WILLOW CREEK WATERSHED ASSESSMENT

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Acknowledgments

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Noxious Weeds
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- Dave Clemens, Tri-County Weed Management Area

Statement of Purpose

The Willow Creek watershed assessment was written for the Grande Ronde Model Watershed Program (GRMWP) with an intended audience of the GRMWP staff and Board of Directors, watershed residents, and the general public. A watershed assessment evaluates how well a **watershed** is functioning. This assessment will serve as a baseline for the GRMWP and watershed residents to identify restoration opportunities.

Methods

Guidelines

The Oregon Watershed Enhancement Board's Oregon Watershed Assessment Manual was used as the guideline for this assessment. The manual provides background information on watershed functions in Oregon and resources for conducting the assessment. It provides step-by-step instruction for completing each chapter of the assessment. Copies of the manual can be downloaded from OWEB's website, http://www.oweb.state.or.us.

The Willow Creek watershed assessment encompasses the entire watershed, with a focus on private lands. For a more detailed assessment of the federal lands within the Willow Creek watershed boundaries, see the Phillips/Gordon Ecosystem Analysis, compiled and written by the Umatilla National Forest.

Data Collection

Information was collected from a variety of sources. Sources are cited in the text of the document and referenced at the end of each chapter.

Glossary

Bolded words in the text of this document are compiled in the glossary found at the end of the document.

Maps

Maps were created using ArcView 3.2, which is software for viewing and creating **Geographical Information Systems (GIS)** data. GIS data has been used when calculating acreage, mileages, and other information included in this document. Copies of all maps and GIS data included in this document can be obtained at the Grande Ronde Model Watershed Program office.

Appendices

Appendices pertinent to each chapter are referenced in the text and are found at the end of each chapter.

Landowner Participation

Landowner meetings were held in the spring of 2001 in Summerville for a Coordinated Resource Management Planning process (CRMP). Issues of concern and general information identified from these meetings were addressed in this document.

about the Grande Ronde Model Watershed Program

The Grande Ronde Model Watershed Program (GRMWP) was selected in 1992 by the Northwest Power Planning Council as the model watershed project in Oregon. This program is to serve "as an example for the establishment of watershed management partnerships among local residents, state and federal agency staffs, and public interest groups concerned with watershed management" (GRMWP charter). The Program covers the Grande Ronde and Imnaha Basins in northeastern Oregon, an area of approximately 5,265 square miles which contains over 2,600 miles of fish-bearing streams.

For more information, contact:
Grande Ronde Model Watershed Program
10901 Island Ave.
La Grande, OR 97850
(541) 962-6590

Funding Sources for Restoration Projects in the Grande Ronde Basin

Bonneville Power Administration (BPA)

Bonneville Power Administration contributes a certain amount of rate-payer income to fish and wildlife habitat mitigation. Projects funded through BPA involve the improvement of anadromous fish habitat, with increasing funding opportunities for wildlife habitat improvement. The Grande Ronde Model Watershed Program administers BPA funds for habitat restoration in the Grande Ronde Basin. **Project proposals are due in mid-December** to the Grande Ronde Model Watershed Program for funding consideration. For more information, contact:

Lyle Kuchenbecker
Grande Ronde Model Watershed Program
10901 Island Ave.
La Grande, OR 97850
541-962-6590

Oregon Watershed Enhancement Board (OWEB)

Oregon Watershed Enhancement Board is a state agency that uses lottery income to fund projects relating to overall watershed restoration. **Project proposals are due February 1st, June 1st, and October 15th**. For more information, contact:

Karen Leindecker
Eastern Oregon Program Representative
Oregon Watershed Enhancement Board
10901 Island Ave.
La Grande, OR 97850
541-963-9076

U.S. Department of Agriculture

Conservation Reserve Program (CRP)
CRP is a voluntary program that offers annual rental payments and cost-share assistance to establish long-term resource-conserving covers on eligible land. The duration of contracts are from 10-15 years.

Continuous CRP sign-up provides management flexibility to farmers and ranchers to implement certain high-priority conservation practices on eligible land. Additional incentives are being offered to encourage producers to participate in the CRP continuous sign-up. The acreage must also be determined by USDA's Natural Resources Conservation Service (NRCS) to be eligible and suitable for one or more of the following practices:

- Riparian Buffers
- Living Snow Fences
- Grassed Waterways
- Shelter Belts
- Field Windbreaks
- Filter Strips

The United States Department of Agriculture has additional programs, including: the **Conservation Reserve Enhancement Program (CREP)** and the **Wetland Reserve Program (WRP)**. For more information, contact:

Jennifer Isley
Farm Services Agency
Agricultural Services Center
10507 N McAlister Road
La Grande, OR 97850
541-963-4178

List of Abbreviations and Acronyms

Acre Foot	AF
Bureau of Land Management	BLM
Channel Habitat Types	CHTs
Conservation Reserve Program	CRP
Cubic Feet per Second	cfs
Department of Environmental Quality	DEQ
Department of Geology and Mining Industries	DOGAMI
Dissolved Oxygen	DO
Division of State Lands	DSL
Environmental Protection Agency (U.S.)	EPA
Geographical Information Systems	GIS
Grande Ronde Model Watershed Program	GRMWP
Large Woody Debris	LWD
National Wetland Inventory	NWI
Natural Resource Conservation Service	NRCS
Oregon Department of Fish and Wildlife	ODFW
Oregon Department of Forestry	ODF
Oregon Water Resources Department	OWRD
Oregon Watershed Assessment Manual	OWAM
Oregon Watershed Enhancement Board	OWEB
Riparian Condition Unit	RCU
Soil and Water Conservation District	SWCD
Total Maximum Daily Load	TMDL
Umatilla National Forest	UNF
United States Forest Service	USFS
United States Geological Survey	USGS
Wallowa-Whitman National Forest	WWNF
Water Availability Basin	WAB
Water Availability RS	WARS
Watershed Professionals Network	WPN

Watershed Conditions Summary

Introduction
This section summarizes the findings of the Willow Creek Watershed Assessment. Data gaps are included. **Figure 1** details the watershed conditions by subwatershed.

Recommendations for improving watershed conditions were generated through the Coordinated Resource Management Plan process for the Willow Creek watershed in Spring of 2001. For a copy of these recommendations, contact the Union Soil and Water Conservation District.

Historical Conditions
Explorers and settlers in the 1800s often described the Grande Ronde Valley in journals, documenting a land dramatically different from today's agricultural valley. The valley was composed of grasslands with fields of camas and riparian forests covered with cottonwood, willow, and other woody species, surrounded on all sides by mountains covered in coniferous forest.

Until the early 1800s, the Grande Ronde Valley was used solely by the Cayuse, Umatilla, Walla Walla, and Nez Perce. The valley was a spring meeting ground and a place of peace.

Early journals indicate beaver were plentiful. In a few decades, with the arrival of the fur trade, beavers were systematically removed from the upper elevations of the watersheds in the Grande Ronde Basin.

The Willow Creek watershed was first settled by homesteaders in 1862. The Thomas and Ruckles Road was completely in 1865 and led from the Grande Ronde Valley, past Summerville, over the Blue Mountains, to the town of Walla Walla.

Trees were cut for timber as early as the 1860s at the base of the forests in and near the Willow Creek watershed. Mills sped the clearing of the land in preparation for cultivation. On federal land, only 7,010 acres have had some sort of timber activity.

In the late 1800s, agriculture in the Willow creek watershed focused in part on fruit production. Currently, there are few orchards, with the majority of agricultural land producing wheat, mint, sugar beets, and grass seed.

The Grande Ronde Valley has a history of spring flooding. As the land has been drained for agriculture and adapted for irrigation, channelization and water diversion have occurred extensively throughout the Willow Creek watershed. Photos from 1937 show many channelized sections and ditches already in existence.

Data Gaps
- interviews with local landowners

Channel Habitat Types

In this chapter, streams were classified as various channel habitat types, in order to understand how land uses and environmental factors affect stream channel form and how channel habitat types can be expected to respond to restoration activities. The following channel habitat types were present in the Willow Creek watershed:

CHTs with Gradient less than 2%

Low Gradient Medium Floodplain Channel: main-stem streams in broad valley bottoms with well-established floodplains (8%)

Low Gradient Small Floodplain Channel: streams in broad valley bottoms with well-established floodplains (7%)

Low Gradient Moderately Confined Channel: low-gradient streams with variable confinement by low terraces and slopes (9%)

Low Gradient Confined Channel: low-gradient streams confined by adjacent, gentle land forms
(2%)

CHTs with Gradient 2-4%

Moderate Gradient Moderately Confined Channel: moderately sloped streams with variable confinement and a narrow floodplain (9%)

Moderate Gradient Confined Channel: moderately-sloped streams confined by adjacent land forms (1%)

CHTs with Variable Gradients from 0-8%

Alluvial Fan Channel: tributary streams located on foot-slope land forms in a transitional area between valley floodplains and steep mountain slopes (16%)

Moderate Gradient Headwater Channel: channels in open valleys with hillslope constrainment occurring in upper reaches of watershed (8%)

CHTs with Gradients 4-8%

Moderately Steep Narrow Valley Channel: single channel in narrow valley with hillslope constrainment and possible narrow floodplain (6%)

CHTs with Gradient 8-16%

Steep Narrow Valley Channel: hillslope constrained single channel in narrow V-shaped valleys (12%)

CHTs with Gradient >16%

Very Steep Headwater: hillslope constrained single channel located in uppermost reaches of watershed (13%)

Data Gaps

- verified current channel habitat types

Hydrology and Water Use

Climate, soils, and geology are major determinants of the natural hydrology of a watershed. As the majority of precipitation in the Willow Creek watershed occurs as snow, snow melts are the cause of peak flows. The period of low flows occurs during summer months, when there is little precipitation.

Of the land uses assessed in this chapter (agriculture, grazing, forestry, roads, and rural residential), all but agriculture and grazing had low potentials to affect peak flows in the watershed. Agriculture and grazing had a low to medium potential. However, other land uses not assessed by OWEB methods may have affected the hydrology of the watershed. Given that there were many historical wetlands in the bottomlands of Willow Creek, the subsequent draining and tiling of these lands has dramatically changed the length of time soils are saturated, therby reducing groundwater recharging in the spring.

Peak flows and low flows in the Willow Creek watershed are to some extent affected by human activities. Conservation measures can reduce some of these effects, to increase the amount of water stored in floodplains and soils, to restore stream structure, wetlands, and riparian areas.

Data Gaps

- flow data
- historical hydrological information
- miles of private and county roads

Riparian Areas

Current conditions of riparian areas in the Willow Creek watershed were assessed as compared with potential riparian ecosystems. Riparian areas along Dry, Mill, and Willow Creeks were assessed for shade and vegetation using 1997 aerial photographs from ODF for a total of 22.7 stream miles. ODFW also had riparian data from the 1995 habitat survey on reaches of Dry, Mill, and Willow Creeks.

Willow Creek had little shade for almost its entire length (95% of reaches = low shade). The lower section of Dry Creek, through crop lands, also had little shade (70% = low shade). Mill Creek had 43% of reaches with low shade. Seventy-three percent of the forested reaches of Dry Creek had moderate shade, with the other twenty-seven percent having high shade. Comparing the percent open sky data from the ODFW habitat survey with data from the aerial photo interpretation shows similar results.

Amounts of large woody debris in Willow Creek, Mill Creek, and most reaches of Dry Creek were found to be low in the ODFW habitat survey. Willow Creek had the least amounts of LWD present in-stream of all three streams. The limited amounts of LWD, along with significant stretches of Mill and Dry Creeks with less than potential woody vegetation indicated that the recruitment potential for LWD is very poor.

Data Gaps

- Shade, LWD, and vegetation information for tributaries to Dry, Mill, and Willow Creeks

Wetlands

Historically, wetlands were more widespread in the Grande Ronde Valley than they are today.

Over time wetlands have been farmed over, disconnected from nearby streams, drained, and leveled. Removal of beavers may have also been responsible for diminishing wetlands, as land flooded above beaver dams was no longer flooded.

Currently, the National Wetland Inventory shows less than one percent of the watershed as being wetlands. As this inventory was done at a large scale with no field checking, the actual amount of wetlands currently present in the watershed is higher. If interested in inventorying wetlands on your property, contact the local Natural Resource Conservation Service office.

There are funding opportunities for wetland restoration. While not possible on a large scale, due to the agricultural nature of the watershed, selected restoration of wetlands can improve the hydrology and water quality of the area. As wetlands play a role in groundwater charging, increasing wetlands can improve late season low flows.

Data Gaps

- hydric soil mapping
- compilation of soil survey characteristics that indicate areas of historical wetlands
- wetland plant community information

Water Quality

Water quality data in the Willow Creek watershed has been collected by Union SWCD and DEQ. The Union SWCD has collected data near the mouth of Willow Creek at Rinehart Bridge since 1996, and in two other sites in the watershed from 1996-1998. To summarize the Union SWCD data, temperature exceeds the daily maximum temperature of 64ºF a good portion of the summer months, at both near the mouth of Willow Creek and just below Mill Creek on Willow Creek. Nutrient levels near the mouth of Willow Creek well exceed the Total Maximum Daily Loads of 33µg/L (dissolved inorganic nitrogen) and 7µg/L (orthophosphates). pH levels are recorded exceeding 9.0. Although there is no flow data, Willow Creek was a high geographic priority area for flow in DEQ's Water Quality Management Plan for the Upper Grande Ronde River Sub-basin. Fine sediment, another form of pollution, is also present at levels affecting fish reproduction.

Data Gaps

- Nez Perce Tribe temperature data
- lack of water quality data in headwaters
- flow data
- monitoring that measures daily DO and pH fluctuations
- amount of natural versus human-caused pollution

Sediment

Surveys by ODFW in 1995 found undesirable levels of fine sediments in riffles, an indication that sediment deposition amounts are too high in the surveyed reaches. It is possible that the sediment loads of Mill and Dry Creeks are more than the streams can handle, hence the deposition in riffles. It is also possible that the distribution of sediment in the stream is out of balance, as there is little large woody debris and low numbers of pools per mile. All four subwatersheds were also given high priorities for sediment in the Upper Grande Ronde Sub-basin Water Quality Management Plan.

Roads, geologic hazards, crop and range lands, streambanks, and ditches were thought to be possible sediment sources to the stream system in the Willow Creek watershed, although there was not enough data to determine the amount of sediment contribution by each. Further sediment data collection is needed to prioritize which sources contribute the most.

Data Gaps

- miles of native and rocked road in the watershed
- assessment on all culverts
- identification and mapping of all landslides in watershed
- sediment data (estimated bedload, estimated suspended sediment load)
- flow data

Channel Modifications

Channelization, ditches, irrigation canals, irrigation diversion dams, roads, and artificial streambank stabilization were identified as the channel modifications present in the Willow Creek watershed. Ditches and diversions are likely the most prevalent, due to the agricultural nature of the watershed. These modifications have changed the hydrology of the watershed, causing less infiltration of water into the soil and water to enter the stream system more rapidly.

Opportunities exist for restoration, such as rerouting channelized sections of streams back into their old channels. Fish passage barriers can be inventoried and adapted for fish passage. Streambank stabilization can be replaced with riparian revegetation in the long term.

Data Gaps

- Inventory of Diversions
- Inventory of all Fish Passage Barriers
- Culvert Inventory

Fish and Fish Habitat

Willow Creek watershed is a summer steelhead system, although it may have supported salmon historically. The earliest steelhead redd counts on Willow Creek and its tributaries occurred in 1965. However, when redd counts on Dry Creek from the Willow Creek watershed were compared with index streams through the Upper Grande Ronde Sub-basin, these streams consistently had median or higher numbers of redds per mile than the index streams. Thus, while there is little documentation before 1965, it can be assumed from the number of redds in the 1960s and 1970s, that the Willow Creek watershed was historically a large producer of summer steelhead.

In the Willow Creek watershed, there are two known potential fish passage barrier sites, both of which occur low in the system. If the fish cannot access habitat above these dams, the amount of habitat available for fish use is greatly limited.

Habitat conditions in the 1995 habitat surveys on Willow, Mill, and Dry Creeks highlighted some undesirable conditions that were prevalent on all streams. Width to depth ratios, percent open sky, fines in riffles, bank erosion, and large woody debris all fell into the undesirable category for many reaches along all three streams. However, on all reaches, the percent gravel available in riffles was equal to or greater than the desirable benchmark of 35%.

Improving fish habitat through bank stabilization, increasing shade, improving riffle and pool habitats, and the placement of large woody debris is one aspect of improving conditions for fish in the Willow Creek watershed. Others include increasing fish access by identifying and removing fish passage barriers and increasing fish presence surveys to determine population trends and the distribution of steelhead in the entire watershed.

Data Gaps

- complete fish distribution map for the Willow Creek watershed
- stream habitat surveys for the entire lengths of Willow, Dry, and Mill Creeks and on tributaries
- minimal current redd surveys in the watershed
- complete inventory of fish passage barriers

Noxious Weeds

Noxious weeds are present in the Willow Creek watershed, although not in as large numbers as other parts of Union County. Unmaintained patches of weeds can quickly jump to large acreages taken over by weeds. Thus, it is important to control weeds while they are still a small problem.

Diffuse knapweed, the most prevalent noxious weed in the watershed, can cause serious land degradation. Its weak roots do not hold soil as well as the native grasses it replaces, which increases surface erosion. In addition to land degradation, it reduces land values and limits the amount of forage available to livestock and wildlife.

Coordinated efforts in weed control are important to contain noxious weed sites. If only one landowner is maintaining his or her lands free from weeds in a given area, weeds will invade from nearby landowners. This includes coordinating with Union County Public Works, which maintains the roadsides, Umatilla and Wallowa-Whitman National Forests and Boise Cascade in the upper watershed, and watershed residents in the lower sections of the watershed. Coordinated efforts are more cost-effective and prevent weeds from re-colonizing an area.

Data Gaps

- information from noxious weed inventory on Wallowa-Whitman National Forest

Forest Health

Forest composition and structure in the Willow Creek watershed have changed over time, as documented in the Phillips-Gordon Draft Ecosystem Analysis. Average tree size has decreased in size, with most stands currently small or medium in size classes. Crown closures are medium to dense, indicative of thick stands. The majority of forests are in dry mix or wet mix types. A smaller amount than historical are ponderosa pine dominated stands.

Forest management is, and always has been, a highly debated issue in the West. People have different ideas about how a forest should be managed. Since how a forest is managed plays an integral role in forest health, how management is influenced should be understood. On public lands, forest management is often subject to public opinion. Private land management has some restriction placed upon it by the Oregon Forest Practices Act. But for the most part it is the landowners' decision on how to manage their forests.

The U.S. Forest Service's current plans for forest management are to restore forests to their historical structure and composition. Current projects include prescribed burning to reduce fuel loads and thinning to reduce stand thickness and alter species composition.

Data Gaps

- historical conditions of specific forest stand structure and composition
- information on Boise Cascade lands
- information from ODF on private forested lands

Figure 1: Summary of Current Watershed Conditions by Subwatershed

Subwatershed	Riparian Conditions	Wetland Conditions	Stream Conditions	Water Quality	Sediment Sources	Channel Modifications	Hydrology and Water Use	Noxious Weeds
Lower Willow	Mostly grasses with some brush species (hawthorne and willow) present along Willow Creek. Low shade coverage and no LWD recruitment potential. Mill Creek has some hardwoods, brush, and grass species. Medium to high shade coverage overall and some LWD recruitment potential.	Current wetlands mostly in riparian areas or around springs.	On Willow Creek, substrate is mostly silt/sand. Number of pools per mile is less than in 1960s. Stream bank erosion is higher than desirable. On Mill Creek, substrate is part silt/sand, part gravel. Number of pools per mile is less than in 1960s. Stream bank erosion is higher than desirable. Fine sediments in riffles is higher than desirable.	On Willow Creek, temperature, dissolved inorganic nitrogen and orthophosphates were sometimes at higher levels than DEQ standards. pH sometimes exceeded 9.0 in summer months. Data collected on Mill Creek near Sanderson Springs showed low D.O. levels, cool, even temperatures, and high orthophosphate levels.	Bank erosion is contributing sediment to Willow and Mill Creeks. Roads are mostly paved. Some agriculture and range activities are on highly erodible soils.	Channel improvement project along 1/4 mile of Willow Creek. Other sections of Willow and Mill Creeks have been channelized and/or artificially confined. Levees at mouth of Willow Creek. Irrigation and drainage ditches are common. Two known dams on Willow Creek..	Water is overallocated during summer months. Irrigation is main use of water.	Diffuse knapweed is most prevalent noxious weed.

Subwatershed	Riparian Conditions	Wetland Conditions	Stream Conditions	Water Quality	Sediment Sources	Channel Modifications	Hydrology and Water Use	Noxious Weeds
South Fork Willow	No specific data.	See Lower Willow.	No specific data.	No specific data.	Some roads are paved, others rock or native surface. Landslides and debris flows are possible along eastem face of Mt. Emily.	Some channelization and artifically constrained reaches. Irrigation and drainage ditches are common.	Water is overallocated during summer months. Irrigation is main use of water.	See Lower Willow.
Upper Willow	See Lower Willow for Willow Creek information.	See Lower Willow.	See Lower Willow for Willow Creek information.	No specific data.	See South Fork Willow. Bank erosion is contributing sediment to Willow Creek.	See South Fork Willow.	Water is overallocated during summer months. Irrigation is main use of water.	See Lower Willow.
Dry	On lower reaches of Dry Creek, grasses and sparse brush species. Low shade and no LWD recruitment potential. On forested reaches of Dry Creek, conifers, hardwoods, and brush species. Medium to high shade and some LWD recruitment potential.	See Lower Willow.	On Dry Creek, substrate is mostly gravel or cobble. Fine sediments in riffles and bank erosion are higher than desirable. Width/depth ratio is higher than desirable.	No specific data.	Dry Creek Road and bank erosion are contributing sediment to Dry Creek. Most roads native surface or rock. Landslides and debris flows are possiblities.	Some channelization and artifically constrained reaches. Irrigation and drainage ditches are common in lower part of subwatershed. Dry Creek is artifically constrained by Dry Creek Road.	Water is overallocated during summer months. Irrigation is main use of water.	See Lower Willow.

Chapter 1: Watershed Overview

Location
The Willow Creek watershed is located in the northwestern part of the Grande Ronde Valley, in Union County, in northeast Oregon. Willow Creek joins the Grande Ronde River at river mile 105. **Map 1.1** shows the location of the watershed.

Watershed Boundaries
The Willow Creek watershed is a **5th-field HUC** watershed, as designated by the State of Oregon 5th Field Watersheds. As the State of Oregon has not designated subwatershed boundaries for eastern Oregon, US Forest Service watershed and subwatershed boundaries have been used instead. The US Forest Service has designated the Willow Creek area as part of a larger Phillips/Willow Watershed (1706010484). There are four subwatersheds in the larger USFS Watershed pertain to the Willow Creek drainage: South Fork Willow Creek, Upper Willow Creek, Dry Creek, and Lower Willow Creek.

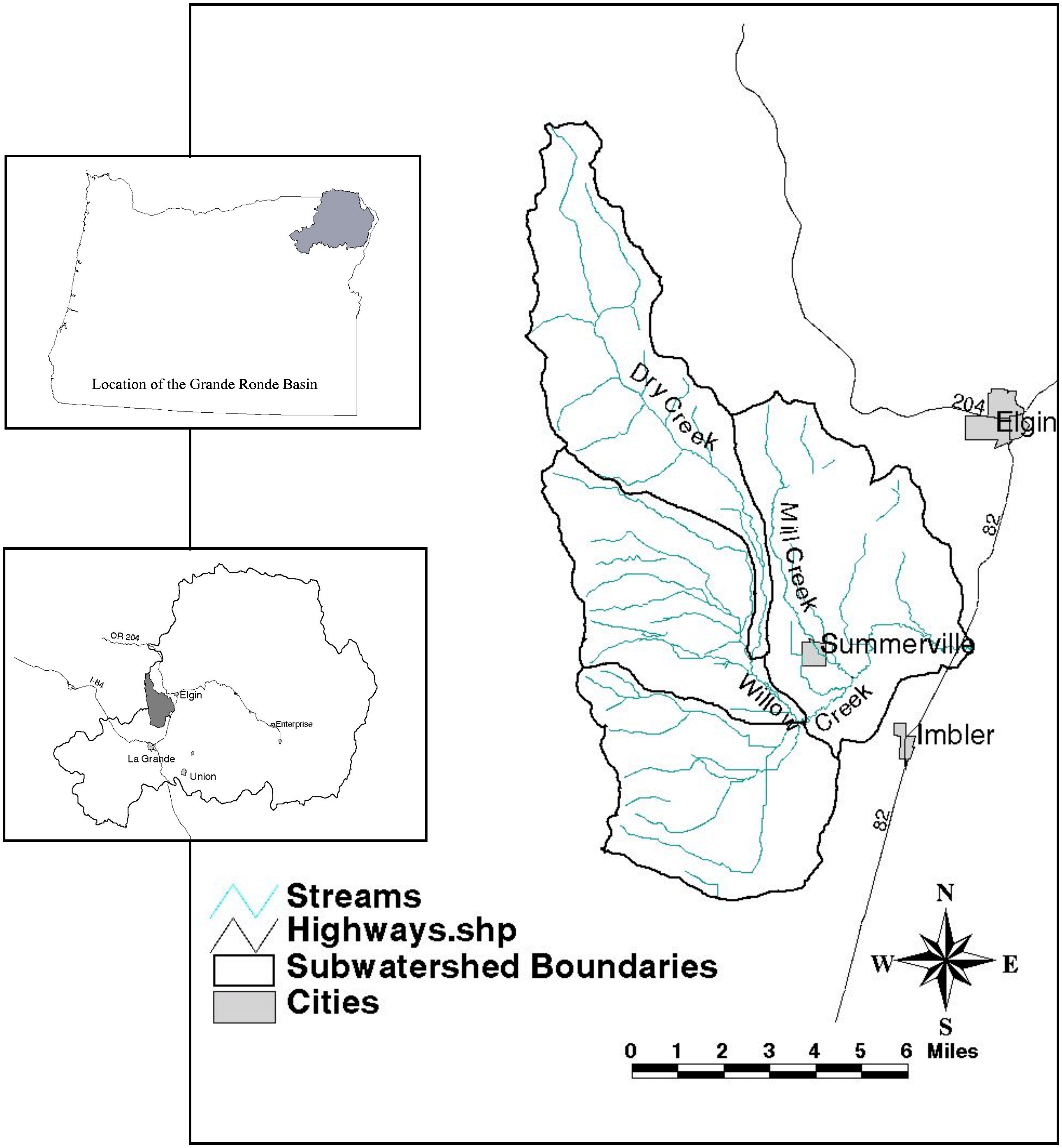
Streams
The three main streams in the Willow Creek watershed are Willow Creek, Mill Creek, and Dry Creek. Mill and Dry Creeks are tributaries to Willow Creek. There are also numerous additional tributaries in the stream system. Note that Mill Creek has an alternate name of Spring Creek. For this assessment, Mill Creek will only be referenced as Mill Creek, even when the pertinent literature refers to the creek as Spring Creek.

Population
Willow Creek watershed is a rural watershed with only one small population center. Summerville, pop. 150, is located in the center of the watershed near the convergence of Mill and Willow Creeks. Rural homes and family farms are dispersed throughout the valley and foothills of the watershed.

Land Uses
Union County zoning in the Willow Creek watershed includes areas of: Rural/Recreation Center, Rural Residential, Exclusive Agriculture, Timber/Grazing, Agriculture/Timber/Grazing, and Farm Residential.

Agriculture: The majority of the valley is devoted to irrigated agriculture. Water is obtained for irrigation primarily from Willow and Mill Creeks and wells. Other tributaries of Willow Creek are small sources of water for irrigation. Wheat, alfalfa, grass seed, sugar beets, potatoes, and mint are the main crops. There are also some cherry orchards in Pumpkin Ridge, which lies in the northern part of the watershed.

Map 1.1: Location of the Willow Creek Watershed



Timber: A majority of the uplands are managed by the Wallowa-Whitman and Umatilla National Forests. Part of the Willow Creek watershed managed by Wallowa-Whitman National Forest is the Mount Emily Roadless Area, which is technically off-limits to harvest. Most of the private forested lands are managed for timber. Boise Cascade also owns a small portion of land in the Willow Creek watershed that is managed for timber.

Grazing: There is one active grazing allotment on National Forest land in the watershed, the North End Allotment. Sheep utilize this allotment from June to September. Cattle, sheep, horses, and other livestock are also grazed on private lands in the watershed.

Rural/Recreation Centers: Summerville is located to the north of where Mill Creek converges with Willow Creek. Imbler, pop. 310, lies near the mouth of Willow Creek and along Hwy. 82, to the east of the Willow Creek watershed boundary.

Rural Residential and Farm Residential: There are a number of residential homes and farms located throughout the Willow Creek watershed.

Land Ownership

Map 1.2 shows land ownership in the Willow Creek watershed. **Table 1.1** shows land ownership acreages in the Willow Creek watershed.

Table 1.1: Land ownership in Willow Creek watershed

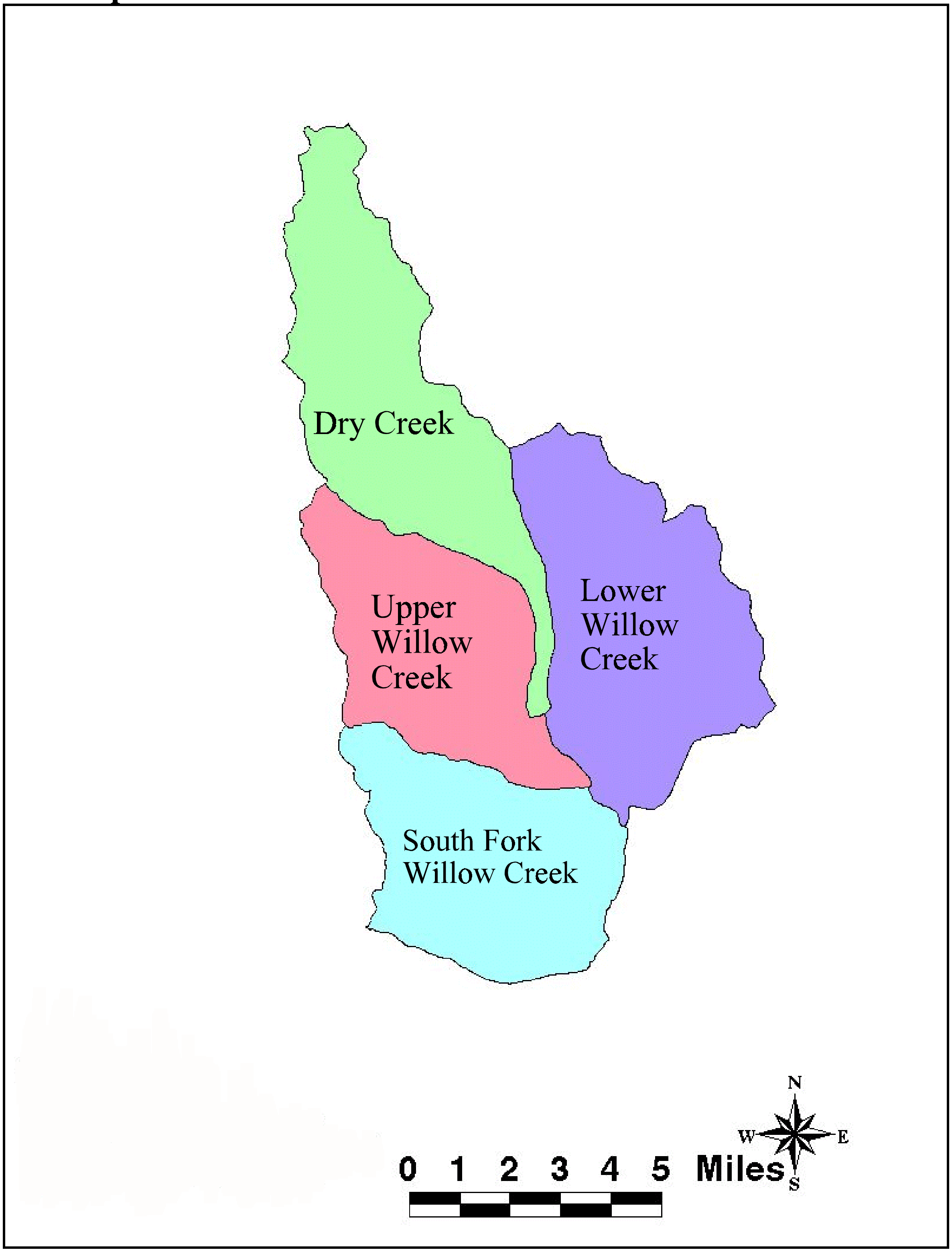
Owner	Acres	% of Watershed
Private, Non-Industrial	35,399	66.7%
Boise Cascade	3,961	7.5%
Bureau of Land Management	249	0.4%
State of Oregon	146	0.3%
U.S.F.S.	13,337	25.1%
All Lands	53,092	100%

sources: USFS and BCC shapefiles

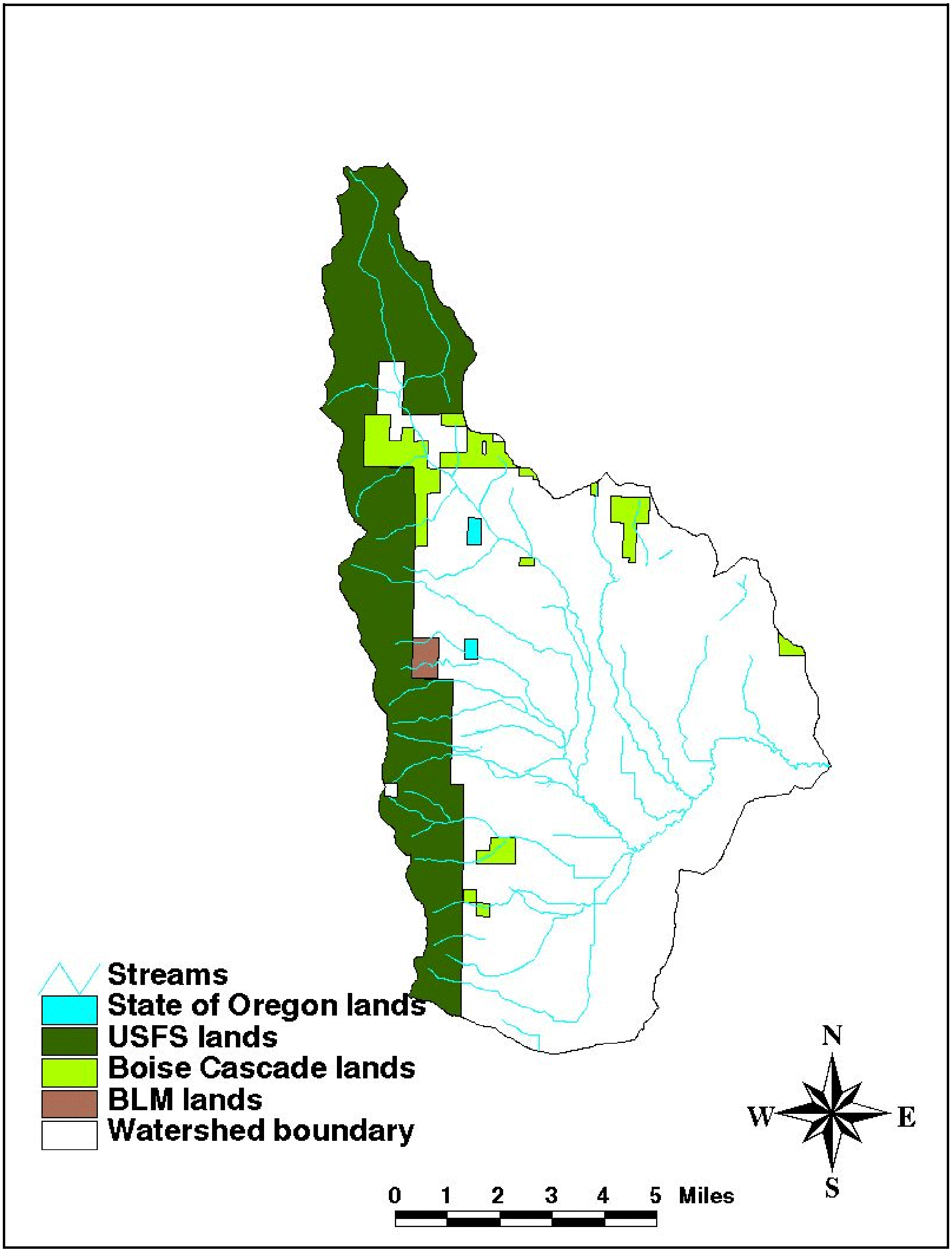
Climate

The Willow Creek watershed is included in the Maritime-Influenced Zone, an area of the Blue Mountains that intercepts marine weather systems. Precipitation in this zone of the Blues receives more precipitation than anywhere else in the Blue Mountains, except the high Wallowas and Elkhorns (Phillips-Gordon Draft Ecosystem Analysis, UNF, 2001).

Map 1.2: Subwatersheds of the Willow Creek Watershed



Map 1.3: Land Ownership in the Willow Creek Watershed



Mean monthly temperature changes with the seasons and elevation in the watershed. The coolest month is January, with a mean temperature of 29.7ºF at Elgin. The warmest month is July, with a mean temperature of 66.8ºF (Oregon Climate Service, 1961-1990).

Average annual precipitation varies within the watershed. In the valley, precipitation is less than 20 inches per year. In the uplands, it varies between 20 and 40 inches per year, and on the ridgetops, it ranges from 40 to 60 inches per year. The majority of precipitation occurs during the winter and early spring. The driest month is July and the wettest month is December (Oregon Climate Service).

Geology

The geology of the Willow Creek watershed is dramatically diverse. In the uplands, **basalt** and other volcanic rocks characterize the geology. In the transitional area between the uplands and the valley, **colluvium** is the dominant rock group. The geology of the west part of the Upper Willow Creek subwatershed, from Pumpkin Ridge to just south of Summerville is comprised of **fan alluvium**. The lowest elevations of the watershed are characterized by **lacustrine deposits** (Hampton and Brown 1964).

Grande Ronde River basalt and associated volcanic rocks These impervious rocks are the most widespread rock units in the Grande Ronde Basin. They originated in the Miocene and possibly early Pliocene age. They are composed of basaltic and andesitic lava flows, interflow beds of lacustrine and fluvial sedimentary deposits, and scoriaceous tuff (Hampton and Brown 1964).

Colluvium These deposits are derived from weathered blocks and fragments of basalt and andesite indescriminately mixed with soil and stream alluvium. As this material is porous, many streams that headwater above this rock infiltrate the colluvium in a slow downhill gradient beneath the surface, reappearing as springs in the lower part of the colluvium and other rock groups further downstream (Hampton and Brown 1964).

Fan alluvium Willow Creek is one of five well-developed alluvial fans in the Grande Ronde Valley. This fan was formed by deposits of Willow and Mill Creeks. The size of these deposits depends on the discharge and sediment load of the contributing streams. The further down a stream, the smaller the particle sizes are deposited (Hampton and Brown 1964).

Lacustrine deposits These deposits are sedimentary fill composed of clay, silt and fine sand. They interfinger with the coarser sediments of the alluvium and colluvium and lie up to 2,000 feet deep in the center of the Grande Ronde Valley (Hampton and Brown 1964).

There are numerous faults in the Blue Mountains, with many alongside Mt. Emily's eastern face. In the middle Pleistocene period, fault activity dropped the Grande Ronde Valley floor and elevated what are now the mountain ridges surrounding the valley (Hampton and Brown 1964). The faults are still considered active (Ferns 1999). As rock was eroded and transported downstream, it was deposited in the valley, creating the thick depositional layers found today. In the middle of the valley floor, the deposits are up to 2,000 feet thick. Near the northern edge of the valley, where the Willow Creek watershed is located, the deposits are believed to be much thinner, with the underlying basalt layers closer to the surface (Hampton and Brown 1964).

Forests
Forest lands in the Willow Creek watershed can be divided into three types: lowland dry forest, montane forest, and subalpine forest.

Lowland Dry Forest
The high temperatures and low moisture levels characteristic of this forest type limit the number of species that can grow in this zone. Historically, these forests have been composed of the fire-resistant and fire-dependent tree species ponderosa pine and Western larch, which can survive in this climate. Historically, wildfires that occurred every five to 30 years prevented fuel buildup, so fires were usually low in intensity. Ponderosa pine and Western larch were selected for by fire, as other tree species were more easily killed by these fires. In unmanaged forests, ponderosa pine tends to replace itself as it matures. Because of fire suppression, dense multi-layered stands of other conifer species, such as grand fir, have sprung up underneath the canopy. Now these species ultimately tend to replace the ponderosa pine and Western larch when mature trees die. Shade from the dense understory does not favor seedling and sapling ponderosa pine from surviving and growing. Poor, dry sites with shallow soils, remain dominated by ponderosa pine, even when fire is suppressed, since only ponderosa pine is adapted to the poor growing conditions.

Montane Forest
Mixed-conifer forests are typical between the foothills and the subalpine zones of the Blue Mountains. Here, forests contain a larger number of species than the lower, drier pine-dominated forest. Grand fir, ponderosa pine, Douglas-fir, Western larch, Englemann spruce, lodgepole pine, and other conifer species all can be represented in montane forests. These forests are more productive than lowland dry forests and there is a larger natural fuel build-up. Fires occur every 20-40 years, with some of these fires stand-replacing. These forests are favored by long intervals between fires and disturbances. Insects and diseases are common occurrences in mixed-conifer forests and can kill off entire stands. Trees and insects have co-evolved together, and regeneration can be dependant upon insects to kill entire stands, when not altered for timber production.

Moist Cold/Subalpine Forest
The highest elevation forests in the Blue Mountains are often moist, from snowfall, and cold, from elevation and climate. These forests have the longest fire interval, and all fires are stand-replacing fires. Species include subalpine fir, Douglas-fir, Western larch, grand fir, and Engelmann spruce.

Grassland and Wetland Communities
The Willow Creek watershed includes forest, grassland, and wetland plant communities. Agriculture has replaced many acres of grassland and wetlands in the watershed, but soil types indicate what the potential plant communities are.

In the Soil Survey of the Union County Area, each soil type description describes the potential plant communities found in uncultivated areas of that soil type. In addition to the coniferous forests in the uplands, the soils in the Willow Creek watershed support a number of grassland communities. These include: bluebunch wheatgrass/Idaho fescue/stiff sagebrush; bluebunch wheatgrass/Idaho fescue/Sandburg bluegrass; bluebunch wheatgrass/Idaho fescue, and bluebunch/Sandberg bluegrass/stiff sagebrush. Two other potential plant communities are: water-tolerant grasses/sedges/rushes and basin wheat rye/Indian saltgrass/greasewood.

Riparian Vegetation

Riparian vegetation is dependent upon the elevation and topography of a stream. In the Willow Creek watershed, riparian vegetation will generally be willow, other brush species, and cottonwoods along streams in the valley floor. However, it is thought that only brush species, not hardwoods, grew historically along lower Willow Creek, because of seasonal inundations. In higher, forested regions, riparian vegetation will generally be comprised of conifers, such as grand fir, hardwoods, such as cottonwood and alder, and some brush species such as willow (OWEB, Ecosystem Appendix, 1999).

Fish and Wildlife

Summer steelhead, rainbow trout, and brook trout are among the cold water fish species currently found in the Willow Creek watershed. Spring chinook salmon are known to use the lower reaches of Willow Creek as winter rearing habitat (pers. comm., Brad Lovatt, ODFW). There also are a number of non-salmonid fish, including sculpins, shiners, suckers, and squawfish.

Wildlife residing in the watershed include deer, elk, cougar, bear, numerous migratory and resident bird species, beaver, and many other species. Most species known or suspected to occur historically in the watershed still do, with the exceptions of the grizzly bear and the gray wolf . While species that thrive in early seral stages have increased in numbers, other species' numbers have declined (Phillips-Gordon Draft Ecosystem Analysis, 2001).

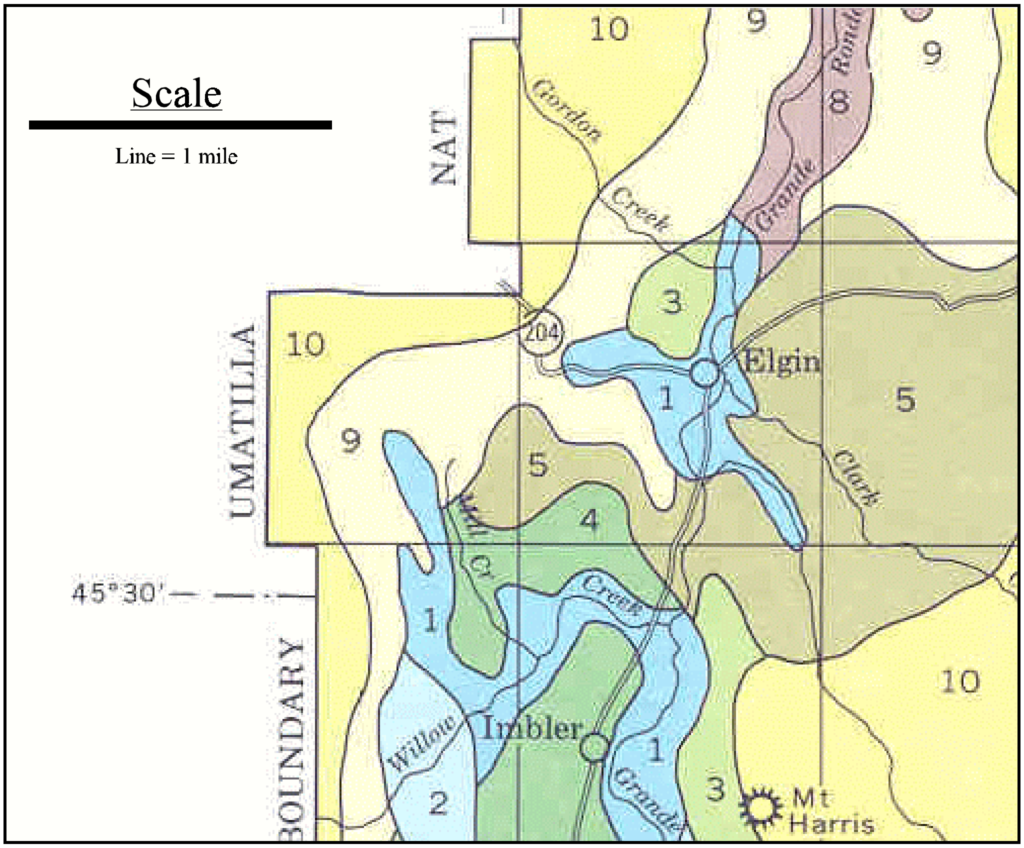
Noxious Weeds

There are a number of noxious weeds found in the Willow Creek watershed. Diffuse knapweed is considered by the Union County Weed Control Board to be the biggest noxious weed problem in the Willow Creek watershed (pers. comm., Gary Dade). It is mostly found in areas of the watershed with human activity, but sometimes alongside roads higher up in the watershed. Knapweed is known to disperse by water, putting riparian habitat at risk of invasion (Sheley & Petrof, 1999).

Soils

Soils in the Willow Creek watershed vary based upon geology and topography. **Map 1.4** shows the soil complexes in the Willow Creek watershed. The numbers on the map correspond to the descriptions below the map.

Map 1.4: Union County Soil Survey General Soil Map



source: Soil Survey of Union County Area, NRCS, 1985.

1: Catherine-La Grande-Veazie: Deep, well drained to somewhat poorly drained soils that formed in alluvial and lactustrine deposits derived mainly from basalt, andesite and granite.

2: Hot Lake-Conley-Hoppal: Moderately deep and deep, somewhat poorly drained soils that formed in lacustrine sediment mixed with diatomaceous sediment and volcanic ash.

4: Imbler-Palouse-Alicel: Deep, well drained soils that formed in sandy and silty eolian material.

5: Watama-McMurdie-Lookingglass: Moderately deep and deep, well drained soils that formed in old alluvial deposits mixed with volcanic ash, tuff, and loess

9: Lookingglass-Emily-Wolot: Deep, well drained and moderately well drained soils that formed in colluvium and residuum derived from volcanic tuff and basalt and in volcanic ash and loess.

10: Tolo-Klicker-Cowsley: Moderately deep and deep, well drained and moderately well rained soils that formed in volcanic ash and loess and in colluvium and residuum derived from volcanic tuff and basalt.

Ecoregions
Oregon is divided into ecoregions based upon climate, geology, physiography, vegetation, soils, land use, wildlife, and hydrology (OWEB manual, Ecoregion Appendix, 1999). Each ecoregion has characteristic disturbance regimes that shape the form and function of watersheds in the region. Generalized ecoregion information characterizes patterns within a watershed that can aid in understanding watershed processes.

Willow Creek watershed lies within the Blue Mountains ecoregion (level III) and two level IV ecoregions: Blue Mountains Basins and Mesic Forest Zone. The Blue Mountains Basins ecoregion includes scattered basins in the Blue Mountains, and includes the lower elevations of the Willow Creek watershed. The Mesic Forest Zone ecoregion includes upper slopes throughout the Blue Mountains.

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Chapter 2: Historical Conditions

Introduction

Explorers and settlers in the 1800s often described the Grande Ronde Valley in journals, documenting a land dramatically different from today's agricultural valley. Fremont described the valley as "a beautiful level basin, or mountain valley, covered with good grass on a rich soil, abundantly watered, and surrounded by high and well-timbered mountains, and its name descriptive of its form, the great circle" (1845). The valley was composed of grasslands with fields of camas and riparian forests with cottonwood, willow, and other woody species, surrounded on all sides by mountains covered in coniferous forest (Gildemiester 1999). John Johnson observed springs flowing from the mountainsides, in groves of willows and cottonwoods (ibid). Wolves, grizzly bears, and coho salmon were then found in the valley (ibid).

Today, virtually all historic wetlands, camas fields, and cottonwood forest have been drained, cleared, and converted to farm land (Gildemiester 1999). Forest structure and composition have changed, through natural processes and human intervention (Langdon 1995). Below is an environmental history of Willow Creek watershed, describing human-based changes in the landscape from the first humans in the watershed to present day.

Methods

Various oral histories, historical reports, and compilations of historical information were gathered for this chapter. Pertinent information has been included in the text of this chapter, with references at the end of the chapter.

Results

Native Americans

Until the early 1800s, the Grande Ronde Valley was used solely by the Cayuse, Umatilla, Walla Walla, and Nez Perce (Gildemiester 1999). The Valley, or "land where the cottonwood grows" was a spring meeting ground for many tribes and was a place of peace (Hug 1961). The tribes came annually to fish, hunt, and hold horse races (Johnson 1985). They also dug roots (Brigham 1998). The Umatillas came over the north part of Mount Emily, now known as Ruckle, past Sanderson Springs and Phillips Creek Canyon, into the Grande Ronde Valley (Hug 1961). Elgin is the location of a historical Tribal camp, where Tribal members used spears and fish weirs to harvest salmon, eels, and trout (Brigham 1998).

Camas root, a main staple of the Native Americans' diet, was plentiful in the Grande Ronde Valley. Early emigrants commented: "When the plant is in blossom, the whole valley is tinted by its blue flowers, and looks like the ocean when overcast by a cloud" (Captain Bonneville, qtd. in Hug 1961) and "The camas grow here in abundance and it is the principle resource of the Cayouses and many other tribes." (Narcissa Whitman August 28, 1936, qtd. in Gildemiester 1999).

Before 1815, when fur trappers began finding their way to the Grande Ronde Valley, the Blue Mountains' only human influence was that of the local Native Americans (Gildemiester 1999). In addition to natural fires from lightning, the Native Americans set fires to maintain open forests for game (Gildemiester 1999). Early journals document large ponderosa pine forests and mixed-conifer forests.

Columbia Basin tribes acquired horses in the 1730s (Hug 1961). When the first white visitors came to the Grande Ronde Valley, they observed that thousands of horses would come to graze in the valley each spring when the tribes made their annual visit to the Grande Ronde Valley (Gildemiester 1999).

Fur Trappers and Explorers

Early journals indicate beaver were plentiful (Gildemiester 1999). In a few decades, with the arrival of the fur trade, beavers were systematically removed from the upper elevations of watersheds in the Grande Ronde Basin (ibid). This was the first documented major impact to the Upper Grande Ronde Watershed. By the 1860s, when the beaver were almost removed entirely, the control beaver had over stream flows, water quality, and sediment was removed as well. Meadows previously "irrigated" by beaver dams became drier (ibid). Nathaniel Wyeth wrote in 1832 that "Streams are being trapped out by mountain men"(qtd. in Gildemiester 1999).

Upon following the trail from the Grande Ronde valley to Walla Walla, Fremont wrote in his journal " in the northwest corner of the Rond(sic) is a very heavy body of timber, which descends into the plain" (Fremont 1845).

The Oregon Trail

The Oregon Trail began in 1841, the largest historical migration of people in the United States (Evans 1990). When passing through the Grande Ronde Valley, the emigrant trail stayed to the southern edge of the valley, passing through what is today Union and La Grande. While the trail itself did not enter the Willow Creek watershed, the people that it brought would shape the area's future.

First Settlers

The Grande Ronde Valley, for years passed through by travelers of the Oregon Trail, was first settled in 1861 (Hug 1961). A small village, Rinehart, to the northeast of present Summerville was settled in 1862. Summerville was settled in 1865 (ibid). For many years it was the only trading post north of La Grande or Island City. Once the railroad came to the Valley, bypassing Summerville, the size of the town began to shrink. In 1891, Imbler was established (Johnson 1985).

Logging

Early journals document that the Blue Mountains forests were historically 70-85% in mature or over-mature stages (Langdon 1995). Trees were cut for timber as early as the 1860s. It wasn't until 1889 that timber was harvested on a significant scale in the Upper Grande Ronde Sub-basin (Johnson 1985). Ponderosa pine was the main source of timber. Grand fir and other species were viewed as undesirable (Langdon 1995). Splash dams were commonly used as a means of transporting logs downstream to roads and transportation (Gildemiester 1999).

Timber harvest focused on the lower elevations of forests until the 1930s, when the United States

Forest Service began building logging roads and managing the higher elevations for timber production in the Upper Grande Ronde Sub-basin (Gildemiester 1999). In the Willow Creek watershed, harvested Forest Service land has been primarily in the Dry Creek subwatershed, with 7,070 additive acres of timber activity (Phillips-Gordon Draft Ecosystem Analysis 2001). In the 1970s, 4,634 acres of Upper Willow and South Fork Willow subwatersheds were designated the North Mt. Emily Roadless Area (ibid). Before that date, they were not significantly harvested.

Small mills were built at the base of the forest in and near the Willow Creek watershed. Mills sped the clearing of the land in preparation for cultivation. Once the land was cleared, the mills then moved to more central locations (Rush 1981). In 1865, Hiram Oliver built a mill in the Dry Creek subwatershed, which received timber harvested to the north and east, in the area known as Pumpkin Ridge (ibid). Much of Pumpkin Ridge was originally forested. After the mill was sold, a pine needle factory was built in 1905-1906. Before 1900 a sawmill was built on the Blumerstein property in the Pumpkin Ridge school district (ibid).

Agriculture

In the late 1800s, agriculture in the Willow Creek watershed focused, in part, on fruit production. Prunes, pears, peaches, cherries, and apples were grown. The Smith-Rinehart Dryer was located in Summerville, which dried fruit from the north end of the valley (Drobish 1989). Pumpkin Ridge was also known to specialize in growing potatoes (Rush 1981). An article in the Elgin Recorder in 1940 described the development of agriculture in the northern part of the Grande Ronde Valley: "In the years from 1875 to 1885 that area of about 25 square miles developed from an expanse of bunch grass and pine forests to one of the finest orchard and garden spots of the entire country" (Rush 1981).

Aerial photos taken by the Soil Conservation Service in 1937 show numerous orchards in the Willow Creek watershed, compared to few orchards visible in the 1997 aerial photos. Currently, there are few orchards, with the majority of agricultural land in the watershed producing wheat, mint, sugar beets, alfalfa, and grass seed.

Grazing

In the early 1830s, the Umatilla, Cayuse, and Walla Walla tribes acquired cattle, which were grazed in their various territories depending upon the season (Brigham 1998).

By the 1880s, non-Indian grazing of livestock had grown into a livelihood for many in the Grande Ronde Valley (Gildemiester 1999). Climate partly determined the pattern of grazing in the Blue Mountains. With dry summers, the native bunch grasses essentially stopped photosynthesis during this period. Thus, grazing year-round on the low elevation grasslands was not feasible. Meadows in the higher elevation forests still were lush in the driest summer months, providing forage for livestock (Langdon 1995). When the Forest Service started the Blue Mountain Preserve in 1906, it annually assigned grazing rights on its lands. Unfortunately, throughout the Blues, pressure was placed on the Forest Service to continue and increase stock numbers. By the 1930s, the effects of overgrazing on both private and public land were obvious.

Historically, there were two grazing allotments on USFS land in the Willow Creek watershed.

The Mount Emily Allotment includes only the western edge of the Upper Willow Creek and South Fork Willow Creek subwatersheds, where sheep were historically grazed**.** It is no longer used (Aric Johnson, pers. comm., USFS, La Grande Ranger District). The North End Allotment on the Umatilla National Forest includes the Dry Creek subwatershed. This area has been stocked since the late 1800s, but the first permit was issued in 1920. Since 1972, five bands of sheep have been run annually on the units of the allotment, from June to September in a normal year (Hines 1993).

Transportation
The Thomas and Ruckles Road was completed in 1865 and led from the Grande Ronde Valley, past Summerville, over the Blue Mountains, to the town of Walla Walla. From 1872-1884, it was the main pass west through the Grande Ronde Valley. In 1884, a storm washed the grade out on the Umatilla County side, and the road was closed (Johnson 1985). In later years, the U.S. Forest Service regraded the road for logging and transportation (ibid).

In 1880, the "tollgate" road that led from Summerville to Walla Walla along Little Phillips Creek was opened. This road replaced Ruckles Road as the main thoroughfare from the Grande Ronde Valley to Walla Walla (Johnson 1985).

Flooding and Channel Modifications
The Grande Ronde Valley has a history of flooding in the spring, as the snow melts. **Map 2.1** shows a representation of the valley's original hydrology, before river channels were straightened and ditches were dug. The green area on the map shows bottomland, which historically flooded every spring. Some years would flood more than others. Major historical floods where Willow Creek flooded include 1894, 1948, and, most recently, 1997.

In 1950, the Army Corps of Engineers conducted a flooding study to evaluate flood protection possibilities for the Grande Ronde Valley. In the resulting document, it estimated that a moderate flood (1,040 cfs) would inundate 870 acres of cropland, 100 acres of pastureland, and 20 acres of marginal land. A major flood (3,000 cfs) would inundate 2,800 acres of crop land, 150 acres of pasture land and 30 acres of marginal land (ACOE, 1950).

In 1965, a project was undertaken to channelize lower Willow Creek (from the Rinehart Bridge to approximately one-quarter mile upstream) (Warren 1965). Approximately 1,300 feet of new channel were aligned and constructed. The new channel was approximately one-third larger than the channel below the bridge (Allen 1965).

Channelization and diversions have occurred extensively throughout the Willow Creek watershed, as the land has been drained for agriculture and adapted for irrigation. Aerial photos from 1937 show that many of the diversions and some channelization present today had already been constructed by that time.

Fire
When the first Europeans arrived in the Upper Grande Ronde Sub-basin, they noted that the Native Americans set fires in the ponderosa pines to maintain the lands for hunting purposes

(Langdon 1995). Early range managers would also set fire to the grasslands to cure the land for the following grazing season.

In the 1920s, the U.S. Forest Service set a no-fire policy. Fires found on Forest Service lands were to be put out by 10 a.m. This policy continues today, although in recent years there have been prescribed burns on the Umatilla and Wallowa-Whitman Forests, in order to reduce fuel loads (Jaindl 1996).

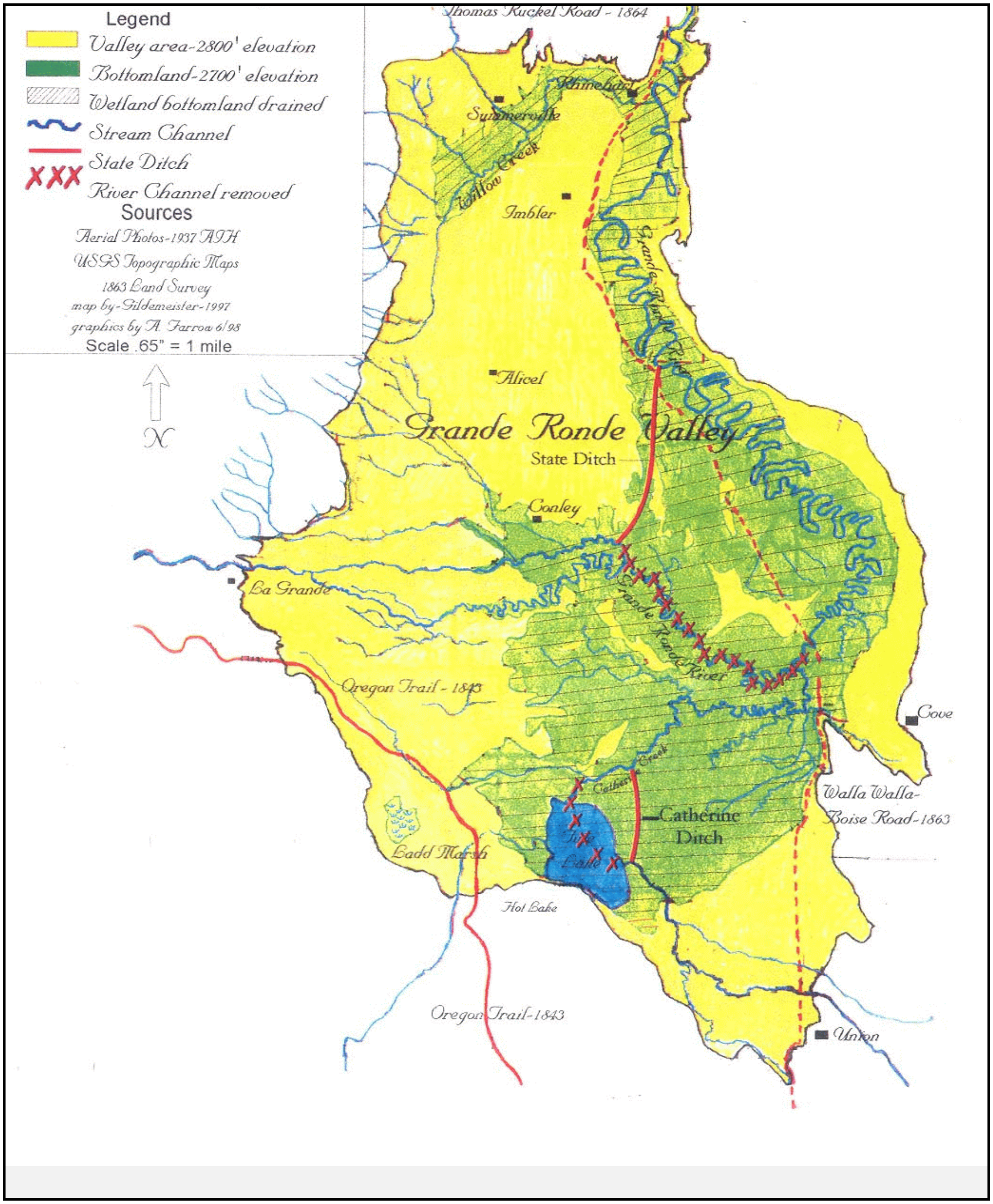
Noxious Weeds
The majority of noxious weeds in the Blue Mountains ecoregion were introduced from Europe or Asia. They arrived accidentally, in weed-infested crop seed and animal feed, or intentionally, as ornamentals or crop plants. Cheatgrass was introduced from Europe and is now widely established in western North America. It can prevent native grasses from re-colonizing disturbed areas (Jaindl 1996). Cheatgrass and a few other early weed species are so prevalent now that they are not classified as noxious weeds. One of the more problematic weeds in the Upper Grande Ronde Sub-basin is diffuse knapweed. Introduced to North America in 1907, it was first reported in 1937 near La Grande (Jaindl 1996).

Discussion

There have been many changes to the Willow Creek watershed since the early 1800s. Fur trappers have come and gone, taking the beaver with them. Settlers have passed through and many have stayed. Land has been cleared; farms have been cultivated. Wetlands have been drained. Roads and train tracks have been built. Noxious weeds have entered the landscape. Humans have changed the landscape, through extracting resources and putting the land into agricultural production.

We cannot entirely return the watershed to its original, pristine state, as the land is now a livelihood for many people. We do not fully understand or know what its “original” state was. Some changes that may have impacted the watershed the most occurred when there was little documentation of their effects, such as the removal of the beaver in the mid 1800s. As things currently stand, we can try to restore aspects of the watershed that benefit the habitat of aquatic and terrestrial species that we share the land with, while maintaining a viable economy. The following chapters of this assessment characterize the current conditions of the watershed and identify restoration opportunities.

Map 2.1: Grande Ronde Valley



source: "The Grande Ronde Watershed History Report" by Jerry Gildemiester

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Chapter 3: Channel Habitat Types

Introduction
In this chapter, the streams in the Willow Creek watershed have been classified as various channel habitat types (CHTs). Stream classification groups stream reaches into "types", thereby creating a tool for understanding how land uses can affect and alter stream channel form. Stream classification also can assist in identifying how different "types" will respond to restoration efforts.

Background
Stream classification is the designation of a stream network, stream, or stream segment as a generic "type", based upon certain characteristics of the stream. The OWEB system, Channel Habitat Typing, is used to classify stream segments in Oregon into basic channel types. This system is a compilation of previously existing classification systems, including Rosgen and the Tongass National Forest systems. By using a classification system at this scale, patterns can be predicted in channel physical characteristics, but the scale is still broad enough to be identified from topographic maps and limited field work (WPN 1999).

By dividing stream segments into channel habitat types, the processes that affect stream structure in a watershed can be better understood. Inferences can be made about how land uses can alter physical channel form and process, and thus alter fish habitat. Also, by knowing an area's channel habitat types, opportunities for restoration can be identified and prioritized. Certain CHTs will respond more readily to restoration efforts than others. However, since these channel type classifications apply to broad areas, field verification of actual conditions is necessary before individual projects are implemented. It is important to recognize that CHTs cannot be managed as isolated segments, as activities elsewhere in the watershed affect each segment as well.

Methods
USGS topographic maps were used as the base map for channel habitat typing. A map wheel was used to calculate the length of each reach.

Streams were divided into individual reaches based upon the following guidelines:
- minimum segment length of 1,000 feet
- segments were broken out at stream convergence
- segments covered a minimum of 3 contour lines on USGS topographic 1:24,000 scale maps
- segments were broken out where distance between contour lines changed significantly
- segments that were channelized/straightened were broken out

Once streams were divided into reaches, channel gradient and channel confinement were calculated for each reach. According to the OWEB manual, channel gradient is defined as "the slope of the channel bed along a line connecting to the deepest points of the channel". Channel gradient was calculated by dividing the difference in elevation by the horizontal distance of a given length of stream. This was done by measuring the length of the reach, using a map wheel, and the difference in elevation, using USGS topographic maps. Once channel gradients were calculated, they were divided into gradient classes: <1%, 1-2%, 2-4%, 4-8%, 8-16%, and >16%.

The OWEB manual defines channel confinement as "the ratio of bankfull channel width to width of modern floodplain". For Channel Habitat Typing, confinement is broken into three classes: Unconfined, Moderately Confined, and Confined. As channel confinement is difficult to accurately determine from topographic maps alone, in this assessment, confinement was classified based upon both topography and flood maps, which show the **100-year flood plain**. While the 100-year flood plain does not necessarily correspond with modern flood plain, or the "**flood-prone area**", using flood maps helped verify the confinement classes assigned to reaches using USGS topographic maps.

Completely channelized reaches as mapped on the 1:100,000 EPA stream layer and the USGS topographic maps were not assigned CHTs. As the length of the stream is shortened when channelized, designating a channel habitat type based upon this method may result in an inaccurate CHT.

Results

The uppermost reaches of streams coming off of Mount Emily are steep narrow valleys, broadening out into alluvial fans as they enter the valley, and emptying into the floodplain channels of Willow Creek and lower reaches of Mill and Dry Creeks. The upper reaches of Dry and Mill Creek are more moderate gradients with little or no floodplain. **Map 3.1** shows the streams in the Willow Creek watershed broken out by channel habitat type. Detailed descriptions of channel habitat types can be found in **Appendix 3.1**.

Channel habitat types were classified for 123.2 stream miles, out of a total 124.6 stream miles mapped in the 1:100,000 EPA stream layer. **Figure 3.1** shows the percentages of each channel habitat type. Moderate gradients were 43% of all reaches (including alluvial fan reaches); low gradients, 26% ; steep gradients, 31%; and channelized reaches, 9%.

Map 3.1: Channel Habitat Types

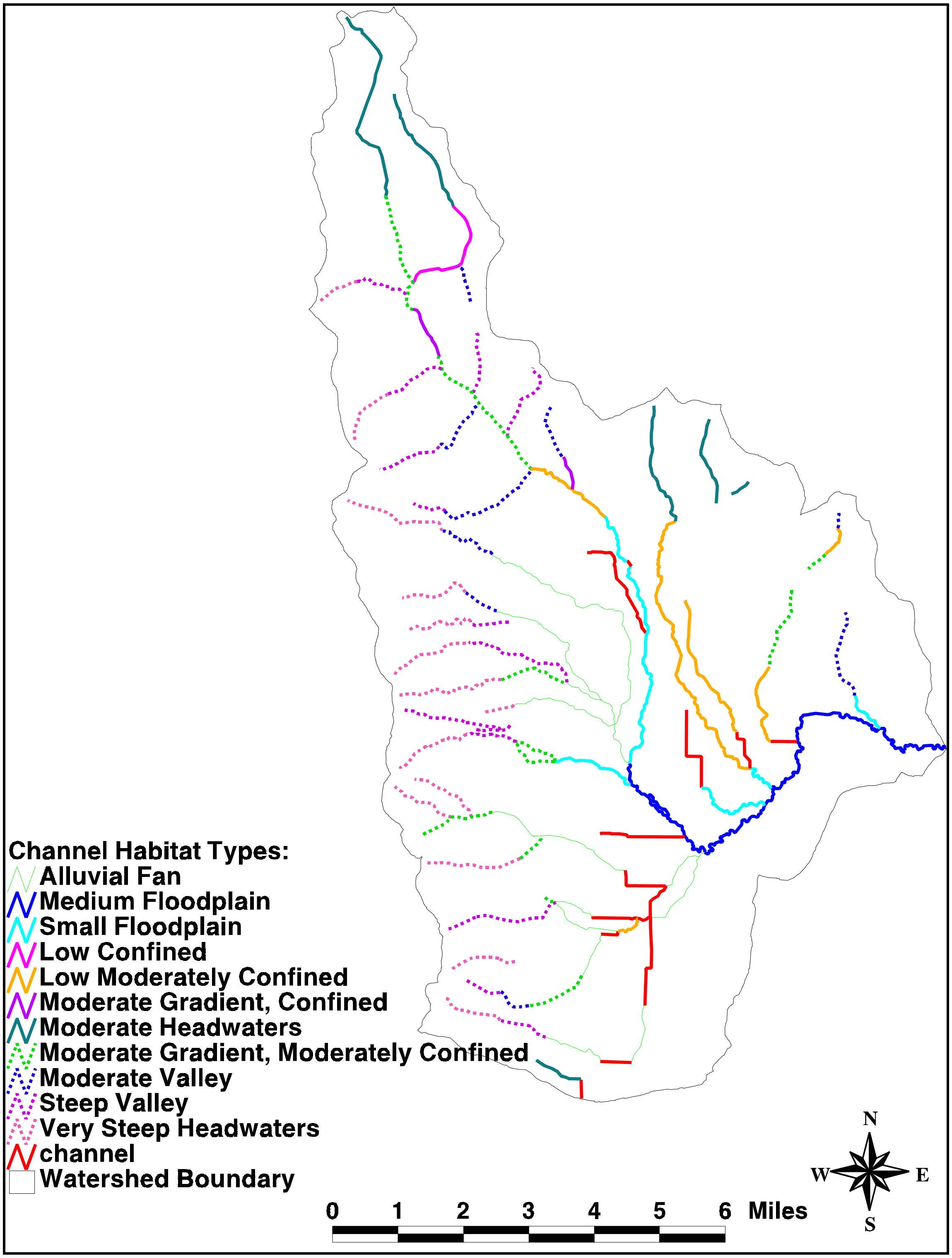
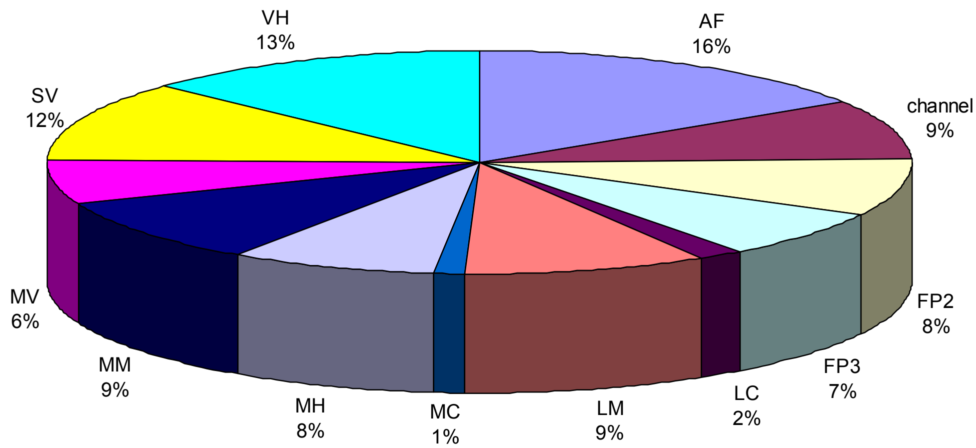


Figure 3.1: Channel Habitat Types in the Willow Creek Watershed



Discussion

As stated in the channel habitat type characterizations in **Appendix 3.1**, some channel habitat types are more responsive to stream enhancement efforts than others. However, all respond favorably to riparian revegetation. Revegetation of riparian areas is the single most important aspect of riparian restoration. Riparian vegetation helps to stabilize stream banks, reduce water temperatures, and provide flood control and other benefits to riparian areas. It can also act as a buffer between aquatic ecosystems and adjacent land uses. For more information on the conditions of riparian areas in Willow Creek, see *Chapter 5: Riparian Areas*.

Channel habitat types are most useful when determining how a section of stream will react to in-stream treatments. The active energy and lateral movement of floodplain channels (FP2 and FP3) limit the success of in-stream treatments except at a very local scale. The steeper channel types (SV, VH, and MV) also are often only responsive locally, as the steepness and confinement of the stream channel limits the effectiveness of treatments. Alluvial fans (AF) do not easily lend themselves to stream enhancement, as the high levels of sediment deposition can limit the success of habitat complexity efforts, such as large wood placement for creation of pools.

The most responsive CHTs to in-stream treatments are moderately confined to unconfined and low to moderate gradient (LM, MM, and MH). These channel habitat types are the best areas to concentrate on increasing stream habitat complexity. They also are among the most responsive to changes in land management activities (floodplain CHTs are the others). As they are not confined by topography, these channel habitat types are more affected by changes in sediment loads (fine and coarse), peak flows, and large woody debris. For example, removing woody debris can decrease the number of pools and other stream habitat complexities. An increase in sediment load can cause streambed scouring and/or bank erosion. When streams are artificially confined (limited in lateral movement), the channel may react by down cutting or scouring. This can result in bank erosion, bed erosion, and deterioration of habitat complexity.

As the channel habitat types were designated using topographic maps, these types represent the *potential* CHT. They may not be what is actually currently present, as many streams have **downcut** over time. Downcutting can separate the stream from its floodplain and, thus, change how the stream would react to restoration or land use activities. For example, a low-gradient moderately confined (LM) reach, when downcut, will become artificially confined. Thus, technically, this section of a stream would react to activities as a low-gradient confined (LC) CHT, but its *potential* channel habitat type is still a low-gradient, moderately confined (LM). It is beyond the scope of this assessment to identify which stream reaches in the watershed have been altered from their potential channel habitat type. This disparity between potential and actual channel habitat type can be identified at the project level. Information on how to restore a stream reach to its *potential* channel habitat type is included in *Chapter 10: Fish and Fish Habitat.*

Data Gaps

- field verified *current* channel habitat types

References

Stream Corridor Restoration: Principles, Processes, and Practices. The Federal Interagency Stream Restoration Working Group, October 1998.

Watershed Professionals Network. Oregon Watershed Assessment Manual. Salem, Oregon: prepared for the Governor's Watershed Enhancement Board, 1999.

Appendix 3.1: Description of Channel Habitat Types

Included below are descriptions of channel habitat types present in the Willow Creek watershed. This information is taken from the OWEB Watershed Assessment Manual. More detail on these and other channel habitat types can be found in Appendix A of Component III of the manual.

Note that the descriptions focus on in-stream processes. As all channel types respond favorably to riparian revegetation, this is not emphasized in the descriptions. But it is still an integral, perhaps the most important, part of stream and riparian restoration.

Low Gradient Medium Floodplain Channel: FP2

Low gradient medium floodplain channels are main-stem streams in broad valley bottoms with well-established floodplains. Channels are often sinuous, with extensive gravel bars, multiple channels, and terraces. The dominant substrate is sand to cobble.

Sediment deposition is prevalent, with fine-sediment storage evident in pools and point bars and on floodplains. Bank erosion and bank-building processes are continuous, resulting in a dynamic and diverse channel morphology. Stream banks are composed of fine alluvium and are susceptible to accelerated bank erosion with the removal or disturbance of stream-bank vegetation and root mats. Channel gradient is low, and high stream flows are not commonly contained within the active channel banks, resulting in relatively low stream power.

Channel Responsiveness

Floodplain channels can be among the most responsive in the basin. The limited influence of confining terrain features and a fine substrate allow the stream to move both laterally and vertically. Although often considered low-energy systems, these channels can mobilize large amounts of sediment during high flows. This often results in channel migration and new channel formation.

Riparian and Instream Enhancement Opportunities

Due to the unstable nature of these channels, the success of many enhancement efforts is questionable. Opportunities for enhancement do occur, especially in channels where lateral movement is slow. Lateral channel migration is common. Efforts to restrict this natural pattern will often result in undesirable alteration of channel conditions downstream. Side channels may be candidates for efforts that improve shade and bank stability.

Low Gradient Small Floodplain Channel: FP3

FP3 streams are located in valley bottoms and flat lowlands. They frequently lie adjacent to the toe of foot slopes or hill slopes within the valley bottom of larger channels, where they are typically fed by high-gradient streams. They may be directly downstream of a small alluvial fan and contain wetlands. FP3 channels may dissect the larger floodplain. These channels are often the most likely CHT to support beavers if they are in the basin. Beavers can dramatically alter channel characteristics such as width, depth, form, and most aquatic habitat features.

These channels can be associated with a large floodplain complex and may be influenced by flooding of adjacent main-stem streams. Sediment routed from upstream high and moderate gradient channels is temporarily stored in these channels and on the adjacent floodplain.

Channel Responsiveness

Floodplain channels can be among the most responsive in the basin. The limited influence of confining terrain features and fine substrate allows the stream to move both laterally and vertically. Although often considered low-energy systems, these channels can mobilize large amounts of sediment during high flows. This often results in channel migration and new channel formation.

Riparian and Instream Enhancement Opportunities

Floodplain channels are, by nature, prone to lateral migration, channel shifting, and braiding. While they are often the site of projects aimed at channel containment (diking, filling, etc.), it should be remembered that floodplain channels can exist in a dynamic equilibrium between stream energy and sediment supply. As such, the active nature of the channel should be respected, with restoration efforts carefully planned. The limited power of these streams offers a better chance for success of channel enhancement activities than the larger floodplain channels. While the lateral movement of the channel will limit the success of many efforts, localized activities to provide bank stability or habitat development can be successful.

Alluvial Fan Channel: AF

Alluvial fans are generally tributary streams that are located on foot-slope land forms in a transitional area between valley floodplains and steep mountain slopes. Alluvial fan deposits are formed by a rapid change in transport capacity as the high-energy mountain-slope stream segments spill onto the valley bottom. Channel pattern is highly variable, often dependent on substrate size and the age of the land form. Channels may change course frequently, resulting in a multi-branched stream network. Channels can also be deeply incised within highly erodible alluvial material. Smaller alluvial fan features may be difficult to distinguish from FP3 channels.

Alluvial fans are usually at the lower end of small tributaries. Their dominate substrate is fine gravel to large cobble. Their size varies from small to medium.

Channel Responsiveness

The response of alluvial fans to changes in input factors is highly variable. Response is dependent on gradient, substrate size, and channel form. Single-thread channels confined by high banks are likely to be less responsive than an actively migrating multiple channel fan. The moderate-gradient and alluvial substrate of many fans result in channels with a moderate to high overall sensitivity.

Riparian and Instream Enhancement Opportunities

As many alluvial fans are actively moving at a rate greater than most channels, they are generally not well-suited to successful enhancement activities. Although they are considered responsive channels, long-term success of enhancement activities is questionable. High sediment loads often limit the success of efforts to improve habitat complexity such as wood placement for pool development.

Low Gradient Moderately Confined Channel: LM

These channels consist of low-gradient reaches that display variable confinement by low terraces or hill slopes. A narrow floodplain approximately two to four times the width of the active channel is common, although it may no run continuously along the channel. Often low terraces accessible by flood flows occupy one or both sides of the channel. The channels tend to be of medium to large size, with substrate varying from bedrock to gravel and sand. They tend to be slightly to moderately sinuous, and will occasionally have islands and side-channels.

Channel Responsiveness

The unique combination of an active floodplain and hillslope or terrace controls acts to produce channels that can be among the most responsive in the basin. Multiple roughness elements are common, with bedrock, large boulders, or wood generating a variety of aquatic habitat within the stream network.

Riparian and Instream Enhancement Opportunities

Like floodplain channels, these channels can be among the most responsive of channel types. Unlike floodplain channels, the presence of confining land form features often improves the accuracy of predicting channel response to activities that may affect channel form. Additionally, these controls help limit the destruction of enhancement efforts common to floodplain channels. Because of this, LM channels are often good candidates for enhancement efforts.

In forested basins, habitat diversity can often be enhanced by the addition of roughness elements such as wood or boulders. Pool frequency and depth may increase, and side-channel development may result from these efforts. Channels of this type in nonforested basins are often responsive to bank stabilization efforts such as riparian planting and fencing. Beavers are often present in the smaller streams of this channel type. Fish habitat in some channels may benefit from beaver introduction through side-channel and scour pool development. Introducing beavers, however, may have significant implications for overall channel form and function and should be thoroughly evaluated by land managers as well as biologists as a possible enhancement activity.

Low Gradient Confined Channel: LC

LC channels are incised or contained within adjacent, gentle land forms or incised in volcanic flows or uplifted coastal land forms. Lateral channel migration is controlled by frequent bedrock outcrops, high terraces, or hill slopes along stream banks. They may be bound on one bank by hill slopes and lowlands on the other and may have a narrow floodplain in places, particularly on the inside of meander bends. Stream-bank terraces are often present, but they are generally above the current floodplain. The channels are often stable, with those confined by hill slopes or bedrock less likely to display bank erosion or scour than those confined by alluvial terraces.

High-flow events are well-contained by the upper banks. High flows in these well-contained channels tend to move all but the most stable wood accumulations downstream or push debris to the channel margins. Stream banks can be susceptible to landslides in areas where steep hill slopes of weathered bedrock, glacial till, or volcanic-ash parent materials abut the channel. The dominant substrate varies from boulder, cobble, or bedrock with pockets of sand/gravel/cobble.

Channel Responsiveness
The presence of confining terraces or hill slopes and control elements such as bedrock limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a modest magnitude.

Riparian and Instream Enhancement Opportunities
These channels are not highly responsive and in channel enhancements may not yield intended results. In basins where water temperature problems exist, the confined nature of these channels lends itself to establishment of riparian vegetation. In non-forested lands, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

Moderate Gradient Moderately Confined Channel: MM
This group includes channels with variable controls on channel confinement. Alternating valley terraces and/or adjacent mountain slope, foot slope, and hillslope land forms limit channel migration and floodplain development. Similar to the LM channels, a narrow floodplain is usually present and may alternate from bank to bank. Bedrock steps with cascades may be present. The dominant substrate is gravel to small boulder.

Channel Responsiveness
The unique combination of a narrow floodplain and hillslope or terrace acts to produce channels that are often the most responsive in a basin. The combination of higher gradients and the presence of a floodplain set the stage for a dynamic channel system. Multiple roughness elements such as bedrock, large boulders, or wood may be common, resulting in a variety of aquatic habitats within the stream network.

Riparian and Instream Enhancement Opportunities
Like floodplain channels, these channels are among the most responsive of channel types. Unlike floodplain channels, however, the presence of confining land form features improves the accuracy of predicting channel response to activities that may affect channel form. Additionally, these controls help limit the destruction of enhancement efforts, a common problem in floodplain channels. The slightly higher gradients give a bit more uncertainty as to the outcome of enhancement efforts as compared to LM channels. MM channels, however, are often good candidates for enhancement efforts.

In forested basins, habitat diversity can often be enhanced by the addition of roughness elements such as wood or boulders. Pool frequency and depth may increase as well as side-channel development as the result of these efforts. Channels of this type in nonforested basins are often responsive to bank stabilization efforts such as riparian planting and fencing.

Beavers are often present in the smaller streams of this channel type. Fish habitat in some channels may benefit from beaver introduction through side-channel and scour pool development. Introduction of beavers, however, may have significant implications for overall channel form and function, and should be thoroughly evaluated by land managers as well as biologists as a possible enhancement activity.

Moderate Gradient Confined Channel: MC

Moderate Gradient Confined Channels flow through narrow valleys with little river terrace development, or are deeply incised into valley floors. Hill and mountain slopes composing the valley walls may lie directly adjacent to the channel. Bedrock steps, short falls, cascades, and boulder runs may be present; these are usually sediment transport systems. Moderate gradients, well-contained flows, and large-particle substrate indicate high stream energy. Landslides along channel side slopes may be a major sediment contributor in unstable basins. The dominant substrate is coarse gravel to bedrock.

Channel Responsiveness

The presence of confining terraces or hill slopes and control elements such as bedrock substrates limits the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a modest magnitude.

Riparian and Instream Enhancement Opportunities

These channels are not highly responsive. In-channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from controlling livestock access.

Moderate Gradient Headwater Channel: MH

These moderate-gradient headwater channels are common to plateaus in Columbia River basalts, young volcanic surfaces, or broad drainage divides. They may be sites of headwater beaver ponds. These channels are similar to LC channels, but occur exclusively in headwater regions. They are potentially above the anadromous fish zone.

These gentle to moderate headwater streams generally have low streamflow volumes and, therefore, low stream power. The confined channels provide limited sediment storage in low-gradient reaches. Channels have a small upslope drainage area and limited sediment supply. Sediment sources are limited to upland surface erosion. The dominant substrate varies from sand to cobble or bedrock. Boulders may be present from erosion of surrounding slopes and soils.

Channel Responsiveness

The low stream power and presence of confining terraces or hill slopes and control elements such as bedrock substrates limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a moderate magnitude.

Riparian and Instream Enhancement Opportunities

These channels are moderately responsive. In basins where water temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In nonforested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from controlling livestock access.

Moderately Steep Narrow Valley Channel: MV

MV channels are moderately steep and confined by adjacent moderate to steep hill slopes. High flows are generally contained within the channel banks. A narrow floodplain, one channel width or narrower, may develop locally.

MV channels efficiently transport both coarse bedload and fine sediment. Bedrock steps, boulder cascades, and chutes may be common features. The large amount of bedrock and boulders create stable streambanks; however, steep side slopes may be unstable. Large woody debris is found commonly in debris jams that trap sediment. The dominant substrate varies from small cobble to bedrock.

Channel Responsiveness

The gradient and presence of confining terraces or hill slopes and control elements such as bedrock substrates limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is localized and of a minor magnitude.

Riparian and Instream Enhancement Opportunities

These channels are not highly responsive, and in channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In nonforested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

Steep Narrow Valley Channel: SV and Very Steep Headwater: VH

These two channel types are very similar, except that VH channels are steeper. Because of this similarity, they are presented together. SV channels are situated in a constricted valley bottom bounded by steep mountain or hill slopes. Vertical steps of boulder and wood with scour pools, cascades, and falls are common. VH channels are found in the headwaters of most drainages or side slopes to larger streams, and commonly extend to ridge-tops and summits. These steep channels may be shallowly or deeply incised into the steep mountain or hill slope. Channel gradient may be variable due to falls and cascades. The dominant substrate varies from large cobble to bedrock.

Channel Responsiveness

The gradient and presence of confining terraces or hill slopes and control elements, such as bedrock substrates, limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is localized and of a minor magnitude. These channels are also considered source channels supplying sediment and wood to downstream reaches, sometimes via landslides.

Riparian and Instream Enhancement Opportunities

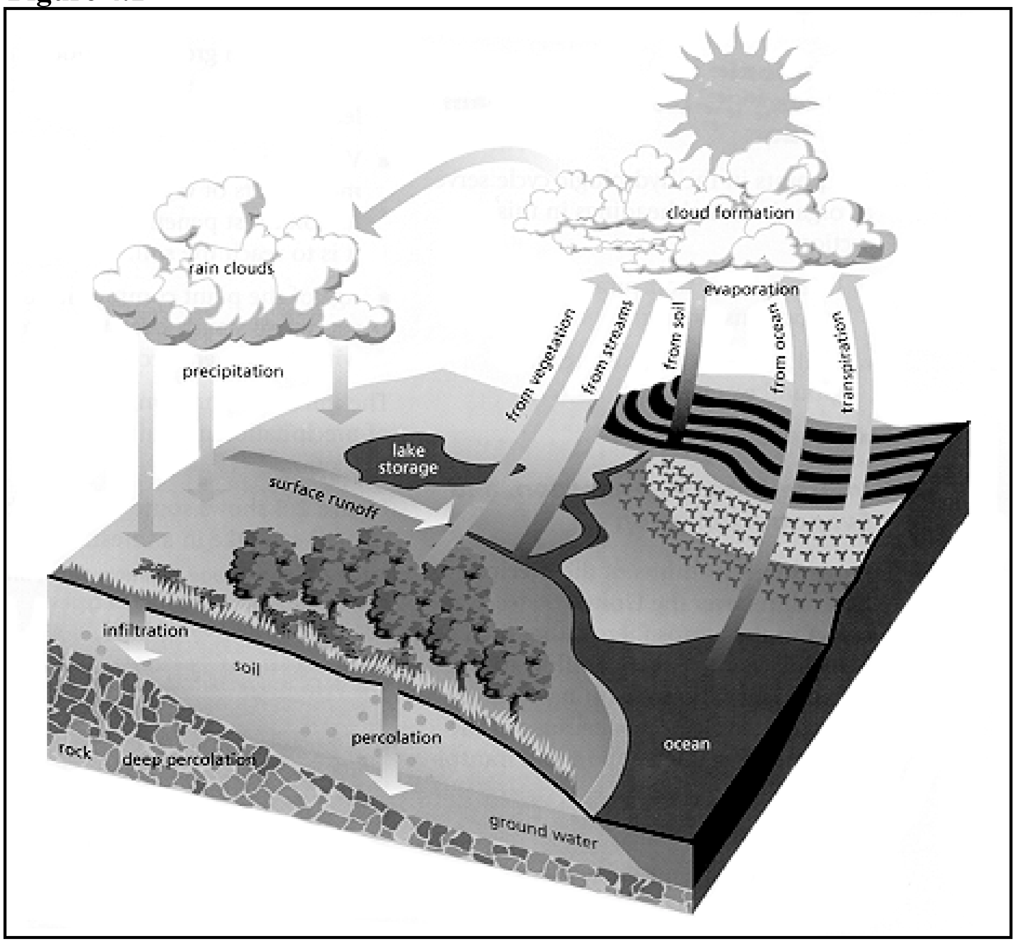
These channels are not highly responsive and in-channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. This may also serve as a recruitment effort for LWD in the basin.

Chapter 4: Hydrology and Water Use

Introduction
The purpose of this component is to evaluate the major potential impacts of land and water use practices on the hydrology of the Willow Creek watershed. Alterations to the natural hydrologic cycle can potentially change peak flows and/or low flows. Depending on the alteration, water quality and aquatic ecosystems can be positively or adversely affected.

Background
To understand how water moves through a watershed, from ridgetop to mouth of stream and back, it is important to review the hydrologic cycle. **Figure 4.1** demonstrates the hydrologic cycle.

Figure 4.1



source: <u>Stream Corridor Restoration: Principles, Processes, and Practices</u>

Surface water
Surface water is fed by runoff from precipitation or groundwater seepage. Groundwater seepage occurs to streams when the ground water elevation is higher than the stream, resulting in a **hydraulic gradient** from the ground to the surface, due to the water table level and flow levels.

Groundwater
Groundwater is water held underground by soils and rock. As water infiltrates, it migrates vertically to the groundwater table. The amount of water held in the groundwater is dependent upon precipitation, hydraulic gradient, and void space in the soils or rock. During times of low flows, groundwater may supply water to stream channels. During high flows, groundwater can be recharged from nearby stream channels.

Storage
Water storage can occur through manmade or natural conditions. Types of natural storage include snowpack, ponds, and wetlands. Manmade storage includes reservoirs and ponds.

Peak Flows
Peak flows are the highest flow of water in a stream in a given year, and are not necessarily floods. Spring snowmelt or the occasional rain-on-snow event result in peak flows in the Willow Creek watershed. However, precipitation is not the only factor influencing peak flows. Human changes in the landscape can cause areas to drain more rapidly than naturally, resulting in a higher, earlier peak flow. Human created storage can also cause areas to retain water further in the season, thereby decreasing the intensity and extending the duration of peak flows.

Low Flows
Low flows are the period of lowest flows of water in a stream in a given year. In the Willow Creek watershed, low flows generally occur between July and September. Low flows affect water quality, as there is less water in a stream to dilute pollutants. Less water also heats more rapidly, contributing to increases in water temperature. Usually, the months when low flows occur are the months that irrigated crops require the most water.

Land Uses' Potential Effects on Hydrology

Forestry practices can result in the removal of vegetative cover, compaction of soils, road building, and culvert installation. Removing vegetative cover can lead to a short-term decrease in **evapotranspiration** and increased seasonal run-off (WPN 1999). Forestry practices can also have neutral to positive effects on the hydrology of an area.

Grazing alters plant community composition and can affect soil characterisitics. Both can adversely affect infiltration rates, thus increasing runoff. Surface runoff is the most common type of runoff on grazed lands (WPN 1999).

Agriculture can also dramatically affect stream flows. Farming can alter runoff rates on soils, depending upon the soil type and the agricultural practices. Agriculture has a greater effect on naturally highly permeable soils, as it can reduce the infiltration rates of the soil. In soils that are naturally of low permeability, this effect is much smaller (WPN 1999). Certain agricultural practices can increase infiltration rates, such as increasing organic matter in the soil.

Leveling and field drainage have resulted in the elimination of many wetlands and depressions that previously diffused flood peaks by providing detention storage (WPN 1999). These practices also have reduced infiltration opportunities, as surface and subsurface flows move faster into the channel network when not temporarily stored in wetlands and depressions.

Water removed from streams for irrigation can result in lower stream flows. Irrigation ditches increase the velocity of surface and subsurface flows, thereby reducing infiltration opportunities. Removal of groundwater for irrigation and other consumptive uses can alter water table levels and affect stream flows (WPN 1999).

Rural residential development can result in larger impervious surfaces, reduced infiltration, and increased surface runoff. Ditches, gutters, and roads divert and route precipitation to streams faster than infiltration into the soil (WPN 1999).

Water Use

Water Rights

In Oregon, all water is publicly owned. To remove surface water, a water right is necessary. Some methods of removing groundwater also require water rights. Water rights are managed by the Oregon Water Resources Department (OWRD). Water rights information, including maps of points of diversion and places of use, can be accessed on the ORWD website. For more information on water rights, contact the Union/Wallowa Watermaster.

Water Availability

Oregon Water Resources Department allocates current water rights based on water availability in their Water Availability Basins (WABs). A Water Availability Basin is an area of land that drains to the mouth of a stream, designated by OWRD for planning purposes. In the Willow Creek watershed there are three WABs, one for the land that drains to the mouth of Mill Creek, one for the land that drains to the mouth of Dry Creek, and one for the land that drains to the mouth of Willow Creek. **Map 4.3** shows the Water Availability Basins in the Willow Creek watershed.

For Water Availability Basins without historical streamflow data, a computer model is used to estimate water availability. As there have been no stream gages in the Willow Creek watershed, this is the method for measuring water availability in the watershed. The model uses drainage area, elevation, precipitation, and other characteristics to calculate natural stream flow.

OWRD defines water availability as the amount of water physically and legally available for future **appropriation**. It is calculated as “natural streamflow minus consumptive uses minus instream water rights”. Consumptive use is “any water use that causes a net reduction in stream flow”. It is calculated with the assumption that the nonconsumed water is returned to the stream from which it was diverted. In-stream water rights are “water rights held in trust by OWRD for the benefit of the people of Oregon to maintain water in-stream for public use.”

When calculating water availability for water appropriation, OWRD determines natural streamflow at two exceedance levels: 50% and 80%. Streamflow data from the base period (1958-1987) is used to calculate exceedance levels. At the 50% exceedance level, half the time the natural flows are above this value and half the time flows are below this value. Surface and ground water rights are allocated based on the 80% exceedance level (OWRD). In-stream and storage water rights are allocated using the 50% exceedance level (WPN 1999).

Water availability is calculated by the following formula:

water availability = natural streamflow (at the 50% or 80% level) - consumptive use of diverted water - in-stream rights

Methods

Data was gathered from a variety of sources. Caty Clifton, a hydrologist on the Umatilla National Forest, developed the estimated hydrograph for Willow Creek. Geological information was gathered from maps and communication with Oregon Department of Geology geologists. Water rights and water availability information was accessed on-line at www.wrd.state.or.us.

Results

Climate

Average annual precipitation varies within the watershed. The driest month is July and the wettest month is December (NOAA annual precipitation map). **Map 4.1** shows levels of annual precipitation in the Willow Creek watershed. **Table 4.1** shows precipitation, area and elevation by subwatershed.

Part of all four subwatersheds include the transient snow zone (3,000-5,000 feet). This is the area where rain-on-snow events will occur (pers. comm., Caty Clifton, UNF). A rain-on-snow event is a peak flow generating process that occurs during a quick warming in the late winter, where rain falls on snow and causes large-scale runoff. In years when rain-on-snow events occur, they are the primary peak-flow generating event. But rain-on-snow events do not occur every year. Most years, the peak-flow generating process is spring snowmelt, which usually occurs between March and May.

Streamflow data was analyzed at the gage near Elgin on the Grande Ronde River, just downstream of Willow Creek for rain-on-snow occurences. Of the 27 years of data (1955-1981), there were 5 years where rain-on-snow peak flow events in winter (Dec, January, early February) exceeded the later spring snowmelt peak flows in discharge (cfs).

Map 4.1: Precipitation Map of the Willow Creek Watershed

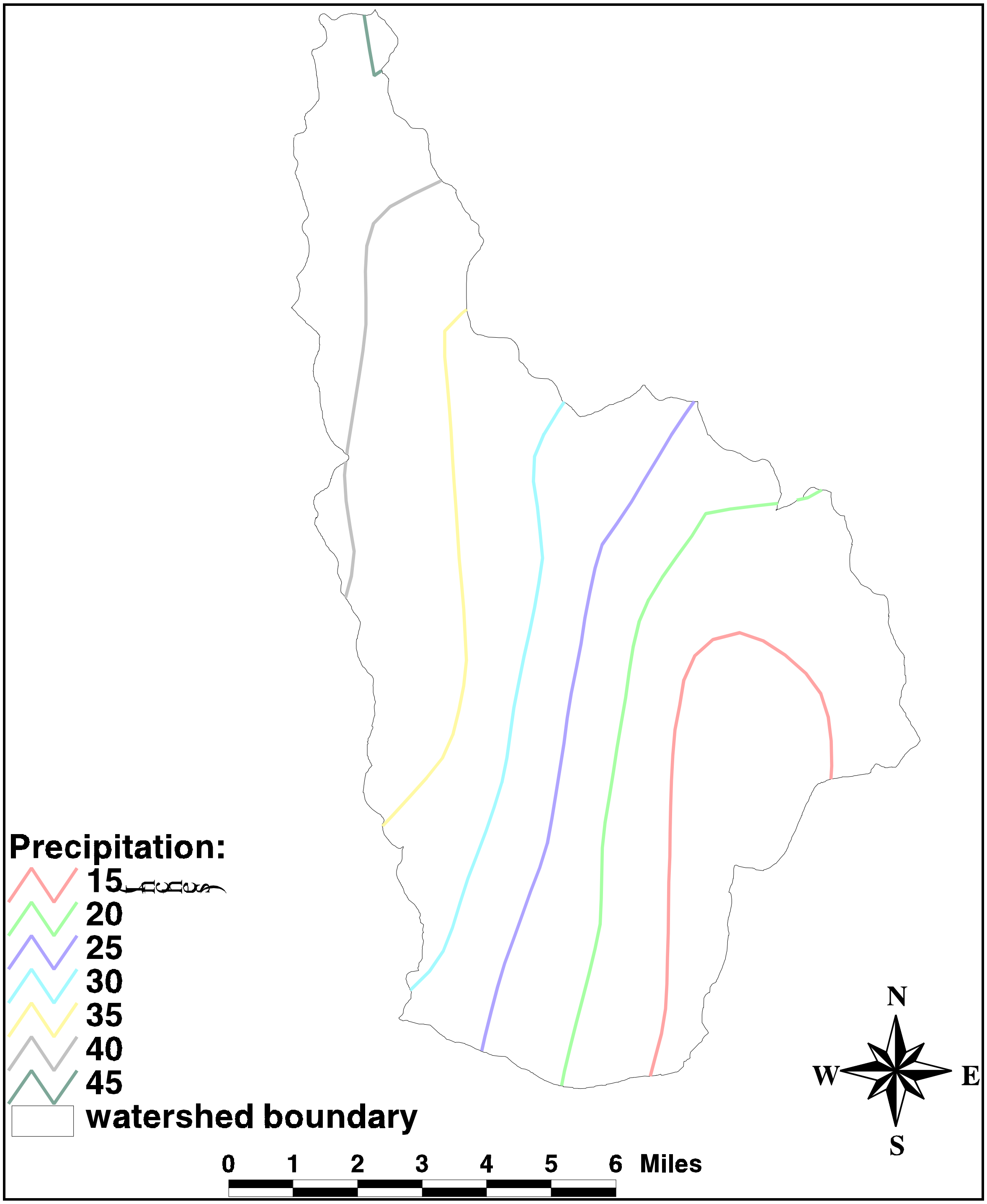


Table 4.1: Area, Elevation, and Annual Precipitation by Subwatershed

Subwatershed	Area (mi^2)	Minimum Elevation (ft)	Maximum Elevation (ft)	Mean Annual Precipitation (in)
Lower Willow Creek	23.9	2760	3280	20-40
South Fork Willow Creek	18.9	2700	6100	under 20
Upper Willow Creek	17.5	2700	5700	20-40
Dry Creek	22.7	2720	4600	20-40

sources: USGS topographic maps and NOAA annual precipitation map

Geology

Map 4.2 shows the geology of the Willow Creek watershed. Fault lines are included in the map. It can be speculated that the fault line along the length of Dry Creek is the reason the creek is seasonally dry (pers. comm., Mark Ferns, DOGAMI). The fault may act as a sink for the water, causing it to enter the fault and leave both the groundwater and surface water systems.

Springs and seeps are common in the Willow Creek watershed. Many are the result of water stored in between basalt layers coming to the surface as the basalt erodes. As the sides of these ridges erode, they do so in a stairstep fashion, with the permeable rock exposed horizontally. It is here along the sides of ridges around the Grande Ronde valley that springs are located (pers. comm., Vicky McConnell, DOGAMI.).

Stream Density

Table 4.2 shows stream density (# stream miles/area) by subwatershed in Willow Creek watershed. These densities were calculated from the EPA 1:100,000 stream layer, which does not include all the small streams in the upper watershed, nor the artifical stream miles of irrigation ditches. Stream density can indicate the potential infiltration and runoff of an area.

Stream Flow

One way to summarize and display hydrologic information is through the development of a hydrograph. A hydrograph is the plot of streamflow over time. Streamflow is measured by stream gages placed in streams at specific locations. Where there is no stream gage, it is possible to create a representative hydrograph for the stream in question. Within the same basin, another stream of similar topography and drainage area that has a stream gage may be used instead.

Map 4.2: Geology of the Willow Creek Watershed

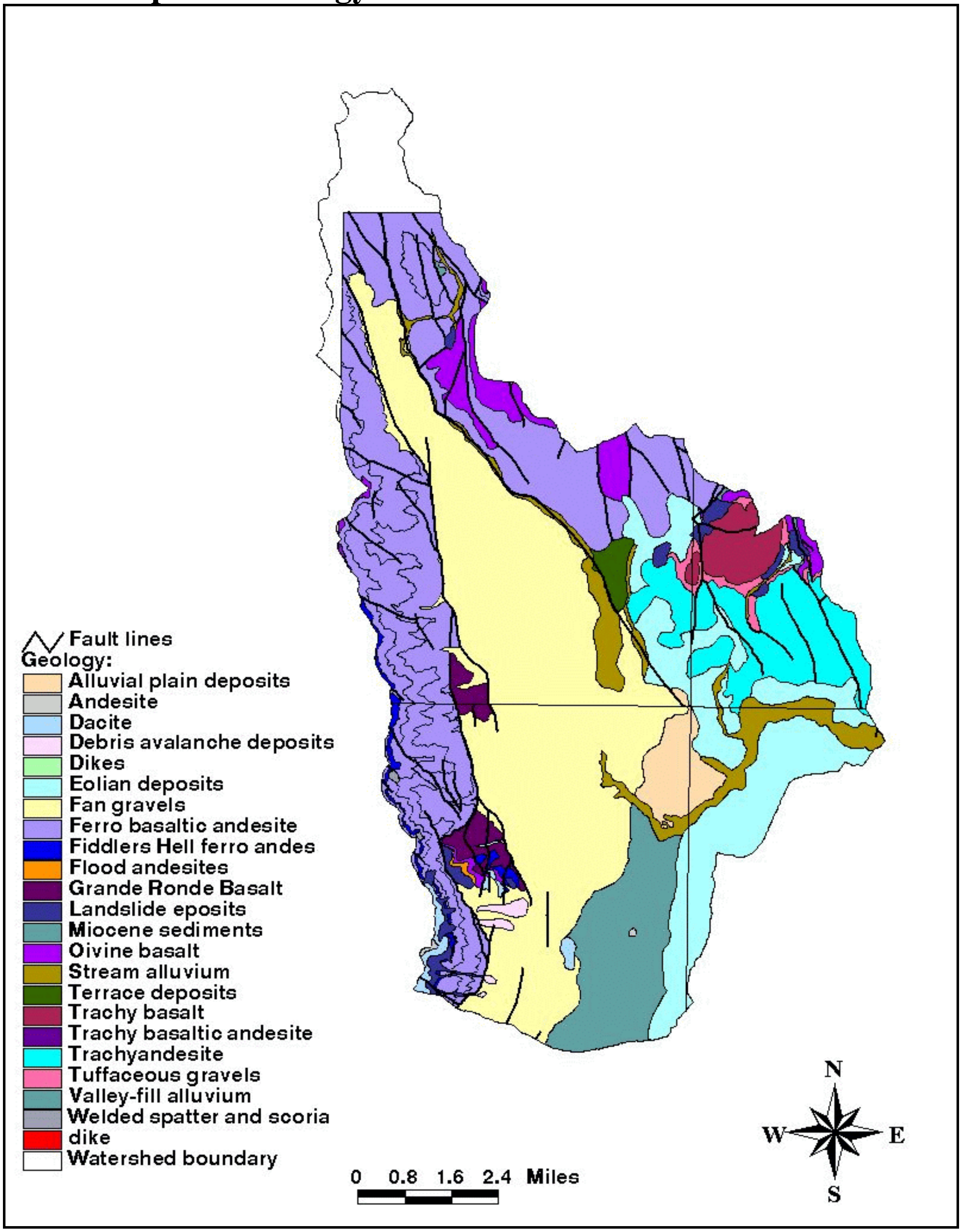


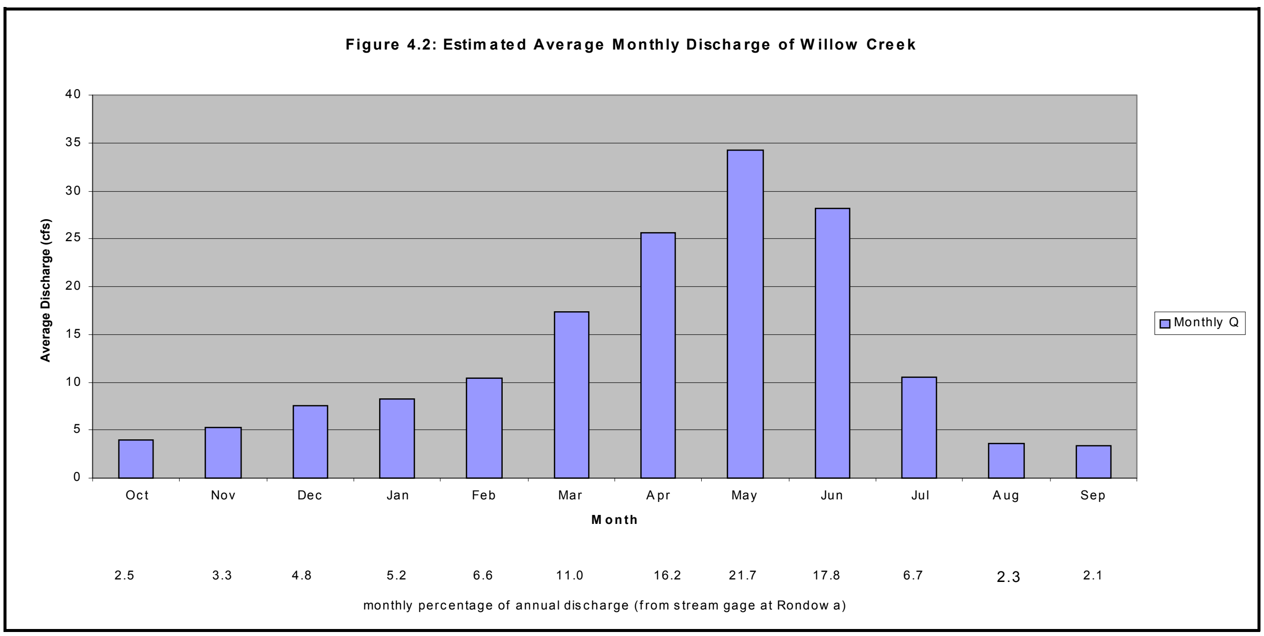
Table 4.2: Stream Density

Subwatershed	Stream Density (mi/mi^2)	Total Stream Miles
Dry Creek	1.42	32.2
S Fork Willow Creek	1.41	24.7
Lower Willow Creek	1.06	25.4
Upper Willow Creek	1.82	34.3
Total Watershed	1.40	116.6

source: EPA 1:100,000 Stream Layer

As Willow Creek has never had a stream gage, this method was used to generate its hydrograph. Nearby Indian Creek (drainage area = 22 mi^2; average unit discharge = 1.89cfsm^2) and Lookingglass Creek (drainage area = 78.3 mi^2; average unit discharge = 1.78 cfsm^2). Both have had stream gages and are of a similar drainage area and stream size. Their average unit discharges (average discharge divided by the drainage area) were averaged, as to minimize watershed-specific differences in drainage area and flow. The average cfs/year was multiplied by a percentage for each month, to generate the hydrograph over a year's time. The percentages per month were obtained from the statistical summaries calculated for the stream gage at Rondowa on the Grande Ronde River.

Figure 4.2 shows the generated hydrograph for Willow Creek. Monthly percentages used to calculate monthly discharges are listed at the bottom of the table. This is an estimated average hydrograph, which will only show the general characteristics of flow in the Willow Creek watershed. Peak flows are generated in late spring/early summer. Low flows generally occur during late summer to early fall.



Analysis of Hydrologic Impacts of Land Uses

Peak flows and low flows can be affected by land uses, as mentioned in the introduction of this component. This section includes basic analyses that measure the *potential* of various land uses to affect peak and low flows in the watershed.

Forestry

Historically, lower elevation forests in the watershed were open and park-like, with a species composition of large ponderosa pines. The **crown closure** (the amount of canopy cover in a given area) was historically less than 30% in these stands. In higher elevation forests, the species composition was a variety of conifers, and the forests were denser, with a crown closure greater than 30%.

Map 4.3 shows the current crown closure of forest stands in the Willow Creek watershed. As species composition in the once ponderosa pine forests has diversified to include other conifers, the crown closure has increased. Stands that have always been dense, mixed conifer forests for the most part, still have crown closures greater than 30%. Potential of crown closure to affect peak flows was analyzed using the Washington State Department of Natural Resources Interim Rain-on-Snow Rules. This process determines potential as low or at risk by looking at the percent of forestry land use area above rain-on-snow elevations and the percent of rain-on-snow area with less than 30% crown closure. About 50% of the forestry land use area is in the 3,000-5,000 feet rain-on-snow zone. In order for the rain-on-snow forested lands to affect peak flows, there would have to be 65% of those lands with less than 30% crown closure. There are only an estimated 20% of the forested lands in the rain-on-snow zone with less than a 30% crown closure, Therefore, the potential is **LOW** for the forested lands to be contributing to changes in peak flows in the Willow Creek watershed at this time.

Percent Equivalent Clearcut Acre (ECA) is a measurement used to estimate the effect of timber harvesting on the hydrology of a watershed. It is the "extent of harvested openings in a watershed, at some level above which increases in water yields and peak flows would be expected" (Phillips-Gordon Draft Ecosystem Analysis 2001). Equivalent clearcut acres were calculated for the Umatilla National Forest Phillips-Gordon Draft Ecosystem Analysis. The Dry Creek subwatershed's ECA was 4.1% and the Upper Willow subwatershed was 0%. As the level of concern for Equivalent Clearcut Acres is 15%, both of these subwatersheds are well under the level where timber harvest would detrimentally affect the hydrology of the area (Phillips-Gordon Draft Ecosystem Analysis 2001).

Agriculture and Range Lands

Agriculture is the major land use in the Willow Creek watershed, accounting for 45% of total acres. The most abundant crops types are: wheat, mint, grass seed, and sugar beets. Potential range lands (grasslands) in the watershed account for 21% of the acreage (ODF digital vegetation data).

The Natural Resources Conservation Service has calculated runoff curves for various agricultural and range practices, along with background curves of runoff for lands in natural condition. Runoff curves are dependent upon crop type/range use, hydrologic condition (poor or good), precipitation, and hydrologic soil group. Soil types are assigned a hydrologic soil group, depending upon infiltration rates. Hydrologic soil group (HSG) A has the highest infiltration rate and HSG D has the lowest infiltration rate.

Potential change in runoff was calculated for each agricultural and range practice in the Willow Creek watershed by comparing each practice's runoff curve with background curves. The background curves used were grassland in good hydrologic condition and woods in good hydrologic condition (for areas where forests were converted into farmland). **Appendix 4.1** details the results. The majority of crop and range land cultivation practices had a low or moderate potentials to cause a change in runoff that would affect peak flows in the watershed. Thus, the overall potential of agriculture and range land uses affecting peak flows in the Willow Creek watershed was **LOW TO MODERATE**. This is only a measurement of cultivation practices and their effects on the hydrology. It does not account for how irrigation ditches, tiling, land leveling, loss of wetlands, conversion of land from forest to crop land, and other changes in the watershed that have improved conditions for agriculture have affected the hydrology of the watershed. To understand these practices' effects on the watershed's hydrology would require a more in-depth analysis.

Roads

Road density in the Willow Creek watershed was calculated by multiplying road mileage by an average width of .0066 for county and private roads and an average width of .0047 miles for forest service roads. **Table 4.3** shows the total miles of roads and road density in the Willow Creek watershed, by subwatershed.

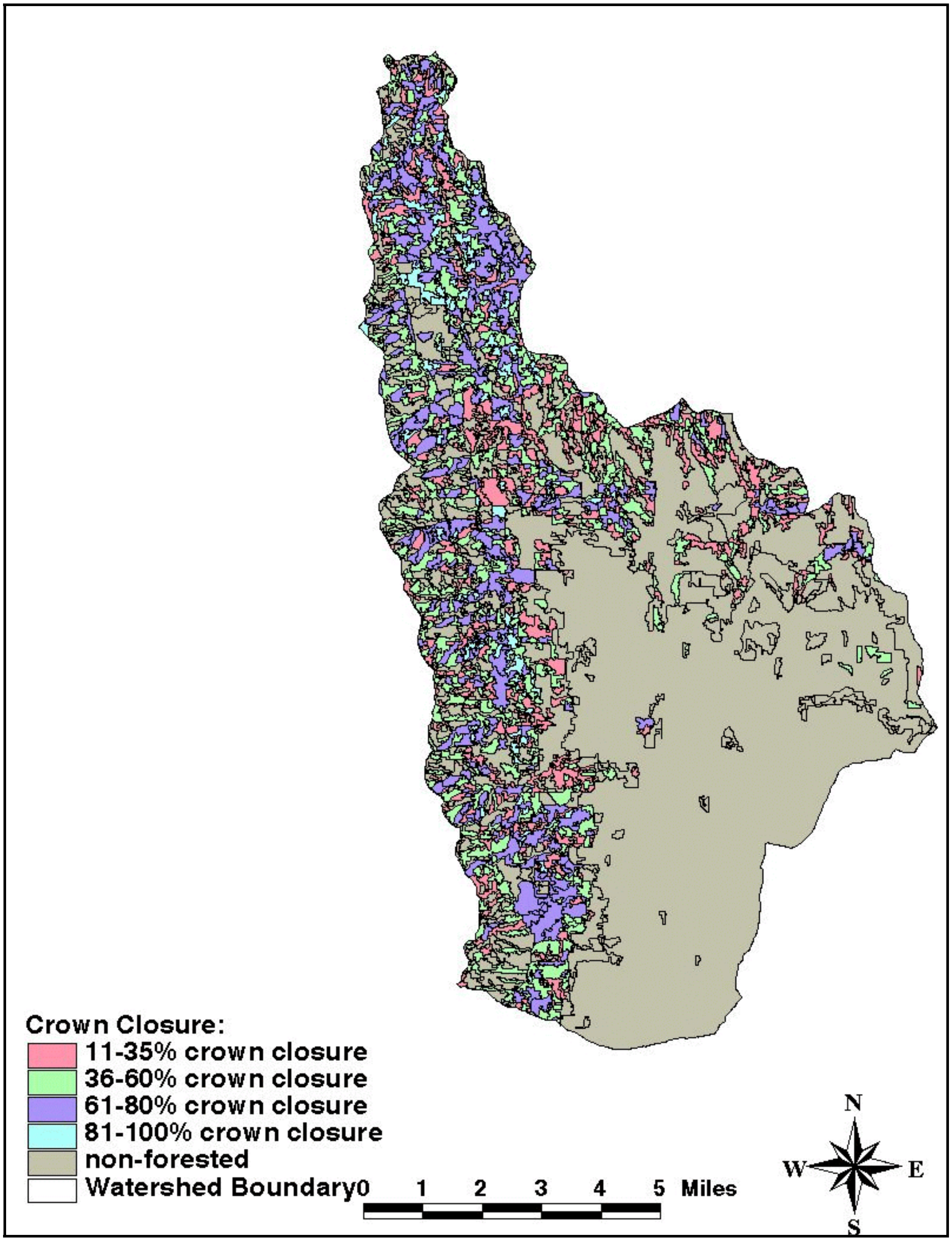
Table 4.3: Road Mileage in the Willow Creek Watershed

Subwatershed	Total Road Miles	Forest Service Road Miles	Road % of total Area	Total Road Area (mi^2)
Lower Willow Creek	42.7	0	1.2	0.3
South Fork Willow Creek	23.6	0.36	0.8	0.15
Upper Willow Creek	21.5	0.61	1.2	0.14
Dry Creek	50.3	26.94	0.8	0.28
Total Watershed	83	27.9	1.04	0.87

source: ODOT road shapefile data

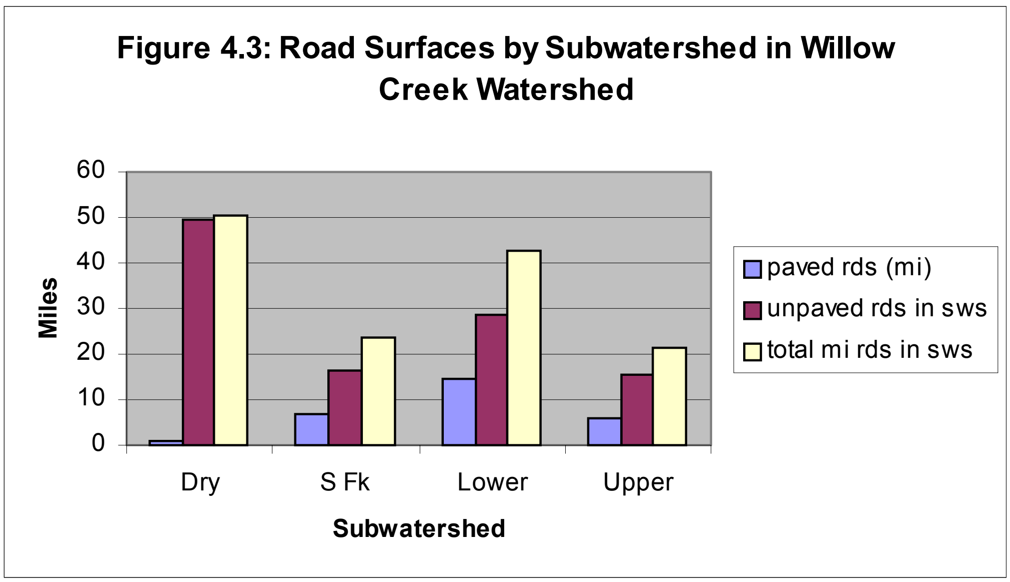
Road densities greater than 4% of total land area are considered to have the potential to affect runoff and peak flows (WPN 1999). As the Willow Creek watershed and each of its subwatersheds fall far below road densities of 4%, the potential that roads are influencing peak flows and runoff is **LOW**.

Map 4.3: Crown Closure of Forests in the Willow Creek Watershed



As infiltration rates and runoff patterns are affected by road surfaces, paved and unpaved road mileage was calculated. **Figure 43** shows paved and unpaved road mileage. Unpaved roads include both native surface and rock, which differ in infiltration rates.

Rural Residential
Impervious surface was calculated using the estimated acreage of Rural Residential (306 acres, 0.5% of watershed). Average lot size of the rural residential area was estimated at 1 acre, with a corresponding average impervious area of 20%. Percent of impervious surface in the Willow Creek watershed was determined to be 0.1%, with a corresponding **LOW** potential for affecting peak flows. Low potential is any watershed with an impervious surface of less than 5 percent (OWEB 1999).



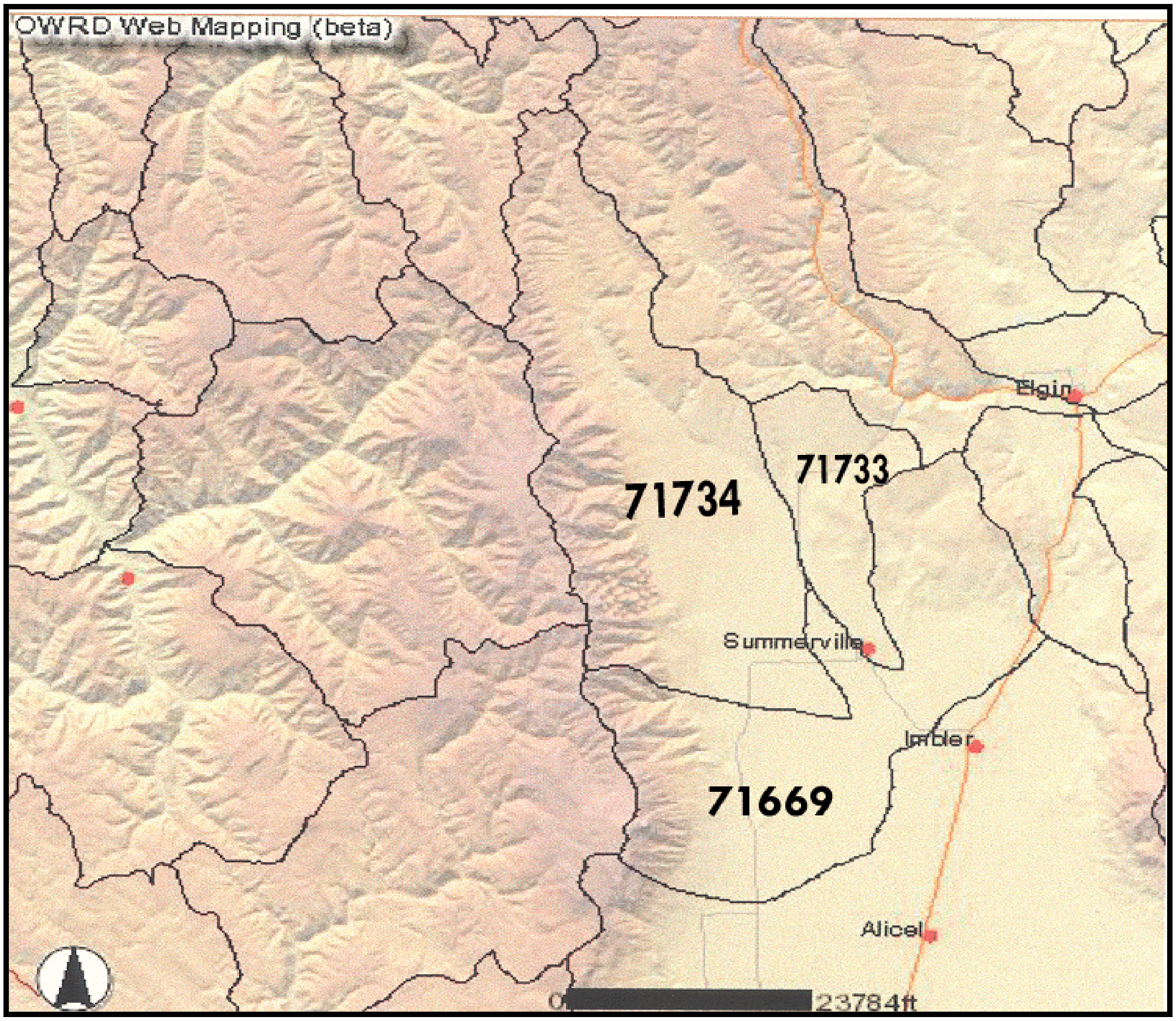
source: ODOT road shapefile data

Water Use
Types of consumptive uses in the Willow Creek watershed were obtained from the WARS database for each Water Availability Basin. **Table 4.4** show these uses in each WAB. In each WAB, irrigation is the primary consumptive use. **Map 4.4** shows the Water Availability Basins in the Willow Creek watershed.

Table 4.4: Consumptive Uses by Water Availability Basin in the Willow Creek Watershed

Water Avail. Basin	Irrigation	Domestic	Storage
71734 (Mill Creek)	98%	1%	1%
71669 (Willow Creek)	95%	1%	4%
71733 (Dry Creek)	100%	<1%	<1%

Map 4.4: Water Availability Basins in the Willow Creek Watershed



source: OWRD interactive mapping site

Water Availability
Water availability information at the 50% and 80% exceedance levels was obtained from the Water Availability Database System (WARS) at the OWRD website (www.wrd.state.or.us). **Figure 4.4-4.6** graph water availability and natural stream flow for each WAB at the 80% exceedance level. Note that both in-stream water rights and consumptive uses are the difference in cfs between water availability and natural streamflow. Where water availability goes negative, water rights are over-allocated.

Figure 4.4: Water Availability and Natural Streamflow in WAB 71669 (Willow Creek)

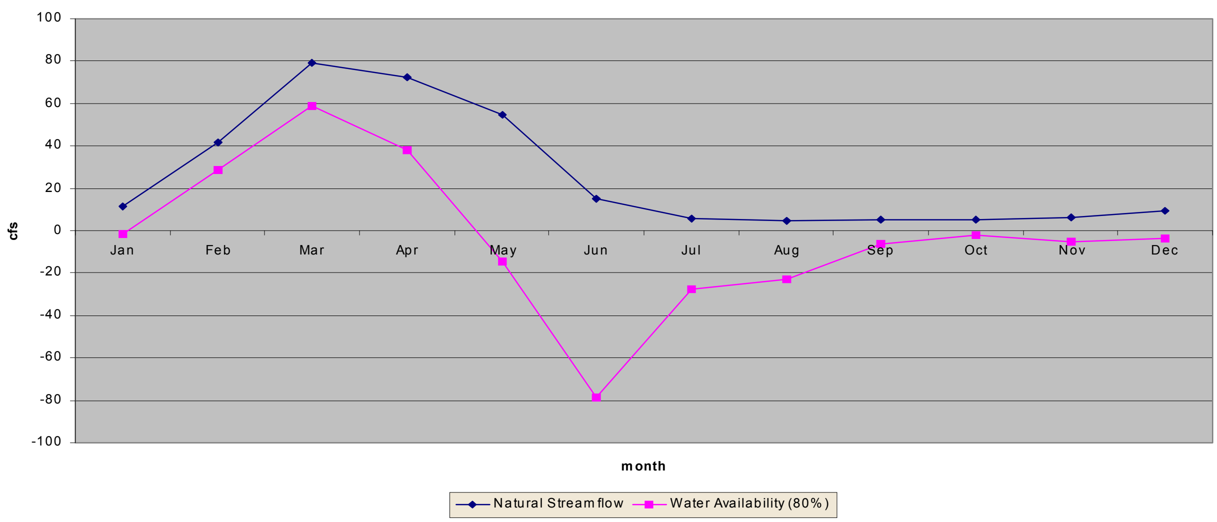
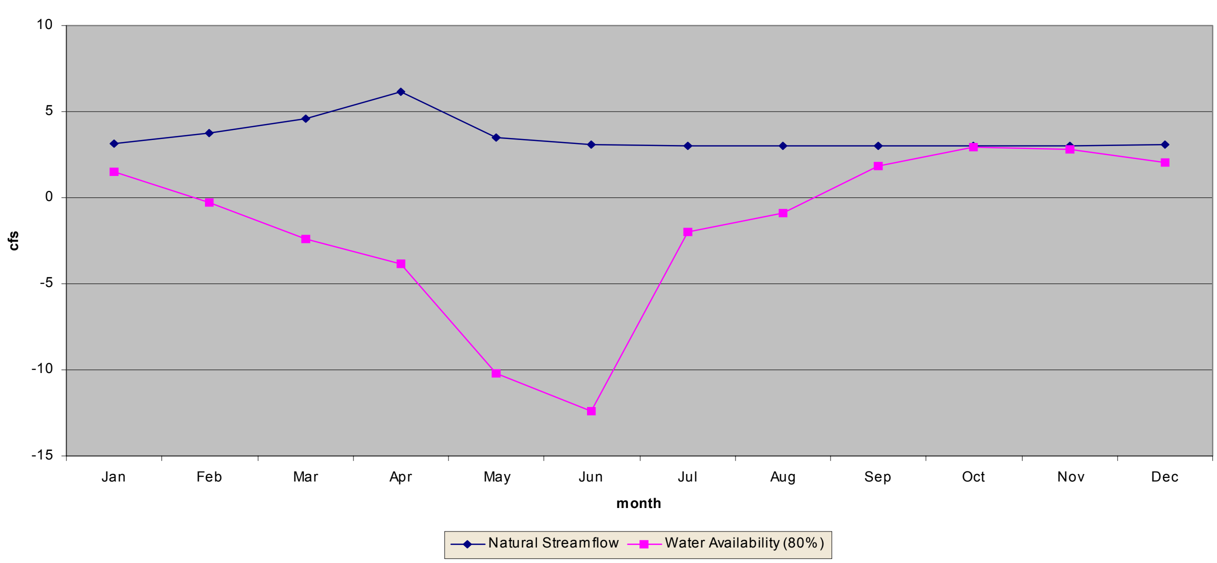
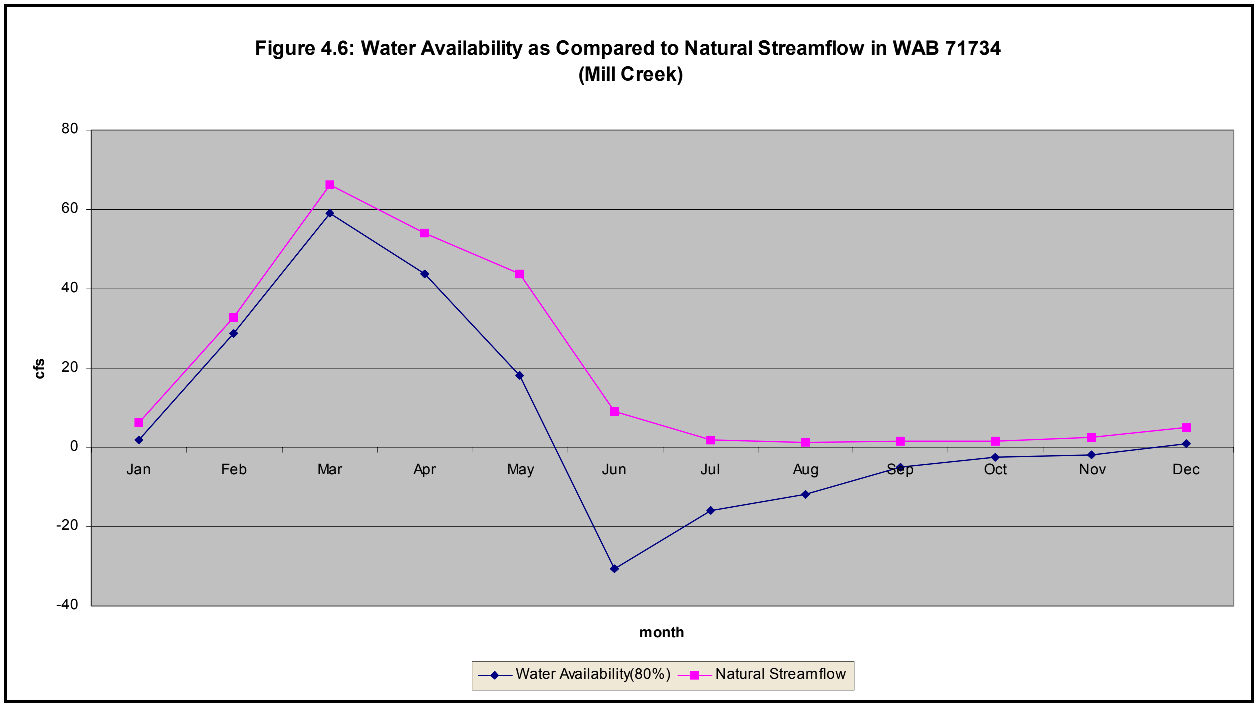


Figure 4.5: Water Availability and Natural Stream Flow in WAB 71733 (Dry Creek)





Discussion

Climate, soils, and geology are major determinants of the natural hydrology of a watershed. Since the majority of precipitation in the Willow Creek watershed occurs as snow, snow melts are the cause of peak flows. The period of low flows occurs during summer months when there is little precipitation. There are also a number of springs in the watershed located in the transitional area between mountain and valley along the Mt. Emily face and Pumpkin Ridge. Some of these springs, such as Sanderson Springs at the headwaters of Mill Creek, provide cool, clear water to the stream system year round. Others are seasonal springs, releasing water during the late winter and early spring months. The flat valley floor has low infiltration rates in the soils around Willow Creek and lower Mill and Dry Creeks. Thus, during peak flows in the spring, water is not rapidly absorbed into the soils, instead flooding bottomlands in the valley. **Map 2.1** from *Chapter 2: Historical Conditions* shows the area of the Willow Creek watershed that historically has flooded in the spring. This water is eventually absorbed into the soil, creating a "sponge effect". During periods of low flows, this subsurface water is released into surface flows, as the hydraulic gradient has reversed. Since subsurface water is cooler than water heated by solar radiation and ambient temperature, contributing subsurface water during low flows can cool water temperatures. Both springs and subsurface water stored in the soil are examples of cool water sources during low flows.

Land uses have affected the hydrology of Willow Creek through changing soil infiltration rates, the relationship between ground and surface waters, and diminishing already natural low flows. Given that there were many historical wetlands in the bottomlands of Willow Creek (see *Chapter 6: Wetlands*), the subsequent draining and tiling of these lands has dramatically changed the length of time soils are saturated, thereby reducing groundwater recharging in the spring. Land drainage not only limits water being absorbed by soil, but also adds water to the stream system

earlier than historically, which can cause increases in peak flow discharges.
Of the land use effects on hydrology assessed in this chapter, all, except agriculture, had low potentials to affect peak flows in the watershed. Change in crown closure over time has probably not affected peak flows, as there is currently denser crown closure than historically and the amount of ECAs is small. Other forest activities have likely affected the hydrology, such as the conversion of forest to crop land and road building, but they have not been assessed in this document. Road densities are low, thereby having a low potential to affect peak flows. Still, road ditches change how water flows through a watershed and do affect a watershed's hydrology. Rural residential lands in the watershed have a relatively small impervious area, thus not affecting overall hydrology. Agriculture and range lands had a low to moderate potential to affect peak flows. Agriculture and range lands were assessed only by the difference in runoff rates due to crop and grass management practices, not in how irrigation and land drainage have effected the hydrology. These are much more difficult to quantify, especially given the lack of data, but are probably the land use activities that have most greatly impacted the watershed's hydrology.

Water is primarily used for irrigation, with some allocated for domestic uses. As shown by OWRD's Water Availability modeling, water is over-allocated from May-September, meaning that there are more water rights than there is flow in the stream system. As these months include months of low flow (July-September), water uses in the Willow Creek watershed *are* affecting low flows. Each water availability basin in the watershed has in-stream water rights allocated for fish habitat, but as these rights date to only 1991, in periods of low flow senior water rights take precedence. Thus, flows can, and do, drop below in-stream water rights allocated for remaining in the streams.

Data Gaps

- flow data
- historical hydrological information
- miles of private and county roads

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Appendix 4.1: Analysis of Agricultural and Range Lands for Potential Change in Peak Flow

Cover Type/Conservation Practice/Hydrologic Condition/HSG	Runoff Curve #	Background	Backgr. Runoff Curve #	Rainfall, Lower Range (in)	Rainfall, Upper Range (in)	Runoff Depth, Lower Range	Runoff Depth Upper Range	Runoff Depth, Backgr., Lower Range	Runoff Depth Backgr., Upper Range	Change in Runoff, Range	Potential to Affect Peak Flows
Previously Forested, Now Cultivated/Range Land											
Row Crop/Straight Row/Poor/B	81	Woods Good B	55	1.4	1.8	0.24	0.44	0	0	0.24-0.44	Moderate
Row Crop/Straight Row/Good/B	78	Woods Good B	55	1.4	1.8	0.24	0.44	0	0	0.24-0.44	Moderate
Row Crop/Straight Row/Poor/C	88	Woods Good C	70	1.4	1.8	0.61	0.93	0.06	0.17	0.55-0.76	Moderate
Row Crop/Straight Row/Good/C	85	Woods Good C	70	1.4	1.8	0.39	0.65	0.06	0.17	0.33-0.48	Moderate
Small Grain/Straight Row/Poor/B	76	Woods Good B	55	1.4	1.8	0.13	0.29	0	0	0.13-0.29	Low
Small Grain/Straight Row/Good/B	75	Woods Good B	55	1.4	1.8	0.13	0.29	0	0	0.13-0.29	Low
Small Grain/Straight Row/Poor/C	84	Woods Good C	70	1.4	1.8	0.39	0.65	0.06	0.17	0.33-0.48	Moderate
Small Grain/Straight Row/Good/C	83	Woods Good C	70	1.4	1.8	0.39	0.65	0.06	0.17	0.33-0.48	Moderate
Pasture, grassland, or range/Poor/B	79	Woods Good B	55	1.4	1.8	0.24	0.44	0	0	0.24-0.44	Moderate
Pasture, grassland, or range/Fair/B	69	Woods Good B	55	1.4	1.8	0.06	0.17	0	0	0.06-0.17	Low
Pasture, grassland, or range/Good/B	61	Woods Good B	55	1.4	1.8	0	0.03	0	0	0-0.03	Low
Pasture, grassland, or range/Poor/C	86	Woods Good C	70	1.4	1.8	0.39	0.65	0.06	0.17	0.33-0.48	Moderate
Pasture, grassland, or range/Fair/C	79	Woods Good C	70	1.4	1.8	0.24	0.44	0.06	0.17	0.18-0.27	Low
Pasture, grassland, or range/Good/C	74	Woods Good C	70	1.4	1.8	0.13	0.29	0.06	0.17	0.07-0.12	Low
Previously Grassland, Now Cultivated/Range Land											
Row Crop/Straight Row/Poor/B	81	Herbaceous/Good/B	62	1.4	1.8	0.24	0.44	0	0.03	0.24-0.41	Moderate
Row Crop/Straight Row/Good/B	78	Herbaceous/Good/B	62	1.4	1.8	0.24	0.44	0	0.03	0.24-0.41	Moderate
Row Crop/Straight Row/Poor/C	88	Herbaceous/Good/C	74	1.4	1.8	0.61	0.93	0.13	0.29	0.48-0.64	Moderate
Row Crop/Straight Row/Good/C	85	Herbaceous/Good/C	74	1.4	1.8	0.39	0.65	0.13	0.29	0.26-0.36	Moderate
Small Grain/Straight Row/Poor/B	76	Herbaceous/Good/B	62	1.4	1.8	0.13	0.29	0	0.03	0.13-0.26	Low
Small Grain/Straight Row/Good/B	75	Herbaceous/Good/B	62	1.4	1.8	0.13	0.29	0	0.03	0.13-0.26	Low
Small Grain/Straight Row/Poor/C	84	Herbaceous/Good/C	74	1.4	1.8	0.39	0.65	0.13	0.29	0.26-0.36	Moderate
Small Grain/Straight Row/Good/C	83	Herbaceous/Good/C	74	1.4	1.8	0.39	0.65	0.13	0.29	0.26-0.36	Moderate
Pasture, grassland, or range/Poor/B	79	Herbaceous/Good/B	62	1.4	1.8	0.24	0.44	0	0.03	0.24-0.41	Moderate
Pasture, grassland, or range/Fair/B	69	Herbaceous/Good/B	62	1.4	1.8	0.06	0.17	0	0.03	0.06-0.14	Low
Pasture, grassland, or range/Good/B	61	Herbaceous/Good/B	62	1.4	1.8	0	0.03	0	0.03	0	Low
Pasture, grassland, or range/Poor/C	86	Herbaceous/Good/C	74	1.4	1.8	0.39	0.65	0.13	0.29	0.26-0.36	Moderate
Pasture, grassland, or range/Fair/C	79	Herbaceous/Good/C	74	1.4	1.8	0.24	0.44	0.13	0.29	0.09-0.15	Low
Pasture, grassland, or range/Good/C	74	Herbaceous/Good/C	74	1.4	1.8	0.13	0.29	0.13	0.29	0	Low

rainfall was estimated from NOAA 2 yr 24 hr precipitation map, runoff curves used were calculated by the NRCS and obtained from the OWEB Watershed Assessment manual, background curve used was "Herbaceous-mixture of grass, weeds, and low-growing brush, with brush the minor element" in Good hydrologic condition

Chapter 5: Riparian Areas

Introduction
This chapter describes current conditions of riparian areas in the Willow Creek watershed as compared with potential riparian ecosystem for the purpose of identifying restoration opportunities.

Background
Riparian vegetation, or the plant communities along streams and rivers, plays many important roles in aquatic ecosystems. It shades streams, keeping water temperatures from warming. It furnishes cover for fish populations, dissipates stream velocity, stabilizes stream banks, helps filter pollutants and sediments, and provides food and habitat for many aquatic and terrestrial animals. During peak flows, riparian vegetation may slow and dissipate floodwater energies, thereby preventing streambank and bed erosion (WPN 1999). Riparian vegetation can provide a buffer between aquatic ecosystems and adjacent land uses.

By measuring riparian vegetation cover, the amount of shade and potential recruitment for large woody debris (LWD) can be estimated. Large woody debris, which includes dead trees, root wads, and large limbs, is important to stream structure and fish habitat. When dead trees or limbs enter the stream system, water flow patterns are changed and pools are created. These pools capture gravel and sediment and provide sheltered habitats for fish and other aquatic species.

Methods
Aerial photographs taken in July of 1997 for the Oregon Department of Forestry were the primary source used to measure riparian cover. Stream banks were divided into numerous Riparian Condition Units (RCU), where the amount of riparian vegetation and adjacent land uses were relatively constant throughout each individual unit. For each RCU, the following parameters and descriptions of the unit and stream were also noted: RCU number; bank (right or left); length of RCU; stream name; subwatershed; ecoregion; channel habitat types; stream size; width of vegetation directly along streambanks; discontinuities due to land use; riparian recruitment situation; level of shade; and vegetation. Some field checking was made to ensure correct identification of vegetation. This data should only be used as a general overview of riparian conditions in the watershed.

Materials used in the riparian assessment were:
- 1997 ODF aerial photos of private lands in the Willow Creek watershed
- map wheel (for measuring stream length)
- stereoscope (for viewing aerial photos)
- USGS topographic maps
- ODFW habitat surveys

Shade was measured in terms of low, medium, and high, as determined by the OWEB assessment manual. Low shade is where the stream surface is visible and banks are entirely visible or visible at times (<40%). Medium shade is where the stream surface is visible, but the banks are not visible (40-70%). High shade is where the stream surface in not visible, is slightly visible, or is visible in patches (>70%).

Riparian vegetation was measured in terms of abundance (sparse/dense), size (small, medium, large **diameter breast height**), and dominant species (herbaceous/grasses, brush, hardwood, conifer, mixed species (conifer/hardwood). Results of vegetation were simplified, thus excluding size of dominant vegetation. Full detail can be found in the tables and corresponding maps of individual riparian condition units available at the Grande Ronde Model Watershed Program office.

Habitat surveys conducted on Willow, Dry, and Mill Creeks by the Oregon Department of Fish and Wildlife in 1995 were obtained and the sections pertaining to large woody debris and stream shading were included in the results section.

Results

Riparian conditions were measured on the three main streams (Willow, Dry, and Mill) in the Willow Creek watershed. A total of 112 units were assessed for a total of 22.7 stream miles. Mill Creek was measured from the mouth to Sanderson Springs (6.3 miles). The entire length of Willow Creek was assessed (8.54 miles). The lower 7.9 miles of Dry Creek were surveyed,from the mouth to Moonshine Canyon.

Table 5.1 shows the results of the amount of shade on each stream (Willow, Mill, and Dry). Dry Creek was surveyed in two sections, as one section was in agricultural land and another in forested land.

Table 5.1: Amount of Shade along Willow, Mill, and Dry Creeks

Shade category	Willow Creek	Mill Creek	Dry Creek (agricult. land)	Dry Creek (forested land)
High (>70%)	0%	14%	14%	27%
Medium (40-70%)	5%	43%	16%	73%
Low (<40%)	95%	43%	70%	0%
Total	100%	100%	100%	100%

Table 5.2 shows the amount of different vegetation types along Mill, Willow, and Dry Creeks.

Table 5.2: Vegetation Types on Willow, Mill, and Dry Creeks

Vegetation	Willow Creek	Mill Creek	Dry Creek (agricult. land)	Dry Creek (forested land)
herbaceous/grasses	86%	20%	7%	0%
sparse brush	14%	24%	43%	0%
sparse hardwood	0%	5%	27%	29%
sparse mixed trees	0%	0%	8%	23%
sparse conifer	0%	0%	0%	31%
dense brush	0%	46%	15%	0%
dense hardwood	0%	5%	0%	0%
dense mixed trees	0%	0%	0%	17%
dense conifer	0%	0%	0%	0%
total vegetation	100%	100%	100%	100%

Figure 5.1 shows the percentage of open sky along Willow, Dry, and Mill Creeks. This information is taken from the 1995 ODFW Habitat Survey.

Figure 5.1: Percentage of Open Sky, 1995 ODFW Habitat Survey

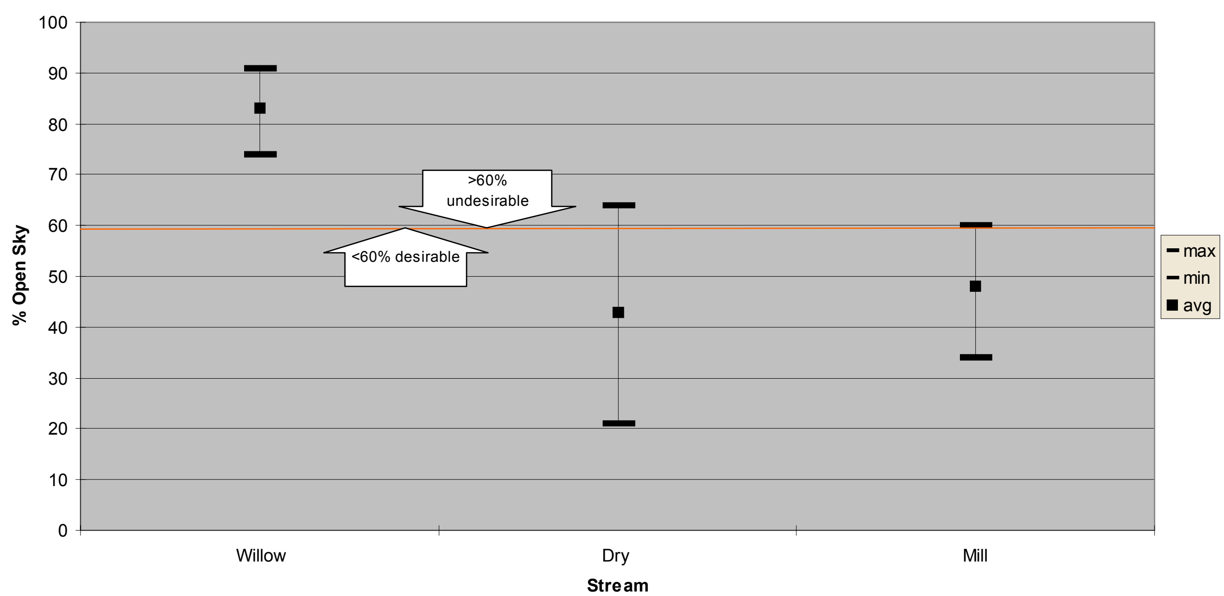
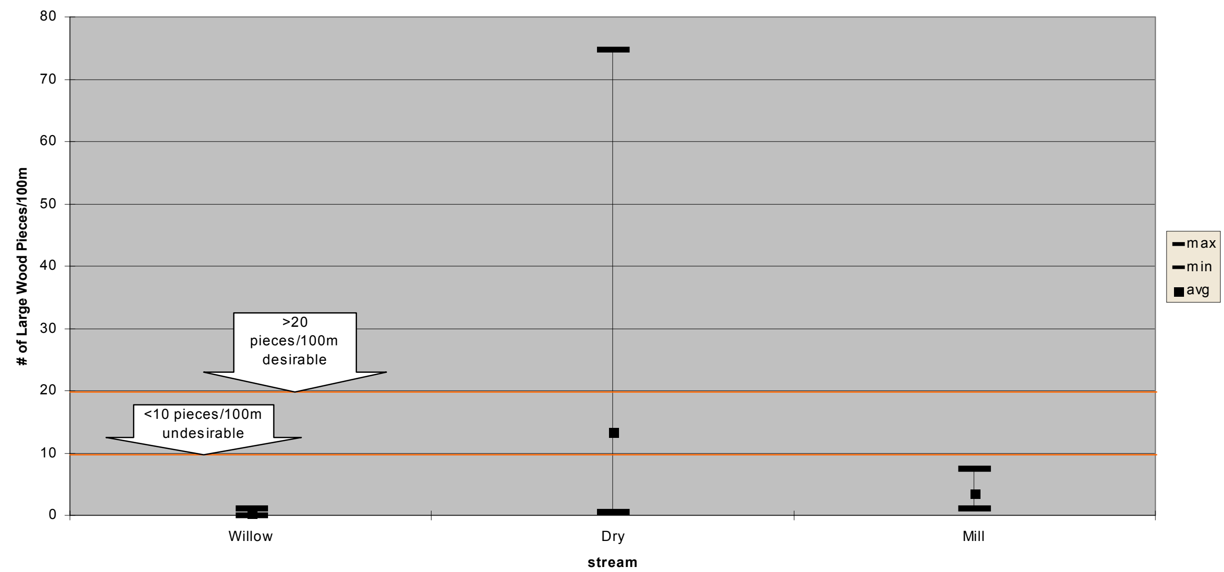


Figure 5.2 shows the amount of large wood pieces found during the 1995 ODFW Habitat Survey in Willow, Dry, and Mill Creeks.

Figure 5.2: Large Wood Pieces per 100m of Stream, 1995 ODFW Habitat Survey



Appendix 5.1 shows potential streamside vegetation by **ecoregion** in the watershed. Of the streams surveyed, all but the forested reaches of Dry Creek are included in the Blue Mountain Basins ecoregion. The forested reaches of Dry Creek are part of the Mesic Forest Zone ecoregion.

Streamside vegetation width (how far from the stream riparian vegetation extends) is naturally dependent upon ecoregion and the confinement of the stream (See **Appendix 5.1**). Land uses can also limit riparian vegetation widths. Agriculture, the dominant land use in the lower elevations of the Willow Creek watershed, limited riparian width in many reaches to less than what would occur naturally. In some reaches, native riparian vegetation was almost entirely replaced with agriculture or altered by pasture use.

In 1995, Oregon Department of Fish and Wildlife conducted a habitat survey along certain reaches of Willow, Mill, and Dry Creeks. **Figure 5.1** shows the percent of open sky (the inverse of shade) on surveyed reaches of Willow, Mill, and Dry Creeks. **Figure 5.2** shows large woody debris presence in surveyed reaches of Willow, Mill, and Dry Creeks. Below are the written summaries of riparian areas and in-stream wood for each creek.

Willow Creek: "Riparian vegetation consisted of perennial/annual grasses and hawthorn and alder. Often croplands abutted the creek. In places cut banks were bare and slumping into the creek." "Instream woody debris was almost nonexistant in the creek and consisted of alder and cottonwood."

Dry Creek: "Riparian vegetation in the lower reaches of the creek consisted primarily of perennial/annual grasses and hawthorn and alder. Often croplands abutted the creek. In the upper reaches, the riparian vegetation was dominated by second growth coniferous forest with some mature deciduous trees (mostly cottonwood)." "Instream woody debris was low in the lower reaches and consisted of alder and cottonwood; woody debris became much more common in the coniferous dominated sections of the creek."

Mill Creek: "Riparian vegetation was well developed along all of Mill Creek and consisted of dense hawthorn, alder and willow thickets and perennial/annual grasses." "In general, there was little instream woody debris in the creek. Woody debris consisted entirely of alder and cottonwood".

Discussion

Shade from riparian vegetation is important for maintaining cool water temperatures. As Willow Creek has little shade for almost the entire length of stream, its high summer temperatures (see *Chapter 7: Water Quality*) are likely due, in part, to lack of shade. Seventy percent of the non-forested section of Dry Creek has little shade coverage. Mill Creek and the forested section of Dry Creek have more shade, but still less than potential shade, as evidenced by comparing the potential vegetation with actual vegetation. Twenty percent of Mill Creek's vegetation was grasses and 24% was sparse brush, while the potential vegetation was dense shrubs and hardwoods. On the forested section of Dry Creek, where the potential vegetation was dense trees and shrubs, 31% of the reaches were sparse hardwood and 29% were sparse conifer. Comparing the percent open sky graphs for Willow, Dry, and Willow Creeks from the 1995 ODFW habitat survey with these aerial photo interpretation figures from 1997 photos shows similar results.

Amounts of large woody debris in Willow Creek, Mill Creek, and most reaches of Dry Creek were found to be low in the ODFW habitat survey. Only one reach on Dry Creek had a desirable condition for Large Woody Debris. Willow Creek had the least large woody debris present in-stream, out of all three streams. That is to be expected, as there are no trees on Willow Creek to provide large woody debris. All wood would have to come downstream from tributaries. The limited amounts of large woody debris in Mill and Dry Creeks, along with significant stretches of those streams with less than potential riparian vegetation, indicate that the recruitment potential for large woody debris is very poor. As large woody debris plays an integral role in pool creation, this lack of in-stream wood and a lowered potential for future recruitment can have far-reaching effects on stream structure and fish habitat See *Chapter 3: Channel Habitat Types* for the CHTs most changed by the presence or absence of LWD. *Chapter 8: Sediment* discusses potential effects of lack of large woody debris on sediment transportation and deposition in Willow Creek, and *Chapter 10: Fish and Fish Habitat* further discusses the role of large woody debris in habitat complexity and the importance of habitat complexity to salmonid life cycles.

Lack of riparian vegetation or vegetation without large and deep root systems also can contribute to bank instability. Bank instability is quantified as bank erosion, which can contribute to sediment problems. It also widens streams, which can make the vegetation present less effective for maintaining cool water temperatures. **Figure 8.1** in *Chapter 8: Sediment* shows bank erosion in the watershed. As many stream reaches were found to have little woody vegetation, the high levels of bank erosion in the 1995 ODFW habitat survey are not surprising.

Data Gaps:

- Shade, LWD, and vegetation information for tributaries to Dry, Mill, and Willow Creeks

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Appendix 5.1: Potential Streamside Vegetation

Table 1: Blue Mountain Basins Ecoregion

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Confined	0-25'	**Type**: Hardwoods (cottonwoods), and shrubs (willows). **Size**: Small **Density**: Dense	N.A.	**Type**: N/A **Size**: N/A **Density**: N/A	
Semi-confined	0-50'	**Type**: Hardwoods (cottonwoods), and shrubs (willows). **Size**: Small **Density**: Dense	N.A.	**Type**: N/A **Size**: N/A **Density**: N/A	.
Unconfined	0-75'	**Type**: Hardwoods (cottonwoods, aspen), and shrubs (willows). **Size**: Small **Density**: Dense	N.A.	**Type**: N/A **Size**: N/A **Density**: N/A	Under certain circumstances, there are a few potential plant communities having no woody vegetation in RA1, and are characterized by herbaceous plants such as beaked sedge, or aquatic sedge at higher elevations. See Crowe (1997) and Kovalchik B. (1987) for more details about specific plant communities and where they occur.

Current Streamside Conifer Regeneration: none

source: Draft Ecoregion Appendix for the Oregon Watershed Assessment Manual

Table 2: Mesic Forest Zone Ecoregion

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Confined	0-25’	**Type**: Hardwoods and shrubs (willows, bog blueberry, dogwood, mountain alder) **Size**: Small **Density**: Dense	25-100'	**Type**: Conifers (Engelmann spruce, Douglas-fir, true fir, larch, lodgepole pine) **Size**: Large **Density**: Dense	Disease, insects, and fire often suppress one or more tree species. Under certain circumstances, there are a few potential plant communities which have no woody vegetation in RA1, and are characterized by herbaceous plants such as aquatic sedge at higher elevations, queencup beadlily and widefruit sedge. See Crowe (1997) and Kovalchik (1987) for more details about specific plant communities and where they occur.
Semi-confined	0-50’	**Type**: Hardwoods and shrubs (willows, bog blueberry, dogwood, mountain alder, Pacific ninebark, common snowberry). **Size**: Small **Density**: Dense	50-100'	**Type**: Conifers (Engelmann spruce, Douglas-fir, true fir, larch, lodgepole pine) **Size**: Large **Density**: Dense	Disease, insects, and fire often suppress one or more tree species. Under certain circumstances, there are a few potential plant communities which have no woody vegetation in RA1, and are characterized by herbaceous plants such as aquatic sedge at higher elevations, queencup beadlily, smallfruit bulrush, widefruit sedge, beaked sedge, or aquatic sedge at higher elevations. See Crowe (1997) and Kovalchik (1987) for more details about specific plant communities and where they occur.

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Un-constrained	0-75’	**Type**: Hardwoods and shrubs (willows, bog blueberry, dogwood, mountain alder, Pacific ninebark, common snowberry). **Size**: Small **Density**: Dense	75-100’	**Type**: Conifers (Engelmann spruce, Douglas-fir, true fir, larch, lodgepole pine) **Size**: Large **Density**: Dense	Disease, insects, and fire often suppress one or more tree species. Under certain circumstances, there are a few potential plant communities which have no woody vegetation in RA1, and are characterized by herbaceous plants such as aquatic sedge at higher elevations, queencup beadlily, smallfruit bulrush, bluejoint reedgrass, aquatic sedge, and widefruit sedge. See Crowe (1997) and Kovalchik (1987) for more details about specific plant communities and where they occur.

Current Streamside Conifer Regeneration: Engelmann spruce, Douglas-fir, true fir, lodgepole pine

source: Draft Ecoregion Appendix for the Oregon Watershed Assessment Manual

Chapter 6: Wetlands

Introduction

This chapter identifies wetlands in the watershed and examines their role in the hydrology of the area. Restoration opportunities are also discussed.

Background

Wetlands are areas with saturated, or **hydric**, soils dominated by water tolerant plants (The Oregon Wetlands Conservation Guide). The term "wetlands" generally include swamps, marshes,
bogs and similar areas. The Army Corps of Engineers defines wetlands as "those areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated conditions"(qtd. in WPN 1999). Wetlands are often located in riparian areas, but they also can occur in upslope areas with no obvious connection to stream channels.

Wetlands in Oregon are protected and regulated by the Division of State Lands, under the state Removal-Fill Law, the Army Corps of Engineers, under the federal Clean Water Act, and for some agricultural wetlands, the Natural Resources Conservation Service, under a provision in the Federal Food Securities Act (Morlan 1990).

Wetlands provide many important functions to the landscape, including water quality improvement, flood control, groundwater charging, and habitat for fish and wildlife. By trapping sediments and contaminants and slowing the flow of runoff, wetlands help maintain good water quality. By storing, intercepting, and delaying runoff, wetlands can reduce downstream flooding. Wetlands are also strongly associated with groundwater. Some wetlands can recharge aquifers, which can help extend streamflows during the drier months. In eastern Oregon, the duration of streamflow has been extended by restoring wet meadows in headwaters (WPN 1999). Many plants, fish, and wildlife have co-evolved with wetlands and are dependant upon them for habitat and food sources.

As wetlands can contribute to critical hydrological and biological functions in a watershed, it is important to determine the locations and extent of wetlands in a watershed.

Methods

For the Willow Creek watershed assessment, digital National Wetland Inventory (NWI) maps were downloaded from www.nwi.fws.gov and created on GIS for the Willow Creek watershed. Acreage and wetland type were determined. No other wetland inventories have been conducted in the watershed.

The National Wetland Inventory was conducted by the U.S. Fish and Wildlife Service in 1974. NWI maps are based on aerial photography for an initial wetlands inventory of large areas (Morland 1990) and are not created for regulation purposes. As the scale of these surveys is rough, representation of individual wetlands may be inaccurate. Oregon has adopted the NWI maps as a basis for a State Wetlands Inventory and Wetlands Management program.

Results

Historical Wetlands in the Watershed

Historically, a large majority of the Grande Ronde Valley flooded in the spring. **Map 2.1** in *Chapter 2: Historical Conditions* shows the part of Willow Creek that historically flooded. It is in this area, along with areas surrounding springs, that wetlands would have been located in the watershed. It is unknown the extent of historical wetlands in the watershed, as many potential wetland sites have been drained and/or farmed.

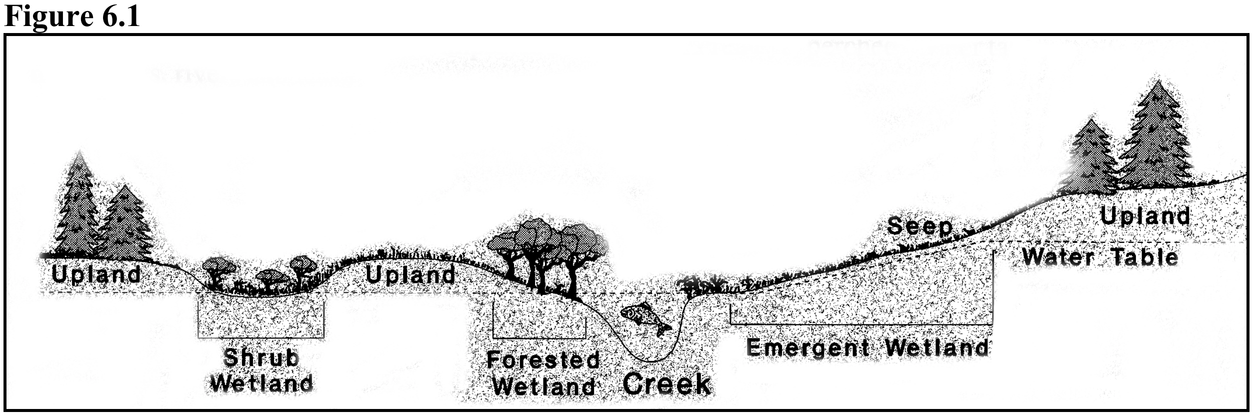
Appendix 6.2 describes potential wetland plant communities in the Willow Creek watershed as described by the Natural Resource Conservation Service.

Current Wetlands in the Watershed

The National Wetland Inventory is the only wetland inventory available for the Willow Creek watershed. Of the 53,077 acres in the Willow Creek watershed, 480 acres were identified as wetlands.

The National Wetland Inventory divides wetlands into five systems: marine, estuarine, riverine, lacustrine, and palustrine. Willow Creek watershed's wetlands are all palustrine in nature. Palustrine wetlands are defined as including "all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand" (qtd. in Morlan 1990). Once a wetland has been classified by system, it is then classified by subsystem and class. Palustrine wetlands are not divided into subsystems, only classes. Classes in the palustrine system are shown in **Table 6.1**. **Figure 6.1** shows locations of wetlands in relation to land forms.

Figure 6.1

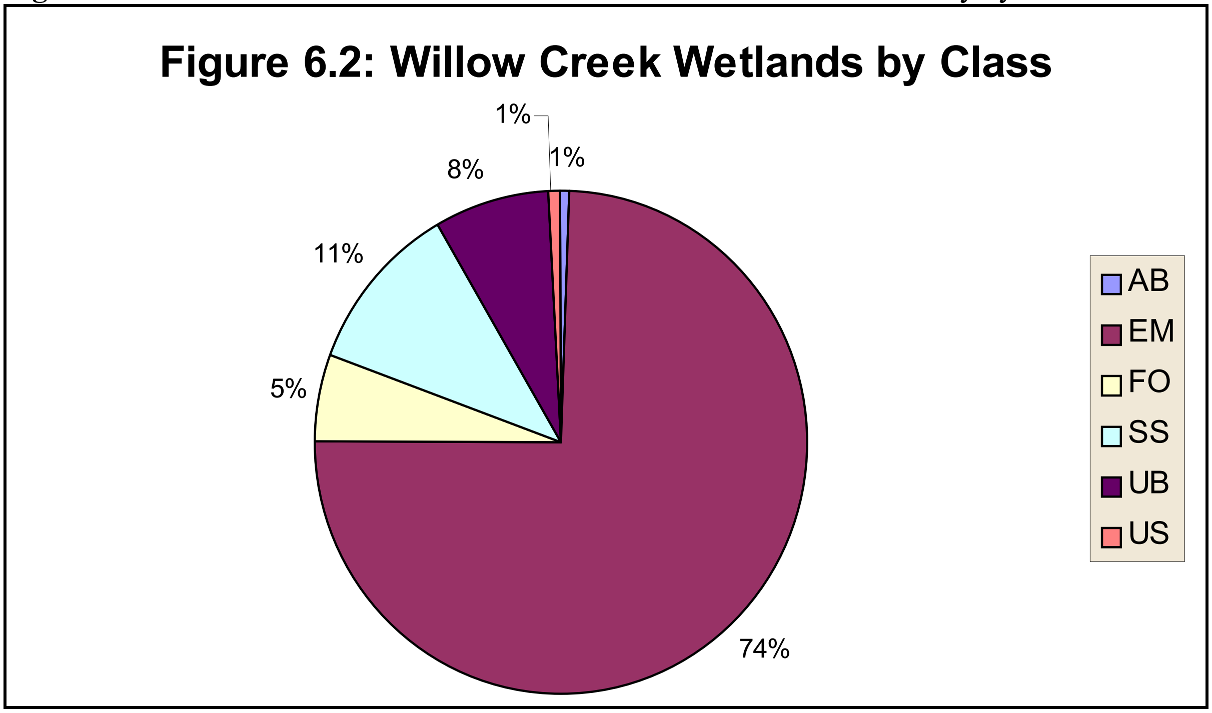


Source: Just the Facts #4

Table 6.1: Classes of palustrine wetlands

Class	Symbol
Rock Bottom	RB
Unconsolidated Bottom	UB
Aquatic Bed	AB
Unconsolidated Shore	US
Moss-Lichen Wetland	ML
Emergent Wetland	EM
Scrub/Shrub Wetland	S
Forested Wetland	FO
Open Water/Unknown Bottom	OW

Figure 6.2 shows the wetlands identified in the National Wetland Inventory by Class.



Some of the current wetlands in Willow Creek have been excavated or diked/impounded. Of the wetlands identified in the NWI survey, 6% have been diked or impounded and 4% have been excavated.

Location of NWI Wetlands in the Watershed
Wetlands are typically found in depressions and the lower part of the landscape (Just the Facts #4). In the Willow Creek watershed, the majority of wetlands are distributed alongside streams with smaller, isolated wetlands scattered throughout the alluvial fan areas of Mill, Coon, Slide, Smith, and Dry Creeks. A map was not included in this assessment as the level of detail requires a larger map size. Digital NWI maps of the area can be obtained at the Grande Ronde Model Watershed Program office.

Lower Willow Creek Subwatershed - 320 acres of wetlands
The majority of wetlands in the watershed are found along the lower reaches of Willow Creek. A large part of these wetlands are emergent wetlands, but unconsolidated bottom and scrub-shrub wetlands are also found along Willow Creek or adjacent to other wetlands. Sanderson Springs, the source of Mill Creek, is a concentrated area of wetlands composed of scrub-shrub, forested, and emergent wetlands. As the elevation of the valley floor rises into Pumpkin Ridge, the intermediate alluvial fan area houses small, isolated acres of unconsolidated bottom wetlands.

South Fork Willow Creek Subwatershed - 66 acres of wetlands
The majority of wetlands in this subwatershed are distributed along the middle reaches of Coon and Slide Creeks, in the alluvial fan area. These wetlands are mainly emergent wetlands alongside or near the streams. There are some smaller unconsolidated bottom wetlands that are not directly adjacent to stream channels as well.

Upper Willow Creek Subwatershed - 71 acres of wetlands
Wetlands in this subwatershed are, for the most part, distributed along the middle reaches of Smith, Pfeffercorn, Lanman, and Lewis Branch Creeks. These wetlands are scrub-shrub and emergent wetlands, with a few isolated forested wetlands. Most of these wetlands are not directly adjacent to stream channels, but appear closely tied to other wetlands. There are a few small, scattered unconsolidated bottom wetlands further upland and away from the convergence of these streams.

Dry Creek Subwatershed - 21 acres of wetlands
This subwatershed contains the least amount of acres of wetlands in the watershed. Some emergent and scrub-shrub wetlands are located along Dry Creek. There are numerous small, isolated unconsolidated bottom wetlands not adjacent to any stream channel and in upland areas.

Hydric Soils
While hydric soils have not been mapped in the Willow Creek watershed, there are soil types that can include hydric soils. The entire soil type is not a potential hydric soil, rather, just areas with a certain landform (such as a depression). **Appendix 6.1** lists the potential hydric soil types according to the Union County Hydric Soil List. The column "local landform" list the areas where the soil type could be hydric. To confirm hydric soils in an area, soil testing would need to be conducted.

Discussion

Historically, wetlands were more widespread in the Grande Ronde Valley than they are today. Over time wetlands have been farmed over, disconnected from nearby streams, drained, and leveled. Removal of beavers may have also been responsible for diminishing wetlands, as land flooded above beaver dams was no longer flooded.

Currently, the NWI shows less than one percent of the watershed as being wetlands. As this inventory was done at a large scale with no field checking, the actual amount of wetlands currently present in the watershed is higher. If interested in inventorying wetlands on your property, contact the local Natural Resource Conservation Service office.

There are funding opportunities for wetland restoration. While not possible on a large scale, due to the agricultural nature of the watershed, selected restoration of wetlands can improve the hydrology and water quality of the area. As wetlands play a role in groundwater charging, increasing wetlands can improve late season low flows

Data Gaps

- hydric soil mapping
- compilation of soil survey characteristics that indicate areas of historical wetlands
- wetland plant community information

References

"Enhancing Wetlands Inventory Data for Watershed-based Wetland Characterizations and Functional Assessment". Power Point presentation by National Wetlands Inventory available on-line as .pdf file at nwi.fws.gov.

Oregon Division of State Lands. Wetlands Program. "Just the Facts #4: How to Identify Wetlands." 1992.

Morlan, Janet. Oregon Division of State Lands. Oregon Wetlands: Wetlands Inventory User's Guide. Publication 90-1, 1990.

United States Department of Agriculture. Natural Resources Conservation Service. SCS-OR MLRA B10. August 1990.

The Oregon Wetlands Conservation Guide: Voluntary Wetlands Stewardship Options for Oregon's Private Landowners. Oregon Wetlands Conservation Alliance.

Watershed Professionals Network. Oregon Watershed Assessment Manual. Salem, Oregon: prepared for the Governor's Watershed Enhancement Board, 1999.

Appendix 6.1: Potential Hydric Soils in the Willow Creek Watershed

Soil type	Name	Inclusion	Local Landform	Criteria Met
7	Catherine silt loam	wet spots	depression	saturation
8	Catherine silt clay loam	wet spots	depression	saturation
9A	Conley silty clay loam, 0-2% slopes	marsh and wet spots	alluvial fan	saturation; ponding
9B	Conley silty clay loam, 2-5% slopes	marsh and wet spots	alluvial fan	saturation; ponding
25	Hot Lake silt loam	poorly drained	basin floor	saturation; ponding
25	Hot Lake silt loam	wet spots	depression	saturation; ponding
39C	Lookingglass Silt Loam, 2-12% slopes	poorly drained soils	hill	saturation
39C	Lookingglass Silt Loam, 2-12% slopes	seep areas	hill	saturation
58E	Starkey very stony silt loam, 2-35% slopes	marsh and wet spots	hill	saturation
59E	Tolo silt loam, 12-35% slopes	marsh and wet spots	depression	saturation
62	Umapine silt loam	marsh and wet spots	flood plain	saturation; flooding
72C	Wolot silt loam, 2-12% slopes	poorly drained soils	hill	saturation

source: Union County Hydric Soils List, *NRCS*

Appendix 6.2: Potential Wetland Plant Communities in the Willow Creek Watershed (from NRCS Site Descriptions)

Wet Meadow

- Occurs on low floodplains of perennial streams and rivers.
- Soils of this site are recent, very deep and poorly drained. The potential for erosion is moderate. The optimum growth period for native plants is from April through August. The soils are in hydrologic group D. The soils of this site have high runoff potential. The soils in this site have excellent water holding capacities providing late season water for plant growth and slow water releases to streams.
- The potential native plant community is strongly dominated by sedges. Rushes and tufted hairgrass are common.

Meadow

- Occurs on low floodplains of perennial streams and rivers.
- Soils are recent, very deep and somewhat poorly drained. The potential for erosion is moderate. The soils are in hydrologic group D. The soils of this site have high runoff potential. The soils in this site have excellent water holding capacities providing late season water for plant growth and slow water releases to streams.
- The potential native plant community is dominated by tufted hairgrass. Sedges and rushes are common. Tufted hairgrass production is dependent on the extent and duration of subsurface water flows.

Loamy Bottom

- Occurs mainly on the floodplains of perennial streams and rivers. It is near channels occupying secondary terraces.
- Soils are recent, very deep and well drained. The soils in this site have excellent water holding capacities providing late season water for plant growth and slow water release to streams. The soils are in hydrologic group B. The soils of this site have moderately low runoff potential.
- The potential native plant community is dominated by basin wildrye.

Sodic Bottom

- Occurs on low to mid-elevation floodplains of perennial streams and rivers.
- The soils of this site are recent, very deep and somewhat poorly drained. The soils are in hydrologic group D. The soils of this site have high runoff potential. The soils in this site have good water holding capacities providing late season water for plant growth and slow water releases to streams.

- The potential native plant community is dominated by basin wildrye

Willow Riparian

- Occurs on depositional floodplains along perennial streams and rivers. Floodplains are well connected.
- Soils are silt loam over gravelly silt loamy and are deep.
- The potential native plant community is dominated by willow with an unknown understory. Current plant community is willow and reed canarygrass. As willows decrease reed canarygrass becomes strongly dominant.

Gravelly Braided Bottom

- Occurs on floodplains of perennial streams and rivers.
- The soils of this site are recent, very deep, gravelly and well to excessively well drained. The soils are in hydrologic group B. The soils of this site have moderately low runoff potential. The soils of this site typically reflect hydric soil characteristics.
- The potential native plant community is dominated by black cottonwood and tall willows. Alder, hawthorn, rose and basin wildrye are present.

Chapter 7: Water Quality

Introduction

In this chapter, water quality data collected in the Willow Creek watershed is presented and summarized.

Background

Water quality is influenced by both natural and human activities. Human-caused point and non-point source pollution, land use activities in riparian zones, in-stream disturbances, and water withdrawals or diversions all affect water quality. Natural conditions of streams, such as low summer flows and low stream gradient, can result in streams being more susceptible to water quality changes and less able to handle pollution levels.

Under the Clean Water Act, the U.S. Congress required the Environmental Protection Agency to "protect and maintain the chemical, physical and biological integrity of the nation's waters." EPA has, for the state of Oregon, put the Oregon Department of Environmental Quality in charge of setting the state's standards for water quality and to enforce them.

Water quality in Oregon is evaluated by comparing existing conditions to criteria contained in water quality standards set by the Oregon Department of Environmental Quality (DEQ). These criteria were set as a way to determine whether the quality is sufficient to support the beneficial uses of each basin. In the case of multiple beneficial uses in a body of water, federal law requires DEQ to protect the most sensitive of those beneficial uses. This premise assumes that by protecting the most sensitive beneficial use, all will be protected. Beneficial uses vary from basin to basin to account for land use patterns and existing aquatic life. The Oregon Water Resources Department has listed 14 beneficial uses for all waters in the Grande Ronde basin:

- public water supply
- domestic water supply
- industrial water supply
- irrigation
- livestock watering
- anadromous fish passage
- salmonid fish rearing
- salmonid fish spawning
- resident fish and aquatic life
- wildlife and hunting
- fishing
- boating
- water contact recreation
- aesthetic quality

Stream reaches that do no meet one or more of the Oregon Water Quality Standards are considered impaired or threatened and placed on the **303(d) list**. For all reaches on the 303(d) list and any waterbody designated as water quality impaired, DEQ is required to establish a **Total Maximum Daily Load**. When Total Maximum Daily Loads were set for the Upper Grande Ronde Sub-basin, DEQ identified criteria, including temperature, dissolved oxygen (DO), pH, nutrients, bacteria, turbidity, habitat and flow modification, and aquatic weeds or algae.

Oregon Department of Environmental Quality has signed Memorandums of Agreement (MOA) with Oregon Department of Agriculture and Oregon Department of Forestry. The MOA with

Oregon Department of Agriculture assigns ODA with the task of implementing TMDLs on state and private agricultural lands. According to **Senate Bill 1010**, ODA will implement TMDLs through water quality management plans for each **sub-basin** in the state of Oregon. Oregon Department of Forestry is assigned to implement TMDLs on state and private forested lands. This will be done through **Best Management Practices** and revisements of the **Forest Practices Act** in order to meet water quality standards.

Temperature

Cool water temperatures are a basic requirement for many aquatic species, including chinook salmon and summer steelhead, that have evolved in the Grande Ronde basin. Reproduction and development are adversely affected when water temperatures are outside the ranges these species have historically lived in.

Temperature is also closely linked with other water quality parameters, like dissolved oxygen and pH. Dissolved oxygen levels and pH are inversely related to temperature.

Solar radiation is one of the primary sources of heating water in streams. The amount of surface area versus volume affects stream temperature. A stream that is widening but not increasing its net flow will have a greater exposed surface area for the volume of water it holds. This can result in increased temperatures. Shade from riparian vegetation and topography decreases the amount of solar radiation hitting a stream, thereby slowing the rate of stream temperature increases due to heat radiation. At night, stream temperatures decrease.

DEQ's temperature standard states that "where salmonid fish rearing is a designated beneficial use," no increase in temperature should be caused by human activities when temperatures exceed 64ºF. Thus, when temperatures exceed 64ºF, only the portion of heating that results from human activity is considered to be pollution. The 64ºF criterion refers to the seven-day moving average of maximum daily temperature. This method of reporting temperature decreases the effect of a single peak temperature in data interpretation.

Dissolved Oxygen

The amount of dissolved oxygen (DO) in water is vital to fish and other aquatic animal respiration. In the Pacific Northwest, these species have evolved in the high dissolved oxygen levels characteristic of the region's waters. Developing salmon and trout eggs and fry are especially sensitive to low DO levels. Nearly saturated levels are necessary for salmonids to maintain normal metabolic function. Lower levels inhibit salmonids' ability to find food and shelter.

Oxygen is usually dissolved in running water in equilibrium with the atmosphere. Water temperature and atmospheric pressure determine oxygen saturation. Dissolved oxygen levels fluctuate throughout the day, because of stream temperature and the processes of **photosynthesis** and **respiration** of plant and algal species. During the day, when photosynthesis is occurring, plants convert carbon dioxide into energy, expelling oxygen as a waste product. This causes dissolved oxygen levels to rise. Plants and algae respire continuously, consuming oxygen and producing carbon dioxide. During the night, when algae and plants do not photosynthesize but do respire, dissolved oxygen levels fall. Because of this daily fluctuation, dissolved oxygen is best measured over a 24-hour period for the results to be useful. Samples taken in the early morning and late afternoon can also capture this daily fluctuation (pers. comm., Mitch Wolgamott, DEQ).

For the Willow Creek watershed, the DEQ 30-day average standard for Dissolved Oxygen is **8.0mg/L**. The TMDL target for DO in the Grande Ronde River is **6.5 mg/L**.

pH

pH is a measurement of the acidity or basicity of a body of water. The pH scale is 1-14, with 1 being the most acidic, 7 being neutral, and 14 being the most basic. This scale is logarithmic, meaning that the difference between a pH of 1 and 2 is not 1 but a factor of 10. Therefore, a pH of 9 is 10 times more basic than a pH of 8.

The pH of natural waters varies according to an area's level of precipitation and geologic composition. In arid northeast Oregon, higher average pH levels are to be expected. But geology and precipitation cannot explain the large daily fluctuations in pH. pH varies throughout the day because of aquatic plant and algal photosynthesis and respiration, making it difficult to measure the maximum daily pH without sampling an entire 24-hour period. DEQ has set the pH standard of the Grande Ronde Basin to be between **6.5 and 9.0**. Also, if pH is noted as being often higher than 8.7 during the late summer months, further testing should be conducted, as it is likely that the pH is often exceeding 9.0.

Nutrients

Phosphorus and nitrogen are the primary growth-limiting macronutrients in water and, therefore, are the two nutrients most often measured when monitoring water quality. In moderation, these nutrients promote a healthy stream system, increased levels of dissolved oxygen, and food for macroinvertebrates by plant growth. High nutrient levels in streams can be unhealthy for fish and other aquatic organisms because they lead to excessive algae growth which causes problematic changes in DO and pH levels. Algal blooms also inhibit recreation and the aesthetic value of the water.

Nitrogen is present in streams as nitrates, nitrites, ammonia, and organic forms. The forms readily available for plant uptake are nitrates, nitrites, and ammonia (or Dissolved Inorganic Nitrogen). The Upper Grande Ronde Sub-basin has determined a Total Maximum Daily Load (TMDL) of Dissolved Inorganic Nitrogen of **33µg/L** for the reach of the Grande Ronde River that Willow Creek empties into.

Phosphorus is also present in streams in organic and inorganic forms. The form of phosphorus readily available for plant use is called orthophosphate. The Upper Grande Ronde Sub-basin TMDL for orthophosphate on the reach of the Grande River River that Willow Creek empties into is **7µg/L**. .

For this assessment, the TMDLs for phosphorus and nitrogen set on the segment of the Grande Ronde River where Willow Creek enters will be used as criteria to evaluate nutrient levels in the

Willow Creek watershed. There are no water quality standards for nutrients in the Grande Ronde Basin, only TMDLs

Bacteria
Coliform bacteria are used as indicators for testing the sanitary quality of water for drinking, swimming, and shellfish culture. Oregon Water Quality Standards for bacteria are: no single sample shall exceed 406 *E.coli* organisms per 100mL of water and no 30-day log mean shall exceed 126 *E. coli* organisms per 100 mL of water. For the purposes of this assessment, the single sample standard shall be used, due to limited data. However, this method shows only a moment in time, not trends of bacterial contamination.

Turbidity and Suspended Sediment
Turbidity measures the clarity of water. Turbidity can be caused by suspended sediments, algae, or other suspended material. Turbidity is measured by passing a light beam through a sample. The more suspended material, the less the light that passes through the sample, resulting in a higher turbidity value. Turbidity is measured in NTUs (nephelometric turbidity unit).

Suspended sediment is all the sediment suspended in the water column. It is measured by drying water sample and then weighing the residual sediment. Concentrations are usually reported in mg/L, the equivalent of parts per million (ppm). To calculate sediment load, discharge data is needed.

Turbidity and suspended sediment will vary naturally with soil types. Silts and clays will stay suspended for long periods and cause turbidity, while larger particles, like sand, will settle to the bottom. Turbidity will also increase during storm and runoff events.

DEQ specifies a criterion that compares an activity's turbidity level relative to a background level measured upstream. An increase in turbidity greater than 10% exceeds the turbidity standard.

Methods
Data presented in this component was gathered from the Union Soil and Water Conservation District's Water Quality Monitoring Program and Oregon Department of Environmental Quality. The data was compiled and then compared against Oregon Department of Water Quality (DEQ) criteria for each parameter. Oregon Water Quality Standards set for the Grande Ronde Basin, or nutrient TMDLs set for the reach of the Grande Ronde River that Willow Creek empties into were used as parameters for comparison.

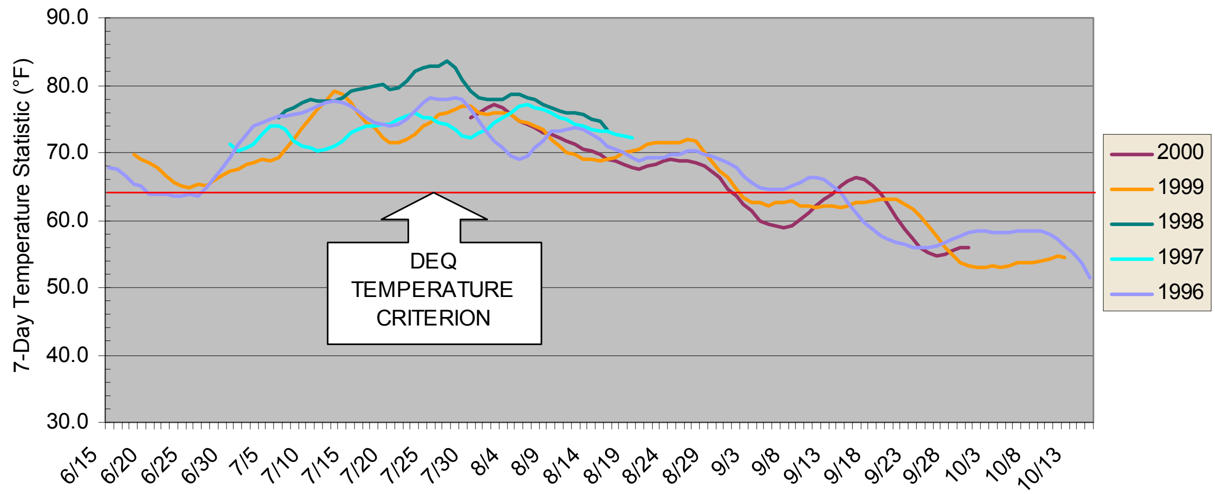
Results

Water Quality Data from Union SWCD
Three sites have been sampled for water quality in the Willow Creek watershed by Union SWCD. **Map 7.1** shows their locations. The site near Rhinehart has been sampled from 1996-2000; the site just below the confluence of Mill and Willow Creeks on Willow Creek was

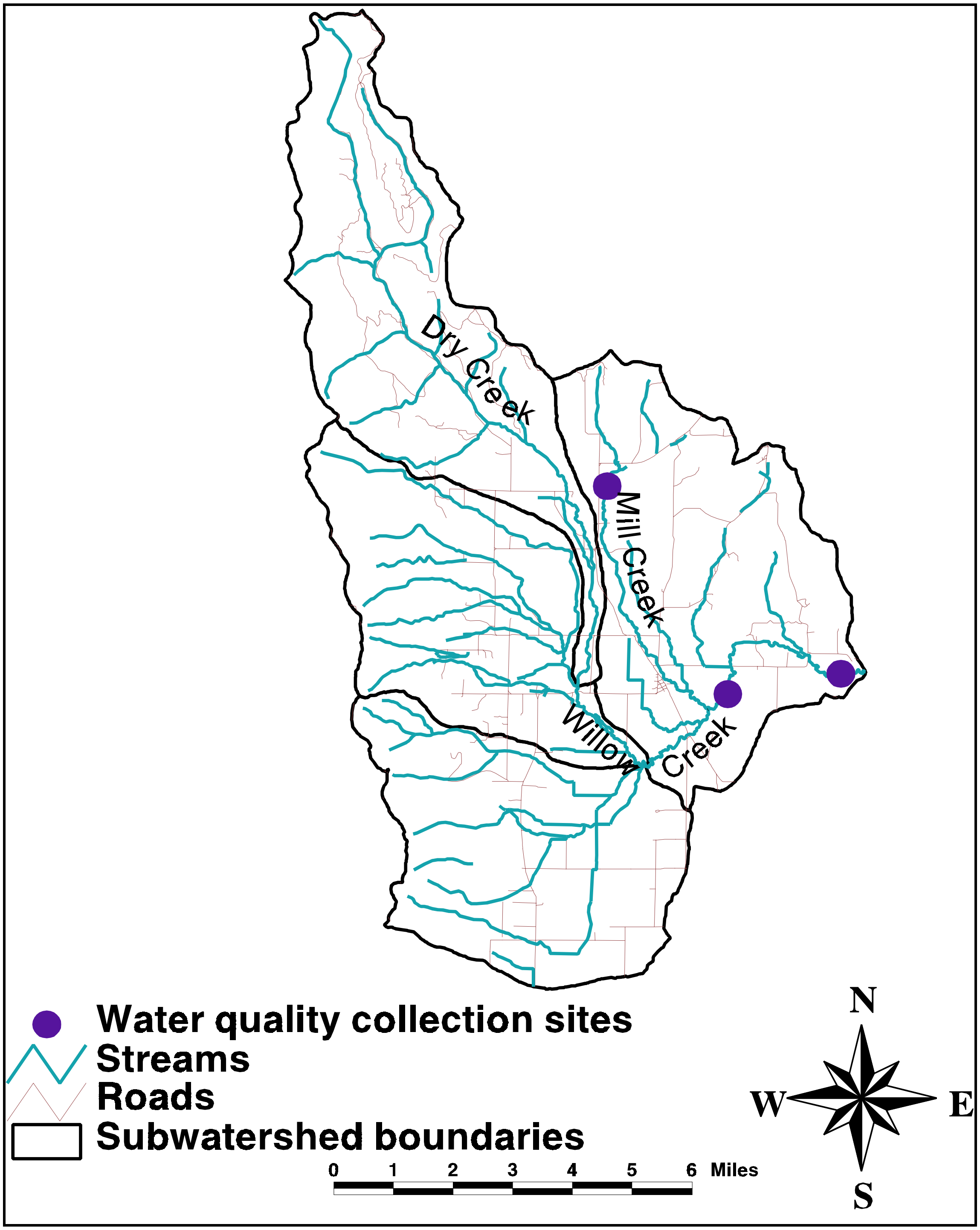
sampled from 1996-1998; and the site below Sanderson Springs on Mill Creek was sampled from 1996-1998. Sites were generally sampled from April to October, although total months sampled varied from year to year. Temperature was sampled every hour using a data logger. Chemistry data was collected with grab samples, usually once a month.

Figures 7.1, 7.2, and 7.3 graph temperature data collected on Willow Creek near Rhinehart, on Willow Creek below its convergence with Mill Creek, and on Mill Creek below Sanderson Springs.

Figure 7.1: Willow Creek near Rhinehart



Map 7.1: Water Quality Data Collection Sites in the Willow Creek Watershed



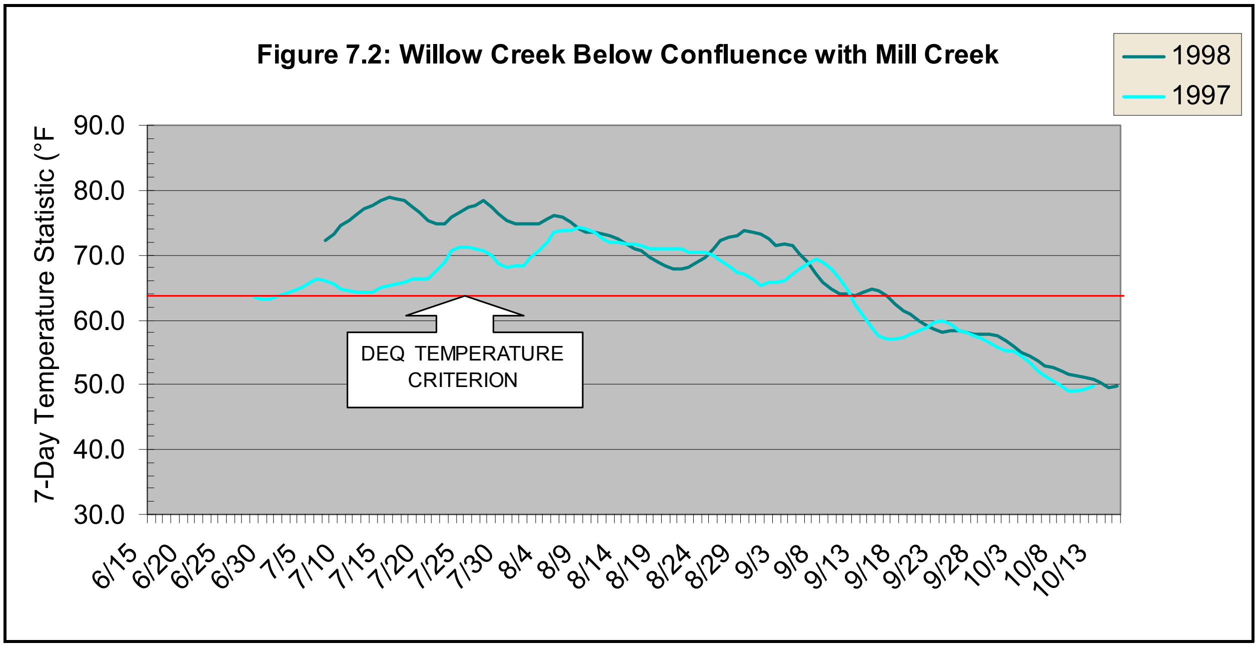


Figure 7.2: Willow Creek Below Confluence with Mill Creek
1998
1997
7-Day Temperature Statistic (°F
90.0
80.0
70.0
60.0
50.0
40.0
30.0
DEQ TEMPERATURE CRITERION
6/15 6/20 6/25 6/30 7/5 7/10 7/15 7/20 7/25 7/30 8/4 8/9 8/14 8/19 8/24 8/29 9/3 9/8 9/13 9/18 9/23 9/28 10/3 10/8 10/13

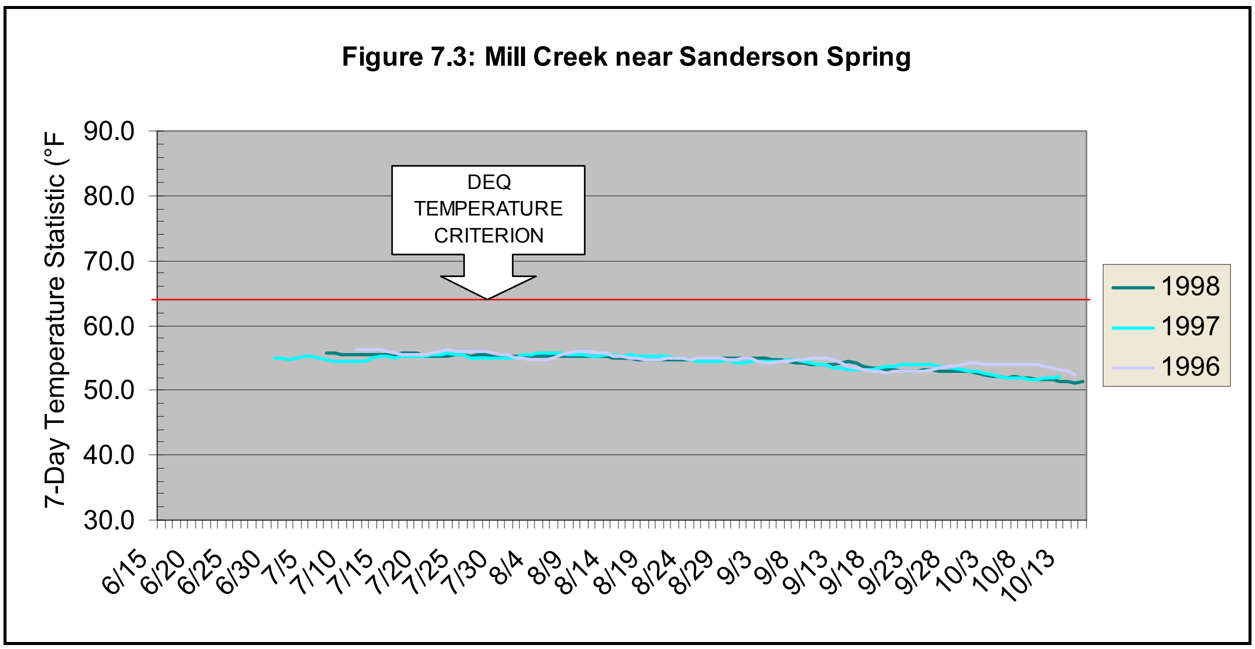


Figure 7.3: Mill Creek near Sanderson Spring
7-Day Temperature Statistic (°F
90.0
80.0
70.0
60.0
50.0
40.0
30.0
DEQ TEMPERATURE CRITERION
1998
1997
1996
6/15 6/20 6/25 6/30 7/5 7/10 7/15 7/20 7/25 7/30 8/4 8/9 8/14 8/19 8/24 8/29 9/3 9/8 9/13 9/18 9/23 9/28 10/3 10/8 10/13

Figure 7.4 shows pH data collected on Willow Creek near Rhinehart.

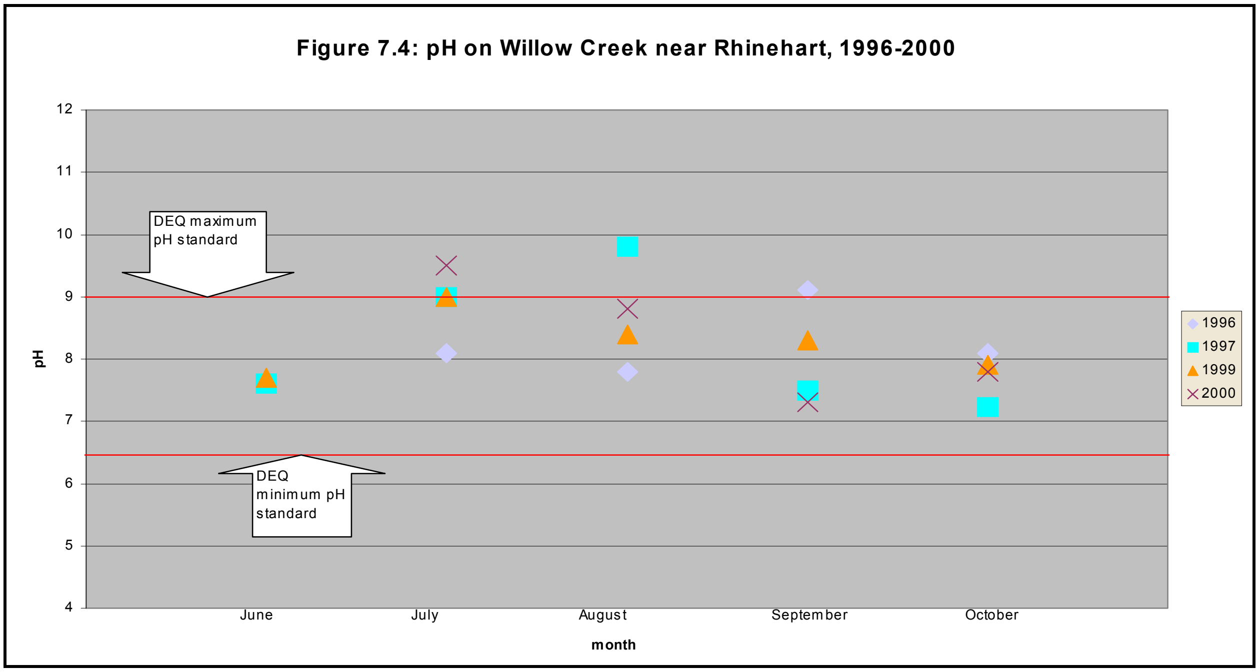


Figure 7.5 shows dissolved inorganic nitrogen data collected on Willow Creek near Rhinehart.

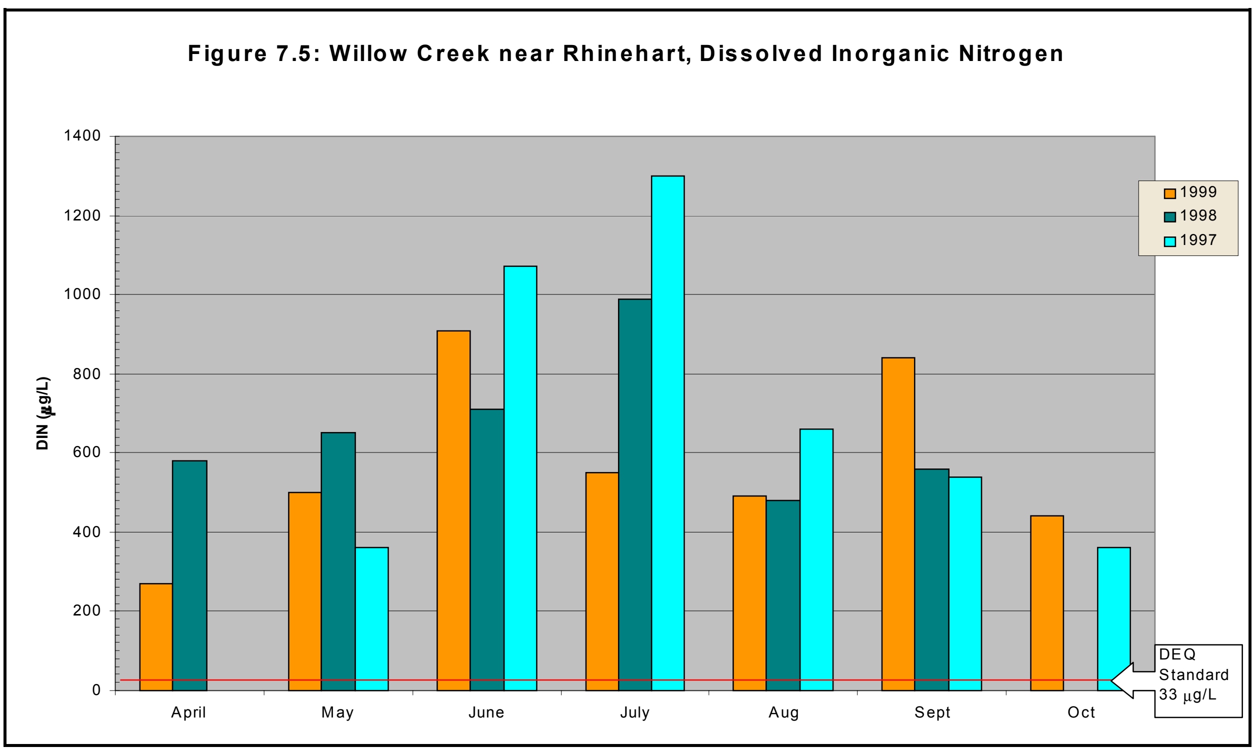


Figure 7.6 shows orthophosphate data collected on Willow Creek near Rhinehart.

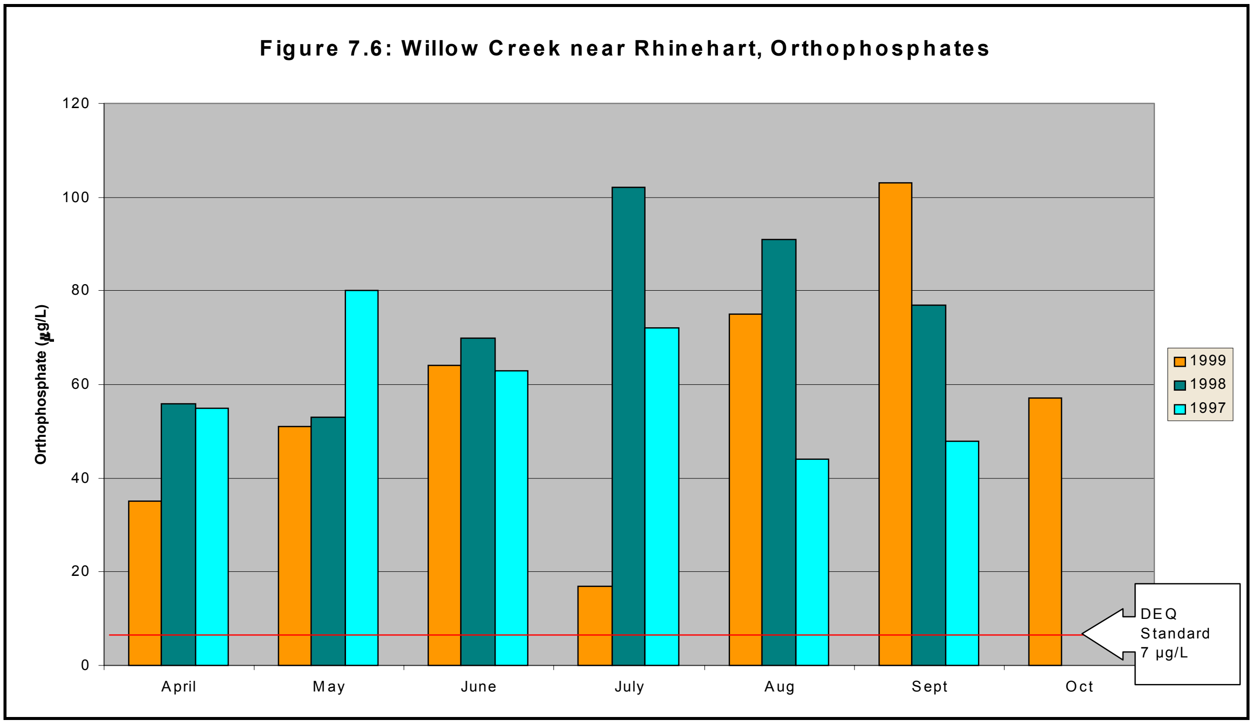
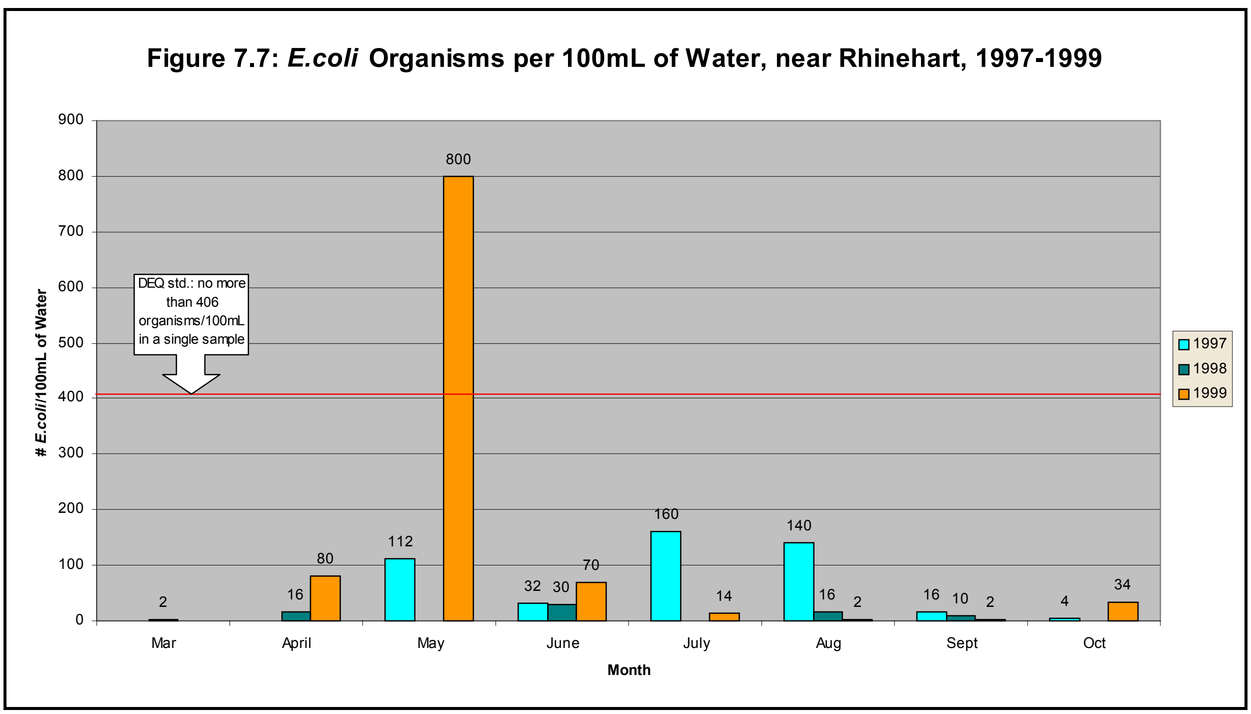


Figure 7.7 shows *E.coli* data collected on Willow Creek near Rhinehart.



DEQ water quality data
Oregon Department of Water Quality has sampled temperature along Willow Creek. On August 25, 1999, ODEQ commissioned a helicopter to fly over Willow Creek for a FLIR (Forward Looking Infrared) measurement of temperature. The length of Willow Creek was flown, from the mouth to just above the confluence with Dry Creek, for a total of 10.2 miles. Stream temperatures at the upstream end of the survey were warm (68.4ºF) and increased progressively downstream to river km 8.9 (mi 5.5) where the maximum temperatures (76.1ºF) for the survey were recorded. From river km 8.9 downstream there was considerable evidence of thermal stratification throughout the stream rendering interpretation of the imagery of minimal use. At the confluence with the Grande Ronde River, Willow was contributing cooler flows (75.7ºF) to the mainstem (79.3ºF).

Nez Perce Tribe
The Nez Perce Tribe has collected temperature data on Willow Creek. This data needs to be obtained and incorporated into this document.

Discussion
Water quality is a difficult topic to adequately address with minimal data. The existing data shows Willow Creek's impact on the water quality of the Grande Ronde River, but is too limited to show what portions are natural and human caused. To summarize the data, temperature exceeds the seven day moving average maximum temperature of 64ºF a good portion of the summer months near the mouth of Willow Creek and just below the Mill Creek confluence on Willow Creek. Nutrient levels in Willow Creek near Rhinehart well exceed the Total Maximum Daily Loads of 33µg/L (dissolved inorganic nitrogen) and 7µg/L (orthophosphates) set for the reach of the Grande Ronde River at the mouth of Willow Creek. pH levels are recorded exceeding 9.0 and dissolved oxygen sometimes drops below the standard of 8.0 mg/L at the mouth of Willow Creek. Although there is no flow data, Willow Creek was a high geographic priority area for flow in DEQ's Water Quality Management Plan for the Upper Grande Ronde River Sub-basin. Fine sediments, another form of pollution, is also present at levels affecting fish reproduction (see *Chapter 8: Sediment*).

What does this all mean? How is water quality affecting salmonid fish rearing in the Willow Creek watershed? High nutrient levels, low flow, exposure to direct sun, and high water temperatures promote algae growth. Algal growth increases the magnitude of daily fluctuations in dissolved oxygen and pH. When dissolved oxygen, temperature, and pH fall outside the range which salmonids are adapted to, mortality and reduced reproduction occur. Extreme fluctuations place additional stress on the fish. As salmonid fish rearing is the most sensitive beneficial use in the Willow Creek watershed, current water quality conditions are not adequate to support this beneficial use. Algal growth, with its effects on fish habitat requirements, is a large factor in this. By minimizing algal growth and minimizing human-caused increases in temperature, fish habitat parameters can be improved and Willow Creek's most sensitive beneficial use protected.

Minimizing algal growth requires limiting exposure to sunlight, lowering water temperatures and reducing nutrient levels in streams. Reducing the heating of streams by solar radiation can be accomplished through increasing shade from riparian vegetation. This will also limit the light available to algae. Reducing nutrient loading can be accomplished through reducing manures and fertilizers reaching the stream system and minimizing leakage from septic tanks. As nutrients reach streams in part through attachment to sediment, reducing erosion on agricultural lands can also reduce nutrient levels. Willow Creek is probably a nitrogen-limited system (pers. comm., Mitch Wolgamott, DEQ). This means that when its quantities are limited in the Willow Creek watershed, so are the abilities of plants to grow. Thus, of nitrogen and phosphorus, nitrogen is the nutrient to focus on minimizing.

Additional monitoring in the future will provide a stronger basis with which to assess and improve water quality in the Willow Creek watershed. By monitoring in the headwaters of the watershed, information on how much pollution is natural and how much is human-induced can be gathered, providing further insight on how to improve water quality in the watershed.

Data Gaps

- Nez Perce Tribe temperature data
- lack of water quality data in headwaters
- flow data
- monitoring that measures daily DO and pH fluctuations
- amount of natural versus human-caused pollution
-

References

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. Environmental Protection Agency. May 1991.

Upper Grande Ronde River Subbasin Total Maximum Daily Loads (TMDL). Prepared by Oregon Department of Environmental Water Quality. April 2000.

Upper Grande Ronde River Subbasin Water Quality Management Plan. Prepared by Grande Ronde Water Quality Committee. April 2000.

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Chapter 8: Sediment

Introduction
In this chapter potential sediment sources to streams are identified and discussed. As high levels of sediment can negatively affect salmonid reproduction and cause undesired change in channel form, understanding sediment's current role in the watershed is needed.

Background
Erosion is a natural occurrence. Fish and other aquatic organisms have adapted to a range of sediment amounts entering streams in their habitat. Erosion and sediment load in streams vary throughout the year, with most sediment moving during the short time periods with the highest flows. In the Willow Creek watershed, this usually occurs during spring snowmelt.

Humans can also induce erosion in a watershed. Separating human-induced erosion from natural erosion can be difficult because of the highly variable nature of natural erosion patterns. Generally, the greater a stream's sediment load deviates from natural conditions, the greater the chance that fish will be affected.

Sediment in streams can also negatively affect humans. High sediment levels can increase the costs of treating drinking water, can be aesthetically displeasing, and can decrease angling success.

Sediment Transport Processes
Sediment moves in a system and eventually is deposited. Sediment processes are often discussed in terms of collection, transport, and deposition. Rock is eroded through runoff into high gradient streams, from where it is transported through the stream system until the gradient lowers and the confinement eases. As the gradient levels out, the stream's energy is dissipated, through increased **sinuousity** and slower flows. This causes the stream to deposit its sediment load into **alluvial** and **floodplain** channels of the stream system. Generally, the larger the particle of sediment, the less distance it will travel. Thus, boulders will only move a few feet, while sand may move miles. Sediment input into streams can come from two sources: hillslope or channel sources.

Hillslope Sources
Sediment moves downslope by surface erosion and mass wasting. Landslides are a form of mass wasting. They can occur when soil cohesiveness is exceeded by high soil moisture content or when slope steepness causes soils to detach and move downslope rapidly.

Surface erosion can occur when precipitation exceeds the ability of the soil to absorb water or where soil surfaces have been exposed or compacted (ex. road surfaces, heavily grazed areas, areas compacted by heavy machinery). Surface erosion includes many types of erosion: **sheet erosion**, **raindrop splash erosion**, **rill and gully erosion**, and **ravelling** (see glossary).

Sediment transport to a stream is dependent on soil type, slope, proximity to the stream, and the duration and intensity of rainfall. Vegetative cover can affect the likelihood of sediment impacting streams. Erosion potential can also be affected by the degree of soil compaction, road drainage systems, and land management activities.

Channel Sources
Channel sources are associated with debris flows and bank sloughing. Debris flows occur when a landslide reaches a steep stream channel and incorporates logs, boulders, soil, and water. It grows in size as it heads downstream and stopping when the slope lessens. Most streams that have experienced debris flows will probably have more in the future (Williams Creek Watershed Assessment, 1999). Bank sloughing occurs when stream channels migrate laterally. It is often increased by a lack of riparian vegetation and is more prevalent in unconstrained channels.

Methods
Information was collected from Union County Public Works, Oregon Department of Geology, Umatilla National Forest, Oregon Department of Fish and Wildlife, and Natural Resources Conservation Service. USGS topographic maps, Geographical Informational Systems data, aerial photos, and Department of Geology maps were also used.

Results
Sediment Sources in the Willow Creek Watershed
The following were assessed as potential sediment sources: roads, channel erosion, slope instability, erosion from land uses, and erosion from burned lands.

Roads
Roads account for 1.04 % of the entire area of the Willow Creek watershed (see Chapter 4). There is minimal information available about roads in the watershed. For more information than presented below, see *Chapter 4: Hydrology and Water Use*.

Culverts
Culvert assessments have been conducted on nine culverts in the Willow Creek watershed. None of the evaluated culverts were given a high priority for replacement. The two culverts on Forest Service land in the Willow Creek watershed were moderate fish passage barriers but were given low priority due to the poor fish habitat upstream (Phillips/Gordon Draft Ecosystem Analysis, 2001). **Appendix 8.2** shows the details of the culverts assessed on county roads.

Road Conditions
Roads can contribute to sediment in streams, especially if not properly maintained. Where roads are placed in relation to the topography of an area can either cause small or large amounts of sediment to wash off the road. If a road is placed at the bottom of an incline, the water running off the incline will likely pass over the road, picking up sediment as it continues on its path to the stream. Water bars only last a number of years until they are in need of repair (OWEB 1999). An assessment needs to be conducted on the conditions of roads in the watershed, to determine which roads are contributing sediment into the stream system.

After the 1996 flood, the Union County Public Works conducted a number of projects to repair road damage. **Appendix 8.1** lists the projects undertaken in the Willow Creek watershed. While there have been no road assessments on county roads in the watershed, this list is a good beginning. It points out sections of roads that are the most at risk during peak flows. Culverts that were either destroyed or plugged during the flood were replaced by 100-year floodplain culverts (pers. comm., Bob Kelly, Union County Public Works).

Streams and Roads
Roads that are within 200 feet of streams can affect a stream's morphology by artificial constrainment and can be direct contributors of sediment to streams. **Table 8.1** shows the miles of roads that are within 200 feet of streams in each subwatershed. Finley and Dry Creeks are the streams most affected by roads.

Table 8.1: Road miles in the Willow Creek Watershed within 200 feet of streams

Subwatershed	Miles of roads within 200 feet of streams	Total road miles	% of roads within 200 feet of streams
Dry	9.7	50.3	19%
Upper	0.3	21.5	1%
Lower	2.4	42.7	6%
South Fork	0.3	23.6	1%
Entire Watershed	12.3	83	15%

source: ODOT spatial data

Channel and Near Channel Erosion
In the Oregon Department of Fish and Wildlife's habitat surveys of Willow, Dry, and Mill Creeks, channel erosion was measured in terms of bank erosion and fine sediment in **riffles**. **Figure 8.1** shows the percentage of actively eroding banks and **Figure 8.2** shows the percentage of fine sediments in riffles on reaches of Willow, Dry, and Mill Creeks surveyed by ODFW. **Appendix 8.2** in the *Fish and Fish Habitat Chapter* lists the ODFW benchmarks for fish habitat.

Bank erosion greater than 20% is considered unnatural and undesirable (pers. comm., Brad Lovatt, ODFW). Streams that are **dynamic** will often have eroding banks as one bank erodes to move laterally. Channel habitat types in the Willow Creek watershed that move laterally include medium floodplain (FP2) and small floodplain (FP3). In more confined CHTs, natural bank erosion may result from fallen trees, landslides, and/or debris flows (EPA 1991). For more information about channel habitat types in the Willow Creek watershed, see *Chapter 3: Channel Habitat Types*.

Figure 8.1: Percent of Actively Eroding Streambank, 1995 ODFW Habitat Survey

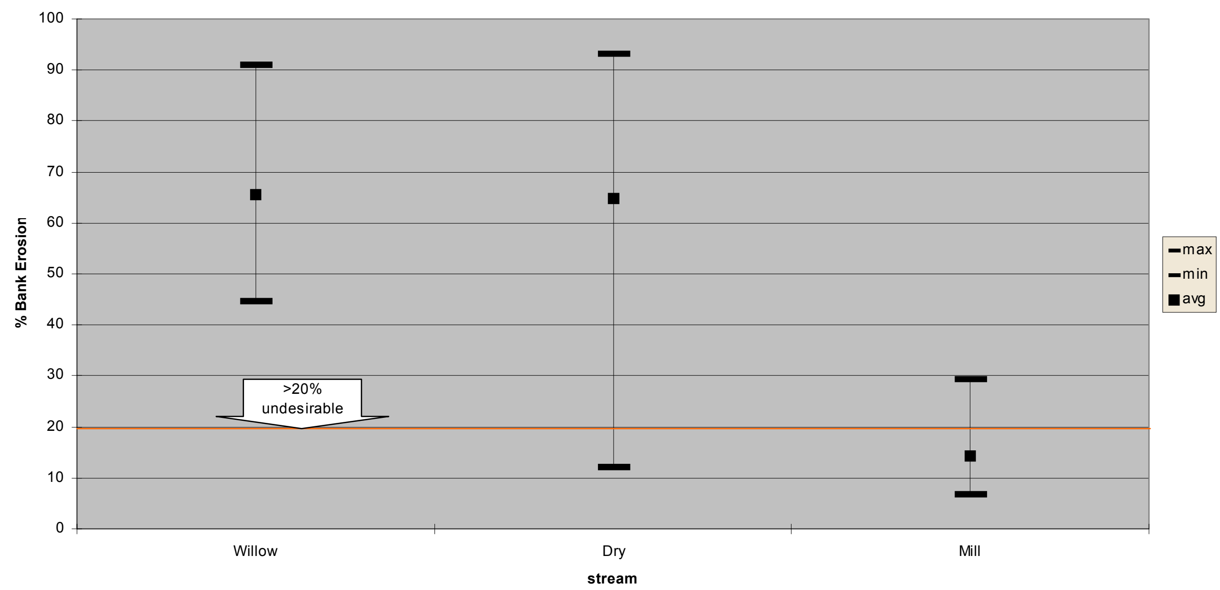
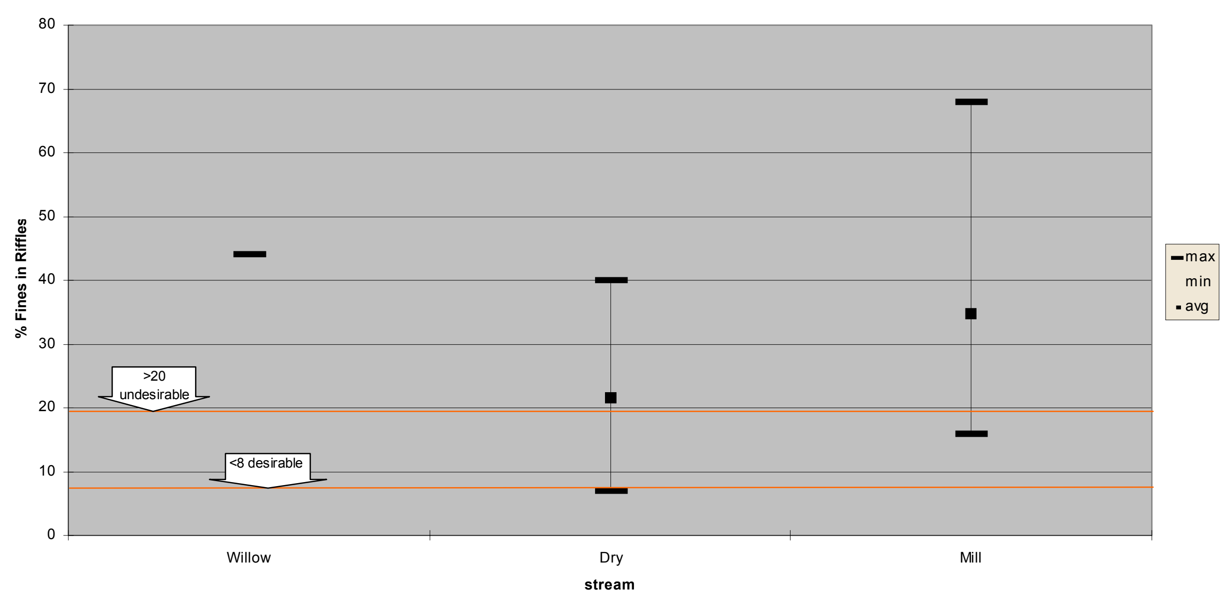


Figure 8.2: Percent Fines in Riffles, 1995 ODFW Habitat Survey



Fine sediments in riffles are an indication of the ability of a stream to manage its sediment load. In ideal conditions, slow moving pools are where most deposition occurs. However, if the sediment load is too high for the stream or there are not enough pools, then the stream will deposit sediment in other sections of the stream, such as riffles. Because riffles are where spawning gravel is most likely to be found, this can result in a net loss of spawning gravel, or impede the successful reproduction of cold-water fish. The ODFW undesirable benchmark for fine sediments in riffles in eastern Oregon has been set at 20% and the desirable benchmark at 8%.

Slope Instability Not Related to Roads

Historically the upper watershed has had slope instability due to landslides and debris avalanches. In draft geology quad maps the Oregon Department of Geology has recently created, there are a number of landslides that have occurred in the Holocene period (the last 11,000 years). **Map 4.2** in *Chapter 4: Hydrology and Water Use* shows these landslides. The majority are on the eastern face of Mt. Emily, near the headwaters of End Creek and Indian Trail Canyon, but there are a number of small landslides in the Pumpkin Ridge area and one south of Colt Canyon near Finley Creek.

The Department of Geology considers landslides a geologic hazard of the watershed and has stated that a landslide could occur at any given time (Mark Ferns 2001). Land use practices such as harvesting trees and road building on steep slopes can increase the risk of landslides.

No major recent landslides are known to occur on U.S. Forest Service land in the watershed, but it is possible there have been small landslides (Phillips-Gordon Draft Ecosystem Analysis, 2001).

Debris flows are known to occur in the watershed. In the 1996 rain-on-snow event, debris flows that began in the upper watershed brought debris and sediment downhill (pers. comm., Bob Kelley, UCPW). Debris flows can be a significant source of sediment in streams when they do occur.

Erosion from Agricultural and Range Lands

The Natural Resource Conservation Service (NRCS) has divided soils in the Union County Soil Survey into two categories: non-highly erodible and highly erodible. Soils can be highly erodible from wind and/or water. Thirty-five percent of agricultural soils in the Willow Creek watershed are highly-erodible by water (NRCS, digital Union County soil survey data). Seventy-two percent of potential range soils on private land in the Willow Creek watershed are highly-erodible by water. Three soil types in the watershed are highly-erodible by wind. For more information about soils, see the Union County Soil Survey. **Appendix 8.3** lists the soil types present in the private lands of the watershed.

Soil types are not the only factor in erosion from crop and rangelands. Cover type, conservation measures, precipitation, and slope also determine whether an area is likely to be contributing sediment to streams. A detailed assessment of agriculture's sediment contribution to streams needs to be conducted.

Erosion from Ditches

There are uncounted miles of ditches in the Willow Creek watershed, used for road drainage, irrigation, and land drainage. Unstable ditches can contribute sediment directly into the stream system. Annual cleaning of ditches can increase sediment contributions to streams from ditches.

Erosion from Burned Land

In 1986, 250 acres of Wallowa-Whitman National Forest land were burned due to forest fire, in the Frizzell Creek drainage. There are no other recent fires within the Willow Creek watershed. The fuel loads of many forest stands are large enough to have increased fire risks. For more information, see *Chapter 12: Forest Health*.

Discussion

Too much sediment in spawning gravels can adversely affect salmonid spawning. Fine sediment in riffles ranged from 7 to 68 percent in surveyed reaches in the Willow Creek watershed. As the ODFW benchmarks are set for fish needs, the excessive fines in riffles of the surveyed reaches indicates that fish reproduction and development may be impaired in those reaches. This also means sediment deposition amounts are too large for quality fish habitat in those reaches. Most deposition occurs in pools, where there is less flow. It is possible that the sediment loads of Mill and Dry Creeks are more than the streams can handle, hence the deposition in riffles. It is also possible that the current lack of large woody debris (LWD) and low numbers of pools per mile (See *Chapter 10: Fish and Fish Habitat* discussion) have changed the distribution of sediment in the stream. Megahan found that a reduced recruitment rate of LWD can increase sediment yield at the mouth of a watershed when there is no net difference in the rate of sediment delivery from the hillslope into the channel system (as cited in EPA 1991). To determine whether sediment loading, stream structure, or both are the causes of excessive fines in riffles, more sediment data needs to be collected.

All four subwatersheds in the Willow Creek watershed were listed as high priority areas for sediment in the Upper Grande Ronde Sub-basin Water Quality Management Plan (DEQ 2000). The WQMP also suggests that sediment is an issue of concern for the area. If the sediment loads **are** too large for the streams to handle, what can be done? Sediment sources need to be identified and minimized. Possible sediment sources in the Willow Creek watershed include: roads, crop and range lands, stream bank erosion, ditch erosion, and landslides.

Roads can be one of the major contributors of sediment to streams, especially when there are high road densities. In the Willow Creek watershed, the entire watershed and each subwatershed all have relatively low road densities. But a large majority of the roads in the watershed are unpaved, and thus are contributing some amount of sediment to streams. Native surface roads contribute more sediment to streams than rocked or paved roads.

There are a number of stream reaches constrained by nearby roads. Dry Creek road parallels Dry Creek on both private and public lands. Unpaved but rocked, this road is a source of sediment to Dry Creek. The Umatilla National Forest recognizes that Dry Creek Road is contributing sediment to Dry Creek and has developed a project for improving the road to reduce erosion.

The geology and topography of the upland sections of the watershed show landslides as a potential occurrence. While the geology and topography cannot be changed, they can be recognized and land uses adjusted to minimize landslides and debris flows.

One-third of crop and range lands are highly-erodible and some of those lands are on moderate slopes. These lands are probably contributing sediment to streams. Conservation practices and riparian buffers can minimize the amount of sediment that reaches streams and also conserve soil on crop and range lands.

The ODFW habitat survey shows high levels of bank erosion in Dry, Mill, and Willow Creeks. Therefore, streambank erosion is a source of sediment to streams in the watershed. The erosion can be a result of streambank instability or from peak flows reshaping the channel form. Flows passing through channelized reaches may have more energy than when in original channels, with the added energy resulting in streambank and streambed erosion. Streambank instability can be the result of lack of riparian vegetation. As the results in Chapter 5: Riparian Areas show limited woody and brush vegetation in riparian areas, especially along Willow Creek, this is likely the case in the Willow Creek watershed.

Erosion from ditches is also a source of sediment to streams in the Willow Creek watershed. How and when ditches are cleaned can help control ditch erosion.

Understanding the geology, topography, climate, and soils of the watershed, along with how human activities can contribute sediment to streams and alter how streams manage their sediment loads is a good beginning for improving sediment conditions and fish habitat. Implementing actions to control sediment and improve stream structure will be the next step.

Data Gaps

- miles of native and rocked road in the watershed
- assessment on all culverts
- identification and mapping of all landslides in watershed
- miles of ditches in the watershed

References

Lovatt, Brad. Aquatic Inventory Project Stream Report, Willow, Dry, and Mill Creeks. ODFW, 1995.

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Watershed Professionals Network. Oregon Watershed Assessment Manual. Prepared for the Governor's Watershed Enhancement Board, Salem, Oregon, June 1999.

Appendix 8.1: Locations of County Road Sections Affected in 1996 Flood

Name of Road	Location	Problem	Work Done
Pumpkin Ridge Road	Myers Road, east ½ mile	washout	shoulder restoration
Sanderson Road	Summerville Rd., north ½ mile	road washed out in one area, culvert washed out, ditch washed and eroded into edge of road	replaced 3 existing pipes with larger CMPs
Behrens Lane	location ½ mile west	culvert washed out	replace CMP
Wagoner Hill Lane	Hunter Road, west 1 mile	½ mile washed out, ditches out both sides of road	rebuild road with base, top rock, replace CMPs and ditches
Hunter Road	5 miles north of Island City	washout	repair washout; shoulder restoration
Summerville Road	Imbler north to Sanderson Road	shoulders washed	shoulder restoration
Hug Road	1 mile north of Courtney Lane	road washed from ditches, eroding and flowing over banks	reconstruct road, replacing existing concrete pipe
Courtney Lane	1 mile east of Summerville	CMP plugged, washing out riprap and shoulder material	riprap, base rock, top rock
Ruckle Road		up in draw, washout in couple of spots	

source: Union County Public Works

Appendix 8.2: Culvert Assessment on County-Owned Roads in Willow Creek Watershed by ODFW, 1998

Road	Rd Mi	Stream	Type	Length	Diameter	Drop	Depth	Slope	Species	Stream Mi	Hab Qual	Priority
10A	1.7	Slide Creek	CPC	35	24	12	0	0.5	RT	3.5	P	L
14	1.81	Coon Creek	CPC	50	24	48	0	2	RT(ST)	3.2	P	L
17	0.81	End Creek	CMP	40	44	6	13	1	RT	4.8	P	L
20	0.08	Dry Creek	CBC	55	216	30	0	0.5	ST	12	F	M
20	0.23	Little Dry Creek	CMP	50	64	0	8	2	(RT)	1	P	L
20	0.5	Smith Creek	CPC	60	36	8	3	0.5	RT ST	6	P	L
20A	1.95	Fir Creek	CPC	50	24	8	3	1	RT ST	3	P	L

Legend
Road: the State (ODOT) or county road number
Road Mile: Road mile of the culvert's location
Stream: the stream containing the culvert
Type: the material the culvert is composed of and the culvert's shape
CMP: Corrugated Metal Pipe
Length: length of culvert, in feet
Diameter: culvert diameter, in inches
Drop: measured or estimated distance in inches between water surface in culvert to the water surface of the stream below at the time of the survey
Depth: measured or estimated depth, in inches, of the pool below the culvert (if present) during the period of migration
Slope: estimated slope of the culvert from horizontal, in percent
Species: fish species present in the subject stream. Species suspected but not verified to be present are enclosed in parentheses.
RT: redband trout; ST: steelhead
Stream Mile: estimeated miles of stream above the subject culvert to either (1) the verified end of the fish distribution or next known upstream passage barrier or the apparent end of the stream as indicated on USGS quad maps
Habitat Quality: an assessment of habitat quality by ODFW field personnel. Possible ratings are Good, Fair, Poor and Unknown. In most cases, the rating reflects firsthand knowledge of the stream. In others, the streams are not known individually and are ranked based on the rater's knowledge of the area in general
Priority: ODFW district personnel rated each culvert as High, Medium, or Low priority for repair based on personal knowledge of fish populations and habitat conditions

Chapter 9: Channel Modification

Introduction
The purpose of the channel modification component is to identify current and historic channel modifications in the Willow Creek watershed. By knowing the types and amount of channel modifications, current watershed functions can be better understood and restoration opportunities identified.

Background
Channel modifications occur when humans alter stream channels. These modifications can change channel geomorphology and biotic function in the altered reach and in reaches and streams downstream of the modification. Modification types include: dams, roads, bridges, rip-rap, ditches, channelization, culverts, in-stream mining, dredging, levee building, and other bank stabilization efforts. These activities typically result in more uniform channel cross sections, steeper stream gradients, and reduced average pool depths.

By changing stream gradients and straightening channel paths, channel modifications cause increases in the energy of stream flows. This energy, no longer dissipated over length and meandering channels, instead can cut into the stream bed and banks, causing instability and increased erosion. This causes an increase in the sediment load on the stream. An undisturbed stream's sediment load is in equilibrium, as the stream is able to handle the sediment eroded and transported and then deposited. Channel instability occurs when the scouring process leads to **degradation**, or excessive sediment deposition results in **aggradation**.

Channel modifications have significantly altered salmonid habitat in the Pacific Northwest. Dams along the Columbia, Snake, and other rivers have created fish passage barriers for sea-migrating species such as the spring chinook and summer steelhead. Changes in salmonid spawning and rearing habitat have also affected salmonid population numbers.

Methods
Topographic maps, aerial photographs, and other records were gathered and used in identifying channel modifications in the Willow Creek watershed. Stream lengths were estimated using a map wheel.

Results
Channelization
Aerial photos were used to estimate the amount of channelization on Willow, Dry, and Mill Creeks. The entirety of Willow Creek has been modified in some way, with the majority of the stream confined by adjacent land practices, such as agriculture and roads. About 40% of Willow Creek has been channelized, although there are reaches of the creek that, once channelized, appear to have created new channel and left the channelized reaches. Mill Creek was estimated at 30% channelized, with the majority of the stream artificially confined by agricultural and range lands on each side of the stream. Dry Creek was estimated at 15% channelization. Roughly half of Dry Creek was artificially confined by agricultural and range lands; the other half was

confined by Ruckles Road. These estimates do not match the amount of channelization in *Chapter 3: Channel Habitat Type* because they were estimated from aerial photography taken in 1997, not the digital EPA stream layer, which digitized only large channelized sections. The EPA stream layer shows no sections of Mill, Dry or Willow as channelized. The detail level of the EPA layer is much coarser than examining aerial photographs, hence the differences in what is channelized.

Some stream reaches have not only been channelized, but placed in artificial channels. Potential stream reaches for rechanneling streams into their historical channels were identified. On Willow Creek, from its convergence with Mill Creek to its mouth, there were visible old channels and cutoff oxbows. The total length of ox-bow cutoffs equaled 5,200 feet. Returning channelized sections to historic channels would result in reaches equaling 6,000 feet where current channels total to 3,600 feet. On Willow Creek, from the mouth of Dry Creek to its convergence with Mill Creek, 2,300 feet of oxbow cutoffs could potentially be reconnected. Returning channelized reaches to historic channels would result in 4,500 feet of stream where there are currently 2,500 feet.

Ditches/Irrigation Canals

As land has been drained for agriculture, more and more ditches have been dug in the Willow Creek watershed. Aerial photos from 1937 show many of the ditches already in existence. With the increase in irrigated agriculture in the 1960s, the need to divert water through ditches for irrigation has also increased. Ditches are used as drainage alongside roads in the watershed. The miles of ditches in the Willow Creek watershed far exceed stream miles.

Irrigation Diversions

Agriculture in the Willow Creek watershed is mainly irrigation-based. There are numerous irrigation diversions. Some are for diverting water into ditches and others for the purpose of pumping water. Many of these could be fish passage barriers since not all have fish ladders. Fish may also become entrained in ditches since not all diversions have fish screens. A diversion inventory is necessary to determine the number of fish passage barriers in the watershed.

Dams

Two dams are known to exist on Willow Creek. One is a potential fish passage barrier; the other had a fish passage ladder constructed in 1998. On Dry Creek, a dam below the Union County gravel pit was recorded in ODFW's habitat survey in 1995. No other permanent dams are known to exist in the Willow Creek watershed, but a complete survey of streams in the watershed has not been conducted.

Roads

Roads that parallel streams affect stream structure by actinically constraining the stream in a narrow area. They also contribute sediment to streams and decrease infiltration rates, depending upon their surfaces. *Chapter 4: Hydrology and Water Use* includes information on the hydrological effects of roads in the Willow Creek watershed. *Chapter 8: Sediment* provides more information on sediment contributions of roads, the mileage of streams affected by nearby roads, and culvert information.

Restoration Projects
Projects that restore natural lands or conserve resources can also be considered channel modifications. In the Willow Creek watershed, two projects have been funded: Bill Howell Water and Sediment Control Project, through the Oregon Watershed Health Program in 1995 and Willow Creek Passage, through the Grande Ronde Model Watershed Program in 1997. The Sediment Control Project was to stop an active head cut from working further up the swale of a cropland field and reduce sediment entering Willow Creek. The Willow Creek Passage project was to create a fish ladder for fish passage by a dam on Willow Creek. Both projects were in the Lower Willow subwatershed.

Discussion
Several types of channel modifications were identified while researching this chapter. Ditches and diversions are likely the most prevalent, due to the agricultural nature of the watershed. As mentioned in the background section of this chapter, these modifications have changed the hydrology of the watershed, causing less infiltration of water into the soil and water to enter the stream system more rapidly.

Stream channelization is common in the agricultural areas of the watershed, especially on smaller sized streams. Agricultural land uses on both sides of streams and roads that parallel streams have also artificially confined stream channels. This can result in effects similar to those of channelization, namely disconnection with the stream's floodplain, loss of habitat complexity, and unstable streambanks.

Many of the channel modifications in the Willow Creek watershed are necessary to infrastructure and agriculture. Irrigation and road ditches are necessary for crop production and road stability. Diversion dams are necessary for irrigation purposes. However, the effects that these necessary modifications have on fish habitat and stream structure can be minimized. Fish passage barriers can be identified and actions taken to provide passage, such as the fish ladder project on lower Willow Creek. Roads and ditches can be maintained in order to have minimal sediment enter the stream system. Inadequate culverts can be replaced with 50-year or 100-year flood sized culverts.
Opportunities exist for rerouting channelized sections of streams into their old channels. This would increase the length of stream channels and the amount of time that water stays within the watershed, thereby assisting with diminishing the intensity of peak flows and potentially decreasing the amount of time of low flows. Increasing the amount of channel could be combined with riparian buffers (see *Chapter 5: Riparian Areas*) to improve the adjacent floodplain's ability to store and hold water, thereby increasing the amount of water available for release during low flows.

Streambank stabilization through the use of riprap and other manmade materials is a channel modification that can ultimately do more harm that good. While temporarily preventing bank erosion, peak flow events can whittle stream banks out from behind riprap, causing even further erosion problems. Although sometimes necessary in the short term, manmade streambank stabilization is best minimized in the long term. A long term alternative is riparian revegetation, which can provide natural bank stabilization that will not alter channel form.

Data Gaps
- Inventory of diversions
- Inventory of all possible fish passage barriers
- Culvert Inventory on all culverts in the watershed

References
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Chapter 10: Fish and Fish Habitat

Introduction
This chapter discusses fish presence and distribution, migration barriers, and habitat conditions in the Willow Creek watershed.

Background
Salmonids are the most widespread group of fish in the state of Oregon and are well-recognized as indicators of watershed health (OWEB manual, 1999). Thus, protecting and restoring salmonid habitat will ultimately result in improving the health of a watershed. To do so, we must understand salmonid life cycles and habitat needs and evaluate current habitat conditions.

Declining salmon and steelhead populations in the Interior Columbia Basin have prompted the National Marine Fisheries Service to list the Snake River spring chinook run as threatened in 1992, and the Snake River summer steelhead run as threatened in 1998. Declining salmonid populations in the Grande Ronde Basin are believed to be caused by a combination of factors in the basin, along with the Snake and Columbia Rivers, and the Pacific Ocean. Habitat degradation in all habitats, fish passage barriers due to the dams on the Columbia and lower Snake Rivers, ocean conditions, and overexploitation of mixed-stock fisheries are the downstream causes of population loss (NPPC 1986, ref. in McIntosh 1992). In the Grande Ronde Basin, the major in-basin causes of salmonid population declines are in-channel and riparian habitat degradation, along with high summer and low winter water temperature (James 1984; ODFW 1987 and NPPC 1990, ref. in McIntosh 1992).

The Oregon Department of Fish and Wildlife has developed a series of habitat benchmarks of undesirable and desirable conditions. Since loss of habitat complexity is a major cause of population decline, it is important to understand what provides complexity in streams. Important components of habitat complexity include: the amount of pools, riffles, and gravels, stream width to depth ratio, large woody debris, and riparian vegetation. Removal of large woody debris beginning in the 1950s and continuing on to the 1980s in the Grande Ronde Basin has been one of the reasons behind loss of habitat complexity. Removing the large wood (in an effort to increase dissolved oxygen for fish) caused a drastic reduction in the pool area on streams (McIntosh 1992). Pools, mostly found on lower unconstrained channels, are important rearing habitat. Loss of riparian vegetation due to adjacent land uses has also reduced the amount of in-stream large woody debris and shade and increased width to depth ratios.

The currently supports summer steelhead populations and resident species. The lower reaches of Willow Creek also provide rearing habitat for spring chinook salmon (pers. comm., Brad Lovatt, ODFW). Historically, the Grande Ronde Basin supported the now extinct coho salmon and fall chinook salmon, but it is unknown if these species were present in the Willow Creek watershed.

Methods
Stream surveys, fish presence surveys, redd surveys, stocking records, and salmonid distribution maps were obtained from the Oregon Department of Fish and Wildlife and the U.S. Forest Service. Information from these sources and other published reports were used to document

salmon life cycles, distribution, origin, population trends, habitat conditions, and limiting factors. Oregon Department of Fish and Wildlife and U.S. Forest Service fisheries biologists were consulted for additional assistance and professional opinions.

Results

Fish Life Cycles

Summer Steelhead

Steelhead trout (*Oncorhychus mykiss*) are a sea-run, or **anadromous**, form of rainbow trout. Steelhead juveniles migrate in the spring to the sea and undergo a physiological transformation known as "smolting" to adapt to salt water. Steelhead in the Grande Ronde basin are considered part of the subspecies *Oncorhychus mykiss gairdneri*, or Inland Columbia Basin Steelhead, and are part of the "A-run" part of the Snake River Run. "A-run" steelhead typically spend only one year in the ocean before returning to spawn (ODFW 1995).

Steelhead in the Grande Ronde Basin are also known as summer steelhead. This signifies that juvenile steelhead return to freshwater from spring to early fall (May-Oct). They then mature and spawn from January through May of the following year (ODFW 1995).

Female steelhead dig redds and deposit eggs in gravel. The eggs hatch 35-50 days later, depending upon the water temperature. The alevins (young fish that still survive off their yolk sac) remain 2 to 3 weeks longer in the gravel, until their yolk sacs are absorbed. They then emerge as fry and begin to feed (ODFW 1995).

Steelhead life cycles are unpredictable and juveniles can rear in freshwater from 1 to 4 years. Juvenile steelhead head to the ocean as "smolts" when they are approximately 6-8 inches, migrating individually. Steelhead can remain in the ocean as little as a few months or as long as two years, until they return to spawn. (ODFW 1995).

Spring/Summer Chinook Salmon

Spring chinook (*Oncorhynchus tshawytscha*) are an anadromous species of fish, meaning they spawn in fresh water and spend some time rearing in salt water. Those that spawn in the Grande Ronde basin are part of the Snake River spring/summer chinook run (ODFW 1995). They are a "stream-type" chinook, which spend a large part of their time in headwater freshwater streams, as opposed to the "ocean-type" chinook, which spend more time in estuary waters and the ocean.

Chinook salmon can spend one to six years at sea, although 2-4 years is more typical. Some males, known as precocious fish, mature in freshwater. Other males return after only two to three months in saltwater. Spring chinook enter the Grande Ronde basin in May-September. After spawning, the adults die. The eggs incubate for 90-150 days. Juveniles typically emerge February through June. Juvenile chinook rear in freshwater streams from three months to two years before smolting. They migrate in schools during April and May to the ocean (ODFW 1995).

Resident Rainbow Trout
Some rainbow trout born in the watershed do not migrate to the sea. Rather, they remain in freshwater their entire lives. They typically spawn two to four years after emerging from their eggs. Isolated populations of resident rainbow may occur above natural or artificial barriers (ODFW 1995).

Brook Trout
Brook trout (*Salvelinus fontinalis*) are an introduced species whose original habitat range was from the Great Lakes to Georgia in the eastern United States. Brook trout generally spawn from August to December, when water temperatures cool to 4.5ºC to 10ºC. They mature sexually at one year and live no longer than four years (Ohio DNR website).

Distribution
Salmonid distribution maps for the Grande Ronde Basin have been created digitally by ODFW's state GIS department. **Map 10.1** show summer steelhead distribution in the . This is based upon limited redd surveys. Thus, it is possible for steelhead to be present in other streams in the watershed, but there is no data to support this. **Table 10.1** lists miles of fishbearing and nonfishbearing streams by subwatershed.

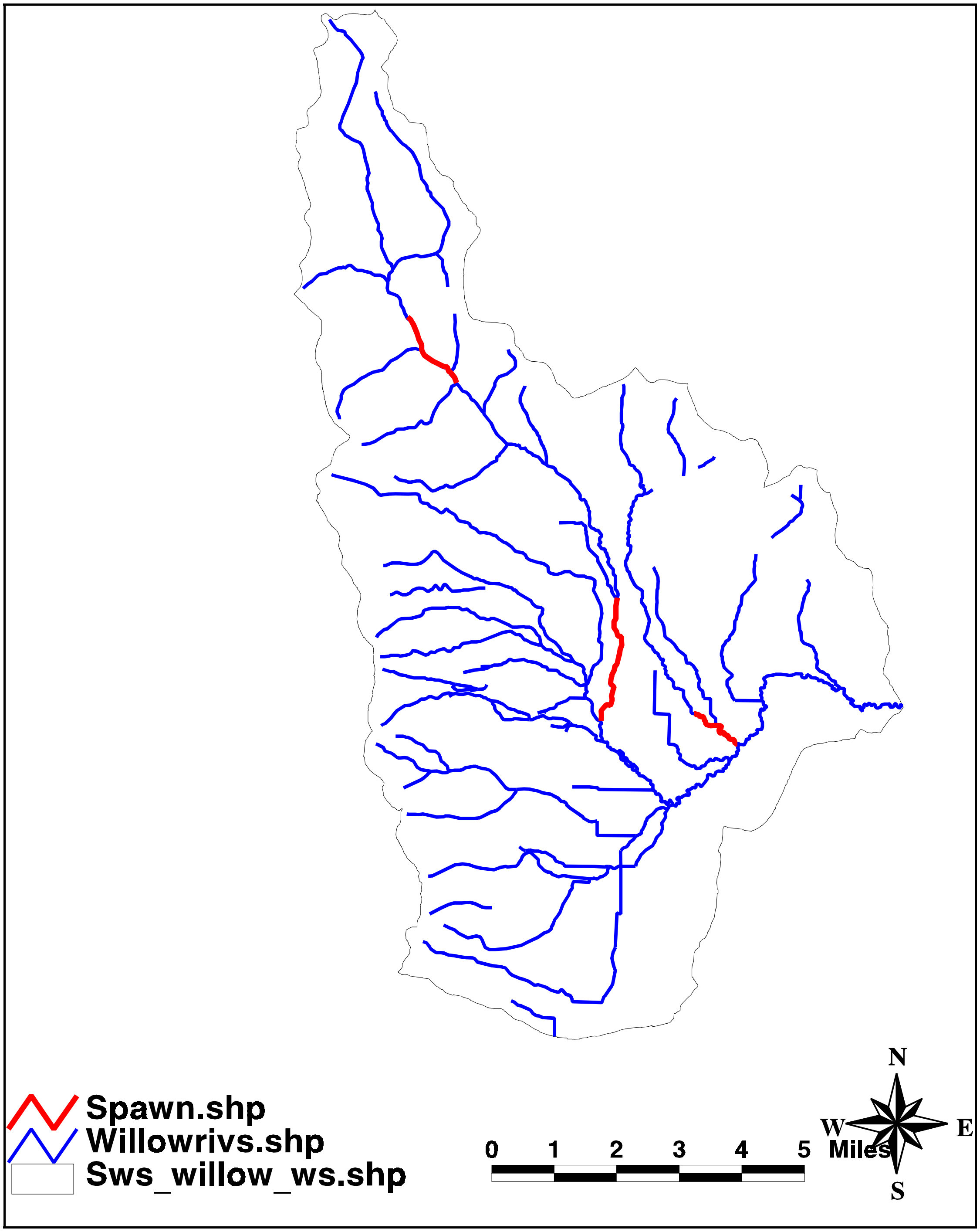
Table 10.1: Miles of Fishbearing and Non-fishbearing Streams in the Willow Creek Watershed

Subwatershed	Fish-bearing	Non-fishbearing	Total Stream Miles
Lower Willow	12.0	0	12.0
South Fork Willow	21.0	16.0	37.0
Upper Willow	38.0	17.0	55.0
Dry	14.0	8.0	22.0

source: UMGRR Drainage Section 7 Biological Assessment, USFS

"Physical and biological stream surveys conducted by the Oregon State Game Commission in October of 1965 found rainbow trout, dace, sculpins, and redside shiners in Willow Creek. Sculpins were found in the lower 2.5 miles of Mill Creek and rainbow trout were found throughout the system." "In addition, steelhead spawning was observed in Finley Creek in the 1960s" (ODFW annual report, 1965).

Map 10.1: Known Summer Steelhead Distribution in Willow Creek Watershed



created using ODFW summer steelhead distribution shapefile

Stock Status/Origin
Stocking records were obtained from Oregon Department of Fish and Wildlife. Brook trout, rainbow trout, coho salmon, and summer steelhead all have been stocked in the Willow Creek watershed at some time (**Table 10.2**). Currently, no fish species are stocked in the watershed.

Table 10.2: Stocking Records in the Willow Creek Watershed

Species	Stocking Notes	Native or Exotic	Information Source
Coho salmon	in 1966, 375,000 fingerlings (1") were released in Mill Creek	native	ODFW Annual Report, 1966
Summer Steelhead	in 1974, 695 legal were released in Mill Creek	native	ODFW Stocking Records
Rainbow Trout	Historically 1928-1953	native	ODFW Stocking Records
Brook Trout	Historically from 1930-1932	exotic	ODFW Stocking Records

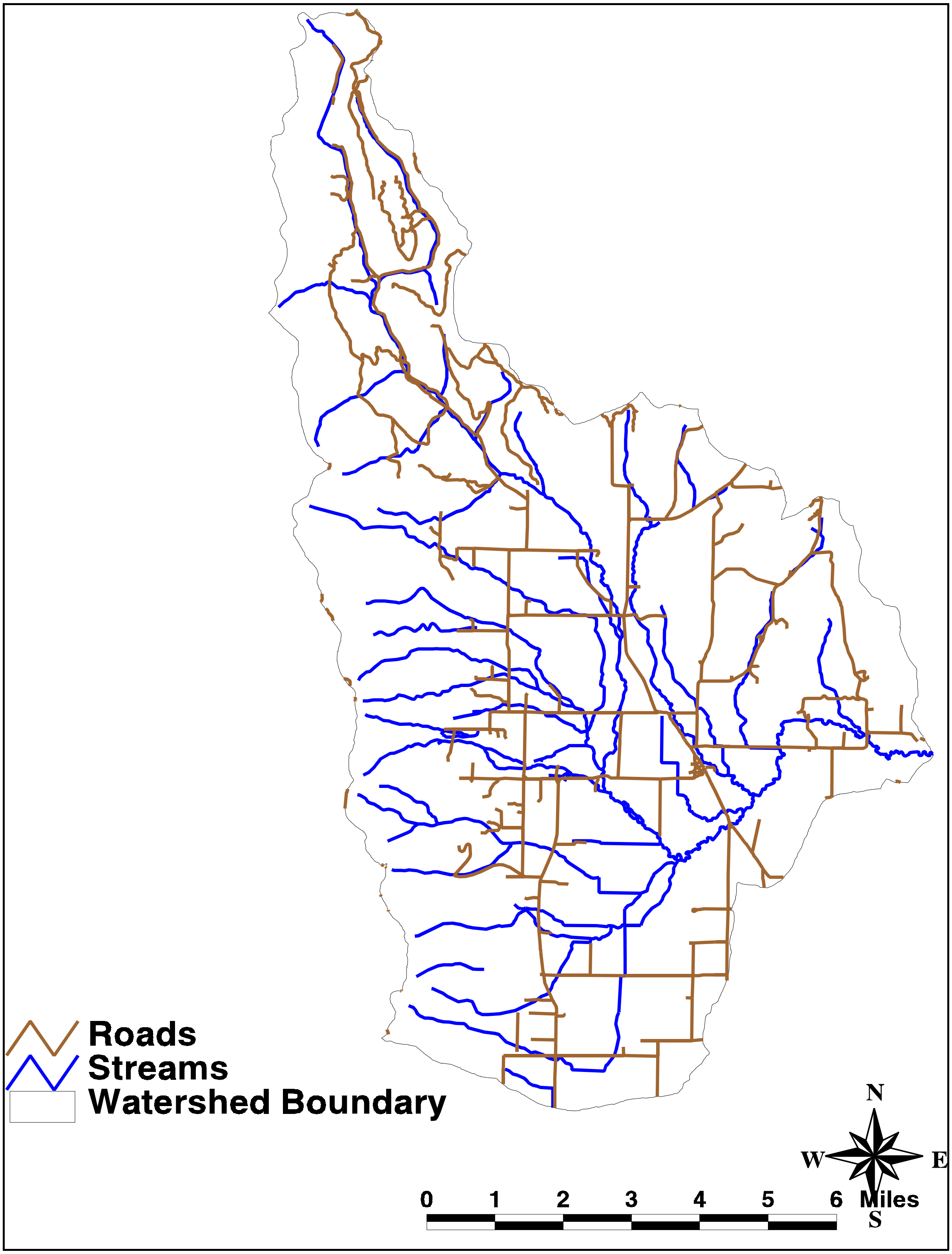
source: ODFW annual reports

Fish Passage Barriers
Culvert studies on county and Forest Service roads have been conducted in the Willow Creek watershed. On Umatilla National Forest roads, two culverts on Dry Creek have been identified as moderate fish passage barriers. For Union County roads, there were two culverts identified as moderate fish passage barriers, and six culverts identified as low potential for fish passage barriers. **Appendix 8.3** in *Chapter 8: Sediment* contains more detailed culvert information for the Willow Creek watershed.

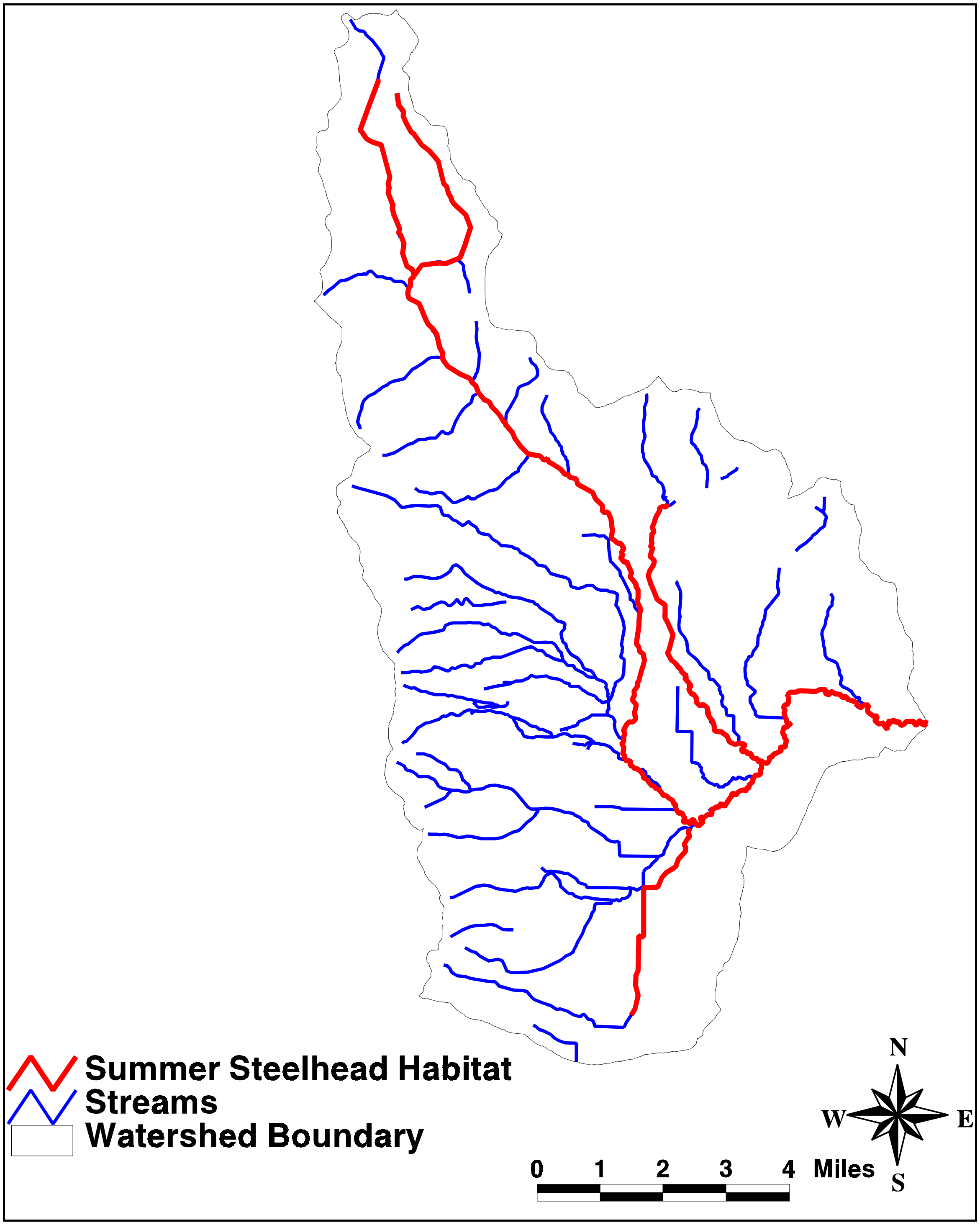
Map 10.2 shows stream and road intersections for the Willow Creek watershed. There are 83 intersections. An assessment needs to be conducted on **fish passage** ability and flow capacity of the remaining culverts present at these crossings.

Fish Presence and Distribution Data
From 1966-1975, the Oregon Department of Fish and Wildlife conducted fish presence and redd surveys on Willow Creek, Mill Creek, Dry Creek, and Finley Creek. Dry Creek was also surveyed in 1980. **Map 10.3** shows which sections of stream were surveyed. In 1997 and 2000, redd surveys were conducted on the index reach of Dry Creek. During 1995, fish presence surveys were conducted on Smith Creek, Jack Canyon, Moonshine Canyon, and Smith Canyon Creek by ODFW and the Oregon Department of Forestry. Fish distribution was also noted during ODFW habitat surveys conducted in 1995 on Willow, Dry, and Mill Creeks.

Map 10.2: Stream and Road Crossings



Map 10.3: Reaches Surveyed for Redds by Oregon Department of Fish and Wildlife



Stream Specific Data
In 1995, the Oregon Department of Fish and Wildlife conducted stream habitat surveys on Willow Creek, Dry Creek, and Mill Creek. However, it is important to note that the 1996 flood may have changed habitat conditions since the survey. In 1995, fish presence surveys were conducted on Smith Creek, Jack Canyon, Moonshine Canyon, and Smith Canyon Creek in conjunction with ODFW and Oregon Department of Forestry. In 1992 and in 2000, the Umatilla National Forest conducted stream habitat surveys on Finley Creek and reaches of Dry Creek on Forest Service land.

Results from these surveys have been summarized and reported below. **Appendix 10.1** contains the ODFW habitat benchmarks against which to compare habitat parameters.

1995 ODFW habitat survey

Willow Creek
In 1995, ODFW surveyed segments of Willow Creek where they had land owner permission. They surveyed 7,623 meters (4.7 mi) (44%) of the 17,265 meter (10.7 mi) length of Willow Creek. The summary of the surveys stated:

"Willow Creek is a low gradient stream meandering within a very broad valley. The overall gradient is 0.1%. Except for the upper mile of Willow Creek, which contains riffle habitat and a high percentage of gravel, the substrate is composed almost entirely of fine sediment (silt, organics, and sand). Approximately one third of the habitat is pools. The pools have little cover for fish, but the large, deep pools offer a substantial amount of habitat for resident trout, and rearing for juvenile steelhead during times of the year when stream temperatures are moderated. The remaining portion of the stream consists of glide habitat. There are few pieces of large wood, low amounts of stream shade, and few riparian trees."

"Of the reaches surveyed, there are a high percent of actively eroding stream banks (57-91%), high values for open sky (74-91%), and high percentages of silt/organic and sand substrate (86-100%). There are also few undercut streambanks and low amounts of large woody debris. Surveyors reported stream temperatures ranging from 17.5°C (63.5°F) in the morning to 20.7°C (69.3°F) in the late afternoon. Dominant habitat for the survey is glide (65%), and dominant substrate is silt/organic (84%)."

Mill Creek
In 1995, ODFW surveyed segments of Mill Creek where they had landowner permission, beginning at the confluence with Willow Creek and ending at County Road 39. Mill Creek was surveyed for 2,905 meters (1.8 mi) (31%) of a total 9,245 meters (5.7 mi). The summary of the habitat surveys stated:

"Mill Creek is a low gradient, meandering stream which flows through a broad valley. The average gradient is 0.6%. The stream is spring fed which provides year round, stable flow. Riffles, which make up a large proportion of the habitat, contains a high percentage of gravel and provide spawning areas. About one fifth of the total habitat is pools, and offer rearing opportunities for juvenile steelhead, as well as habitat for resident trout. Riparian vegetation is well developed in areas, with a high number of riparian trees. The majority of the trees are small diameter hardwoods that provide stream shade and contribute some large wood."

Surveyors described riparian vegetation along Mill Creek as "well developed consisting of dense hawthorn, alder, and willow as well as annual and perennial grasses. Number of pieces of large woody debris within the active channel range from 1.1 pieces/100 meters (328 ft) to 7.5 pieces/100 meters. Volume of large woody debris ranges from $0.6m^3$/100 meters to $4.3m^3$/100 meters."

Dry Creek
In 1995, ODFW surveyed segments of Dry Creek where they had land owner permission. The stream was surveyed for 7,082 meters (4.4 miles) (52%) out of the total 13,713 meters (8.52 miles) of Dry Creek from the confluence with Willow Creek to the Forest Service Boundary. The summary of the survey states:

"The character of Dry Creek changes throughout the length of stream surveyed. In the lower sections, the stream travels through a broad valley where agriculture and grazing land dominate. The upper section of Dry Creek is forested, and the valley gradually narrows and eventually the hillslopes come close to the stream. The average gradient is 1.4%. A large section of the stream goes dry in the summer and 73% of the channel was dry at the time of the survey. Of the portions of the channel with water there was a near equal mix of pools, riffles and glides. The substrate contains an adequate amount of gravel for spawning, egg incubation, and fry to emerge from the gravel. Fry can then move downstream or enter spring areas before the main channel becomes dry. Riparian trees along Dry Creek consist of hardwood trees and numerous conifers especially in the forested section. Some of these trees are large diameter and are a source of large wood, and provide stream shade." "Approximately 66% of the stream channel was dry or puddled at the time of the survey. There are high percentages of actively eroding streambanks (46% to 93%)."

Figure 10.1 shows the percentage of pool habitat on surveyed reaches on Willow, Mill, and Dry Creeks.

No barriers were encountered within the surveyed portions during the 1995 ODFW habitat survey. Two known dams are located on Willow Creek. One is no longer a fish passage barrier, as a GRMWP project constructed a fish ladder for passage. The other dam is seasonal, created by wooden boards that fit into slats. This dam is operational as early as May. It is a potential fish passage barrier as summer steelhead returning upstream in spring (January-May) may be barred from passing upstream in years when the dam is operational earlier in the year. It is unknown if there are fish passage barriers on Mill Creek, as the survey did not cover the entire stream. On Dry Creek, ODFW surveyors found "one upstream fish barrier created by a 1.6 m (5.3 ft) high step-over structure. It was an old dam created by concrete poured over large boulders. Below the plunge pool created by the SS (step-over structure), there was another SL (step-over log) (70 cm high) and a water diversion pump. We found one dead 6' rainbow trout in the PP (plunge pool)." As the entire creek was not surveyed, it is unknown if there are other fish passage barriers.

1992 USFS stream survey, Dry Creek

Two reaches of Dry Creek were surveyed on Umatilla National Forest land in 1992. Reach one began at the confluence of Dry and Finley Creeks continuing 1.7 miles to the culvert under the 31-135 road. Reach two began at the culvert under the 31-135 road, continuing for 2.1 miles to where Dry Creek forks. The survey summary stated:

Reach 1: "The overall stream conditions for reach one were poor. Bank stability was poor with much erosion and sloughing. Canopy cover was very low (20%), increasing the rate of the stream drying up." "Since the stream was designated as dry channel, woody debris was not counted, but it was noted by the surveyors as being very low. It was evident that instream woody debris was very important in providing shade and fish hiding cover. The only pools noted with fish had large woody debris (.20.0 inches in diameter and >35 feet long) located in or over the habitat area." "Dry Creek has been heavily impacted by road construction and road use. Most of the roads surrounding Dry Creek were constructed to access timber harvesting areas. A culvert has been placed under each of these roads. There are several sections in reach one where the right bank consists primarily of road fill from the "31" road. A large amount of sedimentation is added to the stream from this road."

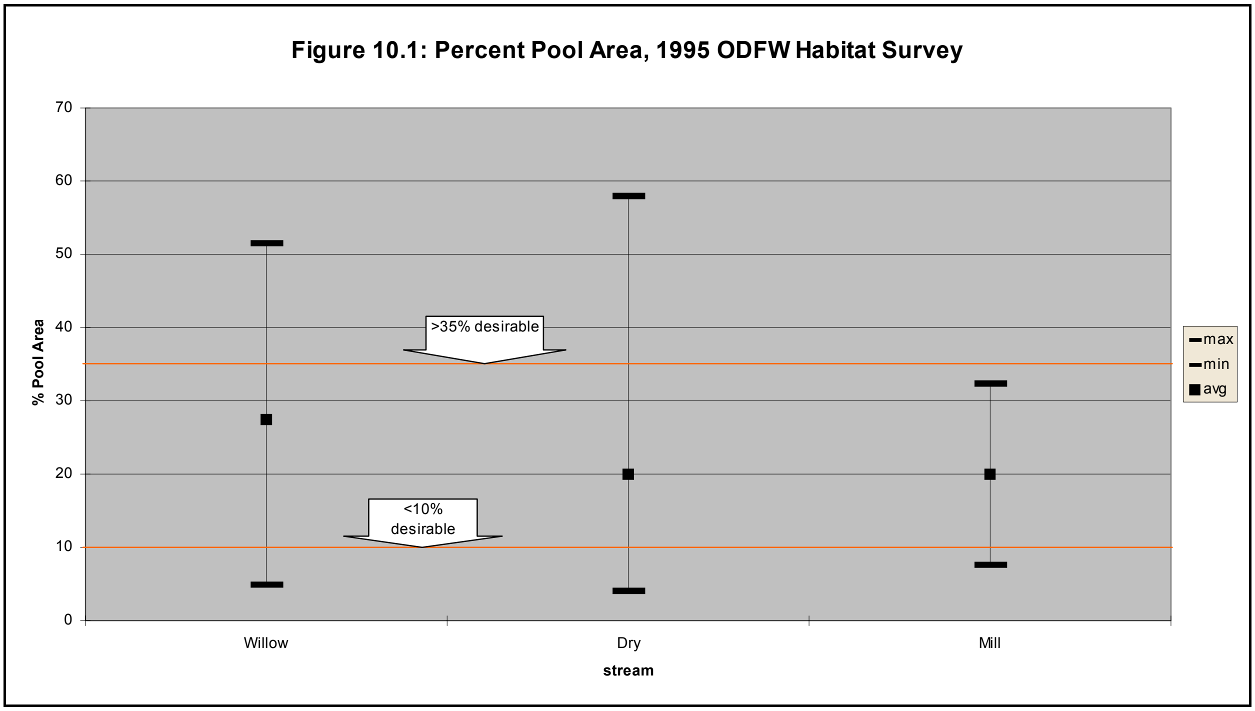
Reach 2: "The overall stream conditions for reach two were moderate. Bank stability was still poor with sloughed banks showing evidence of sheep grazing. Other indicators of intensive sheep grazing were flattened grass, browsed shrubs, and wool found on branches. Canopy cover was much higher than in reach one and classified as good (>61%)."

1965 ODFW habitat survey, Willow, Mill, and Dry Creeks

In 1965, Willow Creek's physical stream habitat was surveyed. Of 24.25 miles surveyed, 3.1% was spawning gravel, 71.5% was pool area, and 25.4% was non-spawning area by ODFW (Table 11, ODFW Annual Report, 1965). This survey included Willow and Dry Creeks.

In 1965, Mill Creek's physical stream habitat was surveyed by ODFW. Of 5.75 miles surveyed, 0.3% was spawning gravel, 50.1% was pool area, and 49.6% was non-spawning area.

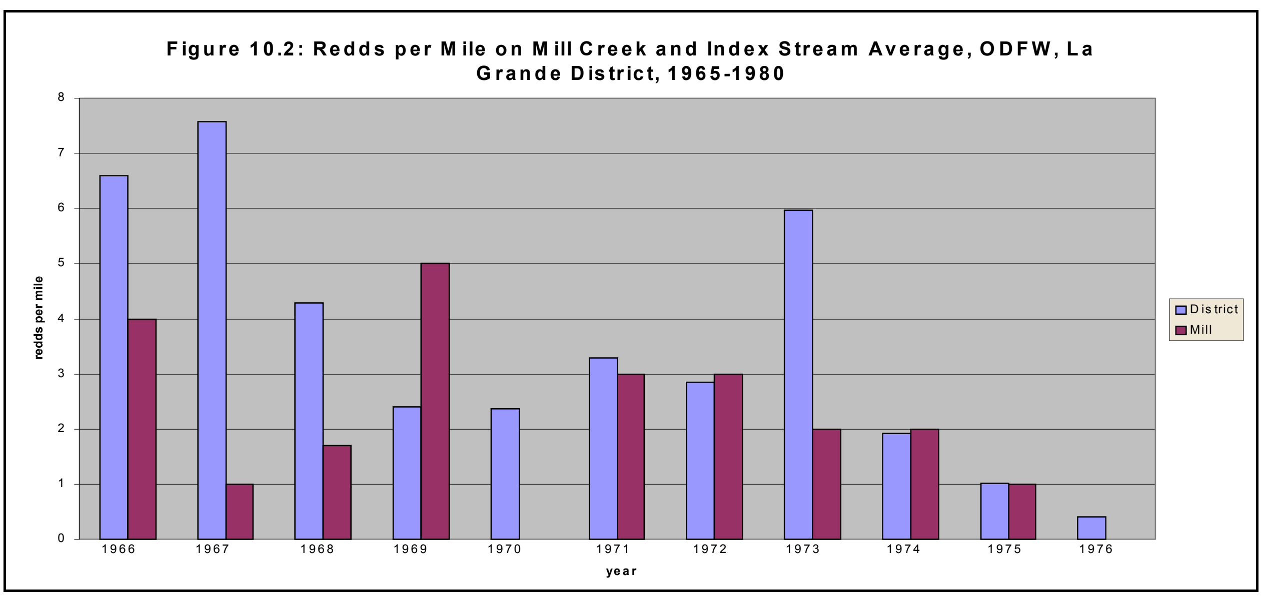
In 1965, Finley Creek's physical stream habitat was surveyed by ODFW. Of 3.75 miles surveyed, 23.8% was spawning gravel, 30.2% was pool area, and 45.9% was non-spawning area.



Redd surveys

Mill Creek

From 1966-1976, steelhead spawning ground counts were conducted on Mill Creek by ODFW (Table 5, ODFW Annual Reports, 1975, 1976). **Figure 10.2** shows the results of these surveys compared to index streams for the district. Index streams are a sample set of streams surveyed annually against which ODFW compares individual streams.



Dry Creek

From 1965 to 1980, steelhead redds were surveyed on two sections of Dry Creek, each two miles in length. In 1997 and 2000, the index section of Dry Creek (two miles) was surveyed. **Figure 10.3** shows the redds/mile on Dry Creek for all years surveyed, as compared with the index stream average district-wide. Of the two reaches surveyed on Dry Creek, the lower reach was consistently found to have more redds (Brad Lovatt, ODFW, personal communication). **Figure 10.4** shows the redds/mile on Finley Creek, as compared with the index stream average.

Figure 10.3: Redds per Mile on Dry Creek and Index Stream Average , ODFW, LaGrande District, 1965-1980

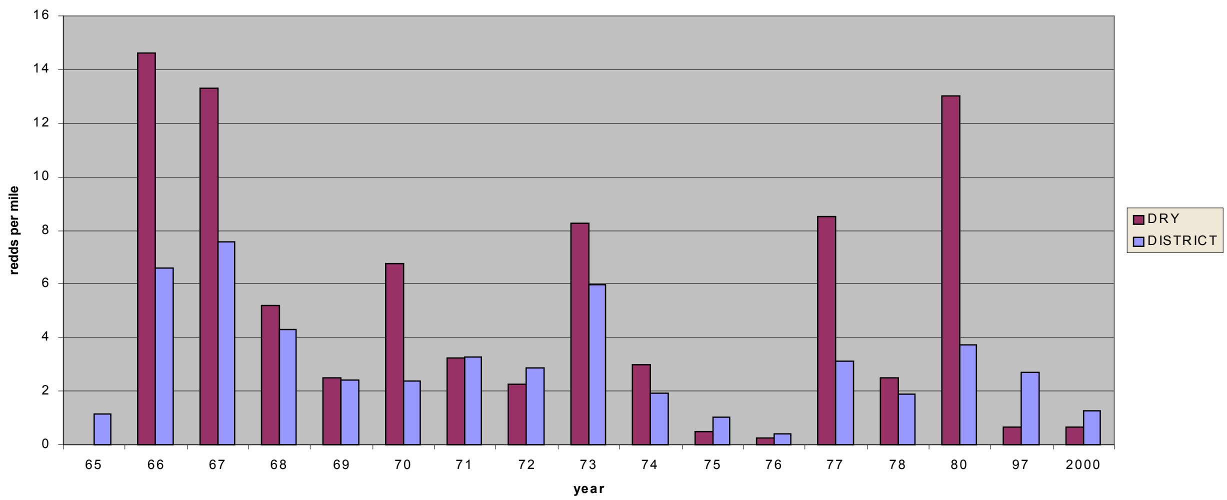
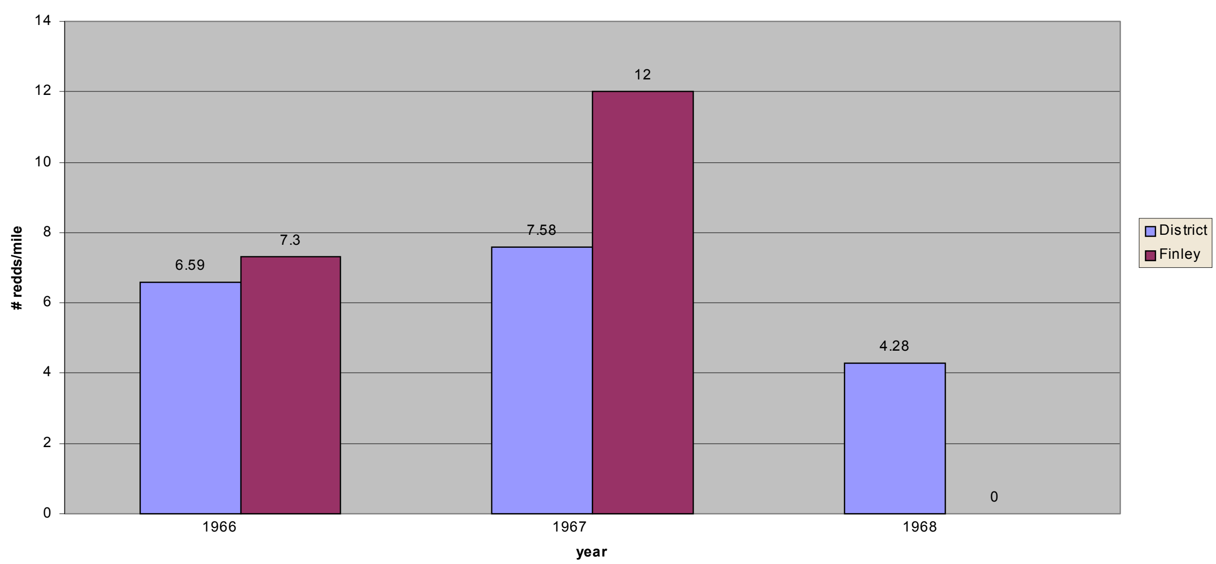


Figure 10.4: Redds per Mile on Finley Creek and Index Stream Average, ODFW, La Grande District, 1966-1968



ODF/ODFW Fish Presence/Distribution Surveys

In June and July of 1995, ODF commissioned ODFW to conducte fish presence/distribution surveys on Smith Canyon Creek, Smith Creek, Jack Canyon, and Moonshine Canyon. Bankfull width, wetted width, and channel gradient were measured at the upstream end of fish use and approximately 300 feet upstream of the end of fish use.

On Smith Canyon Creek twenty-two individual rainbow trout were found. Fish sizes observed were: six 2" fish, seven 3" fish, 4" fish, and four 5"-6"fish. Notes from the ODF survey indicate that fish use of the stream ended at a natural barrier, a 20% gradient cascade. The rainbow trout population was “probably isolated from Willow Creek and are resident in the canyon (sic)”. No other fish passage barriers are known.

On Smith Creek, eight brook trout, two rainbow trout, and numerous one-inch trout species were observed. Where fish were found and 330 feet upstream, bankfull width, wetted width, and channel gradient were determined. It is unknown if there are fish passage barriers on Smith Creek.

On Jack Canyon, no fish were found as the stream was dry at the time of the survey. Bankfull width, current wetted width, and channel gradient were measured. The stream was dry on the date of survey. It is unknown if there are fish passage barriers on Jack Canyon.

On Moonshine Canyon, no fish were observed, but trout species were observed at the mouth of Moonshine Canyon, in Dry Creek. Moonshine Canyon was mostly dammed by logs and debris. It is unknown if there are fish passage barriers on Moonshine Canyon.

Discussion

Historically, the Grande Ronde River and its tributaries supported large runs of spring chinook, summer steelhead, coho salmon, and fall chinook salmon. These runs were historically plentiful, with many people recounting times when the runs were so large “you could pretty well walk across them” (Gildemiester 1999). Now, the fall chinook and coho runs are extinct and the numbers of spring chinook and summer steelhead runs have diminished to where they have been listed as threatened under the Endangered Species Act.

There is less documentation on historical numbers of salmonids using the Willow Creek stream system for spawning and rearing habitat. The earliest steelhead redd counts on Willow Creek and its tributaries occurred in 1965. However, when steelhead redd counts on Dry Creek in the were compared with index streams through the Upper Grande Ronde Sub-basin, Dry Creek consistently had median or higher numbers of redds per mile than the index streams. Thus, while there is little documentation before 1965, it can be inferred from the number of redds in the 1960s and 1970s that the Willow Creek watershed was historically a large producer of summer steelhead.

As redd surveys have only been conducted on certain stream reaches in the watershed, our knowledge of steelhead distribution in the watershed is limited. It is likely that steelhead are found in additional streams than those highlighted in **Map 10.1**, but more extensive surveys would need to be conducted to confirm this.

Fish passage is one of the greatest habitat concerns for salmonids. Dams and diversions can partially or completely cut off fish access to spawning habitat. On a large scale, dams on the Columbia and Lower Snake have impeded fish access to the Grande Ronde Basin, thereby playing a role in declining fish populations. Within the Grande Ronde Basin, fish passage barriers limit fish access to spawning and rearing habitat. In the , there are two known potential fish passage barrier sites, both of which occur low in the system. If the fish cannot access habitat above these dams, the amount of habitat available for fish use is greatly limited.

Habitat conditions in the 1995 habitat surveys on Willow, Mill, and Dry Creeks highlighted some undesirable conditions that were prevalent on all three streams. Desirable and undesirable benchmarks were derived by Oregon Department of Fish and Wildlife as a method of comparing a stream against standards to determine its general condition. As different channel habitat types and geographic location will cause variances in an individual reach's potential habitat, these are general guidelines. Width to depth ratios, percent open sky, fines in riffles, bank erosion, and large woody debris all fell into the undesirable category for many reaches along all three streams. However, on all reaches, the percent gravel available in riffles was equal to or greater than the desirable benchmark of 35%.

What can be done to improve habitat conditions? Width to depth ratios of streams increase as streams widen. Streams widen from increased flows and/or eroding banks. As eroding banks are prevalent in many reaches of Willow, Dry, and Mill Creeks, these streams are likely widening over time. Widening streams are undesirable for their effects on water temperature (see *Chapter 7: Water Quality*). Also, as streams widen, their ability to transport and handle their sediment loads changes. Stabilization of stream banks through riparian revegetation will help decrease the widening of streams. Stream widening is undesirable for fish because of the resulting increase in water temperatures and substrate degradation.

Percent open sky, the percent of open sky present out of 180^{o} at a given point, is the opposite of shade. Thus, high percent open sky numbers mean low shade. As shade limits exposure of the water to solar radiation, it helps reduce the warming of stream temperatures. By increasing the amount of shade in the , the availability of summer habitat and mobility of salmonids also increases, since too-high water temperatures can be fish passage barriers.

In *Chapter 5: Riparian Areas*, in-stream large wood and the recruitment potential of riparian areas for future large woody debris were shown to be limited. As large wood helps in the formation of pool habitat, a critical area for salmonids in the warm summer months, the enhancement of fish habitat in the Willow Creek watershed will ultimately necessitate large woody debris being present in the stream system in greater amounts. This can be accomplished in the short term by large woody debris placement projects and in the long term through increasing the recruitment potential of riparian areas for large wood.

Improving fish habitat through establishing riparian vegetation, increasing shade, improving riffle and pool habitats, and the placement of large woody debris is part of improving conditions for fish in the . It would also be beneficial to increase fish access by identifying and removing fish passage barriers and to increase surveys to determine population trends and the entire distribution of steelhead in the system.

Data Gaps

- complete fish distribution map for the
- stream habitat surveys for all streams
- minimal current redd surveys in the watershed
- complete inventory of fish passage barriers

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Appendix 10.1: ODFW Habitat Benchmarks for Northeast Oregon

	Undesirable	**Desirable**
Pools		
Pool Area (%)	<10	>35
Pool Frequency (Channel Widths)	>20	<8
Residual Pool Depth		
Low Gradient (slope<3%) or Small (<7m width)	<0.2	>0.5
High Gradient (slope >3%) or Large (>7m width)	<0.5	>1.0
Riffles		
Width/Depth Ratio (Gradient <3%), Eastside	>30	<10
Silt-Sand-Organics (% Area), Northeast	>20	<8
Gravel Availability (% Area)	<15	≥ 35
Shade (Reach Average, Percent)		
Stream Width <12 meters, Northeast	<70	>60
Stream Width >12 meters, Northeast	<50	>50
Large Woody Debris (15cm X 3 m minimum piece size)		
Pieces/100 m stream length	<10	>20
Volume(m^3)/100 m stream length	<20	>30
"Key" pieces (>50cm dia. and >ACW long)/100m	<1	>3
Riparian Conifers (30m from both sides of channel)		
Number >20in dbh/1000 ft stream length	<150	>300
Number >35in dbh/1000 ft stream length	<75	>200

source: ODFW

Chapter 11: Noxious Weeds

Introduction
This chapter identifies what noxious weeds are present in the Willow Creek watershed and discusses options for weed control.

Background
Weeds that invade native habitats are an increasing problem in the inland West. For the purposes of this assessment, the term noxious weeds will be defined as: "exotic, non-indigenous species that are injurious to public health, agriculture, recreation, wildlife or any public or property" (Oregon State Weed Board).

The majority of noxious weeds in the Blue Mountains ecoregion were introduced from Europe or Asia. They arrived in weed-infested crop seed and animal feed or as ornamentals and crop plants. Diffuse knapweed was first reported in 1937 near La Grande (Jaindl 1996). Now it has spread to almost all sections of the Grande Ronde Valley. Seeds are spread locally by vehicles, machinery, crop seed, stock feed, livestock, wildlife, highways, irrigation ditches, trails, landings, and railways.

Noxious weeds can negatively affect soils, plants, and animals. Noxious weeds, depending upon species, land, and invasion level, can increase erosion and runoff, alter seasonal water flows when highly infested in an area, increase soil evaporation, reduce organic matter in the upper inches of soil, and deplete soil nutrient reserves. They also can alter the composition of plant communities by out-competing native perennial grasses, changing the community from perennial, multiple species to a few annual species. By changing plant community composition, wildlife distribution changes as well. Animals that have co-evolved with a certain type of habitat often times cannot adapt to the degraded habitat that weeds create (Sheley & Petroff, 1999).

Weeds are also economically detrimental. They reduce the land's carrying capacity for livestock. Some species are toxic to livestock; others are undesirable to animals as food. Land values can be dramatically reduced if invaded with noxious weeds. Weeds can also increase operating costs of ranches and farms through money invested in controlled weed outbreaks (Sheley & Petroff, 1999).

Proper management of noxious weeds involves prevention, early detection, and eradication. Ways of preventing invasion include: limiting seed dispersal, containing nearby weed infestations, minimizing soil disturbance, establishing competing grasses, and properly managing grasses. Early detection is important because of the rapid reproduction rates of noxious weeds. Controlling a one acre problem is much easier than a 100 acre problem (Sheley & Petroff, 1999).

There are many options for weed removal. Cultural, biological, and chemical are the basic types of treatment. Cultural treatment includes the physical removal of weeds (tilling, pulling), replacing weeds with other plants through replanting, and creating barriers to weeds, such as windbreaks. Biological treatments are natural predators of a weed, such as insects, nematodes, and bacteria. Chemical treatments involve the use of herbicides to kill and control noxious weed populations (Jaindl, 1996). Using a combination of treatments to remove weeds is recommended as the most effective method (Sheley & Petroff, 1999).

Methods

Noxious weed information was gathered through conversations with Gary Dade of the Union County Weed Control Board and Dave Clemens of the Tri-County Weed Management Area. Information about noxious weeds on Umatilla National Forest land was obtained primarily from the Phillips-Gordon Draft Ecosystem Analysis.

Results

Appendix 11.1 lists the noxious weed species the Union County Weed Control Board has determined are in the county. Class A weeds are non-natives that have limited distribution or are unrecorded and pose a serious threat to the state. Class B weeds are non-natives with a limited distribution or are unrecorded in particular regions within the state and pose a serious threat to the regions. Class C weeds are generally more abundant than Class A and B weeds (pers. comm., Gary Dade, Union County Weed Board). Diffuse knapweed is the most widespread noxious weed in the Willow Creek watershed (ibid).

Citations by the Union County Weed Board were compiled for 1998-2000. **Table 11.1** shows the results. Earlier citations were also made for diffuse knapweed and Canada thistle.

Table 11.1: Number of Noxious Weed Citations in the Willow Creek Watershed, 1998-2000

Year	Diffuse Knapweed Citations	Canada Thistle Citations
1998	11	8
1999	8	5
2000	5	1

source: Union County Weed Board

During a Coordinated Resource Management Plan (CRMP) meeting in Summerville in March 2001, weeds known to be present in the watershed were identified by local landowners. These included:

- diffuse knapweed
- St. John's wort
- leafy spurge
- white top
- hound's tongue/buffalo burr
- morning glory
- Canada thistle
- catch weed (bedstraw)
- puncturevine

Information and methods of identification for these weeds can be obtained from the Union County Weed Board or the Tri-County Weed Management Area.

The Umatilla National Forest has mapped noxious weed sites for their lands. **Map 11.1** shows weed sites on Umatilla National Forest land in the Willow Creek watershed. There are few prevalent weed sites in the Upper Willow Creek subwatershed, but there are a number of sites located in the Dry Creek subwatershed, especially along Ruckle Road.

Included in the Phillips-Gordon Draft Ecosystem Analysis are risk ratings for the two subwatersheds in which the UNF has land: Dry and Upper Willow. **Table 11.2** shows the acreage in each subwatershed that has a low, medium, and high risk rating. High risk was determined by large amounts of suitable habitat for noxious weeds (warm to hot, dry forest with canopy closure <40%) and relatively large number of existing noxious weed sites (high seed availability).

Table 11.2: Noxious Weed Risk Ratings on Umatilla Nat'l Forest lands in the Willow Creek Watershed

Subwatershed	Low risk	Medium risk	High risk
Upper Willow	1331	1112	101
Dry Creek	0	2823	3972

source: Phillips/Gordon Draft Ecosystem Analysis

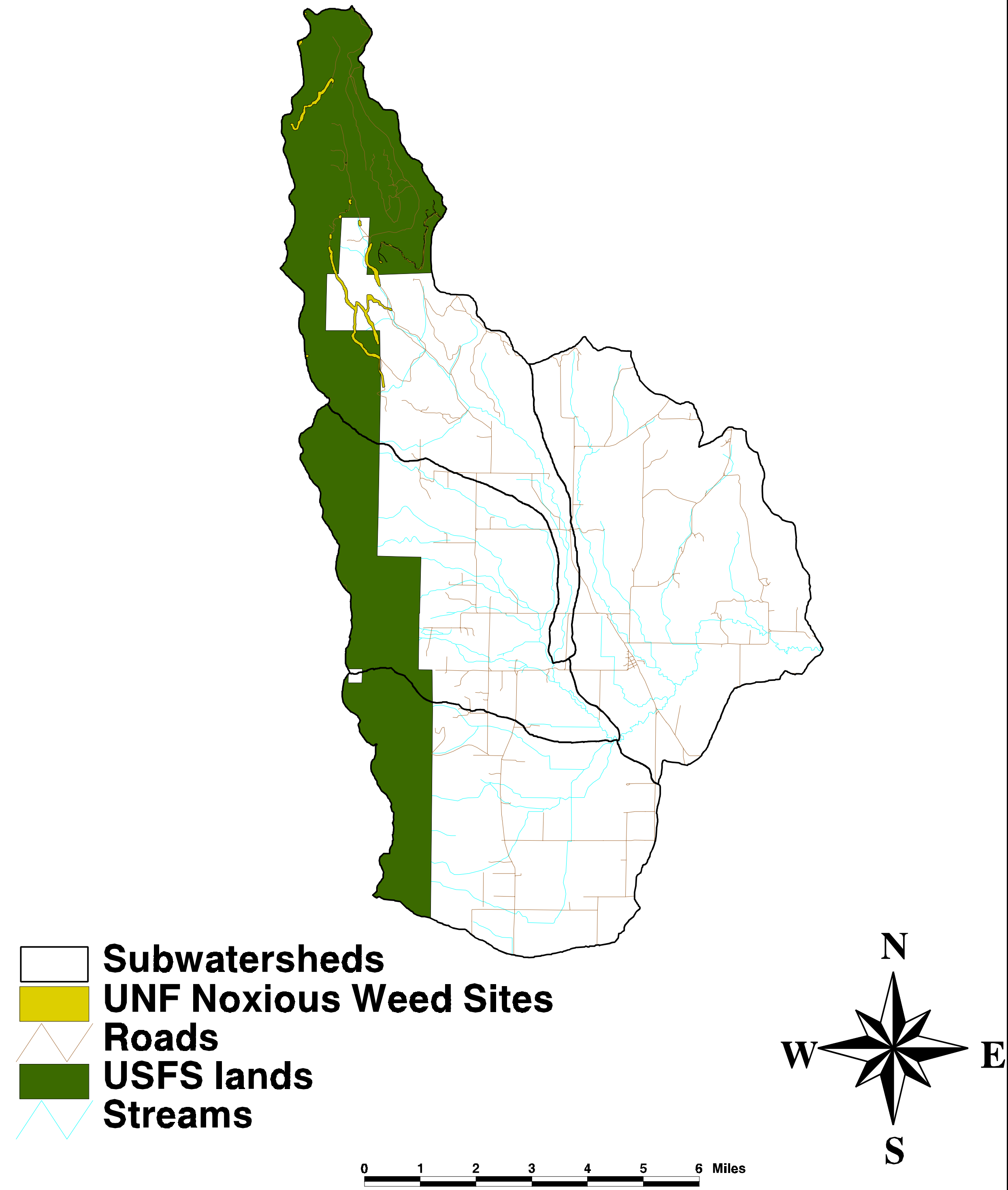
Discussion

Noxious weeds are present in the Willow Creek watershed, although not in as large numbers as other parts of Union County. Unmaintained patches of weeds can quickly jump to large acreages taken over by weeds. Thus, it is important to control weeds while they are a small problem and before it becomes a large and unmanageable one.

Diffuse knapweed, the most prevalent noxious weed in the watershed, can cause serious land degradation. Its weak roots do not hold soil as well as the native grasses it replaces, thereby increasing surface erosion. In addition to land degradation, it reduces land values and limits the amount of forage available to livestock and wildlife.

Coordinated efforts in weed control are important to reducing weed numbers. If only one landowner is maintaining his or her lands free from weeds in a given area, weeds will invade from nearby landowners. This includes coordinating with Union County Public Works, which maintains the roadsides, Umatilla and Wallowa-Whitman National Forests and Boise Cascade in the upper watershed, and watershed residents in the lower sections of the watershed. Coordinated efforts are cost-effective and prevent weeds from re-colonizing an area.

Map 11.1: Noxious Weed Sites on Umatilla National Forest Lands



For information on weeds and how to control them, contact:

Gary Dade
Union County Weed Board
La Grande, OR 97850
541-963-1016

Dave Clemens
Tri-County Weed Management Area
Baker City, OR
541-523-0618

Data Gaps

- information from noxious weed inventory on Wallowa-Whitman National Forest
- location of noxious weed sites on private lands

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Watershed Professionals Network. Oregon Watershed Assessment Manual. Salem, Oregon: prepared for the Governor's Watershed Enhancement Board, June 1999.

Appendix 11.1: Union County 1996 Noxious Weed List

Common Name	**Scientific Name**
Class A Weeds	
Velvetleaf	*Abutilon theophrasti* Medic.
Hoary cress (White Top)-north of Catherine Creek drainage	*Cardaria draba*
Musk thistle	*Carduus nutans*
Spotted knapweed	*Centaurea maculosa*
Russian knapweed	*Centaurea repens*
Scotch broom	*Cytisus scoparius*
Leafy spurge	*Euphorbia esula*
Dyer’s woad	*Isatis tinctoria*
Tansy ragwort	*Senecio jacobaea*
Buffalo burr	*Solanum rostratum*
Class B Weeds	
Hoary cress (White Top)-south of Catherine Creek drainage	*Cardaria draba*
Yellow star thistle	*Centaurea solstitialis*
Dalmation toadflax	*Linaria dalmatica*
Puncturevine	*Tribulus terrestris*
Jointed goatgrass	*Aegilops cylindrica*
Canada thistle*	*Cirsium arvense*
Catch weed bedstraw	*Galium aparine*
Diffuse knapweed-south of Willow Creek drainage*	*Centaurea diffusa*
Class C Weeds	
Quackgrass	*Agropyron repens*
Wild oat	*Avena fatua*

Water hemlock	*Cicuta douglasii*
Poison hemlock	*Conium maculatum*
Morning glory	*Convolvulus sepium*
Horsetail rush	*Equisetum arvense* L.
Kochia	*Kochia scoparia*
Scotch thistle	*Onopordum acanthium*
Russian thistle	*Salsola tenuifolia* (v. kali)
Cereal rye	*Secale cereale*
Diffuse knapweed -north of Willow Creek drainage	*Centaurea diffusa*

* These noxious weeds have been identified by Gary Dade, Union County Weed Control, as being problem weeds in the Willow Creek watershed.

Chapter 12: Forest Health

Introduction

This chapter discusses forest health as it applies to Blue Mountain forests, specifically the forest types found in the Willow Creek watershed.

Background

Forest health has been a growing concern the last few decades in the Blue Mountains. Insect and disease outbreaks beginning in the mid-1970s killed millions of acres of trees, causing forest managers to seek solutions. What they found was a complex problem with no simple solution. Selective logging, fire suppression, and grazing, among other factors, had changed forest structure and composition to types that were more susceptible to attacks by insects and disease (Langston 1995).

Historically, lower elevation and dry mid-elevation forests in the Blue Mountains were dominated by large ponderosa pines (Jaindl 1996). Some of these forests, on south-facing slopes, were mostly pine, while north-facing slope forests contained more Douglas-fir and grand fir (Langston, 1995). Frequent fires on gentle slopes with non brushy plant associations maintained open stands with little understory and grasses as ground cover. Wet mid-elevation forests, which had longer fire intervals, were composed of fire-intolerant conifers, including grand fir, Western larch, and Douglas-fir. At higher elevation, lodgepole pine and Engelmann spruce were the dominant species (Jaindl 1996). Fire's role in higher elevation and moist middle elevation forests was more complex and variable. Fire intervals were longer in these forests, ranging from 40 to 150 years, and were usually stand replacing fires. Most trees were killed in these fires and new stands of pioneer species regenerated in their place.

By the 1930s, the U.S. Forest Service implemented a fire suppression policy for the national forests (Langston 1995). Oregon Department of Forestry was responsible for fire suppression on private forest lands. In the Blues, fire-dependent forest types, such as the low elevation pine forests, would be dramatically changed in forest composition. Without fire to maintain the open, park-like forests, fire-intolerant species were able to invade these stands, resulting in mixed ponderosa pine/Douglas-fir forests on the drier southern slopes, and the entire replacement of ponderosa pine with Douglas-fir/true fir forests on the wetter northern slopes (Jaindl 1996). In addition to a change in species, a forest structural change was made as the forests coming in were smaller in size and denser (Langston 1995).

Selective logging has also played a large role in the changing forests. Selective logging is the practice of removing some trees from a stand and leaving others. Which trees are logged can be a determinant in the future composition of the forest. Ponderosa pine has traditionally been the economically valuable species in the Blue Mountains and thus the most often cut. High grading, the removal of large, high quality trees, while leaving the economically undesirable trees, was common in the early to mid-1900s (Langston 1995). On national forests, harvest levels increased drastically in the 1970s and early 1980s (Jaindl 1996). These harvests were designed to change stands from uneven-aged to even-aged stands, in order to maximize timber production for the demands of a growing nation. Multiple species were planted.

When selective logging in lower elevation forests removed ponderosa pine from a stand, stands were not replaced with the same species. In the first crucial years, the Douglas-fir and true firs can outcompete the ponderosa pine in denser stands. With the presence of historical fire, stands were kept more open, helping ponderosa pine's survival. However, as fire was suppressed at the same time as timber harvesting, the acres of ponderosa pine forests in the Blues decreased as the acres of mixed-conifer forests increased.

Grazing in the Blue Mountains has also helped shape the current landscape. Livestock alter forest dynamics by reducing the biomass and density of understory grasses and sedges, which otherwise outcompete conifer seedlings and prevent dense tree recruitment (Belsky 1997). Grazing thereby assists in the expansion of forests into grasslands. Grazing also affects forest structure and composition by reducing fuel loads in more open stands to fires do not kill as many young trees (pers. comm., John Herbst)

Disease and insect outbreaks in the Blues are thought to have always occurred. In the 1920s, before most of the human impacts to forests took place, there were reports of loss of trees to disease and insects (Langston, 1995). Climate plays a role in disease and insect outbreaks. Drier years stress the trees, opening opportunities for insects and diseases to attack them. Nancy Langston argued in Forest Dreams, Forest Nightmares that insects and disease may be an integral part of the Blue Mountain ecosystem (Langston, 1995). Others believe that the large-scale disease and insect outbreaks in the 1980s and early 90s were an indicator of unhealthy forests. Charles Johnson reported that "outbreaks of the beetle in east-side lodgepole pine forests was an ecosystem response to the lack of stand-replacement fire that normally would have burned many lodgepole pine stands before they would become susceptible to bark beetles" (Johnson, 1994).

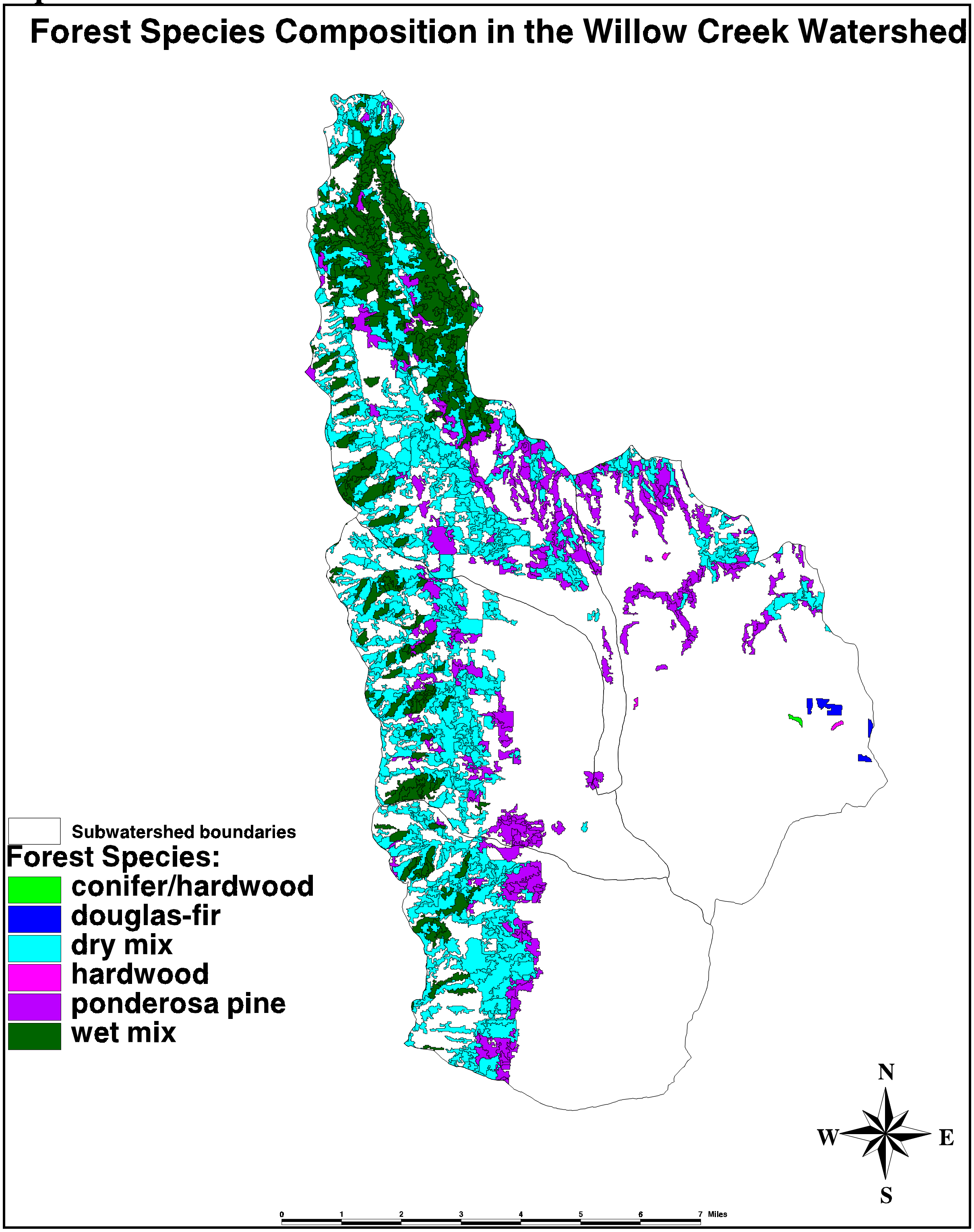
Methods

Forest structure, composition, and fuels information was gathered from Oregon Department of Forestry for the watershed. Maps were created from ODF aerial photo interpreted GIS information on crown closure, tree species, stand sizes, and fuel modeling. This data is based on aerial photographs taken in 1997.

Results

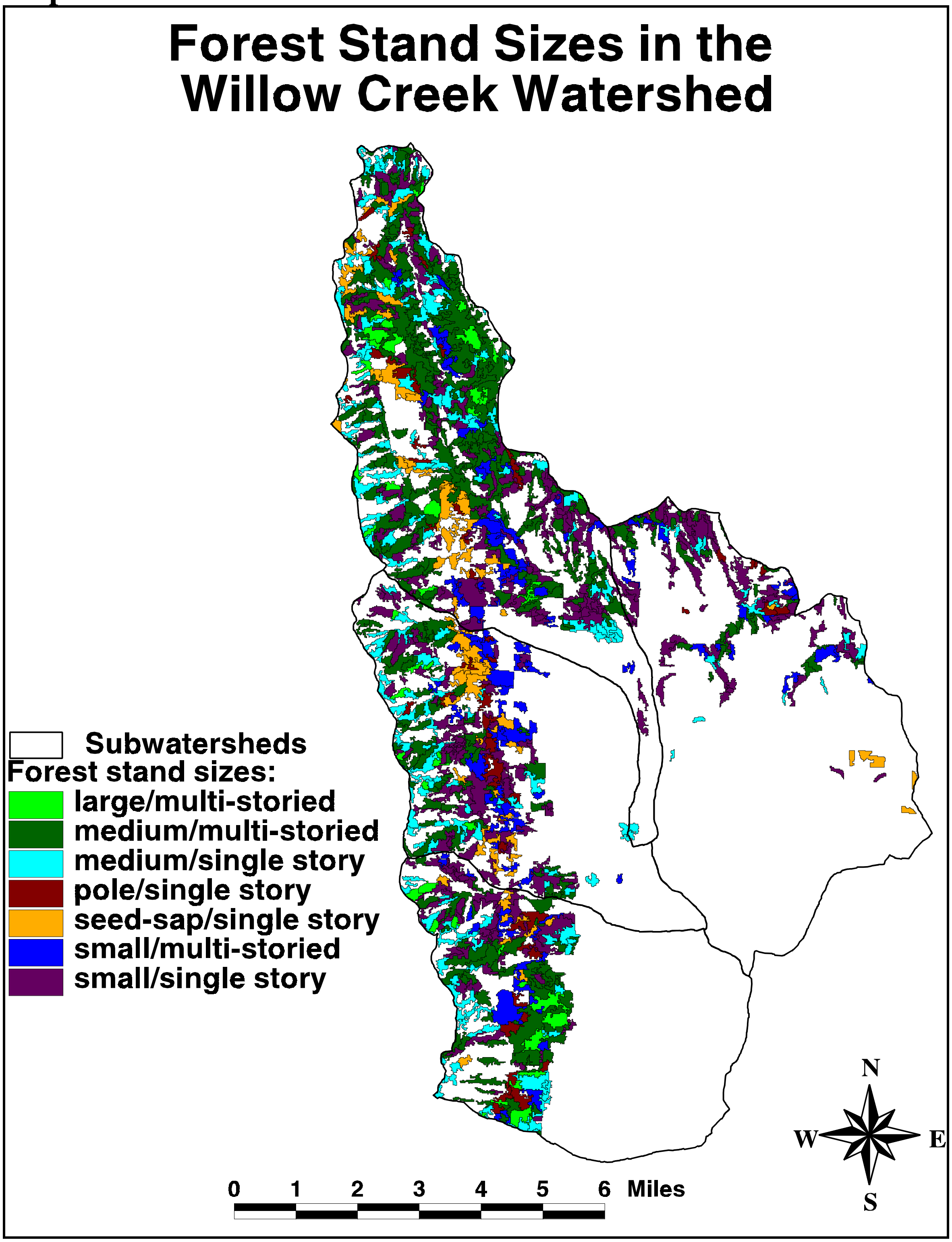
Map 12.1 shows the composition of forest species in the Willow Creek watershed. ODF has classified stands by species associations. *Ponderosa pine* stands are stands with $\geq$80% of the total tree crown closure in ponderosa pine. *Douglas-fir* stands are stands with $\geq$80% of the total tree crown closure in Douglas-fir. *Dry mix* stands are stands with <30% of the total crown closure in True Fir and $\geq$50% in a mixture of ponderosa pine, Douglas-fir, Western larch, and/or lodgepole pine. *Wet mix* stands are stands with 30-80% of their crown closure in True Fir. **Figure 12.1** shows the percentages of each association in the watershed. **Map 12.2** shows stand sizes in the Willow Creek watershed. **Figure 12.2** shows the percentages of each type in the watershed.

Map 12.1



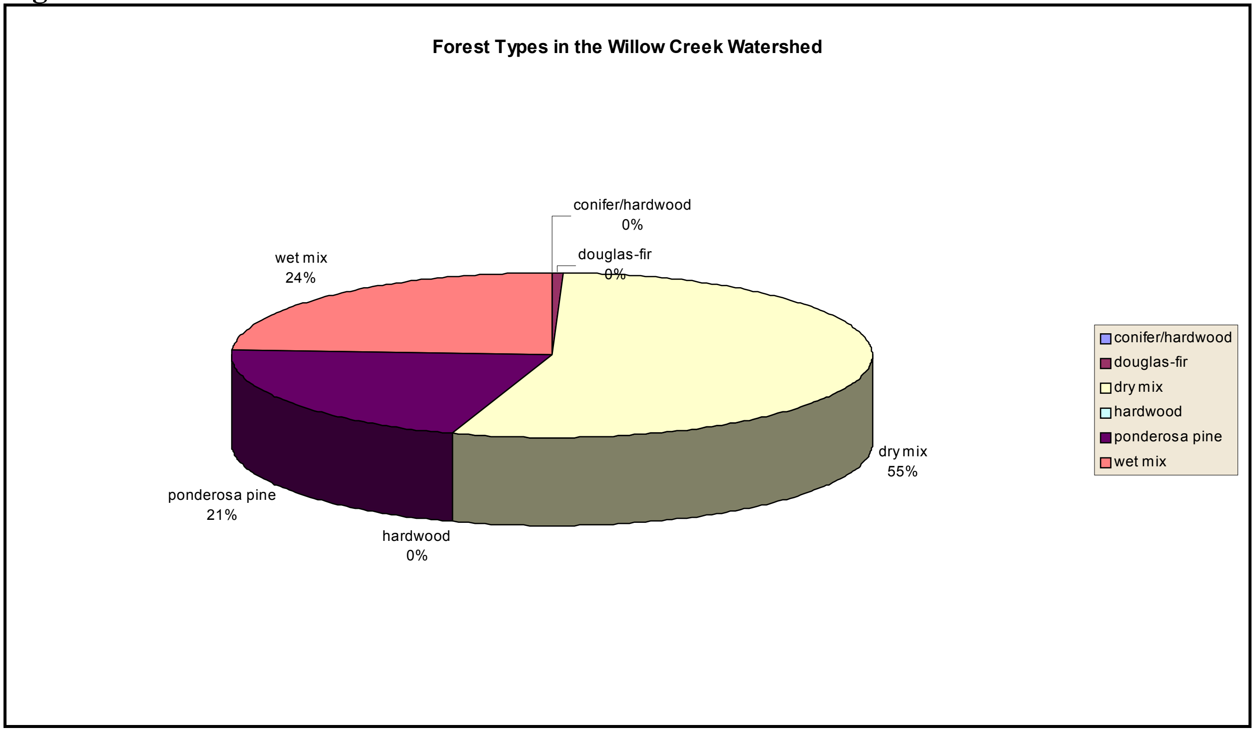
source: Oregon Department of Forestry digital vegetation data

Map 12.2



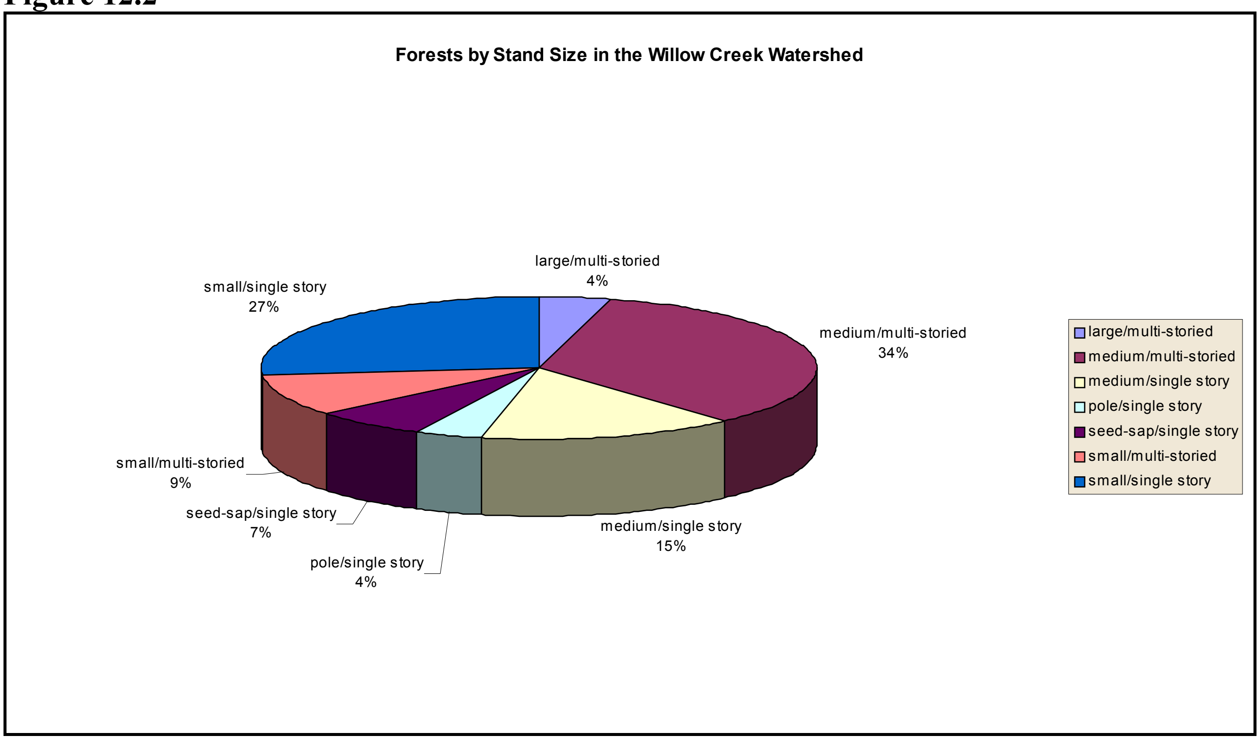
source: Oregon Department of Forestry digital vegetation data

Figure 12.1



source: Oregon Department of Forestry digital vegetation data

Figure 12.2



source: Oregon Department of Forestry digital vegetation data

For more detail on U.S. Forest Service forests, see the Phillips-Gordon Draft Ecosystem Analysis. Changes in forest structure and composition on U.S. Forest Service lands are documented from 1936 to 1999. Fuel models for the U.S. Forest Service lands are also discussed in the Analysis.

Discussion

Forest composition and structure in the Willow Creek watershed have changed over time, as documented in the Phillips-Gordon Draft Ecosystem Analysis. Average tree size has decreased in size, with most stands currently small or medium in size classes. Crown closures are medium to dense, indicative of thick stands. The majority of forests are in dry mix or wet mix types. A smaller amount than historical are ponderosa pine dominated stands.

Forest management is, and always has been, a highly debated issue in the West. People have different ideas about how a forest should be managed. Since how a forest is managed plays an integral role in forest health, how management is influenced should be understood. On public lands, forest management is often subject to public opinion. Private land management has some restriction placed upon it by the Oregon Forest Practices Act. But for the most part it is the landowners' decision on how to manage their forests.

The U.S. Forest Service's current plans for forest management are to restore forests to their historical structure and composition. Current projects include prescribed burning to reduce fuel loads and thinning to reduce stand thickness and alter species composition.

Data Gaps

- historical conditions of specific forest stand structure and composition
- information on Boise Cascade lands

See Phillips/Gordon Ecosystem Analysis for information about UNF land in watershed on:

- overstory species composition from 1936-1999
- fuel models
- condition classes
- current and historic forest canopy layers
- forest size classes

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Glossary

303(d) list: List of water quality impaired water bodies that do not meet ODEQ/EPA water quality standards.

4th-field HUC: Hydrologic Unit Code for sub-basin

5th-field HUC: Hydrologic Unit Code for watershed.

6th-field HUC: Hydrologic Unit Code for subwatershed

100-year floodplain: The area adjacent to the channel which has a 1 in 100 chance of being flooded in any given year.

aggradation: The filling and raising of the level of a streambed by deposition of sediment.

alluvium: Sedimentary material deposited by flowing water, as in a riverbed or delta.

bankfull width: Width of a channel to the top of its banks, at the point where water begins to overflow onto the floodplain.

beneficial uses: Uses of water specified in Oregon Water Quality Standards.

Best Management Practices: Practices developed to best address water quality problems in a specific area.

channel confinement: Ratio of bankfull channel width to width of modern floodplain. Modern floodplain is the flood-prone area and may correspond to the 100-year floodplain. Typically, channel confinement is a description of how much a channel can move within its valley before it is stopped by a hill slope or terrace.

connectivity: The physical connection between tributaries and the river, between surface water and groundwater, and between wetlands and these water sources.

criteria: Elements of Oregon Water Quality Standards expressed as concentrations or narrative statements representing a quality of water that supports a particular use.

crown closure: The amount of canopy cover in a given area. Canopy cover is the overhanging vegetation in a given area.

debris flow: A type of landslide that is a mixture of soil, water, logs, and boulders which travels quickly down a steep channel.

degradation: The general lowering of the earth's surface by erosion or transportation in running water.

diameter breast height (DBH): a standardized measurement of the diameter of a tree, taken at breast height (approx. 4 feet?)

downcutting: When a stream channel deepens over time.

drainage area: The region drained by a stream system.

ecoregion: Land areas with fairly similar geology, flora and fauna, and landscape characteristics that reflect a certain ecosystem type.

evaporation: The conversion of water into water vapor.

evapotranspiration: The amount of water leaving to the atmosphere through both evaporation and transpiration.

exceedence: When a measure of water quality exceeds the criteria. The exceedence needs to be evaluated with respect to natural or human causes.

flood plain: The flat area adjoining a river channel constructed by the river in the present climate, and overflowed at times of high river flow.

Forest Practices Act: The Oregon Forest Practices Act, first enacted in 1972, regulates harvesting practices on private and state forest lands in Oregon.

Geographic Information System (GIS): A computer system designed for storage, manipulation, and presentation of geographical information such as topography, elevation, geology, etc.

gradient: Channel gradient is the slope of the channel bed along a line connecting the deepest points (thalweg) of the channel.

gully erosion: Erosion resulting in a ditch or channel cut in the earth by running water after precipitation.

hydraulic gradient: Water level from a given point upstream to a given point downstream; or the height of the water surface above a subsurface point. Used in analysis of both ground and surface water flow, and is an expression of the relative energy between two points.

hydrograph: A graph of runoff rate, inflow rate, or discharge rate, past a specific point over time.

hydrologic soil group (HSG): Soil classification to describe the minimum rate of infiltration obtained for bare soil after prolonged wetting.

hydrology: The science of the behavior of water from the atmosphere into the soil.

impairment: An interpretation of criteria exceedence which indicates that the beneficial use is harmed.

infiltration: The rate of movement of water from the atmosphere into the soil.

large woody debris (LWD): Logs, stumps, or root wads in the stream channel, or nearby. These function to create pools and cover for fish, and to trap and sort stream gravels.

morphology: A branch of science dealing with the structure and form of objects. Geomorphology as applied to stream channels refers to the nature of landforms and topographic features.

precipitation: The liquid equivalent (inches) of rainfall, snow, sleet, or hail collected by storage gages.

raindrop splash erosion: Erosion caused as raindrops hit the ground during rain.

ravel: Erosion caused by gravity, especially during rain, frost, and drying periods. Often seen on steep slopes immediately uphill of roads.

redd: The gravel-based nest of a salmonid fish.

riffle: Shallow section of stream or river with rapid current and a surface broken by gravel, rubble, or boulders.

rill erosion: Erosion caused by water carrying off particles of surface soil.

riparian area: Areas bordering streams and rivers in which ecosystem processes are within the influence of stream processes.

Riparian Condition Unit (RCU): A portion of the riparian area for which riparian vegetation type, size, and density remain approximately the same.

riparian vegetation: Vegetation growing on or near the banks of a stream or other body of water in soils that are wet during some portion of the growing season. Includes areas in and near wetlands, floodplains, and valley bottoms.

riprap: Rock and or concrete placed along streambanks for artificial streambank stabilization.

Senate Bill 1010 (SB 1010): Oregon Senate Bill that placed Oregon Department of Agriculture in charge of developing water quality management plans for agricultural lands, across the state.

sheet erosion: Soil erosion caused by surface water that occurs somewhat uniformly across a slope.

sinuosity: The amount of curves or turns in a stream or river.

sponge effect: need definition

spring snowmelt: The time when the seasonal snowpack melts out.

stream density: Total length of natural stream channels in a given area, expressed as miles of stream channel per square mile of area.

stream reach: A section of stream possessing similar physical features such as gradient and confinement; usually the length of stream between two tributaries.

Total Maximum Daily Load (TMDL): A written plan and analysis established to ensure that water bodies will attain and maintain water quality standards

transpiration: Loss of water to the atmosphere from living plants.

waterbar: A deep trough in a skid trail or road that is excavated at an angle to drain surface water from the skid trail or road to an adjacent area that is not compacted.

wetland vegetation: Plants that are adapted to living in saturated or inundated conditions for at least part of the growing season.