraea betulifolia*), bitterbrush, (*Purshia tridentata*), baldhip rose *(Rosa gymnocarpa*), myrtle pachistima (*Pachistima myrsinites*), and several huckleberries (*V. membranaceum, V. scoparium, V. uliginosum, and V. caespitosum*).

Grasses dominate some understories with few shrubs. Pine grass (*Calamagrostis rubescens*), Ross' sedge (*Carex rossii*), elk sedge (*Carex geyeri*), bluebunch wheatgrass (*Agropyron spicatum*), western needlegrass (*Stipa occidentalis*), Idaho fescue (*Festuca idahoensis*), prairie junegrass *(Koeleria macrantha*), and mountain brome (*Bromus carinatus*) are commonly found.

Landscape Setting. Since this forest cover type usually is the response following wild fires there is no environmental relationship that controls its distribution. This cover type appears as a mosaic within the larger, regionally important cover types.

References. Hopkins 1979, Johnson and Clausnitzer 1986, Johnson and Simon 1987, Crawford *et al.* 1999, Kagan and Caicco 1992.

Subalpine Fir-Lodgepole Pine Montane Forest (45)

Geographic Distribution. A common mid to high elevation conifer forest cover type in the mountains of northeastern Oregon, and along the crest of the Cascades.

Structure and Appearance. Short stature single story canopy forests. Crown closure ranges from open to closed. At its lower elevation range, this cover type grades into various montane forest types and maintains a continuous canopy. At its upper elevation range, (which can be the timberline), the type grades into subalpine parkland, or it takes on the clumpy appearance of a parkland cover type.

Composition. Subalpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*) dominate the canopy overstory. Engelmann spruce (*Picea engelmannii*) can be a locally important overstory tree, especially in northeastern Oregon. Understory tree composition usually is dominated by subalpine fir.

Shrub cover in this type can be extensive and is typified by big huckleberry (*Vaccinium membranaceum*), and grouse huckleberry *(V. scoparium*). Other commonly associated shrubs include: gooseberry (*Ribes lacustre*), shiny-leaf spirea (*Spiraea betulifolia*), and prince's pine (*Chimaphila umbellata*).

Forb cover is often low but diverse in species. Common indicator forbs would be strawberries, (*Fragaria vesca and F. virginiana*), roundleaf violet (*Viola oreganum*), heartleaf arnica (*Arnica cordifolia*), sidebells pyrola (*Pyrola secunda*), skunkleaf polemonium (*Polemonium pulcherrimum*), sweet cicely (*Osmorhiza chilensis*) and meadowrue (*Thalictrum occidentalis*).

Landscape Setting. Occupies the upper elevation range of continuous forest cover for much of northeastern Oregon. As discussed in the structure and appearance section, this type grades into, or takes on the appearance of parkland cover types. Lodgepole pine is successional to subalpine fir, but remains a common component on harsher sites and ridgetops. Successional change is slow in this cover type with its short growing season and persistent snow cover.

References. Hall 1973, Johnson and Simon 1987, Johnson and Clausnitzer 1989, Kagan and Caicco 1992.

Ponderosa Pine Forest and Woodland (54)

Geographic Distribution. This conifer forest and woodland is a major cover type in mid to lower elevation zones along the flanks of the eastern Cascades and the mountain ranges of central and northeastern Oregon.

Structure and Appearance. In its mature form this forest type is typified by large structure, widely spaced ponderosa pine (*Pinus ponderosa*). The overstory is predominantly ponderosa with white fir (*Abies concolor*), grand fir (*A. grandis*), incense cedar (*Calocedrus decurrens*), and Douglas fir (*Pseudotsuga menziesii*) minor overstory trees based on location within the state.

Regeneration and understory tree layers are comparatively sparse in this cover type with regards to other regional forest cover types. A variety of forest related grasses and grass-like forbs are frequently found in this type.

Composition. Overstory tree along low elevation is exclusively ponderosa pine. At higher elevation margin and transition to mixed conifer types, overstory conifers can be white fir, grand fir, western larch (*Larix occidentalis*), incense cedar, Douglas fir, sub-alpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*). Understory and regeneration layers reflect similar composition as overstory.

Shrubs are commonly found and reflect the same environmental trend as associated conifers; lower elevations have fewer shrubs and sparse appearance, increasing in diversity and abundance with elevation and improved soil moisture conditions. Indicative shrubs are bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), snowberry (*Symphoricarpos albus*), serviceberry (*Amelanchier alnifolia*), mountain mahogany (*Cercocarpus ledifolius*), greenleaf manzanita (*Arctostaphylos patula*), and squaw carpet (*Ceanothus prostratus*).

Grasses and grass-like vegetation are common and dominate the understory in many stands. Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria macrantha*), bluebunch wheatgrass (*Agropyron spicatum*), Kentucky bluegrass (*Poa pratensis*), mountain brome (*Bromus carinatus*), elk sedge (*Carex geyeri*), Ross' sedge (*C. rossii*) and western needlegrass (*Stipa occidentalis*).

Landscape Setting. Ponderosa pine is the most tolerant of hot, dry environments of Oregon's conifers and forms the boundary zone between forest and rangeland cover types for much of Oregon. Its presence along the transition zone at lower elevations usually marks the adequacy of soil moisture to grow large stature vegetation. The exception to ponderosa pines types forming the forest/rangeland boundary is in central Oregon where western Juniper (*Juniperus occidentalis*) occupies the transition between sagebrush and ponderosa pine cover types.

Ponderosa pine can also tolerate cold conditions so it occupies a wide elevational range, but in the higher elevations it is restricted to southerly aspects. At these higher elevations ponderosa stands usually are not large enough to form mappable units. Similarly, ponderosa pine stands can be found in the low elevation, western Cascade forests but are not large enough to be mapped.

References. *Volland, 1985, Johnson and Simon, 1987, Topik* et al.*, 1988, Hopkins, 1979, Atzet* et al.*, 1996.*

Douglas Fir Dominant / Mixed Conifer Forest (56)

Geographic Distribution. Common mid elevation forest type in southwestern Oregon. This type also extends north to the Columbia River in a narrow band along the eastern side of the Cascades.

Structure and Appearance. Stand structure can be diverse in undisturbed late seral stands although single story forest canopies typify the type. Overstory tree layer ranges widely in canopy closure based on management practice, disturbance history, and microsite. Understory vegetation is usually diverse and rich in species.

Composition. This cover type contains a diverse array of conifers that complement the ever-present Douglas fir (*Pseudotsuga menziesii*). Fir (*Abies grandis* and/or *A. concolor*), incense cedar (*Calocedrus decurrens*), western white pine (*Pinus monticola*), and ponderosa pine (*P. ponderosa*) are found throughout the range. Sugar pine (*P. lambertiana*) occurs only in southwestern Oregon, and western red cedar *(Thuja plicata*), and Engelmann spruce *(Picea engelmannii*) only in the central and northern regions of the Cascades. Sub-canopy layer generally has the shade tolerant components of the overstory. Western yew (*Taxus brevifolia*) is a frequent sub-canopy component in southwestern Oregon.

Indicator shrubs in this cover type include: vine maple (*Acer circinatum*), Rocky mountain maple (*A. glabrum* var. *douglasii*), serviceberry (*Amelanchier alnifolia*), greenleaf manzanita (*Arctostaphylos patula*), pinemat manzanita (*A. nevadensis*), red huckleberry (*Vaccinium parvifolium*), Oregon grape (*Mahonia nervosa*), snowberry (*Symphoricarpos albus*), oceanspray (*Holodiscus discolor*), sticky currant (*Ribes viscosissimum*), and squaw currant (*R. cereum*).

Common herbs in this cover type include western yarrow (*Achillea millefolium*), silvery lupine (*Lupinus argenteus*), tailcup lupine (*L. caudatus*), strawberry (*Fragaria virginiana*), bull thistle (*Cirsium vulgare*), heartleaf arnica *(Arnica cordifolia*), peavine (*Lathyrus lanszwertii*), starry solomon-plume (*Smilacina stellata*), and white vein pyrola (*Pyrola picta*).

Landscape Setting. In southwestern Oregon this mid-elevation forest transitions between the deciduous dominant foothill forests and the true fir dominant montane conifers. Along the slopes of the eastern Cascades it is also transitional to the ponderosa pine and ponderosa/western juniper at its low end and montane forests at upper elevations.

References. Hopkins and Rawlings 1985, Atzet *et al.* 1996, Atzet and Wheeler 1983, Chappell *et al.* 1999, Kovalchik 1986, Volland 1985.

Ponderosa-Lodgepole Pine on Pumice (59)

Geographic Distribution. The most common forest and/or woodland cover type in the southern half of the eastern Cascades ecoregion. The long taproots of lodgepole (*Pinus contorta*) and ponderosa (*P. ponderosa*) make them especially well adapted to the droughty pumice soils of this region. Pumice soils are derived from the volcanic eruptions of prehistoric Mount Mazama and numerous cinder cones throughout the region. This forest type forms a nearly continuous cover from LaPine to the northern edge of the Klamath Marsh.

Structure and Appearance. Ponderosa and lodgepole dominate the overstory canopy and regeneration layers in these forests. In its mature, undisturbed form, these forests are distinctly two story canopies with large ponderosa over the shorter lodgepole. Due to extensive selective logging in this type most of the large ponderosa have been removed leaving large tracts of single story lodgepole forests. Regeneration and tree growth are slow in these infertile forests. These forests have an active fire history and have evolved with frequent fires.

Shrub and herb layers are poorly developed in this forest type.

Composition. Ponderosa and lodgepole are the most commonly encountered trees. In wet places and riparian strips, Engelmann spruce (*Picea engelmannii*), quaking aspen (*Populus tremuloides*), and white fir (*Abies concolor*) can be found.

The shrub layer in this cover type is poorly developed. The most commonly associated shrubs are bitterbrush (*Purshia tridentata*), greenleaf manzanita (*Arctostaphylos patula*), kinnikinnik *(A. uva-ursi*), and serviceberry (*Amelanchier alnifolia*).

The herb layer in most stands has sparse cover with few species. Several grasses, western needlegrass (*Stipa occidentalis*), squirreltail (*Sitanion hystrix*), Wheeler's bluegrass *(Poa nervosa*), and Idaho fescue (*Festuca idahoensis*) are commonly found. Other forbs can be: wooly wyethia (*Wyethia mollis*), white hawkweed (*Hieracium albiflorum*), and Ross' sedge (*Carex rossii*).

Landscape Setting. The distribution of the ponderosa-lodgepole pine on pumice cover type closely corresponds to the distribution of deep tephra layers from the regions volcanic activity. As such, it doesn't necessarily relate to environment or climatic conditions.

References. Volland 1988, Kovalchik 1987, Hopkins 1979.

SHRUBLAND AND GRASSLAND TYPES

Alpine Grasslands and Shrublands (105)

Geographic Distribution. This cover type depicts the vegetated areas above upper treeline in the highest mountains throughout Oregon.

Structure and Appearance. Dwarf shrubs dominate this cover type, and thickly compacted Carex species that form a grass-like cover called sedge turf. Widely scattered, low stature conifers are also common in this type.

Composition. Shrub layer is dominated by several prostrate shrubs; red mountain heather (*Phyllodoce empetriformis*), green mountain heather (*P. glanduliflora*), white mountain heather (*Cassiope mertensiana*), or crowberry (*Empetrum nigrum*). Other dwarf shrubs found in this cover type include cinquefoil (*Potentilla fruticosa*), juniper (*Juniperus communis*), bearberry (*Arctostaphylos uva-ursi*) and willows (*Salix spp*.).

Alpine sedge turf usually contains one or more of the following: alpine black sedge (*Carex nigricans*), capitate sedge (*C. capitata*), dunhead sedge (*C. phaeocephala*), or showy sedge *(C. spectabilis*).

Landscape Setting. This cover type always occurs above timberline. Typically this type occurs as a mosaic with alpine parkland and alpine fell and snowfields. These types usually are not very extensive and therefore not mapped.

Subalpine Parkland (110)

Geographic Distribution. The highest elevation forest zone in the Cascades, Blues, and Wallowa Mountain ranges of Oregon.

Structure and Appearance. Subalpine parkland is distinctive from subalpine grassland and shrublands due to the presence of the clumpy, scattered tree pockets throughout the cover type.

Conifer overstory typically ranges from 10 to 30% cover. Ground layer can be a dense layer of low-lying shrubs, sedge or grass turf, or montane wetland bogs.

Composition. Subalpine parkland conifer composition varies by region. In the Blues and Wallowas the parkland is usually subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), or lodgepole pine (Pinus contorta). In the Cascades, mountain hemlock (Tsuga mertensiana), subalpine fir, silver fir (Abies amabilis), and to a lesser extent Alaska yellow cedar (Chamaecyparis nootkatensis). In the southern Cascades mountain hemlock, Shasta red fir (Abies magnifica var. shastensis), and whitebark pine (Pinus albicaulis).

The shrub layer is similar in composition to the subalpine shrubland and grassland cover type, where commonly associated shrubs are: red mountain heather (Phyllodoce empetriformis), green mountain heather (P. glanduliflora), white mountain heather (Cassiope mertensiana), or crowberry (Empetrum nigrum). Other dwarf shrubs found in this cover type include cinquefoil (Potentilla fruticosa), juniper (Juniperus communis), bearberry (Arctostaphylos uva-ursi) and willows (Salix spp.).

Alpine sedge turf usually indicates poorly drained soils, or persistent snow pack well into the growing season, and contains one or more of the following; alpine black sedge (Carex nigricans), capitate sedge (C. capitata), dunhead sedge (C. phaeocephala), or showy sedge (C. spectabilis).

On drier sites, the forb layer is characterized by either elk or Ross' sedge (Carex geyeri or C. rossii), smooth woodrush (Luzula hitchcockii), Drummond's rush (Juncus drummondii), or green fescue (Festuca viridula).

Landscape Setting. Forms the high elevation limit to tree growth. Usually is a mosaic with alpine fell and snowfields and the alpine shrubland and grassland.

References. Hopkins 1979, Johnson and Simon 1986, Johnson and Clausnitzer 1987, Hemstrom *et al.* 1987, Volland 1988, Atzet *et al.* 1996, Crawford *et al.* 1999.

Grass-Shrub-Sapline or Regenerating Young Forest (121)

Geographic Distribution. Common throughout the mountains of Oregon.

Structure and Appearance. Captures the range of successional conditions following timber harvest. Site preparation following timber harvest is a ground scarification and burning of slash and large woody debris, followed by seeding of a mix of annual grasses to retard soil erosion and planting conifer seedlings. As the stand matures there may be a phase where resprouting shrub vegetation, or dormant shrub seeds germinated by prescription fire, dominate the overstory canopy layer. Later in the successional phase the conifer saplings have emerged through the shrub canopy and formed continuous canopies

Composition. A variety of shrubs and forbs can be present in this cover type based on regional flora and site history.

Landscape Setting. Appears as a patchwork mosaic woven into surrounding local forest cover types. The several large, continuous polygons that appear on the map in south-central and northeastern Oregon are burned over lands from fires in the 1980's.

OTHER TYPES

Agriculture (125)

Geographic Distribution. Found throughout Oregon. Agriculture is identified as those lands that have been modified for growing crops and/or animal husbandry.

Lava Flows (127)

Geographic Distribution. This cover type is found mostly in southeastern Oregon and eastern Cascades Mountains.

Structure and Appearance. Surface lava flows that are largely unvegetated (less than 15% vegetation cover). In eastern Oregon, lava flows may be thinly vegetated with sagebrush, primarily big sagebrush (*Artemisia tridentata*) and annual grasses, especially cheatgrass (*Bromus tectorum*). The lava flows in the Cascades tend to be largely unvegetated with scattered pockets of soil that are deep enough to sustain vegetation. In these soil pockets, shrubs such as gooseberry (*Ribes cereum*), or snowbush (*Ceanothus velutinus*), or conifers, especially lodgepole pine (*Pinus contorta)* can survive.

Apline Fell and Snowfields (129)

Geographic Distribution. This cover type depicts the non-vegetated areas above upper treeline in the highest mountains throughout the state. Persistent snow cover and rock talus slopes dominate the local landscape. Found in above timberline environments on the higher peaks and ranges of the Cascades, Steens Mountain, and ranges in northeastern Oregon.

Open Water (130)

Geographic Distribution. Lakes, ponds, and reservoirs larger than 10 acres that occur throughout Oregon.

National Wetland Inventory (137) and GAP Estuarine Emergent Wetland (202)

Geographic Distribution. Common wetland vegetation that borders Oregon's coastal river mouths, bays, and estuaries. Estuarine emergent vegetation is occupied by plants that can withstand inundation by salt and brackish water.

Structure and Appearance. Herbaceous wetlands composed of grass, grass-like, and forbs. Vegetation composition and pattern is strongly influenced by tidal inundation and elevational position within the salt marsh.

Composition. The lowest salt marsh plant community occupies exposed tidal flats during periods of low tides and is characterized by such halophytic plants as seashore saltgrass (*Distichlis spicata*), pickleweed (*Salicornia virginica*), jaumea (*Jaumea carnosa*), shore podgrass (*Triglochin maritimum*), and saltmarsh sedge (*Carex lyngbyei*).

The intermarsh community (higher elevation, less flooding) commonly associated plants include redtop bentgrass (*Agrostis alba*), rush (*Juncus articulatus*), Pacific potentilla (*Potentilla pacifica*), yarrow (*Achillea millefolium*), sea-watch angelica (*Angelica lucida*), giant vetch (*Vicia gigantea*), Pacific waterwort (*Oenanthe sarmentosa*), and Douglas aster (*Aster subspicatus*).

The transition zone (upper elevation saltmarsh to terrestrial upland) is characterized by salmonberry (*Rubus spectabilis*), bracken (*Pteridium aquilinum*), sword fern (*Polystichum munitum*), common velvetgrass (*Holcus lanatus*), Alaska fringecup (*Tellima grandiflora*), red alder (*Alnus rubra*), Sitka spruce (*Picea sitchensis*), and western hemlock (*Tsuga heterophylla*).

Landscape Setting. Borders the cover types of open water and adjacent upland types. Agriculture is a common bordering cover type as many of Oregon's estuaries are diked to permit dairy cattle grazing.

References. Weideman 1986, Frenkel and Eilers 1976, Mitchell 1981, Cowardin *et al.* 1982.

National Wetland Inventory (138) and GAP Palustrine Emergent Wetland (203)

Geographic Distribution. Freshwater herbaceous wetlands distributed throughout the state. Especially prevalent in the Klamath Basin, Malheur-Harney and Warner Lakes basins, the Grande Ronde Valley, Willamette Valley, and the coastal margin.

Structure and Appearance. Medium tall (2-4 feet) to tall (>4 feet) grass, or grass-like plants that occur in dense mosaics depending on substrate and water depth.

Composition. Commonly associated herbaceous plants in this type, cattail (*Typha latifolia*), several bulrush species (*Scirpus olneyi, S. acutus, S. validus,* and *S. americanus*), burreed (*Sparganium emersum* and *S. eurycarpum*), flourish in shallow standing water situations. In the drier reaches of this type where the surface may dry out but subsurface is persistently wet numerous sedge (*Carex* spp.) and rush (*Juncus* spp.) dominate. Spikerush, (*Eleocharis* spp.) also can be an important component in this seasonal flooded margin.

Grasses that are commonly associated with this type are blue wildrye (*Elymus glaucus*), tufted hair grass (*Deschampsia caespitosa*), bluejoint reedgrass (*Calamagrostis canadensis*), reed canary grass (Phalaris arundinacea), American sloughgrass (*Beckmannia syzigachne*) and northern mannagrass (*Glycera borealis*).

Landscape Setting. This type is restricted to perennially flooded regions, or where the ground water lies just below the soil surface. Some type of agriculture typically borders emergent wetlands. Their silty soils are very fertile and are drained and converted to agriculture wherever possible.

References. Chappell *et al.* 1998, Christy and Titus 1996, Kovalchik 1986.

Appendix C: Riparian Zone Plant Association Information

From *Riparian Zone Associations – Deschutes, Ochoco, Fremont, and Winema National Forests* (Kovalchik, 1987).

Riparian Zone Associations in the Little Deschutes Watershed

Lodgepole pine/Kentucky bluegrass (*Pinus contorta/Poa pratensis)*

Lodgepole pine/bearberry (*Pinus contorta/Arctostaphylos uva-ursi)*

Lodgepole pine/Douglas spiraea/forb association *(Pinus contorta/Spiraea douglasii/forb)*

Lodge pole pine/Douglas spiraea/widefruit sedge (*Pinus contorta/ Spiraea douglasii/Carex eurycarpa)*

Lodge pole pine/Bog Blueberry/Forb (*Pinus contorta/Vaccinium occidentalis/forb)*

Lodgepole pine/bog blueberry/widefruit sedge *(Pinus contorta/Vaccinium occidentalis/Carex eurycarpa)*

Lodgepole pine/widefruit sedge (*Pinus contorta/Carex eurycarpa)*

Quaking aspen/blue wildrye (*Populus tremuloides/Elymus glaucus*)

Quaking apsen-Lodgepole pine/Douglas Spiraea/widefruit sedge (*Populus tremuloides-Pinus contorta/Spiraea douglasii/Carex eurycarpa)*

Mountain alder (Alnus *incana)*

Mountain alder-Common Snowberry *(Alnus incana-Symphoricarpos alba)*

Mountain alder-Douglas spiraea *(Alnus incana-Spiraea douglasii)*

Willow/Kentucky bluegrass (*Salix/Poa pratensis)*

Willow/widefruit sedge (*Salix/Carex eurycarpa)*

Willow/Sitka sedge (*Salix/Carex sitchensis)*

Cusick Bluegrass (*Poa cusickii)*

Kentucky Bluegrass (*Poa pratensis)*

Tufted hairgrass (*Deschampsia cespitosa)*

Nebraska sedge (*Carex nebraskensis)*

Widefruit sedge (*Carex eurycarpa)*

Short-beaked sedge (*Carex simulata)*

Slender sedge (*Carex lasiocarpa)*

Small-fruit bulrush/Bigleaf sedge (*Scirpus microcarpus /Carex amplifolia)*

Sitka sedge (*Carex sitchensis)*

Inflated Sedge (*Carex vesicaria)*

Beaked sedge (*Carex rostrata)*

Creeping spikerush (*Eleocharis palustris)*

RIPARIAN ZONE ASSOCIATION	SITE SUMMARY	SOILS	WILDLIFE/FISHERIES	FIRE	RESTORATION PATHWAYS
Lodgepole pine/Kentucky bluegrass (*Pinus contorta/Poa pratensis*)	Common in Pumice Plateau Forest, abundant on Cold Wet Pumice Plateau Basins Ecoregion. Various ecological potentials where potential has been altered by grazing or where water table has been lowered.	Soil texture and parent material variable. Parent material includes pumice, rhyolite, basalt, andesite, and tuff. High water holding capacity.	Pocket gophers, mice, and Columbian ground squirrels can have significant periodic impact by increasing the prevalence of perennial and annual forbs. It can take several years to reestablish Kentucky bluegrass after ground squirrel activity. Deer and elk use for cover and shade. Important habitat for raptors.	Cool burns should have little impact on rhizomatous Kentucky bluegrass or perennial forbs. Fire could reduce excessive little buildup on rested pastures with care given to fire sensitive lodgepole pine.	Renovation with native graminoids seems impractical given depleted water tables and morphological flexibility of Kentucky bluegrass. Unless water table is restored these sites will remain with a ground cover dominated by Kentucky bluegrass. 2-3 yrs of rest will restore the vigor of Kentucky bluegrass on fair or better condition pastures. Introduction of domestic species is not recommended.
Lodgepole pine/bearberry (*Pinus contorta/Arctostaphylos uva-urs*i)	One of the driest LPP types. Common on DNF. Occurs on imperfectly drained, low gradient landforms on the edges of meadows, forested drainages & basins.	Surface soils are air laid or flow pumice over buried soils from alluvium, lava, or tuff.	Provides hiding and thermal cover for deer and elk, which feed in adjacent meadows. Raptor perch & nest sites when adjacent to meadows.	LPP is killed by fire while bearberry is moderately resistant to fire. Cool light prescribed fire will provide maximum survival of LPP and regeneration of bearberry.	Revegetation is not normally needed as LLP and bearberry readily regenerate following logging or wildlife. Soils are too dry and course in late summer for Kentucky bluegrass.
Lodgepole pine/Douglas spiraea/forb (*Pinus contorta/Spiraea douglasii/forb*)	Common between 4,100-5,300 ft on DNF especially low gradient, shallowly incised pumice-filled drainages & basins, narrow, deeply incised, moderate gradient drainages with narrow floodplain within the Cold Wet Pumice Plateau Basins Ecoregion.	Deep pumice alluvium or air-laid pumice.	Important raptor habitat where it occurs next to meadows and water. Thermal and hiding cover for deer in adjacent meadow and wetlands. Important trout stream pass though landforms supporting this association.	Wildfire was probably common. Soils are dry in mid summer so fire can encroach from adjacent uplands. Douglas spiraea will resprout from the base. LPP is not fire resistant.	Rehabilitation is not usually necessary with LPP or Douglas spiraea since either regenerate following logging or fire. Soils are likely too dry for Kentucky bluegrass.
Lodge pole pine/Douglas spiraea/widefruit sedge (*Pinus contorta/ Spiraea douglasii/Carex eurycarpa*)	Common between 4,100-5,100 ft on DNF. Strongly associated with deep pumice mantle on Cold Wet Pumice Plateau Basins and Pumice Plateau Forest Ecoregions. Microtopography is flat, slightly undulating, to slightly concave.	Deep pumice alluvium.	Deer use common. Sites provide forage, browse, cover, and water. Raptors use where adjacent to meadows & water. Often occurs along important trout streams such as Crescent Creek and Little Deschutes River.	Wildlife was probably fairly common. Soils usually are surface dry in August allowing fire encroaching from uplands. LPP is sensitive to fires. Shrubs and forbs are well adapted for regeneration following fire. Willow cover may increase following a reduction in LPP.	The association has not been observed in deteriorated condition.
Lodge pole pine/Bog Blueberry/Forb (*Pinus contorta/Vaccinium occidentalis/forb*)	Occurs over a wide range of elevations (4,500-5,900 ft) and most common on Cold Wet Pumice Plateau Basins and Pumice Plateau Forest Ecoregions.	Air-laid pumice, pumice alluvium, or pumice lacustrine deposits.	Important habitat for raptors where next to meadows & water. Provides fawning habitat, shade, and cover for deer and elk.	Ground surface is dry by August so fire can easily move from adjacent uplands. LLP is sensitive to fire but regenerates rapidly on burned sites. Understory species regenerate after fire.	All sampled stands were at or near climax so little is know about methods for rehabilitating disturbed stands.

RIPARIAN ZONE ASSOCIATION	SITE SUMMARY	SOILS	WILDLIFE/FISHERIES	FIRE	RESTORATION PATHWAYS
Lodgepole pine/bog blueberry/widefruit sedge (*Pinus contorta/Vaccinium occidentalis/Carex eurycarpa*)	Not very common because bog blueberry does not extend far below the elevation range of Englemann spruce except on exceptionally cold sites. Fond on flat wet, cold floodplain and basin land forms. All within the Cold Wet Pumice Plateau Basins and Pumice Plateau Forest Ecoregions.	Deep pumice mantles and deep pumice alluvium.	Provides considerable browse, forage, and cover for deer & elk. Important raptor habitat where it occurs next to meadows & water. Streams such as Crescent Creek support good trout habitat.	Fire is suppressed until late summer. LLP is sensitive to fire. Willows, Douglas spiraea, & bog blueberry will resprout. Fire will not change forb layer.	All sampled stands were at or near climax so little is know about methods for rehabilitating disturbed stands.
Lodgepole pine/widefruit sedge (*Pinus contorta/Carex eurycarpa*)	Strongly associated with Cold Wet Pumice Plateau Basins and Pumice Plateau Forest Ecoregions. Occurs below 4,000-5,400 ft. Forested floodplains along streams such as Little Deschutes River, Crescent Ck.	Deep pumice alluvium.	Important raptor habitat where it occurs next to water and meadow. Deer and elk appear to spend considerable time here and in adjacent meadows in spring, summer, & fall. Provides important calving& fawning habitat for elk & deer.	Wildfire was probably infrequent. Widefruit sedge will regenerate from rhizomes.	Site in mid seral or better ecological condition status will increase rapidly in status with rest and late season grazing. Site converted to LLP Kentucky bluegrass may need stream rehab to raise the water table to regain the sedge.
Quaking aspen/blue wildrye (*Populus tremuloides/Elymus glaucus*)	Occurs infrequently on Cold Wet Pumice Plateau Basins, Pumice Plateau Forest. Microtopography is flat to concave.	Variably of alluvium and/or colluvium.	Aspen stands provide a critical source of diversity and habitat for wildlife, particularly birds. Common flickers, chickadees, hairy woodpeckers, yellow-bellied sapsuckers and many other birds nest in aspen. Deer and elk feed, bed, and raise young in aspen stands. Stands near perennial water provide important habitat for beaver. Beaver activity in conjunction with browsing by cattle, deer and elk can severely damage the stand.	Fire suppression has contributed to the conversion of aspen stands to LLP or herbaceous meadow. Fire can be an important tool in stimulating aspen suckers and rejuvenating deteriorated aspens stands.	Clearcutting and prescribed fire will help rejuvenate over mature aspen when done in conjunction with protection from browsing. Aspen resprouts poorly from stem cuttings but can be transplanted successfully from nursery stock.

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Mountain alder (*Alnus incana*)	Found throughout central OR in all physiographic regions with elevations 2,400-5,600 ft. Sites are young seral, active channel shelves that lie between active and flood stage streambank.	Shallow, skeletal alluvium over water worked cobbles and gravels.	Most streams passing through landforms containing alder association are degraded although capable of producing valuable fisheries. Banks anchored by alder are stable and can withstand relatively severe spring runoff. Moderately narrow, moderately deep stream profiles can provide cover, food, and shade for salmonids. Birds find habitat, and deer and elk browse on alder.	Fire is infrequent. Alder will only survive the coolest ground fires. Most fires will destroy the alder, leaving the active fluvial surfaces protected from erosion only by weak rooted graminoids and forbs.	Critical factors for channel shelf formation are season long moisture and rest from grazing. The dish profile stream is often bank full at peak runoff but is dry or nearly so by summer. This condition will not support the development of riparian vegetation and with continued overuse by livestock there can't be any positive change in the condition of the site. In 2-5 yrs with rest a relatively permanent channel with banks and channel shelves stay moist season long and begin to support the growth of riparian vegetation. Once the vegetation is tall enough to trap sediments it will take at least 5 yrs for the alder to grow stems heights and diameters resistant to grazing. 40% utilization of the herbaceous vegetation or less insures that livestock use will not cause degradation.
Mountain alder-Common Snowberry (*Alnus incana-Symphoricarpos alba)*	Abundant between 2,200-5,500 ft in Pumice Plateau Forest, Cold Wet Pumice Plateau Basin Ecoregions.	Sediment deposit has built soil depth to change site potential from Mt alder to Mt alder-common snowberry association.	Alder provides good bank stability and protection from floods. Diversity provided by the alder provides browse for deer and elk and habitat for birds.	Fire is infrequent. Alder will only survive the coolest ground fires. Most fires will destroy the alder, leaving the active fluvial surfaces protected from erosion only by weak rooted graminoids and forbs.	Mt alder is a prolific seeder and will usually reestablish after fire. It will not root from cutting.
Mountain alder-Douglas spiraea (*Alnus incana-Spiraea douglasii*)	Common in mountainous Ecoregions on the Deschutes and narrow, deeply incised, moderate gradient drainages in the Cold Wet Pumice Plateau Basins Ecoregion.	Accumulation of sediment has increased soil depth so that the vegetation composition reflects a drier moisture regime than the mt alder association. Well-aerated alluvium.	The diversity canopy provides habitat for birds, and browse for deer and elk.	Fire is infrequent. Alder will only survive the coolest ground fires. Most fires will destroy the alder, leaving the active fluvial surfaces protected from erosion largely by weak rooted graminoids and forbs. Mt alder is a prolific seeder and will usually reestablish after fire. It will not root from cutting. Weakly rooted spiraea, grasses and forbs provide protection from erosion. Widefruit sedge will provide good bank stability if abundant.	Mt alder will reestablish after fire, but requires protection from overuse by livestock and perhaps deer and elk. Alder seedlings can be planted in well-aerated soils that are moist throughout the summer. When livestock are removed at 40% forage use a return to late seral ecological status can be attained in 10-20 yrs. The rehab process can be accelerated if the pastures are rested for at least 5 yrs.

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Willow/Kentucky bluegrass (*Salix/Poa pratensis*)	Occurs on sites that have been highly altered by grazing, lowering water table or both. It is uncommon on the DNF and may occur in the watershed.	Deep fine textured alluvium over subsurface soils of various textures.	Rodents such as pocket gophers, mice and Columbian ground squirrel can be a significant impact. Willows provide browse for deer and elk and diversity for birds.	Cool burns should have little impact on rhizomatous species such as Kentucky bluegrass and willows will resprout following fire.	2-3 yrs of rest will restore the vigor of Kentucky bluegrass. 5-6 yrs can provide 5-8 ft willows. Unless water table can be restored, these sites will for all practical purposes remain with a ground cover dominate by bluegrass and should be managed as a naturalized community. Renovation of highly degraded site with native grasses and sedge is largely impractical given depleted water table and the flexibility of Kentucky bluegrass
Willow/widefruit sedge (*Salix/Carex eurycarpa*)	Widespread on DNF at 4,100-5,000 ft. on low gradient, low elevation floodplains along the Deschutes River and its tribs in the Pumice Plateau Forest Ecoregion and shallow, pumice filled drainages in the Pumice Plateau Forest and Cold Wet Pumice Plateau Basins Ecoregions.	Variable.	Willow and sedge provides habitat diversity for birds and mammals. Low gradient makes excellent habitat for beavers.	The association will be difficult to burn until late summer or fall. Dried vegetation will carry fire, reduce litter build up and increase productivity. Fire will reduce filtering and buffering capacity until following year. Sedge peat soils are flammable and when dry and can be severely damaged by fire.	Willows are sensitive to fire but will resprout at root crown. Rehab is usually not needed. Widefruit sedge will increase rapidly in cover with rest and late season grazing on sites in mid seral or better ecological status.
Willow/Sitka sedge (*Salix/Carex sitchensis*)	Abundant on the DNF from 3,100 - 5,200 ft. On low gradient streams floodplains in Pumice Plateau Forest Ecoregion such as Little Deschutes River, Crescent Ck. and headwaters of these in wet, poorly drained marshes and swamps such as Upper Big Marsh.	Floodplain soils are very deep alluvium. Headwaters areas have deep sedge peat accumulation.	Structural diversity provides habitat for birds, beaver, deer, elk, and other wildlife.	These sites are difficult to burn until late summer or fall. Dried vegetation will carry a fire, reducing buildup and increasing productivity for several years. Fire may reduce the buffer and filter capacity during next season's runoff. Willows are sensitive to fire however will sprout back from root crown. Peat sedge soils will burn when dry.	This association has been observed in late seral stage only. Sitka sedge will rapidly recolonize after rest and late season grazing.

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Cusick Bluegrass (*Poa cusickii*)	Flat micro relief of dry basins and drainages and inactive floodplains and terraces within the Cold Wet Pumice Plateau Basins Ecoregion.	Pumice alluvium.	Important habitat for raptors. Rodents such as mice, pocket gophers, and Columbian ground squirrel can have a large periodic impact. Feeding ground for deer and elk.	Little is known about the effects of fire. Cusick bluegrass is more sensitive to burning than the rhizomatous species such as Kentucky bluegrass or widefruit sedge. Fire frequency is probably less than 15 yr interval.	Excellent response of this meadow to rest is expected in areas where meadows have reached mid seral or better ecological status. Most sites are highly degraded with a low density of Cusick bluegrass that responds slowly to improved livestock management systems. Floodplains seeded with good results although it would be preferable to plant Cusick bluegrass. Drier sites are more common and may not be suitable for introduction of domestic grass seeds because of fluctuating water tables, soils and extreme summer drought.
Kentucky Bluegrass (*Poa pratensis)*	Uncommon on DNF. Found between 3,000-5,000 ft. Landforms are dry basins & floodplains with gentle slopes and smooth microtopography. This type now occupies sites of various potential including other graminoids and willow and ponderosa pine associations.	Variable.	Important habitat for raptors. Heavy infestations of mice, and other rodents can have a large periodic impact on the meadow resulting in increases in perennial and annual forbs.	Fire is an effective tool in reducing the effects built up litter layers. Cool burns should have little negative impact on this bluegrass.	Avoid early season use to prevent soil compaction. 2-3 yrs will restore lost vigor and vegetative composition on sites in mid seral or better ecological status. Restoring willows and natural sedge will reduce erosion.
Tufted hairgrass (*Deschampsia cespitosa*)	Broad elevational and geographic range results in this as on e of them most abundant and diverse in central OR. Meadow sites in flat to slightly concave drainages and basins and lakeshores.	Variable.	Deer, elk, rodents, and raptors area common.	Repeated burning of this meadow may favor rhizomatous species such as Kentucky bluegrass, beardless wheatgrass, and western needlegrass, but frequent fire is unlikely to provide a noticeable affect on tufted hairgrass.	An upward trend in ecological status requires timing the season of livestock use to both drying soil surface and to maturation of the tufted hairgrass seed heads. Livestock should be removed at 40% utilization of herbaceous forage. Meadows in mid seral or better ecological condition will respond rapidly to improved grazing strategies. Domestic species such as Kentucky bluegrass, Timothy, & meadow foxtail can be seeded but tufted hairgrass is preferred.
Nebraska sedge (*Carex nebraskensis*)	Found in most Ecoregions east of the Cascades at elevations between 4,000-5,000 ft.	Smooth organic loams derived from alluvium.	If willows are supported birds and some mammals will use the area.	It is difficult to burn this wet type except for late summer. Only the top growth would burn which would reduce the water holding capacity and reduce the sediment capture in spring runoff.	Nebraska sedge forms thick, dense, rhizome mats that provide stream bank erosion. It would be desirable to manage these areas to return to willow communities, however Nebraska sedge is very competitive. Grazing should be managed to remove livestock at 40% utilization standard. Excess grazing will result in pedestalling and breaking the sod.

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Widefruit sedge (*Carex eurycarpa*)	Widespread on DNF and most common in Pumice Plateau Forest and Cold Wet Pumice Plateau Basins Ecoregion. In active floodplains, and small shallow pumice-filled drainages.	Deep deposits of pumice alluvium.	Habitat provided for deer, elk, raptors and other wildlife.	It can be burned in late summer or early fall. Fire can reduce litter and increase productivity for several yrs. Hot fires may penetrate organic soils, destroying sedge rhizomes.	Widefruit sedge will rapidly recolonize sites in mid seral or better ecological status with rest and late season grazing. 40% removal utilization will insure maintenance of site in late seral or climax status. Stream bank stabilization can help raise the water table. Willow cutting may be successful where water tables are normal and willow regeneration is protected from browsing by deer, elk, livestock and beavers.
Short-beaked sedge (*Carex simulata*)	Scattered throughout central OR it is found in Upper Big Marsh on the DNF.	Organic loam and sedge peat.	Deer use this when hiding cover is in close proximity. Early spring forage may be provided.	Prescribed fire is not a useful tool. Soil surface becomes dry and the organic soils may become flammable destroying the sedge rhizomes.	Rehabilitation is not needed as the association is in late seral or climax ecological condition.
Slender sedge (*Carex lasiocarpa*)	Locally abundant between 4,600-5,700 ft in Cold Wet Pumice Plateau Basins and Pumice Plateau Forest Ecoregion including Big Marsh.	Marsh and lake sites support deep sedge and sedimentary peat soils, respectively.	If flooded long enough habitat is provided for nesting ducks, especially teal. Limited utility for songbirds and small mammals because of the lack of diversity and flooded soils. Mule deer feed on scattered forbs and seed heads of sedges.	By mid summer the site can burn but the rhizomatous nature of slender sedge would make it resistant to damage. Hot fire will penetrate the peat soils with increased damage.	Slender sedge will regain on disturbed sties. Livestock should be kept off wet soils with only late season grazing as an option. This site is unlikely to support willows.
Small-fruit bulrush Bigleaf sedge (*Scirpus microcarpus Carex amplifolia*)	Common on DNF. It has been observed in the Pumice Plateau Forest Ecoregion in areas 2,400-5,700 ft.	Water worked alluvium.	Overgrazing, trampling, and erosion disrupt the normal successional pattern and prevent development of other sedges and mountain alder, which would provide better wildlife habitat.	Both of these graminoids are resistant to fire. In late summer fire could be used to reduce litter. Fire should not be used on active fluvial surfaces because it would remove above ground plant parts critical to sediment entrapment slowing soil building.	Revegetation is not generally needed as small fruit bulrush and bigleaf sedge have dense, thick rhizomes that respond to rapidly to rest. Both are prolific seeders. Where bank erosion is severe, grasses such as reed canarygrass, Timothy, reedgrass, bentgrass, and meadow foxtail may be used to temporarily stabilize active fluvial surfaces. Areas with soil development may response to willow or mountain alder planting.

RIPARIAN ZONE ASSOCIATION	SITE SUMMARY	SOILS	WILDLIFE/FISHERIES	FIRE	RESTORATION PATHWAYS
Sitka sedge (*Carex sitchensis*)	Abundant on the DNF mostly commonly on low gradient floodplain landforms along the Deschutes River and major tributaries in the Pumice Plateau Forest Ecoregion. Big Marsh is notable.	Deep alluvium high in organics.	Coarse tough Sitka sedge rhizomes are excellent anchors of riverbanks and floodplains and provide shade. Habitat structure and diversity from the complex mix of sedge, willow, and LLP provide habitat for elk, deer, and beaver.	Fire would only be likely in late summer or fall burning dried vegetation. Fire may reduce the buffering and filtering of the sedge the yr following the fire. Proximity of fire sensitive species such as willow and LLP in adjacent associations makes this type difficult to burn without damage. Sedge peat soils are flammable and could destroy sedge rhizomes.	Sites in mid seral or better ecological status will be rapidly recolonized by Sitka sedge with rest and late season grazing.
Inflated Sedge (*Carex vesicaria*)	Wide geographic and elevational (4,000-6,000 ft) distribution in a variety of low gradient landforms supporting shallow flooding or semipermanently saturated soils	Deep sedge and sedimentary peats or organic loam except seral sites such as active channels shelves.	Inflated sedge provides excellent barrier to streambank erosion, helping to form narrow, deep profiles. Ponded sites provide important nesting and feeding habitat for a wide variety of waterfowl. Inflated sedge provides important forage for elk in mid to late summer.	Fire is likely on in late summer or fall. Fire reduces litter and increases productivity for several years but will not change species composition. Peat soils are flammable destroying sedge rhizomes.	Dense rhizomes are very resistant to trampling. Disturbed sites in mid seral or better ecological status will rapidly recolonized by inflated sedge with rest and late season grazing. Revegetation can be accomplished using grasses such as reed canarygrass, tall mannagrass, Timothy, and reedgrass, however these are not as resistant to erosion as inflated sedge. The site is too wet for willow planting.
Beaked sedge (*Carex rostrata*)	One of the wettest riparian associations in wide geographic and elevational distribution (4,000-6,000 ft) in every association in central OR. Low gradient landforms from permanently flooded basins to floodplains and wet meadows. Occurs on wet fluvial surfaces such as streambank, active channel shelves, overflow channels, marshes, and fens.	Deep sedge or sedimentary peats, organic loam, or muck except for recently deposited alluvium.	Semi-permanently flooded sites provide habitat for many species of waterfowl.	Burns will be possible in dry summers when water table is below soil surfaces. Fire will reduce litter accumulation and increase productivity for several yrs but will not change species composition. Peat soils are flammable.	Dense sod is very resistant to trampling and beaked sedge will rapidly recolonize disturbed sites with rest. Banks can be temporarily revegetated with grasses such as reed canarygrass, tall mannagrass, Timothy, and reedgrass, however these are not as resistant to erosion as beaked sedge. The site is too wet for willow planting.
Creeping spikerush (*Eleocharis palustris*)	Found throughout central OR in a range of physiographic regions with elevations 3,000-6,800 ft., riparian landforms, and Ecoregions. Low valley gradient and standing bodies of water in natural or manmade settings, such as stockponds and reservoirs. It frequently forms community in ponded sites between stream rehab structures such as loose rock check dams.	Margins or lakes and older reservoirs are organic loam and sedimentary peat.	Broad zones of creeping spikerush along major lakes, larger stock ponds, and reservoirs offer valuable habitat for waterfowl. Seeds of rushes and sedges provide fair to good forage for duck and geese. Pondweeds, smartweeds, and water lentils are excellent forage for ducks and geese.	Prescribed fire is not a useful tool. Soil surface becomes dry and the organic soils may become flammable destroying the sedge rhizomes and will not change species composition unless fire penetrates organic soil.	Generally not needed. Stock ponds will revegetate rapidly if protected from trampling. The area should be fenced and water gravity fed to stock tanks protecting vegetation and water quality.