Upper Sprague Watershed Assessment

Prepared by:

Klamath Basin Ecosystem Foundation
M. Connelly

Oregon State University Klamath Basin Research and Extension Center:
L. Lyons

With technical assistance from:

E&S Environmental Chemistry, Inc.
PO Box 609
Corvallis, OR 97330

K.U. Snyder
R.B. Raymond
T.J. Sullivan
D.L. Moore
T. McDonnell
D. Vesely

Significant contributions were made by the Assessment Revision Team.

Assessment Revision Team Members:
C. Bienz
G. Bulkley
W. Elmore
C. Leeseberg
S. Mattenberger
A. Rabe
J. Regan-Vienop
J. Staats

Klamath Basin Ecosystem Foundation
700 Main Street Suite 202
Klamath Falls, OR 97601

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Members of the Assessment Team also made significant contributions to this document.

Assessment Team Members:
H. Barrett
E. Bartel
C. Bienz
G. Bulkley
R. Chadwick
D. Cowan
L. Dunsmoor
W. Elmore
K. Fischer
S. Holtzman
J. Honey
B. Hyde
C. Leeseberg
M. Lunn
S. Mattenberger
A. Rabe
J. Regan-Vienop
G. Roseberry
M. Schreder
J. Staats
B. Topham
B. Valladao
R. Valladao
L. Van Riper

Significant contributions additionally made by:

Klamath Basin Ecosystem Foundation:
J. Egenolf
Z. Thompson-Jacobs

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List of Acronyms and Abbreviations

AUM	Animal unit month
BLM	Bureau of Land Management
C-S-R	Capture, store and release
CCC	Commodity Credit Corporation
CCRP	Continuous Conservation Reserve Program
CFS	Cubic feet per second
CHT	Channel habitat type
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CWD	Chronic wasting disease
DEM	Digital elevation model
ECSI	(DEQ) Environmental Cleanup Site Information
ENSO	El Niño/Southern Oscillation
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ERO	Ecosystem Restoration Office (of the U.S. Fish and Wildlife Service)
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
ET	Evapotranspiration
FLIR	Forward Looking Infrared Radiometry
GAP	Gap Analysis Project
GIS	Global (Geographic) Information System
GLO	General Land Office
GPS	Global Positioning System
HSU	Humboldt State University
HUC	Hydrologic unit code
HWG	Hatfield Working Group
IAU	Individual Assessment Unit
ID	Inter-disciplinary
INR	Institute for Natural Resources
IPCC	International Panel on Climate Change
KBEF	Klamath Basin Ecosystem Foundation
KNRD	Klamath Tribes Natural Resources Department
KWC	Klamath Watershed Council
LASAR	Laboratory Analytical Storage and Retrieval Database
LIDAR	Light Detection and Ranging
LRMP	Land and Resource Management Plan
LWD	Large woody debris
LWG	Local working group
MBF	Million board-feet
NCDC	National Climatic Data Center
NF	National Forest
NFCP	Native Fish Conservation Policy
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System

NPS	National Park System
NRCS	Natural Resources Conservation Service
NRST	National Riparian Service Team
NTU	Nephelometric turbidity unit
NWI	National Wetland Inventory
NWCC	National Water and Climate Center
NWR	National Wildlife Refuge
OAR	Oregon Administrative Rules
OC&E	Oregon, California, and Eastern
OCAFS	Oregon Chapter of the American Fisheries Society
OCS	Oregon Climate Service
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Department of State Lands
OGAP	Oregon Gap Analysis Program
OGEO	Oregon Geospatial Enterprise Office
OIT	Oregon Institute of Technology
ONCIC	Oregon Natural Heritage Information Center
ONHP	Oregon Natural Heritage Program
ORS	Oregon Revised Statute
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWQI	Oregon Water Quality Index
OWRD	Oregon Water Resources Department
PDO	Pacific Decadal Oscillation
PFC	Proper Functioning Condition
PNW	Pacific northwest
POR	Period of record
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PSMFC	Pacific States Marine Fisheries Commission
RCU	Riparian condition unit
REO	Regional Ecosystem Office
RUSLE	Revised Universal Soil Loss Equation
SNOTEL	Snowpack Telemetry
SRI	Soil Resource Inventory
SSURGO	(NRCS) Soil Survey Geographic
STATSGO	(NRCS) State Soil Geographic
SWE	Snow water equivalent
(%) TIA	(percent of) total impervious area
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRS	Timber Resource Services
USBR	U.S. Bureau of Reclamation
USDI	U.S. Department of Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey

WAB	Water availability basin
WARS	Water Availability Reporting System
WDNR	Washington Department of Natural Resources
WFPB	Washington Forest Practices Board
WLA	Working Landscapes Alliance
WPCF	Water Pollution Control Facility
WPN	Watershed Professionals Network
WQMP	Water Quality Management Plan
WRCC	Western Regional Climate Center
WRIS	Water Rights Information System
WRP	Wetland Reserve Program

Disclaimer

This watershed assessment is based almost entirely on the work of others. The authors of this document have attempted to organize relevant data and associated interpretation into a format that will be most useful to Upper Sprague River Watershed stakeholders. Citations are provided to key data bases and existing reports that provided the foundation for this assessment. Note, however, that we rely heavily on data interpretations provided in these reference reports, as is standard practice for watershed assessments. We have cited and referenced many borrowed works for this document and maintain the fair use doctrine for such use. Under the fair use doctrine of the U.S. copyright statute, it is permissible to use limited portions of a work for purposes such as scholarly reports.

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Preface

by Mike Connelly, KBEF

As far back as the records go, the Upper Sprague and Sycan watersheds have been "on the edge." This is true in terms of geography, culture, economy, politics, and ecology. For centuries, this was where the Pauite Indians, whose territory stretched all the way down into Nevada, met the Klamath people, who ranged westward into the mountains west of Upper Klamath Lake. The Modocs sometimes came here too, from their homes to the south on Tule Lake and the Lost River.

This area has been on the edge in other ways as well. To the west, it is wetter, and the plants and animals are more numerous. To the east, where it gets dry pretty quickly, the plants and animals change, and generally are fewer and farther apart. When the states were formed, the area ended up near the line between Oregon and California, and when Lake and Klamath counties were formed, these watersheds were shared between the two.

This region contains the headwaters of a drainage that travels several hundred miles and empties into the Pacific Ocean, slicing through the Cascade Mountain Range along the way. The January snowflakes falling on Gearhart's cliffs will make their way downriver, eventually lapping into the saltwater on the coast of northern California. For untold centuries, people and fish have followed the rivers and creeks, upstream and downstream, looking for more hospitable weather and better things to eat.

In some ways, the people were luckier than the fish. People got to climb the mountains during the summer months, breathing the thin air deeply, squinting at the bright blue and sunshine, looking down on the places they lived -- getting a good long look at "The Big Picture."

There are good people that live in the Upper Sprague and the Sycan, people with all different kinds of backgrounds. These are people who work harder than most, and get less in return, at least when it comes to money. But there must be something else that they get, because they stay in this place, working the land day in and day out, fighting the cold, sweating in the heat, swatting the bugs, and watching as the travelers pass on through, on their way to somewhere else. Other times, they sit with people they've known for years, watching the sun come up, watching the sun go down, watching the fish jump and the swallows dive as the water keeps flowing slowly by.

Today, the communities of the Upper Sprague and Sycan are on the edge not just in location, but also in time. Things are changing in these communities, as they are throughout the rural western United States. Some of these changes are good, and some of them aren't any good at all. But either way the change is there, and we've got to find a way to deal with it.

This document is supposed to be a tool. It's meant to help us deal with changes in a way that doesn't sacrifice all the good things about our rural communities -- the common sense, the honesty, the faith, the endurance, the love of the land, the love for your neighbor, and the willingness to do what it takes to make things right.

CHAPTER 1. INTRODUCTION

Watershed assessments are unique in that they are based on science, but also depend to a large degree on old-fashioned town hall democracy. The watershed assessment process was developed by coalitions of farmers, ranchers, environmentalists, scientists, foresters, agency personnel, tribes, business people, and many others. Assessments were intended to give local communities and resource managers the information and tools they needed to take the lead in managing their own landscapes. This process, which was pioneered here in the state of Oregon, grew out of a recognition that science all by itself cannot solve, or even fully understand, the problems we face when it comes to the natural resources we depend upon. To accomplish our goals, it is necessary to integrate scientific knowledge with the social, cultural and economic dynamics of local communities.

In the Klamath Basin, various local organizations have worked since the late 1990s to initiate watershed assessments. But this work took on a new importance after the water crisis of 2001. Many who lived through that unfortunate event came to the conclusion that an overall plan was needed that would keep similar events from happening again. Stakeholders from all sides of the issues called on the scientists and regulators to be much clearer about what the problems were, and what it would take to fix them. Participants wanted to get the problems fixed and go on with their lives, but they couldn't if they didn't even agree on what was broken. The watershed assessments were identified as the approach that would help people sort this out.

Starting in 2003, three different organizations – the Hatfield Working Group, the Klamath Watershed Council, and the Klamath Basin Ecosystem Foundation – began to cooperate to put the project together. The Hatfield Group was made up of representatives of the various interest groups – timber, agriculture, environmentalists, agencies, local government, etc. It was their job to make sure the assessments happened in a way that all the different constituencies could support. The Klamath Watershed Council was made up of representatives of the various sub-watersheds in the Upper Basin. It was their job to make sure that the assessments were done with the input and participation of the people who lived and worked in the areas being assessed. The Klamath Basin Ecosystem Foundation (KBEF) was made up of a diversity of representatives, but it also had its own non-profit status. It was KBEF's job to raise the money, keep the books, negotiate the contracts and do all the paperwork.

This partnership of organizations secured grants from the Oregon Watershed Enhancement Board and the Klamath Basin Ecosystem Restoration Office, and then got to work. The first step was to develop a strategy for doing the assessments. The Upper Klamath Basin is a very big place, and to do the assessments at the scale and pace that they have been done in other parts of the state would take around sixty years and cost somewhere around six or seven million dollars. No one was interested in taking that long or spending that much, so the partnership devised a strategy that balanced the need for detailed analysis with the need to be expedient, and to be responsible with taxpayer dollars.

The upper basin was divided into seven "Assessment Units." The Upper Williamson, The Upper Sprague/Sycan, The Lower Sprague/Williamson, Upper Klamath Lake, Upper Lost, Lower Lost/Klamath Project, and The Klamath River Canyon. The plan was to do one of these a year, in the order they were just listed, for about $100,000 to $150,000 each. This would be less than a tenth of the cost of an average watershed assessment.

From the beginning, it was important to all involved that assessments be based on actual conditions out in the territory, and not just on published studies and reports. It was obvious that there was a wealth of information in the heads of people who have lived on the land for generations, and who may have never gotten around to publishing a scientific report.

It was also obvious that published reports sometimes didn't tell the whole story about conditions on the ground, because they sometimes had to generalize about large areas. Everyone knew that what was true in one place wasn't necessarily true in another. There was interest in finding ways to supplement the published data with information collected from local landowners, and through direct encounters with the landscapes of each watershed. An additional benefit of working at a smaller scale is that it allows greater local involvement in the development of the document, and we hope, eventual support of the resulting action plans.

The project began with guidance provided by the Oregon Watershed Enhancement Board in their Watershed Assessment Manual. This manual is geared toward incorporating community involvement in the assessment process, which was a novel idea back when it was first tried. This process was used in our first assessment in the Upper Williamson, and it was improved by incorporating a series of public field days covering various parts of the watershed. This worked fairly well, but there was still the feeling that the field-based information from the field days (which sometimes contradicted the published reports) wasn't being successfully incorporated into the assessment document itself.

It was also learned during those field days (most of which took place on private lands) that many landowners and managers were eager to make improvements on their property. In many cases they had given considerable thought to what could be done, and in some cases they had already gone ahead and done it. So there was interest in finding ways to make sure that the field days could provide landowners with help right there on the spot, in addition to making sure landowners' perspectives got incorporated into the assessment.

The answer to these needs came in the form of the Working Landscapes Alliance (WLA). The WLA is a unique group of natural resource specialists with decades of experience in the management of natural resources and social dynamics in the western United States. Their approach to stream assessment and enhancement, called "Proper Functioning Condition" or "PFC," has a history here in the Upper Basin.

PFC assessment refers to a methodology for assessing the physical functioning of riparian-wetland areas, including hydrology, vegetation, and erosion/deposition (soils) attributes and processes (Prichard et. al 1998). WLA also has a collaborative adaptive management philosophy and works to create a common vocabulary about upland and riparian-wetland (watershed) function among diverse people and interests. The WLA recognizes that "science doesn't solve problems, people do," and that there is a need to develop shared understanding of basic watershed functions and the impediments to functionality caused by management choices among diverse types of people (landowners, agency representatives, tribes, conservation organizations, etc.) that live in a watershed. This shared understanding is a pre-requisite to carrying out actions to restore functionality for values such as increased forage or threatened species recovery."

As early as 1995, local producer groups, in cooperation with the Oregon Cattlemen's Association, Oregon State University and the Klamath Watershed Council, had been sponsoring workshops teaching the principles of PFC. The PFC approach was successful back then because it focused on actual conditions on specific stream reaches, describing in detail how soil, vegetation and water interact to dissipate the stream energies that cause erosion, resulting in more stable stream channels, improved fish habitat, cleaner water, and even improved forage production. The information gathered through this approach is documented in a way that could contribute to the overall watershed assessment by serving as a "cross-reference" for the published studies. At the same time, it gives a landowner some information that he or she can put to use almost immediately.

Another need that was identified was to look more at the role upland areas play in overall watershed health. The Working Landscapes Alliance includes a specialist in range management and upland function, who focuses on the ability of upland landscapes to "capture, store, and safely release" the precipitation the watershed receives. An "Uplands Discussion Guide" was developed which was adapted from Pellant, et al (2005), and included the professional experience of WLA members. The Discussion Guide parallels the riparian PFC format.

So now there was a process, based on the OWEB Manual, for looking at the existing data and published studies, oriented toward understanding how the watershed as a whole worked, and toward involving the community at large. There was also a process, based on PFC, that took a much closer look at specific upland and riparian sites, oriented toward involving particular resource managers right there on the land they managed.

It is important to understand that the OWEB process and the PFC process are distinct processes. And while the PFC-based field days provided important information that appears in this document, it was the OWEB process, and not PFC, that was used to produce this assessment document.

THE OWEB PROCESS AND ISSUE IDENTIFICATION

The shortest way to describe the OWEB process is as follows:

1) Decide what needs to be assessed.
2) Assess those things.
3) Decide what is going to be done about those things.
4) Do it.

For many, the item of most interest is number 4, and if the assessment process doesn't result in tangible actions in the watershed, then it has all been for naught. This assessment document, although it is thick and heavy, is not the point of this process. It only covers Steps 1 and 2 in the list above – figuring out what we want to know about, and then digging up everything that anyone knows about those things. Sometimes the assessment part of the process can be frustrating, because it seems like a lot of work and expense with not a lot to show for it. Sometimes it only starts to seem practical at step three, the "Action Plan" step.

Action Planning uses what was learned from the assessment steps to make a prioritized list of the practical actions necessary to meet the needs that have been identified. Projects could include setting up off-stream watering or planting trees, or gathering more information on topics or in areas where the existing information was not helpful. Action Planning is usually faster and easier than assessment, in part because by then people are anxious to move on to step 4: doing the actual projects.

But before that could be done, the first two steps had to be accomplished. For the Upper Sprague and Sycan Watershed Assessment, which covers all the territory upstream of the confluence of the Sprague and Sycan, the process started by having an "Issue Identification" workshop. This was held on August 16, 2005, at the Senior Country Café in Bly. Sixteen people attended the workshop, including landowners, agency personnel, and private industry. There were more agency people than anyone else, so the input from the workshop was supplemented by soliciting input by phone, email or personal communication from other parties, including other landowners and the Klamath Tribes.

At the workshop, participants assembled into small groups to generate lists of as many potential issues for the watershed as possible. Participants spent part of the time developing issues from viewpoints different from their own, and part of the time identifying issues that affected them directly.

Individual issues were then classified into a number of categories by the whole group, and then ranked. The ranking process allowed each participant to assign a weight to an issue by distributing colored dots among the issues. In addition, each participant was given a colored star to indicate the one issue that was the most important to him or her individually. Issues were ranked according to the total number of votes (dots and stars) received. In the case of ties, issues with stars ranked higher. This method allowed issues to achieve a high rank by virtue of being very important to a few participants or of lesser importance to many participants.

There were 119 issues raised which were classified into 12 categories. The categories were ranked using a weighting method that combined the number of stars with the average votes per issue. In cases where the total number of votes was the same for different issues, the rank was based on the number of stars received. Of the 119 issues identified during the workshop 56 (nearly half) received no votes. The top issues reflected concern about the effect of property sales to developers, the effect of government regulations on agriculture, and the effect of endangered species on agriculture operations.

The following tables summarize the input received. Table 1-1 lists all the issues raised, organized into categories. Table 1-2 lists the categories ranked by the total number of votes. Table 1-3 presents the categories ranked by the weighted scores.

Table 1-1. Issues raised during the Issues Identification Workshop listed by category.

Category	Issue
Water Quantity	How do we manage annual fluctuations in water amount?
	What impact are wells having on artesian flow and groundwater?
	Water rights adjudication creates uncertainty about water for irrigation and fish and wildlife.
	Mid-elevation uplands* are in fair to poor hydrologic condition. *(sagebrush/grass, sagebrush/grass/juniper, juniper/grass/shrub)
	In-stream flow needs for channel maintenance, biotic support, refugia and migration for healthy riparian function.
	Juniper encroachment may affect water availability for Sprague system.
	Are the water rights such that there is enough water left in channel for physical ecological processes and biology to flourish?
	Weeds and invasive species consume more water and are out-competing native species.
	Irrigation water supply.
	A true balance in water delivery.
	Who owns the water can affect my lifestyle and maybe even livelihood.
	Having enough water to grow hay and water cattle.
	Tribal rights are reduced by over-allocated water resources.
	Availability and quality of water from above Klamath Lake affects flexibility for Klamath Lake irrigation project.

Table 1-1. Continued.

Category	Issue
	Late season flows.
	Irrigation water and tribal rights.
Ranch	Presence of endangered species on my land may retard use and profit.
	Rising land values affect opportunities for agricultural landowners to own and retain land.
	Conservation of open space.
	Increase public land grazing.
	My neighbor doesn't care, why should I?
	River and riparian restoration may affect economic viability of ranching and farming operation.
	Forage production.
	Remove all public land grazing.
	Access to public lands for grazing.
	Grazing allotment reform.
	How will this information increase my bottom line?
Water Quality	Water quality, including temperature and chemistry is a problem for fish recovery.
	Poor water quality issues including temperature, sediment, dissolved O_2, pH, nutrients.
	What limitations do the agriculture water quality management plan impose?
	Need improved water quality by reducing impacts of livestock, roads, forest practices.
	Need to preserve wild and scenic qualities of the waters.
	Streambank erosion affecting H_2O quality.
Riparian	Functional soil, water, and vegetation to sustain creation of what we value.
	How much water does riparian vegetation remove from the system?
	Geomorphology issues including lack of flood plain connectivity, lateral and vertical stability, sediment loads, channel geometry.
	Current condition of riparian areas is very poor.
	Bank stability.
	Flood plain connectivity.
	What regulations control managing riparian areas on private lands?
	Restoration of previous wetland and riparian areas.
	Stream and riparian degradation can be caused or influenced by on-site management, and upland or upstream management. It takes critical thinking to determine cause and effect.
	There is a lack of riparian restoration targets.
	Erosion control into riparian areas.
Culture	Faulty data leads to faulty results.
	Dignity, economy, and biology go hand in hand.
	Local participation.
	Truthful representation on biological issues.
	Tribe: Termination took our land and our spirit.
	Tribal culture and heritage is not respected by non-tribal groups.
	How will the information influence the way we make management decisions?
	Family health.
	Tribes: Don't trust whites and their government and organizations.
	The kids stay in town (hometown).
	There is not enough wilderness.
	Our love of the land is as old as Creation. The white's love of the land is new, artificial,

Table 1-1. Continued.	
Category	**Issue**
	copied, and greedy.
	Community integrity.
	Want to sustain our tribal culture by getting lands back.
	Lack of understanding: What's the big deal?
Recreation	Preserve open lands for public use.
	Provide more recreational opportunity such as trails.
	Recreational opportunities for guests at our B&B.
	Recreational fishing.
	The land and its resources - water, timber, fish, and wildlife belonged to the Klamath Tribes and were taken by the Euro-American settlers.
	Eco-tourism.
Fish Habitat	Fish population are too low: a) redband, b) bull trout, c) sucker.
	Numbers and health of native fish such that there is enough for all to eat.
	Flood control has created fish habitat problems (channelization).
	Concerns on improving sucker population.
	Relationships with landowners and agencies who are managing the fish habitat so that we all get what we need and want from the catchment.
	We need to protect bull trout for the future.
	There is a need for target fish populations by watershed.
	Management and limitation for ESA species including: Lost River and shortnose sucker, bull trout, coho salmon, bald eagle.
	Suckers live in the mud, who cares?
	Maintaining traditional hunting and fishing areas under ESA requirements.
	Fish passage is not complete.
	Fish habitat.
Biological Diversity	Noxious weeds.
	Maintain plant and animal diversity and viability.
Wetland	Does Sycan Marsh reduce water flows to downstream areas?
	What federal or other programs assist people who want to improve streams?
	Why does the Nature Conservancy dry up the Sycan River?
Regulatory	Government regulations on water and land usage and how they are affecting the next generation of agriculturalist.
	Is there a way to recover the watershed while providing protection of private landowners?
	Policy and regulations (state and federal) conflict with watershed recovery (e.g. diking)
	Standards too hard to reach or comply with.
	Governmental agency intrusion.
	Conformity to government standards. Regulation.
Economics	Loss of private lands and rapid sale to developers.
	Sustaining rural economies.
	How much money do the various types of stream restoration cost?
	Economic viability/diversity.
	Not enough money to make changes.
	No time to work on these things and make a living.

Table 1-1. Continued.

Category	Issue
Forest and Uplands	Timber: Juniper encroachment into historically non-juniper areas.
	Need to cover uplands--the other 98% of the watershed.
	Does cutting juniper and pine forest increase stream flow?
	Need to increase timber harvest to reduce fuel loads and release suppressed stands.
	Keep forests healthy and productive.
	How much volume in conifer and juniper thinning is available on an annual bases? Private land? National forest land?
	Need to preserve late and old successional forest.
	Forest stand density/composition.
	Preserve all unroaded areas.
	Make the forest healthy, sustainable, and resistant to fire.
	Timber harvest.
	Roads can act like stream channels if not designed, constructed, maintained.
	Needs flexibility on environmental assessment of Forest Service leases.
	Stop all timber harvest.
	What are primary barriers to forest health thinning?
	The mismanagement of timber resources yielding less production and unhealthy forest stands.
	Timber thinning to release suppressed stands and provide biomass for electricity generation.
	Insect infestation leads to stand degradation.
	High danger of catastrophic fire. (especially near Forest Service and BLM?)
	Forest management.
	Regulatory issues. Oregon Forest Practices Act.
	Current demands of harvest practices increase cost.
	Road maintenance costs (is expensive).
	Low fish populations restrict amount of necessary forest thinning (hazard reduction and wood production).
	Lack of prescribed fire.

Table 1-2. Watershed issues ranked by total votes cast by workshop participants.

Rank	Issue	Category
1	Loss of private lands and rapid sale to developers.	Economics
2	Government regulation on water and land usage and how they are affecting the next generation of agriculturalist.	Regulatory
3	Presence of endangered species on my land may retard use and profit.	Ranch
4	Timber: Juniper encroachment into historically non-juniper areas.	Forest and Uplands
5	Functional soil, water, and vegetation to sustain creation of what we value.	Riparian
6	Faulty data leads to faulty results.	Culture
7	Need to cover uplands—the other 98% of the watershed.	Forest and Uplands
8	How do we manage annual fluctuations in water amount?	Water Quantity
9	What impact are wells having on artesian flow and groundwater?	Water Quantity
10	Noxious weeds.	Biological Diversity
11	Water quality, including temperature and chemistry is a problem for fish recovery.	Water Quality
12	How much water does riparian vegetation remove from the system?	Riparian
13	Is there a way to recover the watershed while providing protection of private landowners?	Regulatory
14	Water rights adjudication creates uncertainty about water for irrigation and fish and wildlife.	Water Quantity
15	Fish populations are too low: a) redband, b) bull trout, c) sucker.	Fish Habitat
16	Dignity, economy, and biology go hand in hand.	Culture
17	Mid-elevation uplands* are in fair to poor hydrologic condition. *(sagebrush/grass, sagebrush/grass/juniper, juniper/grass.shrub)	Water Quantity
18	Rising land values affect opportunities for agricultural landowners to own and retain land.	Ranch
19	Local participation.	Culture
20	Does cutting juniper and pine forest increase stream flow?	Forest and Uplands
21	Geomorphology issues including lack of floodplain connectivity, lateral and vertical stability, sediment loads, channel geometry.	Riparian
22	Does Sycan Marsh reduce water flows to downstream areas?	Wetland
23	Policy and regulations (state and fed)conflict with watershed recovery (e.g. diking).	Regulatory
24	Sustaining rural economies.	Economics
25	In-stream flow needs for channel maintenance, biotic support, refugia and migration for healthy riparian function.	Water Quantity
26	Juniper encroachment may affect water availability for Sprague system.	Water Quantity
27	Current condition of riparian areas is very poor.	Riparian
28	Bank stability.	Riparian
29	Floodplain connectivity.	Riparian
30	Preserve open lands for public use.	Recreation
31	Need to increase timber harvest to reduce fuel loads and release suppressed stands.	Forest and Uplands
32	Keep forests healthy and productive.	Forest and Uplands
33	Conservation of open space.	Ranch
34	Increase public land grazing.	Ranch
35	Poor water quality issues including temperature, sediment, dissolved O_2, pH, nutrients.	Water Quality
36	What limitations do the agriculture water quality management plan impose?	Water Quality
37	Truthful representation on biological issues.	Culture
38	Tribe: Termination took our land and our spirit.	Culture
39	Tribal culture and heritage is not respected by non-tribal groups.	Culture
40	How will the information influence the way we make management decisions?	Culture

Table 1-2. Continued.

Rank	Issue	Category
41	Maintain plant and animal diversity and viability.	Biological Diversity
42	How much volume in conifer and juniper thinnings is available on an annual bases? Private land? National forest land?	Forest and Uplands
43	Need to preserve late and old successional forest.	Forest and Uplands
44	Forest stand density and composition.	Forest and Uplands
45	Are the water rights such that there is enough water left in channel for physical ecological processes and biology to flourish?	Water Quantity
46	Weeds and invasive species consume more water and are out-competing native species.	Water Quantity
47	Irrigation water supply.	Water Quantity
48	A true balance in water delivery.	Water Quantity
49	My neighbor doesn't care, why should I?	Ranch
50	Need improved water quality by reducing effects of livestock, roads, forest practices.	Water Quality
51	Need to preserve wild and scenic qualities of the waters.	Water Quality
52	What regulations control managing riparian areas on private lands?	Riparian
53	Restoration of previous wetland and riparian areas.	Riparian
54	Family health.	Culture
55	Tribes: Don't trust whites and their government and organizations.	Culture
56	Provide more recreational opportunity such as trails.	Recreation
57	Numbers and health of native fish such that there is enough for all to eat.	Fish Habitat
58	Flood control has created fish habitat problems (channelization).	Fish Habitat
59	Preserve all unroaded areas.	Forest and Uplands
60	Make the forest healthy, sustainable, and resistant to fire.	Forest and Uplands
61	Timber harvest.	Forest and Uplands
62	Roads can act like stream channels if not designed, constructed, maintained.	Forest and Uplands
63	Needs flexibility on environmental assessment of Forest Service leases.	Forest and Uplands

Table 1-3. Categories ranked by weighted scores.

Category	Score	No. of Issues
Regulatory	2.83	6
Riparian	2.77	11
Culture	2.37	15
Biological Diversity	2.25	2
Forest and Uplands	2.24	25
Economics	1.92	6
Water Quantity	1.56	16
Ranch	1.32	11
Wetland	1.00	3
Water Quality	1.00	6
Fish Habitat	0.79	12
Recreation	0.33	6

To the extent possible, these prioritized lists of issues were used to guide the assessment work. In some cases, such as the "Culture" or "Economics" categories, it was difficult to get a watershed assessment to address certain issues. It also should be acknowledged that the Issue Identification process may not have resulted in the best possible representation of community concerns in the assessment area, because it did not gather input from everyone, and because it was limited to a brief period of time during the fall of 2005.

THE WORKING LANDSCAPES ALLIANCE PROCESS

As mentioned earlier, the Working Landscapes Alliance (WLA) represented methods for gauging the health of both riparian and upland areas. For the riparian areas, the method is known as Proper Functioning Condition, or PFC. The focus in uplands is also functionality.The Upland Discussion Guide evaluates the ability of a site to "capture, store and release (C-S-R)" available precipitation. These two methods were used during a series of workshops and field days that took place during the spring, summer and fall of 2005.

One reason for these field events was the need to connect the conversations about the watershed to actual conditions and management on the landscape in addition to maps and spreadsheets. In this sense, the field days functioned as a limited "ground-truthing" of published information.

It was also clear that it was very difficult for busy community members, especially farmers and ranchers, to spend daylight hours sitting indoors at a meeting. So another purpose of the field events was to meet landowners on their own territory where it would be more convenient, and where the assessment work would be more likely to be directly useful to them.

Each month during the growing season, a week was scheduled when the people of the Working Landscapes Alliance – Wayne Elmore, Hugh Barrett, Janice Staats, and Mike Lunn – would spend the week in the assessment area. One day of that week would be a public field day at a site that would illustrate a particular type of landscape in the Upper Sprague and Sycan. Participants visited private ranches, Forest Service grazing allotments, the Sycan Marsh Preserve, U.S. Timberlands' timber ground, and other sites. The groups on these field days were always fairly diverse, with landowners, agency people, scientists, and other community members. The best part of these public field days was hearing everyone talk about the same landscape from all their different perspectives. These conversations got a lot of good information out in the open, including facts and figures that otherwise wouldn't have made it into this assessment. The field days also tended to surprise people who thought they knew all about what was happening on a particular piece of property. This happened to landowners, activists and scientists alike.

On the rest of the days during the field weeks, private ranch visits were scheduled that would not be open to the public. Sometimes the ranch owners would invite neighbors or employees, but the point of the visits was not to "educate the public." The point was learn from the landowner what he or she knew to be true on the land where they lived, and to see if there was something the WLA could do to help the landowner. Most times, the WLA would conduct a detailed Proper Functioning Condition site assessment, which included a narrative, reach photos, conclusions and recommendations.

The riparian PFC site assessment is a way to determine if a stream has what it needs to keep itself stable during high-flow events (5-, 10- and 20-year events). The analysis is based on a set of seventeen questions regarding the vegetation, the hydrology and the sediments on the site. It starts with an inter-disciplinary (ID) team that usually includes specialists in hydrology, vegetation, soils, biology, as well as, ideally, the landowner or resource manager. The ID team walks the stream reach together, each looking at the area through their own perspectives based on their experiences and expertise. A similar approach was taken in reviewing upland function.

This approach can take quite a while sometimes, because people are always having to stop and talk about this or that. The botanist finds a plant that is particularly good for holding stream banks in place, or the hydrologist notices where the main flows got cut off from a big meander, or the soils person finds a patch of soil that indicates that the site used to be a lot wetter than it is now. And all the way through, the landowners are talking about how they run animals, how they move water, and what they remember their parents or grandparents saying about what the place was like long ago.

When the group gets to the end of the stream reach, they all sit down and start comparing notes. They talk about each question in turn: "Can frequent flood flows get out of the channel and on a floodplain reasonably often?" "Are there enough of the right kinds of plants on site, and are they healthy?" "Is the stream able to move the sediment that comes onto the floodplain or through the system, or are there big sandbars out in the middle?" "How is water moving across the soil surface?" They go back and forth until they all agree on the answers to each question, and then they make a call. Is the site functioning properly? Is the site at risk, and if so is it on an upward or a downward trend? The answers to these questions really help to clarify what a landowner can do – or can't do for that matter – about the conditions of the stream.

In some cases these site assessments led straight to a stewardship project or to monitoring. In other cases all the WLA experts could say is that things looked good, and that the landowners just need to keep doing what they are doing. But in all the cases, everyone who participated learned a lot about how the Upper Sprague and Sycan watersheds work.

Although there were many finding that came out of these field days (see Riparian and other chapters), two things were particularly striking about what was learned, at almost every site that was visited.

One was how truly resilient and responsive these landscapes and streams are. So often environmental issues are approached like they are enormously complicated and difficult. But over and over again field day participants learned how, with a little better understanding of how these systems function, and some relatively minor adjustments in management, these riparian sites will bounce back both quickly and dramatically.

The other striking thing that was learned was how often a recommended action benefited both the natural system and the landowner. Some stakeholders often tend to think that in order to improve the natural systems there has to be a negative affect on an agricultural operation (or vice-versa). But what was learned on the ranch visits was that sites where the stream wasn't working well were often also the sites where forage production had gone down. And since stream and upland stability is invariably linked to the amount and vigor of the vegetation on the site, the solution to the stream problem often results in improved forage production and quality as well.

THE ECONOMICS OF RESTORATION

No analysis of a watershed is complete without consideration of those social and economic factors that necessarily drive the behavior of those who influence that watershed. Because much of the most important habitat areas within the watershed are owned privately, the influence of these factors, especially economic ones, on landowners is one of the most important determinants of watershed condition.

These landowners, for the most part family ranchers and farmers, run labor intensive, low profit margin operations, which are under increasing economic pressure from rising costs and regulatory requirements. While take the stewardship of their land quite seriously, they must also sustain a viable business that supports their families. Some well meaning attempts at environmental restoration in the past have not been successful long-term precisely because they have failed to take just such factors into account. Some projects have appeared successful at the time of implementation, but the landowners have not had the time and money to maintain the projects long term.

Therefore, while the best scientific approaches and conditions are vital, they need to be applied within the constraints of their social and economic settings. A functional watershed in optimal condition would balance the needs of species, people and economics.

The economics are restrictive at many different levels. There is not an unlimited source of money from granting entities, government agencies and landowners. Projects and management changes must therefore be prioritized.

At another level, it is important to consider economic feasibility from the landowner viewpoint. Quite simply, the landowner is limited in time and money. Often management changes that may be beneficial in the long term are prohibitively expensive in the short term. To a landowner who is extremely busy managing their current operation, it is often difficult to find the time or money to implement idealized management changes. While landowners, no less than others, recognize the importance and benefits of such long-term management changes, their challenge is to balance the cost-benefits of implementing best management practices and beneficial projects with the needs of their business.

Habitat restoration efforts that fail to take into account these issues can also fail to address a more profound threat to the long term environmental health of the basin: The combination of increasing economic threats to the viability of family ranches and farms with the rising value of their land for "recreational use" by increasing numbers of retirees and others threatens these lands with conversion to commercial real estate development. In many areas of the West, including the Klamath Basin, such development has often resulted in substantial degradation of the environment. Therefore, efforts to restore the watershed that fail to account for the social and economic needs of landowners might well have precisely the opposite effect over the long term.

A NOTE ON "REFERENCE CONDITIONS"

Whereas it is often useful to refer to "reference conditions" or a "natural state," it is important to note that such baseline conditions may not be considered desirable for the present. For example, while juniper overgrowth is a problem that can often be addressed by burning, most would agree that the reference condition of completely uncontrolled wildfires that could threaten life and property is inappropriate for today. Similarly, few would advocate closing all roads within the watershed, but this would indeed represent the "reference condition." Another limitation is our limited ability to accurately characterize conditions that existed before detailed records or data were collected.

Therefore, within the text of this Watershed Assessment, the term "reference condition(s)" should be understood to be limited to just that: a frame of reference against which to measure the impact of our civilization, for better or for worse. No inherent value is implied nor should be inferred.

DOCUMENT ORGANIZATION

The format of this document reflects certain principles that have emerged from the watershed assessment process. The topics that are covered, and the order in which they occur, are meant to emphasize that scientific understanding must be joined with social and economic understanding in order to result in lasting solutions that have solid community support. They are also meant to emphasize the conviction that overall watershed condition and function -- in both riparian areas and in the uplands -- are the result of dynamic interactions between soil, water, and vegetation.

The insight that soil, water and vegetation interact dynamically to produce watershed conditions has led to two principles that have informed the content of this document. First is the importance of basing our restoration and/or our management planning on site-specific conditions, rather than on generalized judgments about conditions at the watershed scale. While watershed-scale statements and analyses are very important for context and for the "big picture," any actual on-the-ground actions must be rooted in analysis of the actual conditions on the site in question.

Second is the importance of focusing on "trend over time," rather than on static "snapshots" of watershed conditions. The snapshot approach to assessment of conditions compels the analyst or resource manager to make "black or white" determinations about whether or not a given site is acceptable. Focusing on trend over time, on the other hand, allows the resource managers to determine whether fundamental processes are in place that will produce a stable -- but dynamic -- landscape over the long term.

The preceding principles are reflected in the format of this document in the following ways:

- Initial chapters present information about community involvement in the process, and about social, economic and historical aspects of the watershed
- Chapters Four through Eight present information about soils, water, and vegetation, in that order, for both riparian areas and the uplands; Chapter Nine addresses how the interactions of these components result in different stream channel forms within the watershed
- Chapters Ten through Twelve relate this information to regulatory and species habitat issues, with specific attention to water quality and listed species
- Chapter Thirteen, the Watershed Function Summary, is both brief and general, reflecting the principle that watershed-scale appraisals are important for context and prioritization, but secondary to site-specific analysis when it comes to restoration or regulatory action.
- The document ends with action-oriented chapters, emphasizing both the substantial restoration accomplishments of local stakeholders, as well as the work that is yet to be done.

CONCLUSION

Although this document is printed and bound, the Upper Sprague and Sycan River Watershed Assessment will continue to be a work in progress. The landscapes that support us are always changing, and so are the communities we live in. We will continue to learn more about how the watershed works, even as we get to work on the projects we want to do. In fact, that's probably where the real learning begins: when we get out on the land itself, trying to make things better.

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CHAPTER 2. HISTORICAL CONDITIONS

LANDSCAPE CHANGES THROUGH HISTORY

> On my arrival in the Bly Valley on November 3, 1879, my first impression was very unfavorable. There were no fences, and no houses in sight. The grass grew so high that the low log cabins were hidden from view until one was within a few yards of them. I wondered what made people stay in such a desolate looking place. Little did I think that I would make my home there and raise a family and be happy and contented for thirty years . . .
>
> Mrs. Addie Walker (Helfrich 1974)

Mrs. Walker was not the first white person to settle in the Upper Sprague watershed, but she was close. By most accounts, the first settler was William H. Gearhart, who drove a herd of cattle from Humboldt County, California to Bly around 1874. The tall grass that Addie Walker thought looked "desolate" looked like opportunity to Mr. Gearhart, and Addie's arrival was part of the first wave of settlers who had learned how suited the Upper Sprague was to stock-raising.

But of course, there had been people in the Upper Sprague and Sycan watersheds before the Walkers and the Gearharts arrived. For centuries the area had been a seasonal home to Yahooskin band of the Northern Paiute. Most of the Northern Paiute territory was to the south and east, down through Goose Lake and all the way into central Nevada. But the northern Yahooskins traveled into the Upper Sprague and Sycan each year to harvest and hunt the native flora and fauna. The tribes lower down the river – the Klamaths and Modocs – also visited the Upper Sprague and Sycan on a seasonal basis, but the area was primarily Yahooskin territory, at least at the time of white settlement. It is generally believed that the name of the town of Bly came from the native word "plai," meaning "high country." The native name for the Sprague River is "Plaikni Koke," meaning "river from the high country" (Helfrich 1974).

Despite Addie Walker's description of the place as "desolate," the Upper Sprague watershed appears to have been a very rich and productive landscape when she arrived. Native Americans traveled long distances to hunt and gather here, and very likely competed with each other for access to this bounty. Cattle producers, too, immediately recognized the business potential of both the bottom ground and the uplands. Even Addie herself, after she had been around a while, started to see things differently:

> Cattle and horses from the range, which was covered with bunch grass two or three feet high, were rolling fat when gathered for

> market. . . . In addition to this there was an abundance of wild game for sport and profit; our men hunted bear, panther, and coyotes. For a change of diet they brought home wild ducks, geese, and sage chickens, and when one was lucky enough to bag a brood of young mallards just before they were able to fly, or a brood of young sage chickens following their mother, let me tell you we had delicacies unknown to any but pioneers. Fish – small speckled trout – were almost at our doors; Sprague River ran through our meadow not half a mile from our home, and our little boys could run down and catch a string of these speckled beauties any time in summer. In winter the Indians brought us the large salmon trout from springs along the river. (Helfrich 1974)

There were many early instances of friendliness and cooperation among the people – white and Indian alike -- who lived along the Upper Sprague and Sycan Rivers. J.O. Hamaker, who passed through the area in 1879 on his way to see his brother in Klamath Falls, said it was like "the whole country were [sic] one large Fraternal Family, and the 'Law of Universal Brotherhood' prevailed the country over" (Helfrich 1974). And Addie Walker told of how

> all were ready and willing to help each other as the need arose – sitting long nights through, giving medicine and nursing in the back room of Bill Smith's store at Bly. Once we lined, covered and trimmed the diamond shaped coffin. There was no beautiful hearse filled with flowers – only a handful of neighbors. . . . All stood ready to rejoice with those that did rejoice, and weep with those that wept. (Helfrich 1974)

GETTING THE LINES CROSSED

But there was also conflict from the very beginning. The same violent encounters that occurred in other parts of the Klamath Basin also happened here. And like other areas, the drawing of a reservation boundary in 1864 did not necessarily make the problems go away. In fact, in the Upper Sprague and Sycan there was particular confusion caused by the fact that no one could agree about where the boundary actually fell. This is a primary reason why white settlement began in this area somewhat later than in other parts of the basin.

The dispute arose when, in 1870, a surveyor from Corvallis was hired by the government to survey the boundary agreed to in the Treaty of 1864. When the surveyor submitted the map to the tribal leadership, they claimed that he had cut off from the reservation "a portion of the Sycan valley and the whole upper portion of the Sprague River Valley." The treaty language provided that from a point near the head of the Klamath Marsh the boundary should run to "the point where the Sprague river is intersected by 'Ash-Tish' Creek" (Helfrich 1974; this stream is now called Ish-Tish Creek, and runs through the U.S. Forest Service's Sprague River Picnic Area about four miles east of Bly).

The problem was that back then Ish-Tish Creek, "after emerging from it's upper and mountainous course, spreads out somewhat after the fashion of Lost River over a wide, nearly level, marshy plain," (Helfrich 1974) which is fed by several other streams, including Fish Hole, Fritz, Deming, Paradise, the South Fork Sprague, and others. The surveyor did not consider this vast marsh, which stretched unbroken over much of Bly Valley, to be the Sprague River. In fact he was not able to find a discernible "intersection" until the point where (what is now know as) the North and South Forks of the Sprague meet, "about one mile west of the Old Ivory Pine Road." The surveyor called this the "intersection of the Ash-Tish and the Sprague," and surveyed the reservation boundary to that point. The tribal leadership objected, but the government approved the survey and settlers began moving in almost immediately. Eventually – fifty years later -- the matter was settled with a sizable cash payment agreed to by both parties.

During the 1950s, the U.S. Army Corps of Engineers initiated a program of channelization of flows within this area. It has been difficult to obtain any details about the how these structures were built, or what the main justifications were. But Fish Hole Creek was bermed, and the South Fork Sprague was straightened and diked from a point Northeast of Bly downstream almost to Ivory Pine Road. This channelization, along with some incision of these channels that has taken place over the years, has reduced or, in some areas, eliminated the annual period during which these floodplains are inundated.

There are local citizens who were involved with the construction, who have indicated that the activities occurred at a time when flood control modifications were taking place throughout out the western states. This wave of flood control construction stemmed from passage of a National Flood Control Act in 1936, which authorized and funded the Corps of Engineers to implement such projects. Actual implementation was delayed due to World War II. But after that war was over there two major flood events in the southern Oregon region, one in 1950 and the other in 1964. With funding, personnel and equipment, as well as a strong interest in preventing further flood damage like that which was recently experienced, the Corps of Engineers made major modifications in relatively little time. Officials at the Corps of Engineers have indicated that the structures were likely built under an "emergency authorization," which would mean that little or no planning or documentation of construction activities would be required. (Corps of Engineers, Jennifer Sowell, pers. comm.)

THE FIRST DIVERSION

When Major John Green, commander of the First Cavalry at Fort Klamath, passed through the Upper Sprague valley on his way back from Warner

Valley in October of 1872, he made a sketch of the valley that shows only three habitations: William Gearhart's, James Polk's (Gearhart's business partner), and the cabin of a third early settler, Jacob Fritz Munz, who settled on what would later become the BK Ranch. Munz first appears in the historical record right around the time the Modoc War started in 1872, when he led a drunken vigilante party on a failed attempt to avenge the death of Munz' friend, Wendelin Nus, who was killed on the first day of the war. A year or so later, an Indian had been harassing Munz because he had established his large herd of cattle in the middle of that tract of Bly valley land that was still being disputed by the tribes and the U.S. government. Munz, who was known as a terrible shot, got out his .44 and took a potshot to try and scare the man away. To Munz' amazement he shot the man straight through the jugular vein. Munz was arrested, and reportedly paid a bail of around $9,000 which he jumped, never to be seen again. The only sign of him now is Fritz Creek, which runs through the BK Ranch. (Helfrich 1974)

The BK got its name in 1890, when three brothers -- Henry, Ed and George Bloomingkamp -- bought the 1,240 acre property for $7,000. Sometime in the early 1890s, Henry Bloomingkamp was digging an irrigation ditch from the North Fork Sprague over into the BK's flat pastures. Henry was blasting through a stretch of rocky ground. On one blast, he was hiding 300 yards away under a tree when it went off. But a rock "about the size of a turkey egg" sailed all that way, hit him square in the head, and killed him instantly. Despite this setback, the other two Bloomingkamps finished the ditch, which was almost certainly the first diversion for irrigation purposes built in the Upper Sprague and Sycan. This ditch is still in use today. (Helfrich 1974)

LIVESTOCK & FORAGE

By the time the Bloomingkamps named the BK in 1890, there were an ever increasing number of settlers in the Upper Sprague. The 1890 Census (in which the U.S. government officially announced the "closing of the frontier") counted 119 people in the Postal District. In 1905 the History of Central Oregon said that the town of Bly had "two general merchandise stores, two hotels, a saloon, and a livery barn." It also documented that 150 votes were cast in the last election, which would indicate an actual population of quite a bit more than that.

These early settlers appeared to be hard at work. Documents of the time give an indication of how much this area was already producing:

> The products of this valley consist of horses, cattle, mules and sheep, although the latter are few in number. At least 1,000 head of cattle, 100 head of horses and a like number of mules are sold annually from this valley. The soil products are oats, red clover, alsike clover, Timothy and natural meadow hay. At least 4,000 tons of hay are cut annually (Stern 1965).

Some of the pressure for this level of production stems from the fact that this area was right next to the Klamath Indian Reservation, where at this time the raising of livestock of various sorts – but especially beef cattle – was being strongly encouraged at all levels. Initially, government officials in the Bureau of Indian Affairs and other agencies sought to establish an economy for native people based on the raising of vegetable and grain crops, but because of the climate this failed rather miserably. However, it soon became clear that the reservation lands were ideal for livestock. As early as 1886, Indian Agents reported that there were 1,485 head of cattle, 3,640 head of horses, 340 mules, 195 hogs, and an uncounted number of sheep (Stern 1965). Many Indians became involved in the livestock trade, and many were very successful (Stern 1965).

In the late 19th century, as a result of the passing of a federal law known as the Dawes Act, many of the restrictions on non-Indian use of reservation grazing lands were relaxed or eliminated. When the reservation was first created only Indians could graze on the Indian land, but as the 19th century came to a close, more and more non-Indians were leasing allotments on the reservation. And because much of the reservation was unfenced, there was almost no control over how many animals were brought in. This resulted in somewhat of a boom in livestock numbers in the late 19th and early 20th centuries, which meant that the range immediately adjacent to the reservation, including almost all of the territory covered by this watershed assessment, experienced very heavy grazing pressure on practically a year-round basis. This particularly true of the Upper Sprague Valley, which was considered an ideal location for wintering.

It is often assumed that current livestock husbandry practices by deeded property owners are the cause of degraded ecological conditions in riparian or upland areas. But the most intense grazing pressure the Upper Sprague and Sycan watersheds have experienced took place from eighty to one hundred and twenty years ago. When the Fremont Forest Reserve (which included almost all of the non-reservation forested uplands in the assessment area) was established around the turn of the century, the new Forest Supervisor, Guy Ingram, identified overgrazing as one of his most serious problems:

> In 1907, the ranges were overstocked and overgrazed. One of the most difficult problems was to reduce the numbers of stock on the forest. The first thing was to eliminate from the national forest all stock of owners who did not own ranch property, and limit the number of stock allowed each permittee. Ownership of ranch property was the vital subject for consideration in making a 50 percent reduction in the numbers of stock allowed on the forest. . . . In the early days it was difficult to determine which of the many grazing applicants should be given permits. When several applicants for the same range each claimed that they had been using the

> range for the last twenty years, it was difficult to determine which were the best qualified. (Bach 1954)

This quote describes a situation in which large livestock interests from out of the area were turning out livestock on the same range as local producers. In addition, local producers themselves were turning out on the forest without any effective control over which animals went where, and without any knowledge of total livestock numbers. The result was a degraded range with a reduced capacity to produce forage for livestock. This is something that many local property owners recognized, which is why some of the strongest supporters of laws like the 1930 Taylor Grazing Act were local ranch owners, who were losing their summer forage base to large-scale livestock speculators.

THE TIMBER INDUSTRY

The pace of growth in the Upper Sprague and Sycan watersheds was fairly modest from the time William Gearhart arrived in 1872, through around 1928. This the year the Oregon, California and Eastern (OC&E) Railroad reached the town of Sprague River, and began its extension toward the town of Bly.

The logging industry had been in full swing in the Upper Klamath Basin since the railroad first arrived in Klamath Falls in 1909. From there, extensions of the line were built in all directions – first to the north toward the big stands of yellow pine around Upper Klamath Lake and Klamath Marsh, and then later toward the east. Timber interests had been aware of the massive stands in the region since the 1850s, but had been prevented from exploiting the stands because there was no way to get the lumber to market. This meant that when the railroads finally made it to an area, everyone was chomping at the bit to get things going.

The OC&E announced that they would build to Bly on May 5, 1928, and began work on June 20th. Just six days later the Pelican Bay Lumber Company announced that it would move their operation from northeast of Crater Lake to about twelve miles south of Bly, where they would establish a large logging camp, and build a logging railroad to meet up with the OC&E. A month later the Ewauna Box Company announced that it would buy the 37,000 acre Booth-Kelly Tract just east of Bly, and began buying right of way for its own logging line to meet up with the OC&E. The OC&E arrived in Bly in the winter of 1928-29, and in early spring of 1929 the first shipment of logs was made by Pelican Bay (Bowden 2003). In almost no time, the Upper Sprague and Sycan watersheds went from a quiet ranching community to a full-scale industrial timber economy.

In addition to Pelican Bay and Ewauna Box, Crane Mills built a mill right in the town of Bly, and in 1934 a man named Ed Ivory built a mill about ten miles northwest of Bly, on what is now known as Ivory Pine Road. The

Ivory Pine Company operated until 1948, and when the last log went through the mill had cut 250,000,000 feet of lumber.

The Pelican Bay Company Camp was located about eleven miles south of Bly, up the Fish Hole Creek drainage. In 1929 the *Klamath Herald* reported that the camp was "one of the largest logging camps in Oregon."

> With nearly 200 men employed and several locomotives, many "cats" and jammers in action, the virgin wilds have been transformed into life and activity little dreamed of before. . . . The Pelican Bay outfit is celebrated throughout the west for having the champion log loading crew. In May they broke the record by loading 71 cars ready for the mill in one day, a jump of nearly 20 cars over their own previous championship record. (Bowden 2003)

The Ewauna Box Company's camp was set up near the pass at Quartz Mountain, and included a sizable community of temporary residences, a water system, a service station, and eventually its own post office. When the camp began operations it employed 28 sets of fallers, and was shipping 30 to 40 carloads of logs to Klamath Falls every day.

It should be mentioned that some of the drive to get out this level of cut stemmed not just from the profit motive, but from issues of forest health. In every account of the logging industry of that time, the problem of western bark beetle infestation is highlighted. During the years 1923 through 1928, a survey was conducted by the Forest Insect Laboratory of Stanford University, covering most of the forested upland in the northwest portion of the assessment area. Investigators determined that during this period a total of 450,000,000 board feet had been killed, the maximum loss occurring during 1926, when 120,000,000 board feet were killed. This loss was estimated to be approximately 10% of the total stand in this area. This report was released at almost exactly the time that the OC&E railroad reached Bly, which meant that private, tribal and public forestry managers were highly motivated to cut as much vulnerable timber as possible, just when it became physically possible to get the timber to market (Kinney 1950).

By the 1940s the Upper Sprague and Sycan watersheds were host to some of the most intense logging activity in the western United States. This logging took place on private lands, tribal lands, and public lands, but the most accessible records pertain to the Fremont National Forest, which included most of the forested uplands in the area covered by this assessment. In 1943, to give an indication of just how many trees were getting cut, the Fremont National Forest sold more logs than any other National Forest in the Pacific Northwest Region, including the coastal rainforests (Bach 1954). Table 2-1 shows the sales for that year. Please note that not all of these sales are within the area covered by this assessment (Bach 1954). But also keep in mind that this table does not include any harvest on private or tribal lands.

Table 2-1. Fremont National Forest Timber Sales in 1943. (Source: Bach 1954)

Bidder	Location	Board-Feet
Weyerhaeuser	Horseglades	16,000,000
Underwood	Mud Creek	2,500,000
Big Lakes Box	Tea Table	6,500,000
Adams Mill	Newell Creek	142,000
Ivory Pine	Meryl Creek	11,500,000
Lakeview Lumber	Dicks Creek	2,000,000
Anderson Brothers	Augur Creek	3,000,000
Adams Mill	Newell Creek	1,500,000
Crane Creek	McCoin Creek	2,000,000
Lakeview Lumber	Dog Creek	6,000,000
Goose Lake Box	Willow Creek	2,000,000
Big Lakes Box	Tag End	1,000,000
Anderson Brothers	Cougar Peak	6,000,000
Ivory Pine	Buzz Spring	3,000,000
Weyerhaeuser	Packsaddle	700,000
Big Lakes Box	Lost Creek	20,000
Shevlin-Hixon	Fringe	29,000,000
Goose Lake Box	Horseshoe	2,000,000

Further perspective on the logging activity of this period can be gained from Table 2-2, which gives annual sales in Million Board-Feet (MBF) for the seven-year period from 1946 through 1952 (Bach 1954). Again, keep in mind that these numbers do not include harvest on private or tribal lands.

Table 2-2. Fremont National Forest Total Annual Timber Harvest 1946-1952. (Source: Bach 1954)

Year	MBF
1946	73,070
1947	79,574
1948	102,145
1949	38,059
1950	134,524
1951	92,192
1952	85,174

In December of 1948, the Weyerhaeuser Timber Company bought all holdings of the Ewauna Box Company, including the Booth-Kelly Tract, the Quartz Mountain Unit, and the Bly Logging Company. A year later Weyerhaeuser bought the Longbell Tract, which encompassed most of the Long Creek Drainage in the northwest portion of the assessment area. To support these and other purchases, Weyerhaeuser established logging Camp Six on Ivory Pine Road, Camp Nine on the Summer Lake Rim, and later Camps 11 and 14 on the Klamath Falls-Silver Lake Road. Weyerhaeuser continued logging activity through 1970, when it purchased a small mill in the town of Bly from Modoc Lumber Company. They built a larger mill on the site, and there was enough activity that the Bley-Was and Pine Crest subdivisions had to be built to house the employees and their families (Drew 1979). During these years, Weyerhaeuser distinguished itself with the development of an innovative reforestation program, and by taking measures to protect riparian areas within their holdings. The mill in Bly was closed in 1981, and Weyerhaeuser sold the rest of their holdings in the area some ten years later. .

CONCLUSION

The Upper Sprague and Sycan watersheds were, and still are, ecological treasures. The high biological productivity of these areas has made it possible for plant, animal and human communities to thrive here for thousands of years. In more recent years, the area has produced food ands fiber to meet the needs of a growing nation.

More recently still, efforts are underway to make sure that this high biological productivity is sustained over the long haul. Many changes have taken place on the land and in the streams over the last 150 years, and like anywhere else changes are made, it has been difficult to predict the long term consequences of those changes. In many cases, the changes led to great benefits. In other cases, the long-term consequences have not been quite what we intended, and today we have the opportunity to make adjustments where we think it makes sense.

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CHAPTER 3. GENERAL GEOGRAPHIC CHARACTERISTICS

The Upper Sprague Watershed Assessment has been prepared on behalf of the Klamath Basin Ecosystem Foundation and the Sprague River Watershed Working Group of the Upper Klamath Watershed Council. The assessment is a compilation of available information on the physical, biological, and social characteristics of the watersheds, gathered from a wide variety of sources. The goal of this effort has been to describe the historical and current conditions in the watersheds that occur within the Upper Sprague River subbasin, identify topics and locations where adequate information is lacking, and provide a foundation for future planning, resource management, and ecosystem restoration.

Watershed assessment is not a decision-making process, but rather a stage-setting process. The watershed assessment provides the context for subsequent planning and decision-making. Specific restoration sites and actions will be identified and described in a future Restoration Action Plan, which will be developed by the watershed partners.

This watershed assessment covers the portion of the fourth-field Sprague River basin (USGS HUC number 18010202) upstream of the confluence of the Sprague and Sycan rivers. Previous watershed assessments or watershed analyses have been conducted for the Upper Sycan River (U.S. Forest Service), the Upper Williamson River (KBEF), and South Fork Sprague (U.S. Forest Service) watersheds. Information from these assessments has been incorporated into this report.

This assessment has been prepared following the framework provided by the *Oregon Watershed Assessment Manual* (WPN 1999) developed by the Oregon Watershed Enhancement Board (OWEB). The OWEB manual is heavily weighted towards conditions in smaller (5^{th} Field) watersheds of western Oregon, so some modifications have been made to the OWEB approach to accommodate the significantly larger area encompassed by the Upper Sprague Watershed Assessment, environmental conditions prevalent on the east side of the Cascade Mountains, and the greater emphasis on terrestrial ecosystems pertinent to this subbasin.

PHYSICAL CHARACTERISTICS

Size and Setting

The Upper Sprague River subbasin can be characterized by three distinct regions: the privately-owned lowland valleys of the Sprague and Lower Sycan rivers, which are used mostly for livestock production; the Sycan Marsh, which is owned by a single private landowner, and is used both for livestock production and natural ecosystem preservation and restoration; and the forested upland region, the majority of which is publicly owned and managed by the US Forest Service, and which also includes forest lands owned by private timber companies. Natural resource issues, problems, and concerns often differ among these regions because of variations in climate and environmental conditions, and differences in land use.

The Upper Sprague River subbasin is located in the Upper Klamath Lake basin in Klamath and Lake counties in south-central Oregon, east of the southern Cascade Mountains. The Upper Sprague River drains a varied landscape, from steep-sloped, highly-dissected headwaters to low-gradient floodplains (Map 3-1). Most of the watershed area lies within the Fremont-Winema National Forest. Notable geographic features in the watershed include Sycan Marsh, Gearhart Mountain Wilderness, and the communities of Bly and Beatty.

The area covered by this assessment is approximately 1,126 square miles, as determined by GIS analysis. Within that area lies a variety of aquatic features including perennial, intermittent, and ephemeral streams, constructed ditches, lakes, and marshes (Table 3-1). For the purposes of this analysis, the subbasin has been divided into several watersheds (5th field hydrologic units) that comprise the basic units for many of the analyses presented in this report (Table 3-2).

Only 26.8 percent of the streams in the subbasin are perennial. Rather, most streams are intermittent (45.6 percent) or ephemeral (18.5 percent; Table 3-1). Many small, high-gradient streams with deeply incised channels originate from headwalls at higher elevations. The major streams within the watershed flow generally from east to west, from headwaters along Winter Ridge and

Table 3-1. Stream length (miles) by type of water body in the Upper Sprague River subbasin. (Data Source: USFS 2005)[1]

Stream Type	Watershed: North Fork Sprague	Sprague River above Beatty	Fish-hole Creek	South Fork Sprague	Lower Sycan	Upper Sycan	Sycan Marsh	Total	Percent
Perennial	115.3	85.4	52.4	96.3	61.4	82.0	40.3	533.1	26.8
Intermittent	198.6	123.7	69.2	74.2	228.4	80.1	131.6	905.8	45.6
Ephemeral	87.9	40.7	21.7	41.7	58.0	30.9	86.3	367.2	18.5
Ditch		7.7	3.5	1.4	0.7		18.0	31.3	1.6
Lake	0.7	2.4	4.4	0.1			0.1	7.7	0.4
Marsh	0.8	4.8	5.7	0.9	2.9	1.1	126.5	142.7	7.2
Total	403	265	157	215	351	194	403	1,988	100.0

[1] The length of stream quantified on a map is a function of the scale and resolution of the map; larger scale maps will show more streams. The Assessment stream length is the length of perennial, intermittent, and ephemeral streams that were resolved at the map scale of the GIS data used for the assessment – approximately 1:24,000.

Table 3-2. Watersheds and key streams of the Upper Sprague River subbasin. (Data Sources: USFS 1994, 1995; NRCS 2005)

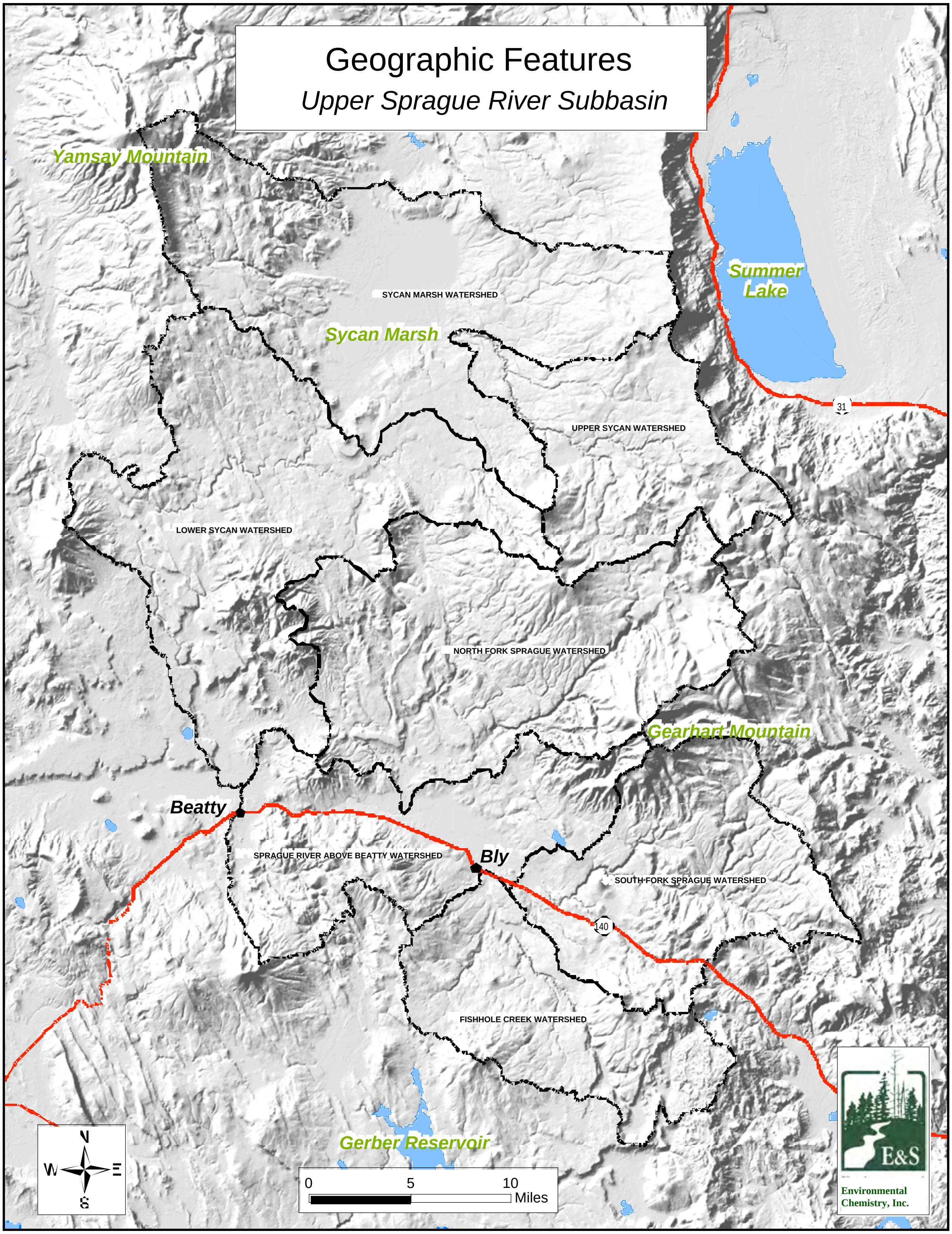
Watershed	Area (mi^2)	Major Streams	
Sprague River Above Beatty	130	Brown Creek, South Fork Sprague River	Deming Creek, Sprague River
North Fork Sprague	208	Boulder Creek, Meryl Creek, Yaden Creek	Fivemile Creek, North Fork, Sprague River
South Fork Sprague	128	Brownsworth Creek, Whitworth Creek, South Fork Sprague River	Ish Tish Creek, Paradise Creek
Fishhole Creek	102	Fishhole Creek, Robinson Spring Creek	Pole Creek
Lower Sycan	232	Merritt Creek, Sycan River	Ponina Creek, Snake Creek
Sycan Marsh	224	Calahan Creek, Long Creek, Sycan River	Chocktoot Creek, Coyote Creek
Upper Sycan	103	Crazy Creek, Skull Creek, Sycan River	Long Creek, Paradise Creek

Gearhart Mountain to the broad valley of the Sprague River near Bly and Beatty. Based on the digital elevation model (DEM), elevations within the watershed range from 4,304 feet at the confluence of the Sprague and Sycan rivers west of Beatty to approximately 6,700 feet along Winter Ridge. Yainax Butte (7,226 feet), Gearhart Mountain (8,364 feet), Green Mountain, (7,210 feet), Black Butte (7,075 feet), Shake Butte (7,138 feet), and Sycan Butte (6,362 feet) are prominent high points in the watershed (OGEO 2005).

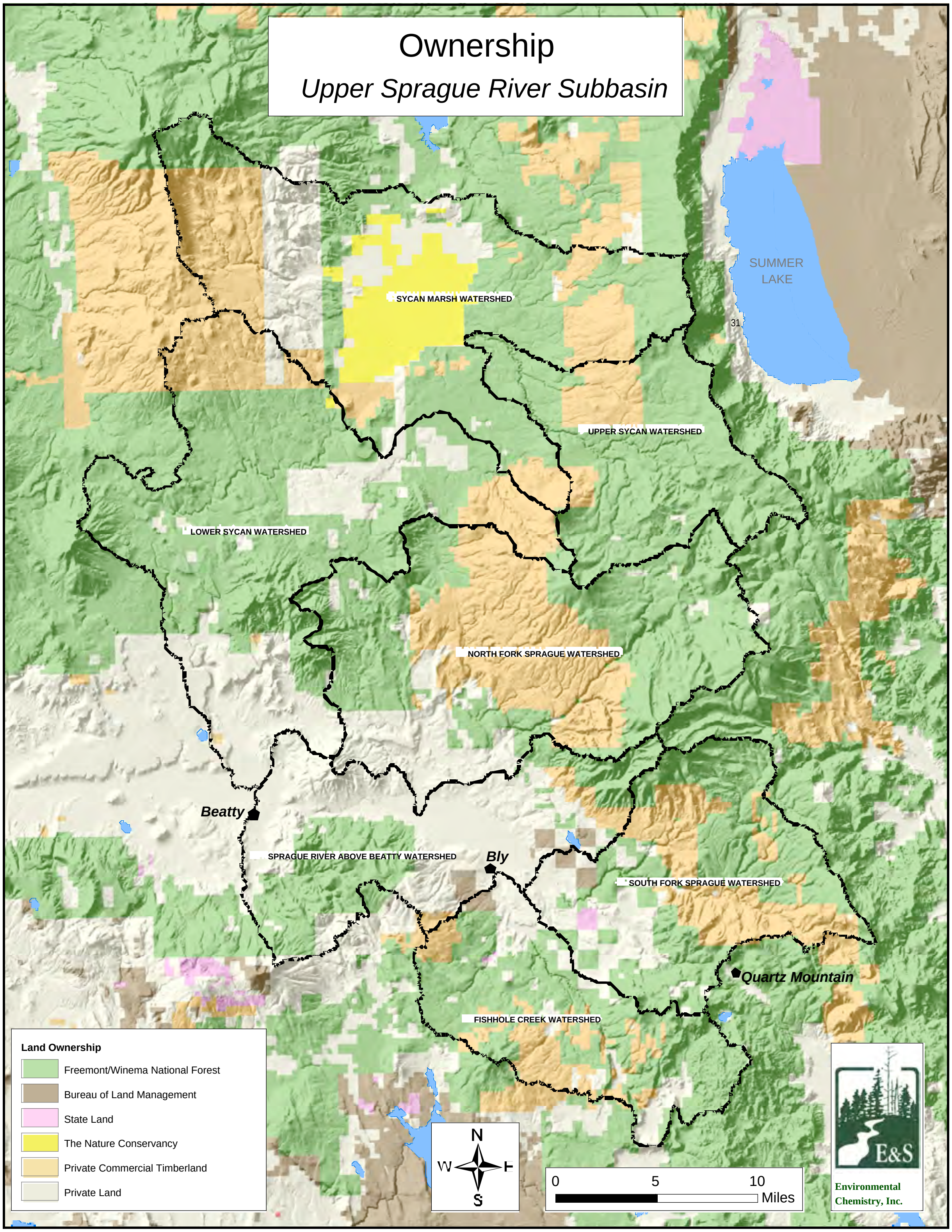
The growing season varies considerably across the subbasin. The Sprague River valley has a growing season of about 50 to 70 days (WRCC 2005). The majority of irrigation is for pasture and alfalfa. Mountainous areas are mostly used for timber, range, and wildlife habitat. Where annual precipitation is between 10 and 16 inches (See map 5-1), plant cover consists mostly of big sagebrush, antelope bitterbrush, western juniper, other shrubs, and bunchgrasses. Where annual precipitation averages between 16 and 35 inches, forests of ponderosa pine, Douglas-fir, sugar pine, white fir, lodgepole pine, and other tree species are predominant. Juniper is common at lower elevations.

Land Cover and Ownership

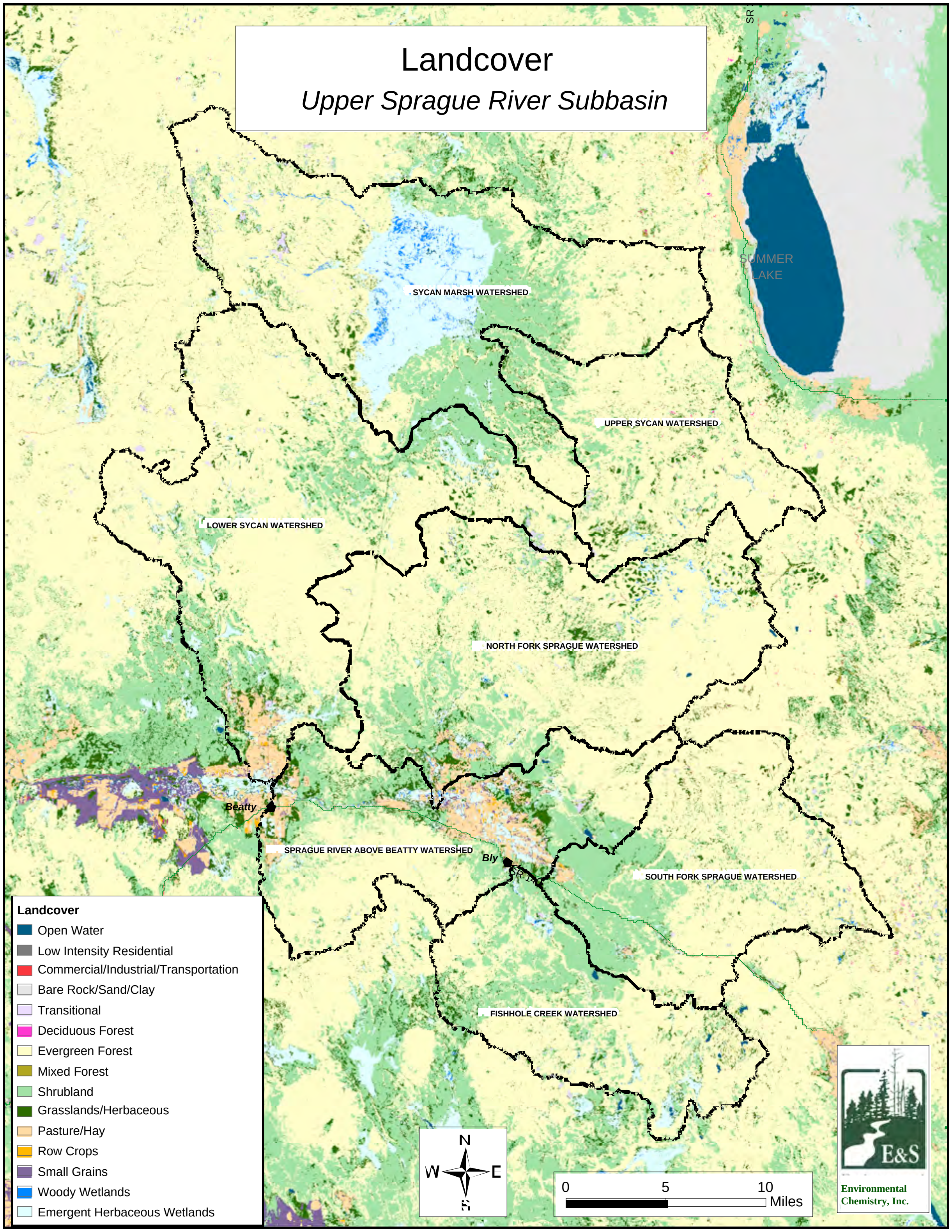
Major land holders are the US Forest Service, private timber companies, other private landowners, and The Nature Conservancy. The Bureau of Land Management (BLM) and the State of Oregon have small holdings in the subbasin (Table 3-3, Map 3-2). The major land uses in the subbasin are industrial forestry and agriculture, and the major vegetation type is coniferous forest. Land cover types are illustrated in Map 3-3 and presented in Table 3-4.



Map 3-1. Geographic features of the Upper Sprague River subbasin. (Data Source: USGS 2005)



Map 3-2. Land ownership in the Upper Sprague River subbasin. (Data Source: USFS 2005)



Map 3-3. Land cover types in the Upper Sprague River subbasin. (Data Source: USGS 1992)

Table 3-3. Land ownership in the Upper Sprague River subbasin (square miles). (Data Source: BLM 1996)

Owner	North Fork Sprague	Sprague River Above Beatty	Fishhole Creek	South Fork Sprague	Lower Sycan	Upper Sycan	Sycan Marsh	Total Area	Percent
US Forest Service	107.7	68.8	62.1	45.4	140.4	88.1	91	603.5	53.6
Bureau of Land Management		1.9	1.2	3.8				6.9	0.6
State Land		1.0	0.2		0.2		33.6	35.0	3.1
Private	33.7	21.4	17.9	74.4	60.0	0.4	43.4	251.2	22.3
Private Commercial Timber	66.7	35.2	20.2	5.8	31.0	14.2	56.4	229.5	20.4
Total	208.1	128.3	101.6	129.4	231.6	102.7	224.4	1,126.1	100.0

Table 3-4. Area of land cover vegetation (acres) in the Upper Sprague River subbasin, by watershed. (Data Source: USGS 1992)

Landcover Type	Fishhole Creek	Lower Sycan River	North Fork Sprague	South Fork Sprague	Sprague River Above Beatty	Sycan Marsh	Upper Sycan	Total
Open Water	269	49	70	17	206	118	2	730
Low Intensity	0	1		1	24			26
Commercial/Industrial/ Transportation	6	35	10	61	64	6	0	182
Bare Rock/Sand/Clay	28	104	30	25	114	20		320
Quarries/Strip Mines Gravel Pits	12				12			24
Transitional	223	697	484	271	241	889	156	2,960
Deciduous Forest	13	23	57	41	8	15	102	260
Coniferous Forest	41,691	105,680	101,907	58,089	42,403	81,124	52,711	483,605
Mixed Forest	67	55	127	117	51	14	44	474
Shrubland	17,367	24,541	18,729	19,492	18,975	28,476	8,613	136,193
Grasslands/Herbaceous	2,924	7,342	7,285	2,810	6,502	4,984	3,369	35,215
Pasture/Hay	16	3,429	1,619	484	8,443			13,990
Row Crops		75	20	27	192			315
Small Grains	2	161	105	29	843	3	1	1,144
Urban/Recreational Grasses	0				0			0
Woody Wetlands	141	37	346	115	132	1838	42	2651
Emergent Herbaceous	2,258	6,021	2,368	542	4,787	26,105	689	42,770
Total	65,015	148,248	133,156	82,122	82,996	143,593	65,727	720,856

Ecoregions and Vegetation

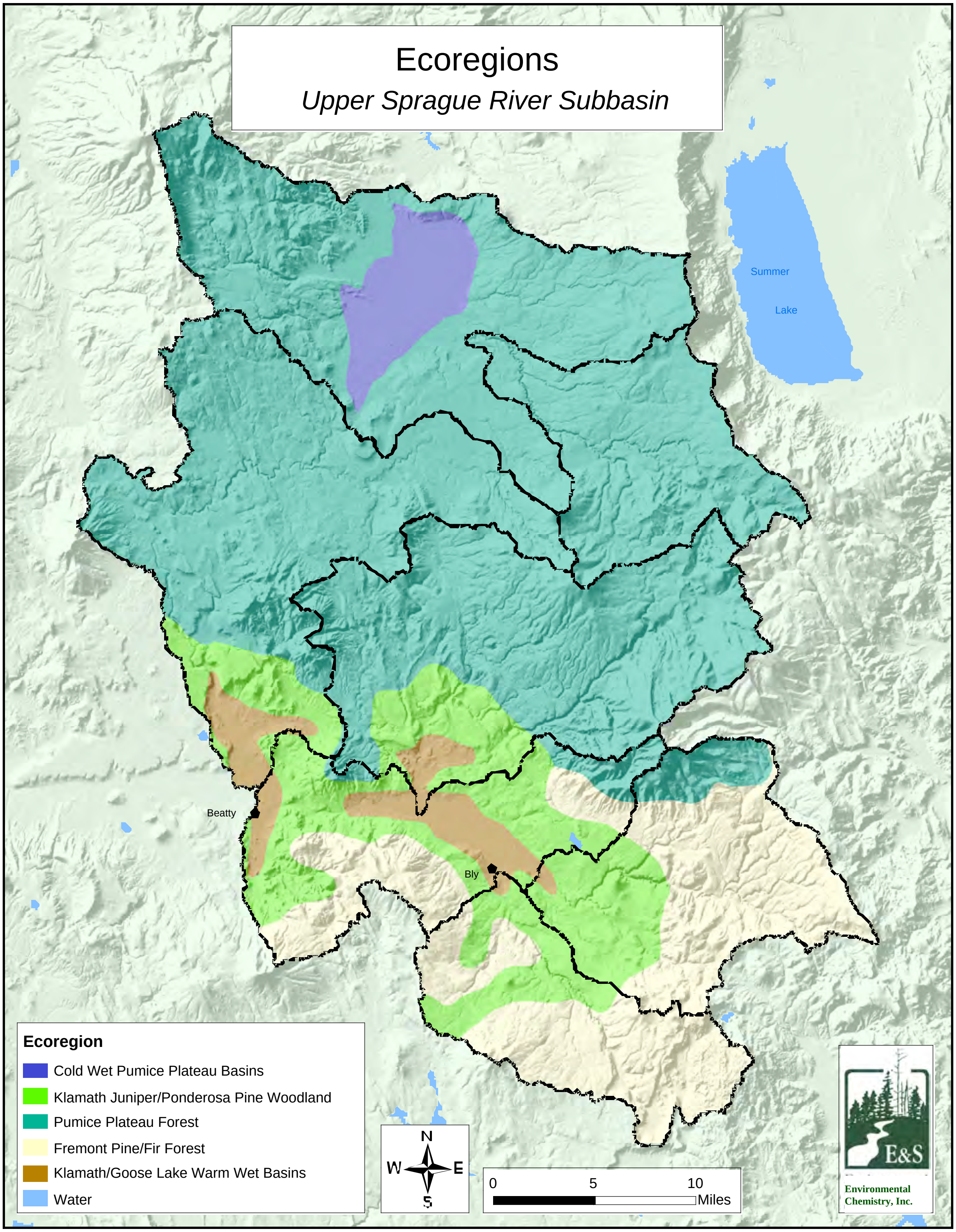
Ecoregions are areas of similar climate, geology, and landform that contain geographically distinct assemblages of natural communities. Natural vegetation and wildlife distributions characteristic of a particular ecoregion tend to be distinct from those of other ecoregions, and shape the form and function of watersheds. Ecoregions can serve as a spatial framework to provide a unifying structure for implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical area. According to the US Environmental Protection Agency (EPA) system of ecoregion classification (Omernik 1995), the Upper Sprague River subbasin includes five ecoregions (Table 3-5, Map 3-4).

The majority of the subbasin (61 percent) lies within the Pumice Plateau Forest ecoregion. This ecoregion is characterized by lodgepole pine in the flats and depressions, with ponderosa pine on the slopes. White fir becomes more common at higher elevation. Understory plants include antelope bitterbrush and Idaho fescue. Riparian areas support mountain alder, stream dogwood, willows, and quaking aspen.

The higher elevations in the southeast portion of the subbasin are within the Fremont Pine-Fir Forest ecoregion (17 percent), characterized by ponderosa pine and western juniper at lower elevation, with white fir, whitebark pine, and lodgepole pine at higher elevation. Understory plants include snowberry, heartleaf arnica, Wheeler bluegrass, antelope bitterbrush, and longstolon sedge.

Table 3-5. Ecoregions of the Upper Sprague River subbasin. (Source: ONHP 1995)

Ecoregion	Area (mi^2)	Characteristics
Cold Wet Pumice Plateau Basins	36	High elevation basins containing forested wetlands, marshes, lakes, reservoirs, and both medium and low gradient rivers. Extensive marsh areas are found in the south.
Klamath Juniper-Ponderosa Pine Woodland	167	Undulating hills, benches, and escarpments containing medium gradient streams. A few small plateau lakes occur but reservoirs are common.
Pumice Plateau Forest	687	High elevation, nearly level to undulating volcanic plateau with isolated buttes, marshes, spring-fed creeks, and streams with low to medium gradients.
Fremont Pine-Fir Forest	193	Steeply to moderately sloping mountains and high plateaus with high-gradient intermittent and ephemeral streams. Reservoirs, a few glacial rock-basin lakes, and many springs occur.
Klamath-Goose Lake Warm Wet Basins	44	Pluvial lake basins containing floodplains, terraces, and low-gradient streams.



Map 3-4. Ecoregions in the Upper Sprague River subbasin. (Data Source: ONHP 1995)

The river bottoms in the vicinity of Bly and Beatty lie in the Klamath-Goose Lake Warm Wet Basins ecoregion (4 percent), where common plant species include bluebunch wheatgrass, Idaho fescue, antelope bitterbrush, mountain big sagebrush, low sagebrush, basin wildrye, and Basin big sagebrush. Wetland areas contain tules, cattails, sedges, and other wetland species.

The surrounding uplands comprise the Klamath Juniper-Ponderosa Pine Woodland ecoregion (15 percent). This ecoregion is characterized by ponderosa pine, juniper woodland, and sagebrush steppe. Wetter areas include ponderosa pine with an understory of antelope bitterbrush and bunchgrasses. Drier sites have low sagebrush, Wyoming big sagebrush, Idaho fescue, bluebunch wheatgrass, and Sandberg bluegrass. Western juniper and mountain-mahogany occur on shallow, rocky soils.

The Pumice Plateau Basins ecoregion (3 percent) is represented by Sycan Marsh, and is characterized by wetland vegetation. Lodgepole pine and scattered ponderosa pine and shrub forest occur on the driest sites.

Climate

The climate of the Upper Sprague River subbasin is largely determined by the prevailing air masses that move across Klamath County from the Pacific Ocean but are greatly modified when moving over the Coast Range and Cascade Mountains. Continental air masses that move down from the interior of western Canada are also a major weather factor. The resulting climate is much drier than that of western Oregon, and has more extreme temperatures, particularly in winter months. Seasonal characteristics are well defined and changes between seasons are generally gradual.

Average annual precipitation ranges from 10 to 15 inches in the valleys, 16 to 25 inches in nearby hills, and 30 to 40 inches at higher elevations. About 44 percent of the moisture in the survey area occurs in winter, 22 percent in spring, 8 percent in summer, and 26 percent in fall. The winter precipitation in the area is characterized by a secondary peak in May just prior to the beginning of the dry summer. Wet days with at least 0.10 inch of precipitation vary from 43 days annually in the valleys to 105 days in the mountains (WRCC 2005).

Snowfall accounts for 30 percent of the annual precipitation in the valleys and as much as 50 percent in the mountains. Annual snowfall averages 15 to 45 inches in the valleys, 60 to 125 inches in the foothills and over 160 inches in some places above 4,500 feet elevation. Maximum snow depths have varied typically from two to three feet in the valleys and from five to six feet in the hills and mountains (WRCC 2005).

Warm days of 90 ° F or above average 15 days per year in the valleys and 5 days per year in the mountains. The average daily maximum temperatures for Klamath Falls and Chiloquin agree closely, but the average daily minimum temperatures at Chiloquin are about 6°F cooler in winter and 12°F cooler in summer. At the 6,500 foot level in the mountains, maximum temperatures average from 5°F cooler in winter to 14°F cooler in summer as compared to Klamath Falls and Chiloquin. Record temperatures in the area have ranged from –28° F at Chiloquin in 1937 to 105° F at Klamath Falls in 1911 (WRCC 2005).

At Klamath Falls, prevailing winds are southerly for November through February; westerly from March through July; and northerly during August, September, and October. Monthly wind speeds average from 4.4 miles per hour in September to 7.3 miles per hour in March. Wind conditions are calm 17 to 33 percent of the time. Conditions differ throughout the assessment area, in part due to elevation and topographic variation (WRCC 2005).

Thunderstorms average about 12 per year with an occasional severe hailstorm. Hailstorm damage, however, is rarely severe or widespread. Average yearly cloudiness is about 50 percent at Klamath Falls; 130 days are clear, 90 are partly cloudy, and 145 are cloudy. Early morning values of relative humidity average 74 to 83 percent year-round, and the afternoon low values range from 26 to 33 percent in summer and 62 to 74 percent in winter (WRCC 2005).

CULTURAL CHARACTERISTICS

Population and Early History

The Upper Sprague River subbasin has been the home of Native Americans for centuries. The area was a seasonal home to the Yahooskin band of the Northern Paiute Tribe who traveled into the Upper Sprague and Sycan River valleys each year to harvest and hunt the native flora and fauna. The tribes lower down the river – the Klamaths and Modocs – also visited the Upper Sprague and Sycan river systems on a seasonal basis. Nevertheless, the area was primarily Yahooskin territory, at least at the time of European settlement.

Europeans came to Klamath County in the early nineteenth century. About 1820, Peter Skene Ogden led a party of Hudson Bay Company trappers into the area to trap and explore. Two military expeditions organized by John C. Fremont explored the area in the 1840s. A military party, surveying a railroad route from the Sacramento Valley to the Columbia River, came through the area in 1855.

The Klamath Indian Reservation was established by treaty on October 14, 1864. The Sprague River Valley west of Ivory Pine Road, the Wood River Valley east of Wood River, and all of the Winema Forest in the assessment area were part of the Klamath Indian Reservation. In 1954, the Klamath Tribes were terminated. The Federal Government ended its supervision over Klamath Indian affairs in 1960, and at that time most of the land on the

Reservation became privately owned. The Tribes regained federal recognition by an act of Congress in 1986.

The population of Lake County was estimated at 7,382 in 2004, a decrease of 40 since 2000, but a 2.6-fold increase since 1900. In contrast, the population of Klamath County was 65,098 in 2004, an increase of 1,323 since 2000, and a 16-fold increase from 3,970 in 1900. Most of the growth in Klamath County has been in and around Klamath Falls, so the population change in the assessment area is more likely to resemble that of Lake County. The population of ZIP code 97621, which includes Beatty, was 363 in 2000, while ZIP code 97622 (Bly) had 476 residents (U.S. Census Bureau).

Agriculture

Range and forest land dominate the landscape in the Upper Sprague River subbasin. Irrigated agriculture is found primarily in the Sprague River valley near Bly and Beatty. The irrigated land is predominately pasture and hayland. Forestland management is an important land use in much of the upper assessment area. The Upper Sprague River subbasin presents numerous challenges as well as opportunities for agriculture. The cool climate, limited rainfall, and short growing season limit the number of crops that can be grown successfully. Farmers currently grow a limited variety of crops, including pasture, grass hay, alfalfa and limited grains.

The Upper Sprague River subbasin is well suited to for raising livestock, and has been intensively used for that purpose for many decades. The most intense grazing pressure within the Upper Sprague and Sycan watersheds occurred from about 80 to 120 years ago. Much of the pre-settlement riverside woodlands, riparian zones, and wetlands have been modified by diking, draining, spraying herbicides, land-clearing, and grazing.

In recent years management methods in both the public and the private sector have been changing in response to shifting economic, social and regulatory developments. Private landowners throughout the assessment area have been pursuing cooperative projects that have resulted in measurable improvements in habitat conditions and function. The Nature Conservancy and ZX Ranch jointly manage land in the Sycan Marsh for restoration and cattle grazing. Federal programs, such as the Wetlands Reserve Program and the Conservation Reserve Enhancement Program, and various state programs provide financial assistance to ranchers who place environmentally-sensitive acreage under conservation easements.

Forestry

The logging industry has operated in the Upper Klamath Basin since the railroad first arrived in Klamath Falls in 1909. Timber interests were aware of the massive ponderosa pine stands in the Upper Sprague region since the

1850s, but were unable to harvest the stands because there was no way to get the lumber to market. The OC&E railroad arrived in Bly in the winter of 1928-29, and in early spring of 1929 the first shipment of logs was made by Pelican Bay Lumber Company. In almost no time, the region around the Upper Sprague and Sycan watersheds went from a quiet ranching community to a full-scale industrial timber economy. Extensive logging from 1929 to 1939 by the Pelican Bay Lumber Company and Ewauna Box Company caused a boom in the early 1930s. Pelican Bay Camp was originally located south of Bly near Robinson Springs and employed 200 men. In 1943, in response to wartime demands, the Fremont National Forest sold more logs than any other National Forest in the Pacific Northwest Region, including the coastal rainforests (Bach 1954). The timber was transported by rail to Bly. Ewauna Box Company was located on Quartz Mountain. Several sawmills were located in or near Bly, with the first being built by Crane about 1931. The last owner was Weyerhaeuser Company who purchased the mill in 1970. The operation was closed in the early 1980s, and Weyerhaeuser sold the rest of their holdings in the area some ten years later.

Forestry activities today are focused more on improvement of forest health conditions, thinning to help achieve properly functioning forest conditions, and management of fire risk. Extractive logging is not as important to the local economy as it was in earlier decades.

Recreation

Recreational opportunities are plentiful in the assessment area. Popular activities include fishing, hunting, backpacking, hiking, cross-country skiing, camping, bird-watching, and leisure driving. Several varieties of trout inhabit the lakes and streams of the subbasin, and the marshes of the subbasin provide habitat for a variety of waterfowl. Small populations of large predators (black bear, cougar, and bobcat) are present, as well as a variety of nongame species. The 22,800-acre Gearhart Mountain Wilderness is located near the eastern edge of the subbasin, and provides opportunities for primitive recreation experience, as well as a benchmark for ecological studies and education.

Sections of two rivers in the Upper Sprague River subbasin are designated wild and scenic under the National Park Service Wild and Scenic Rivers program. The North Fork Sprague River flowing out of the Gearhart Mountain Wilderness is classified as Scenic for 15 miles, and the Sycan River above Coyote Bucket is classified as Recreational for 8.6 miles and Scenic for 50.4 miles.

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CHAPTER 4. GEOLOGIC PROCESSES

CHARACTERIZATION

Erosion and the subsequent transport and deposition of sediment within the stream system are natural processes. The timing and magnitude of erosion varies from watershed to watershed and among stream reaches within a given watershed in response to climate, geology, soil characteristics, slope, and topography. Many aquatic organisms are adapted to deal with a range of sediment conditions, including episodes of intense erosion and sediment movement during large storm events and snowmelt, and following high-intensity fire seasons. Typically, most sediment moves during the few days per year, or per decade, that have the highest flows. However, large volumes of sediment may move following significant disturbance events such as landslides or fire.

The geologic history and current geological setting of the watershed are important to understanding natural resource issues within it. In particular, geologic variation throughout the watershed can influence erosion and the delivery of sediment to the stream system. Excessive sediment can cause problems, but appropriate sediment is critical to maintaining both channel function and suitable fish spawning habitat. A geology map is available covering the entire Upper Sprague River subbasin (Walker and MacLeod 1991).

This section summarizes the geology, geomorphology, and soils of the Upper Sprague River subbasin. It also summarizes available information regarding the potential for soil erosion, mass movement, and streambank erosion. Results are based on existing studies, especially by NRCS (2006a,b), USFS (2005), and ODFW (2001). Discussion of erosion impacts is based on assessment summary information provided by Biosystems (2003) and WPN (1999).

Data that reflect erosion potential are available from the US Forest Service (USFS) Fremont-Winema National Forest, and Natural Resource Conservation Service (NRCS). The Fremont-Winema National Forest (NF) soil surveys provide data on soil type, surface erosion potential, and mass movement potential on the national forest lands. The NRCS Soil Survey Geographic (SSURGO) data are available for the private land areas bordering the Sprague River in the lower portion of the subbasin.

The geological history of the Upper Sprague River subbasin has included periods of extensive volcanic activity. Basalt flows caused by volcanic extrusions blocked rivers that drained the region, creating large, shallow lakes. Large quantities of volcanic material were deposited into the shallow waters from the Cascade Mountains and other nearby volcanic sites (Carlson 1979).

CURRENT CONDITIONS

Geology

Geologic processes have created many different physiographic provinces, or areas of similar geomorphology, within Oregon. The Upper Sprague River subbasin is located within the Basin and Range physiographic province. The subbasin lies in a transitional zone with the adjacent Cascadian physiographic province.

More than 83 percent of the Upper Sprague River subbasin is underlain by geologic material that formed during the Tertiary period. This period began 65 million years ago and ended 1.6 million years ago with the beginning of the Quaternary period. The remaining 17 percent of the Upper Sprague geology is comprised of rocks formed during the transition from the Tertiary period to the Quaternary period, and within the Quaternary period itself (Table 4-1, Map 4-1).

Volcanic activity has generated much of the present day bedrock material in the subbasin. Volcanic eruptions, such as THE eruption of Mt. Mazama approximately 7,000 years ago that formed the Crater Lake caldera (USGS 2006b), resulted in lava flows and ash deposits that followed the local topography, spreading down the mountain slopes and across the lower elevations. Sedimentary rocks are also present in the subbasin, though they cover a much smaller area than the volcanically-derived igneous bedrock. Sycan Marsh is one location that is underlain by sedimentary material (Map 4-1).

Tertiary basalt is the primary form of bedrock found in the Upper Sprague River subbasin. Two main types of TERTIARY basalt, olivine basalt (Tb) and older basalt (Tob), represent approximately 691 square miles (61 percent) of the subbasin.

Basalt is low viscosity volcanic rock with less than about 52 percent silica (SiO_2). Eruptions occur at temperatures between 2,000 to 2,300° F and may release volcanic gasses without creating large eruption columns, or may form lava fountains hundreds of feet tall. In addition to silica, olivine, pyroxene, and plagioclase are commonly found in basalt (USGS 2006c).

Tertiary basaltic or andesitic strato-volcanoes and lava cones (Tvm) can be found on and around several mountain peaks in the Upper Sprague River subbasin. These include Gearhart Mountain and the chain of peaks just to its northwest. Other rocks associated with venting locations are found in the eastern portion of the subbasin near these mountain features. These include rocks having parent material comprised of tertiary vent and near-vent rocks and silicic rocks (Tvs). Bedrock formations that resulted from alluvial processes during the Quaternary period (Qal) can be found near the subbasin outlet in the Sprague River Above Beatty Watershed (Wenzel 1979, Carlson 1979).

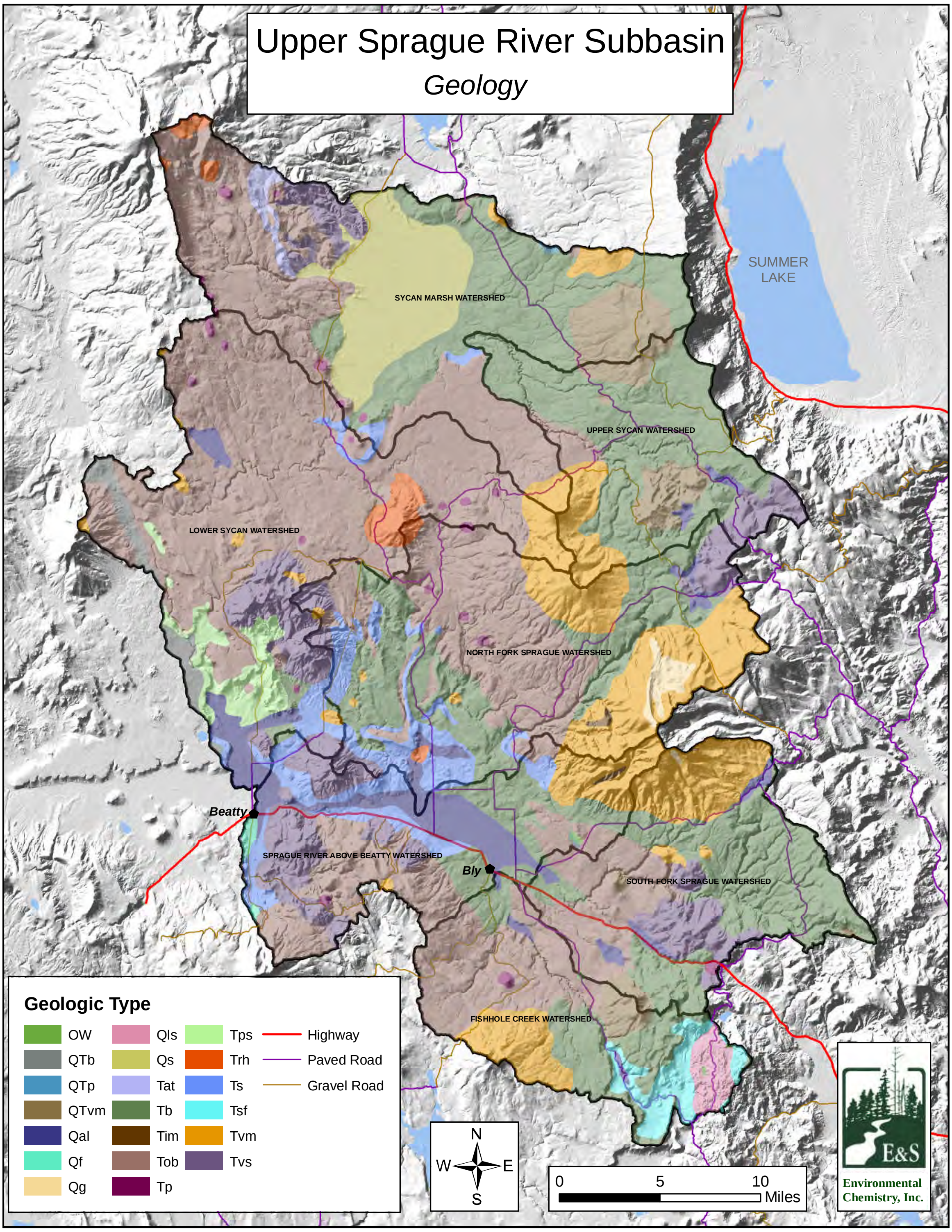
Over time, physical as well as chemical processes have weathered the bedrock and produced the variety of soil types that exist within the Upper Sprague River subbasin. Five major types of bedrock parent material are responsible for the derivation of the various groups of soils within the subbasin (Wenzel 1979), including:

- *rocks of alluvial or lacustrine origin* - these materials were once moved by water or developed within a lake basin;
- *interbedded basalt, andesite, and tuff* - these rock types are found on rolling lava tablelands, block faults, and shield volcanoes;
- *rhyolite* - a fine grained, light colored, extrusive rock. This rock type is highly fractured, moderately hard, and high in silica content;
- *pyroclastic and sedimentary rocks* - highly variable including tuff, breccia, mudflows, lacustrine tuffaceous sandstone, and ashy diatomite. These massive to highly-fractured rocks result in the most unstable regions of the subbasin, typically occurring at lower elevations;
- *eolian Mazama ash and pumice deposits* - mainly occurring in the north and western portions of the Fremont-Winema National Forest.

Rhyolite, pryroclastic rocks, and sedimentary rocks are all typically highly fractured. Locations where the bedrock has a high potential for fracturing are important to understanding the hydrogeology of the subbasin. The US Geological Survey (USGS) is presently conducting a groundwater survey and modeling project in order to better understand the hydrogeologic nature of the Upper Sprague River subbasin (USGS 2006a).

Table 4-1. Geologic parent material of the Upper Sprague River subbasin. (Data Source: Walker and McLeod 1991)

Map Code	Parent Material	Area (sq. miles)
OW	Open water	0.6
Qal	Quaternary alluvial deposits	38.3
Qf	Quaternary flows and breccia	1.4
Qg	Quaternary gabbroic sills & dikes	4.7
Qls	Quaternary landslide deposits	7.0
Qs	Quaternary sedimentary rock	45.9
QTb	Quaternary/Tertiary basalt flows	8.6
QTp	Quaternary/Tertiary pyroclastic rocks of basaltic cider cones	0.3
QTvm	Quaternary/Tertiary basaltic or andesitic starto-volcanoes or lave cones	35.7
Tat	Tertiary ash-flow tuff	4.3
Tb	Tertiary olivine basalt	285.0
Tim	Tertiary mafic and intermediate intrusive rocks	1.1
Tob	Tertiary older basalt	406.2
Tp	Tertiary pyroclastic rocks of basaltic cinder cones	5.2
Tps	Tertiary subaqueous deposits of palagonitized basaltic ejecta	15.9
Trh	Tertiary rhyolite & dacite flows & ash-flow tuffs	10.2
Ts	Tertiary sedimentary rocks	44.1
Tsf	Tertiary rhyolitic tuffs, ash-flow tuffs, tuffaceous sedimentary rocks & flows	13.1
Tvm	Tertiary basaltic or andesitic strato-volcanoes or lava cones	115.3
Tvs	Tertiary vent and near-vent rocks, silicic rocks	83.8
Total		1,126.7



Map 4-1. Map of geologic types within the Upper Sprague River subbasin. The codes for rock types are described in Table 4-1. (Data Source: Walker and McLeod 1991)

Soils

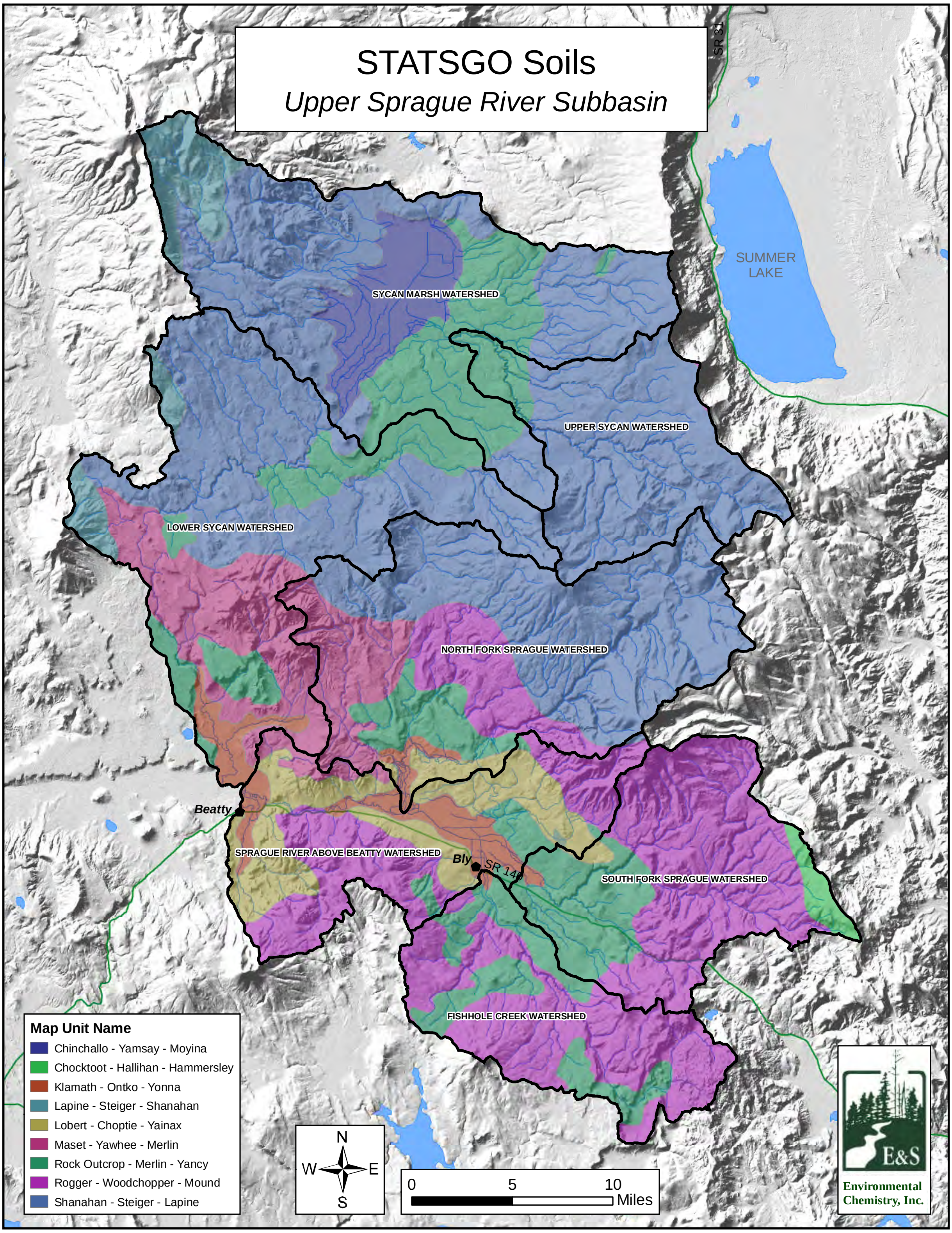
Although detailed soil maps are available for limited areas in the Upper Sprague River subbasin, the only soil map that covers the entire subbasin is the NRCS State Soil Geographic (STATSGO) map (NRCS 2006a). STATSGO provides a description of very general soils types at a coarse scale throughout the subbasin. STATSGO soil types are depicted on the map and described in Table 4-2.

There are three general soil types that predominate within the Upper Sprague River subbasin (Map 4-2). The most common is Shanahan-Steiger-Lapine, which covers about 40 percent of the subbasin, including about two-thirds of the northern half of the subbasin. The soil type that predominates in the southern half is Rogger-Woodchopper-Mound, which covers 21 percent of the overall subbasin. The other common soil type (16.5 percent of total area) is Rock Outcrop-Merlin-Yancy. Unlike the other two common soil types, this one is well distributed throughout the subbasin from north to south. There are six other general soil types present in the subbasin, each covering from 0.6 to 8.0 percent of the total land area.

The US Forest Service conducted Soil Resource Inventories (SRIs) for the Fremont and Winema National Forests in 1979 (Wenzel 1979, Carlson 1979). An SRI provides more detail and higher resolution soil information than does the STATSGO database. The purpose of an SRI is to provide soil, geology, vegetation and landform information to assist forest land managers in applying multiple use principles to forest management. The SRIs are based on field surveys conducted between 1973 and 1976. Maps are produced at a scale of 1:63,360 (Wenzel 1979). Although the Fremont and Winema National Forests are now managed as a single national forest, the SRIs were completed before the two forests were merged, so SRI map data are presented individually for each in this section (Map 4-3).

Tom Mallams of Beatty, Oregon shares how the Mallams Ranch is primarily alfalfa, yielding four tons to the acre of various varieties. Tom shares, "The government's soil information says alfalfa won't grow up there." I once went out in the alfalfa fields with a federal agency person who looked at the field and said, "You can't grow alfalfa in this field because of the soil type, my map says so." Tom shared how the soil information available is often out of date, and does not reflect what landowners have shown to work (pers. comm. January 10, 2007).

The most detailed soil map available is the NRCS Soil Survey Geographic (SSURGO) map (NRCS 2006b), which is based on the Soil Survey of Klamath County (Cahoon 1985). The SSURGO soils are mapped at a scale of 1:20,000, based on aerial photos and field surveys completed between 1963 and 1976. However, the extent of this map is limited to the agricultural regions along the Sprague River and lower Sycan River. Soil types are shown on two pages (because of the large number of soil types, and therefore colors on the maps) in Map 4-3. For these detailed maps, only the soil types that are most common and spatially extensive are shown. The map scale would not allow depiction of all of the less-common soil types.



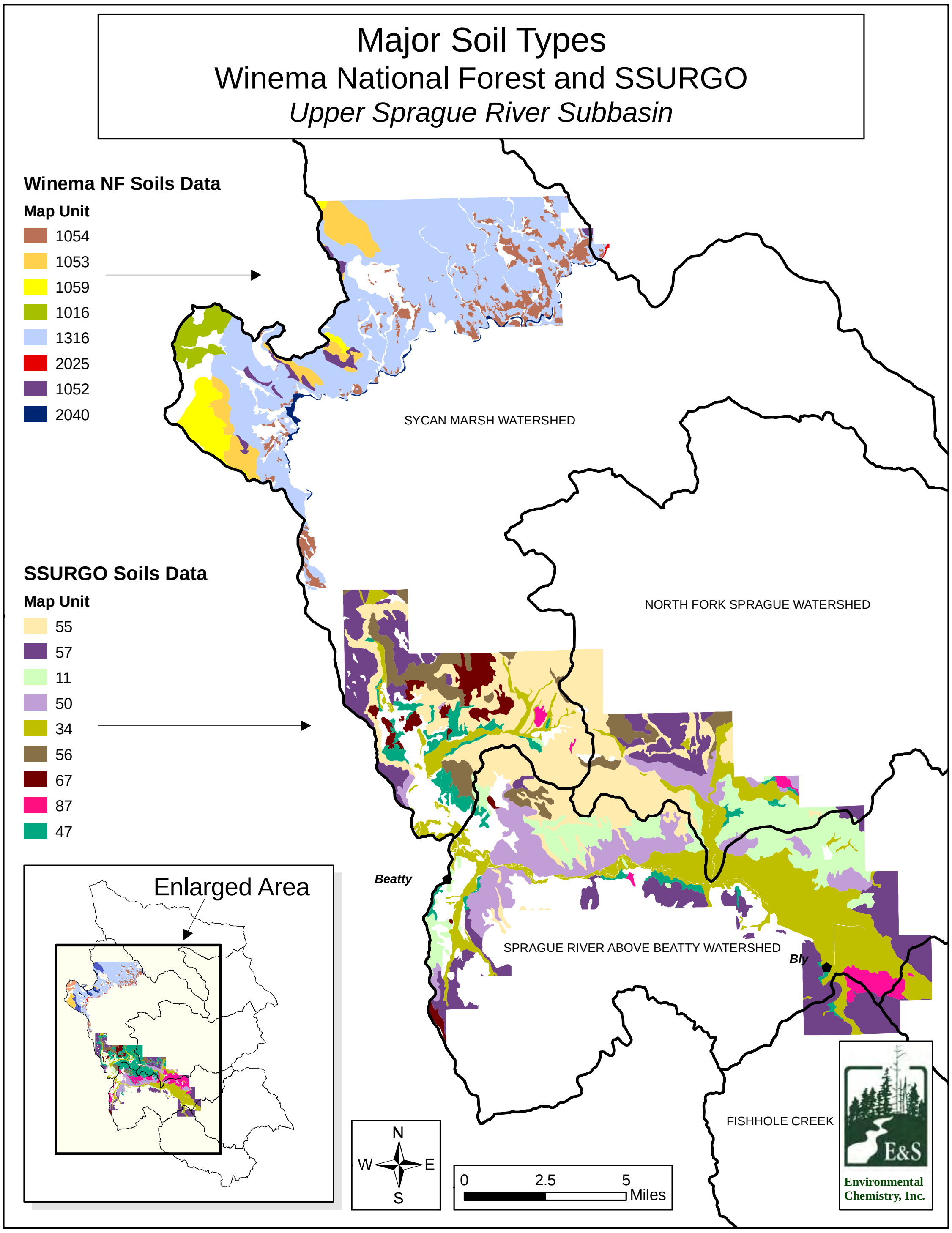
Map 4-2. General soil types from the STATSGO database of county soil surveys. (Data Source: NRCS 2006a)

Table 4-3 shows soil Map Unit characteristics for the SSURGO, Fremont, and Winema soil maps. It is important to note that these studies were not conducted in precisely the same manner, and Map Unit definitions, while similar, are not the exactly the same. In addition, in most cases only a portion of each watershed was mapped. Nonetheless, this information may be useful for project prioritization purposes.

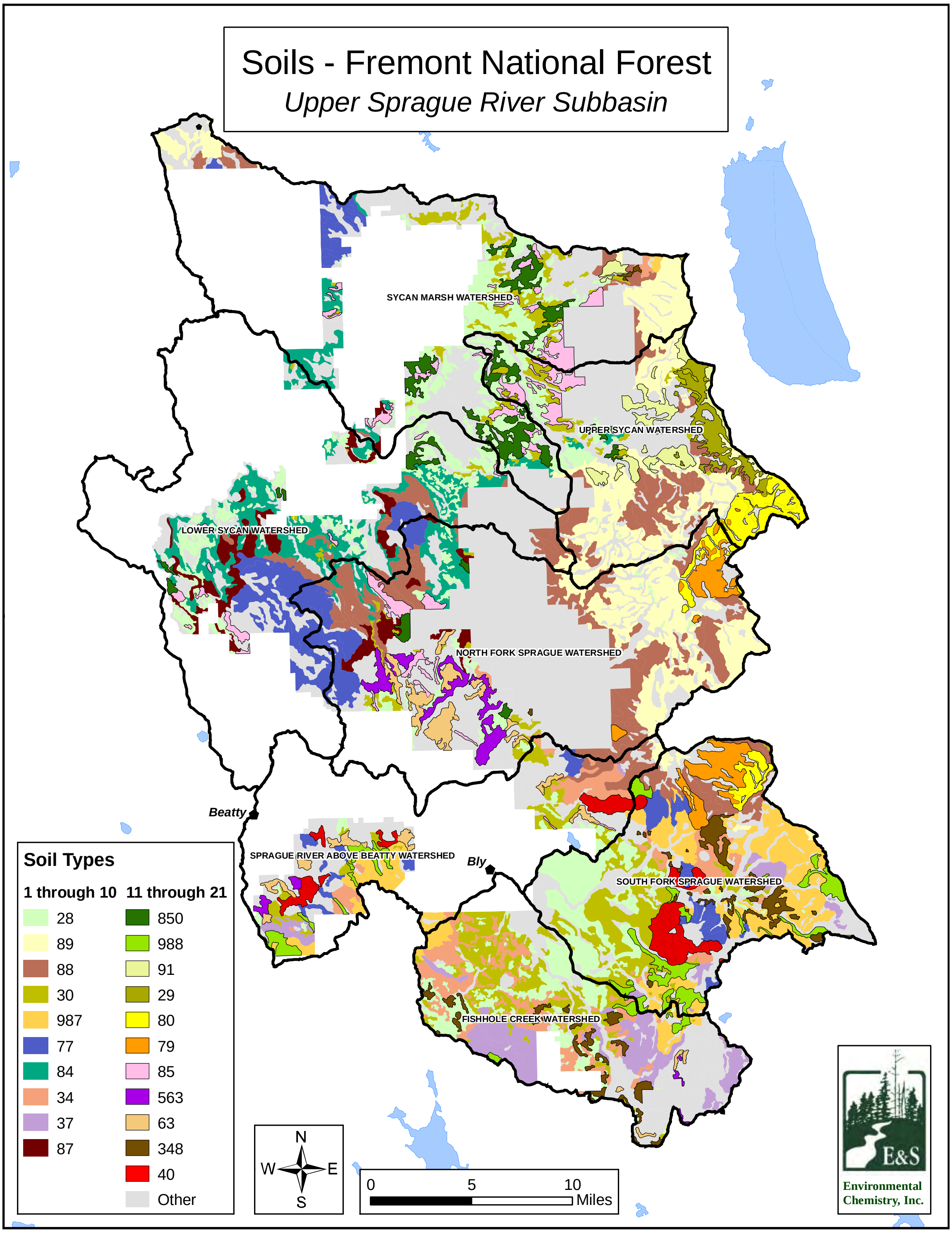
Soils derived from rhyolite, eolian Mazama ash, and pumice deposits are common in some areas. They are poor conductors of heat. These soils can therefore become very hot or very cold in a short period of time. This soil feature largely controls the plant species that are associated with these soil types (USFS 1999).

Table 4-2. STATSGO general soil types found in the Upper Sprague River subbasin. (Data Source: NRCS 2006a)

Map Unit Name	Area (mi^2)	%
Shanahan-Steiger-Lapine	448.9	39.8
Rogger-Woodchopper-Mound	239.8	21.3
Rock Outcrop-Merlin-Yancy	186.4	16.5
Maset-Yawhee-Merlin	90.4	8.0
Lobert-Choptie-Yainax	55.2	4.9
Chinchallo-Yamsay-Moyina	36.7	3.3
Klamath-Ontko-Yonna	32.6	2.9
Lapine-Steiger-Shanahan	30.8	2.7
Chocktoot-Hallihan-Hammersley	6.7	0.6
Total	1,127.5	100.0



Map 4-3. **Detailed soil types, from Forest Service and SSURGO data. The first panel depicts data for the Winema portion of the national forest and SSURGO. The second panel depicts data for the Fremont portion of the national forest. Only major soil types are represented. Map scale limitations prevent the display of less common soil types. Map Unit descriptions may be found in Table 4-3. (Data Sources: NRCS 2006b, USFS 2005, Carlson 1979, Wenzel 1979)**



Map 4-3. Continued.

Table 4-3. Soil characteristics associated with the SSURGO, Fremont, and Winema soil maps. See Map 4-3 for major soil types. (Data Sources: Cahoon 1995, Carlson 1979, NRCS 2006b, Wenzel 1979).

	Map Unit	Area (mi^2)	Depth (in.)	Slope (%)	Bedrock	Surface Soil Texture	Drainage
Sprague River Above Beatty							
Fremont	56	9.6	16-34	0-40	tuff, breccia	medium/moderately coarse	well
	987	5.8			50% of unit 88 and 50% of unit 37		
	34	5.5	20-48	0-100	tuff, basalt	medium	well
	30	5.2	10-25	0-40	andesite, basalt, tuff	medium/moderately fine	well
	40	3.9	30-60	0-100	rhyolite	medium/moderately coarse	excessively well
SSURGO	34	14.0	>60	0-1	-	silty clay	poorly
	11	8.8	10-20	2-20	lithic bedrock	loam	well
	50	8.5	10-20	2-35	lithic bedrock	very stony loam	well
	57	7.3	10-20	1-8	basalt, tuff	extremely stony clay loam	well
	55	5.1	20-40	1-45	paralithic bedrock	coarse sandy loam	well
North Fork Sprague							
Fremont	88	27.3	28-65	0-100	basalt, andesite, tuff	coarse	well
	89	24.8	40-75	0-100	basalt, andesite, tuff	coarse	well
	77	9.0	40-70	0-100	ryholite	coarse	excessively
	563	5.9			40% of unit 56, 30% of unit 30, and 30% of unit 63		
	63	5.6	22-40	0-40	tuff, breccia	medium/moderately corase	well
SSURGO	55	8.1	20-40	1-45	paralithic bedrock	coarse sandy loam	well
	11	3.3	10-20	2-20	lithic bedrock	loam	well
	34	3.2	>60	0-1	-	silty clay	poorly
	57	3.0	10-20	1-8	basalt, tuff	extremely stony clay loam	well
	50	1.9	10-20	2-35	lithic bedrock	very stony loam	well
South Fork Sprague							
Fremont	987	21.4			50% of unit 88 and 50% of unit 37		
	28	15.3	8-20	<5	basalt, andesite, tuff	moderately fine	well
	30	13.9	10-25	0-40	andesite, basalt, tuff	medium/moderately fine	well

Table 4-3. Continued.

	Map Unit	Area (mi^2)	Depth (in.)	Slope (%)	Bedrock	Surface Soil Texture	Drainage
	988	7.7			50% of unit 88 and 50% of unit 37		
	79	6.3	35-65	10-40	rhyolitic, andesite, tuff, breccia, basalt	coarse	excessively/well
SSURGO	57	1.1	10-20	1-8	basalt, tuff	extremely stony clay loam	well
	34	0.8	>60	0-1	-	silty clay	poorly
	87	0.2	12-20	0-8	cemented material	clay loam	well
<u>Fishhole Creek</u>							
Fremont	37	15.8	24-48	0-100	andesite, basalt, tuff	medium/moderately coarse	well
	30	15.5	10-25	0-40	andesite, basalt, tuff	medium/moderately fine	well
	34	14.0	20-48	0-100	tuff, basalt	medium	well
	28	12.5	8-20	<5	basalt, andesite, tuff	moderately fine	well
	348	4.5			40% of unit 34, 30% of unit 30, 30% of unit 28		
SSURGO	57	2.6	10-20	1-8	basalt, tuff	extremely stony clay loam	well
	34	0.5	>60	0-1	-	silty clay	poorly
	87	0.3	>60	0-8	-	clay loam	well
	47	0.1	>60	0-12	tuff	sandy loam	well
<u>Lower Sycan</u>							
Fremont	84	20.9	35-70	<10	tuff, basalt	coarse	well
	28	13.6	8-20	<5	basalt, andesite, tuff	moderately fine	well
	77	12.3	40-70	0-100	ryholite	coarse	excessively
	87	8.7	35-65	<30	basalt, andesite, tuff	coarse	well
	88	7.9	28-65	0-100	basalt, andesite, tuff	coarse	well
SSURGO	55	12.0	20-40	1-45	paralithic bedrock	coarse sandy loam	well
	57	4.7	10-20	1-8	basalt, tuff	extremely stony clay loam	well
	56	3.4	20-40	12-35	paralithic bedrock	coarse sandy loam	well
	34	2.8	>60	0-1	-	silty clay	poorly

Table 4-3. Continued.

	Map Unit	Area (mi²)	Depth (in.)	Slope (%)	Bedrock	Surface Soil Texture	Drainage
	67	2.6	0	5-40	volcanic, metamorphic, and sedimentary rock	loam/clay loam where rock outcrops do not exist	well (loam) - (bedrock)
Winema	1316	31.9	>59	2-12	volcanic ash and pumice	ashy coarse sand	somewhat excessively
	1054	4.4	20-39	1-4	volcanic ash and pumice	ashy loam	well
	1053	4.0	>59	4-12	volcanic ash and pumice	ashy loamy coarse sand	somewhat excessively
	1059	2.5	>59	12-35	volcanic ash and pumice	ashy loamy coarse sand	somewhat excessively
	1016	1.8	>59	2-12	volcanic ash and pumice	ashy loamy course sand	excessively
<u>Sycan Marsh</u>							
Fremont	28	18.3	8-20	<5	basalt, andesite, tuff	moderately fine	well
	89	12.0	40-75	0-100	basalt, andesite, tuff	coarse	well
	30	8.7	10-25	0-40	andesite, basalt, tuff	medium/moderately fine	well
	850	8.4			30% of unit 85, 30% of unit 28, 20% of unit 30, and 20% of unit 93		
	85	6.2	35-65	<10	basalt, tuff	coarse	well
Winema	1316	0.2	>59	2-12	volcanic ash and pumice	ashy coarse sand	somewhat excessively
	1054	0.0	20-39	1-4	volcanic ash and pumice	ashy loam	well
	2025	0.0	>59	0-2	pumice	diatomaceous silt	somewhat poorly
	1052	0.0	>59	12-35	volcanic ash and pumice	ashy loamy coarse sand	somewhat excessively
	2040	0.0	>59	0-2	volcanic rock	medial/ashy soils	moderately well
<u>Upper Sycan</u>							
Fremont	89	22.5	40-75	0-100	basalt, andesite, tuff	coarse	well
	88	13.4	28-65	0-100	basalt, andesite, tuff	coarse	well
	91	7.0	40-75	<15	basalt, andesite, tuff	coarse	well
	29	6.5	20-40	2-12	basalt, tuff	medium/moderately coarse	moderately well
	80	6.4	30-70	0-40	rhyolitic, andesite, tuff, breccia	coarse	well/excessively well

EROSION POTENTIAL

Erosion is a natural process, but it can be aaffected by human activities. Erosional processes transport coarse and fine sediments from upland areas and streambanks to, and down, the stream channel. This movement of sediments influences soil conditions in the source area, including nutrient availability and site fertility, and also sediment conditions in the receiving water. High levels of erosion can interfere with agricultural activities, including rangeland, crop, and forest production, and other activities. Erosion can also alter the balance between coarse and fine sediments in the stream channel, which in turn can impact a variety of critical habitat features, including fish spawning habitat quality, stream width:depth ratio, and water temperature. Several kinds of erosion are potentially important sources of sediment to streams in the Upper Sprague River subbasin, including sheet erosion, streambank erosion, erosion from roads, and gully erosion. Mass movement, an important source of sediment delivery on the west side of the Cascade Mountains, may occur on occasion, but is not an important contributor to sediment delivery to streams within the Upper Sprague River subbasin.

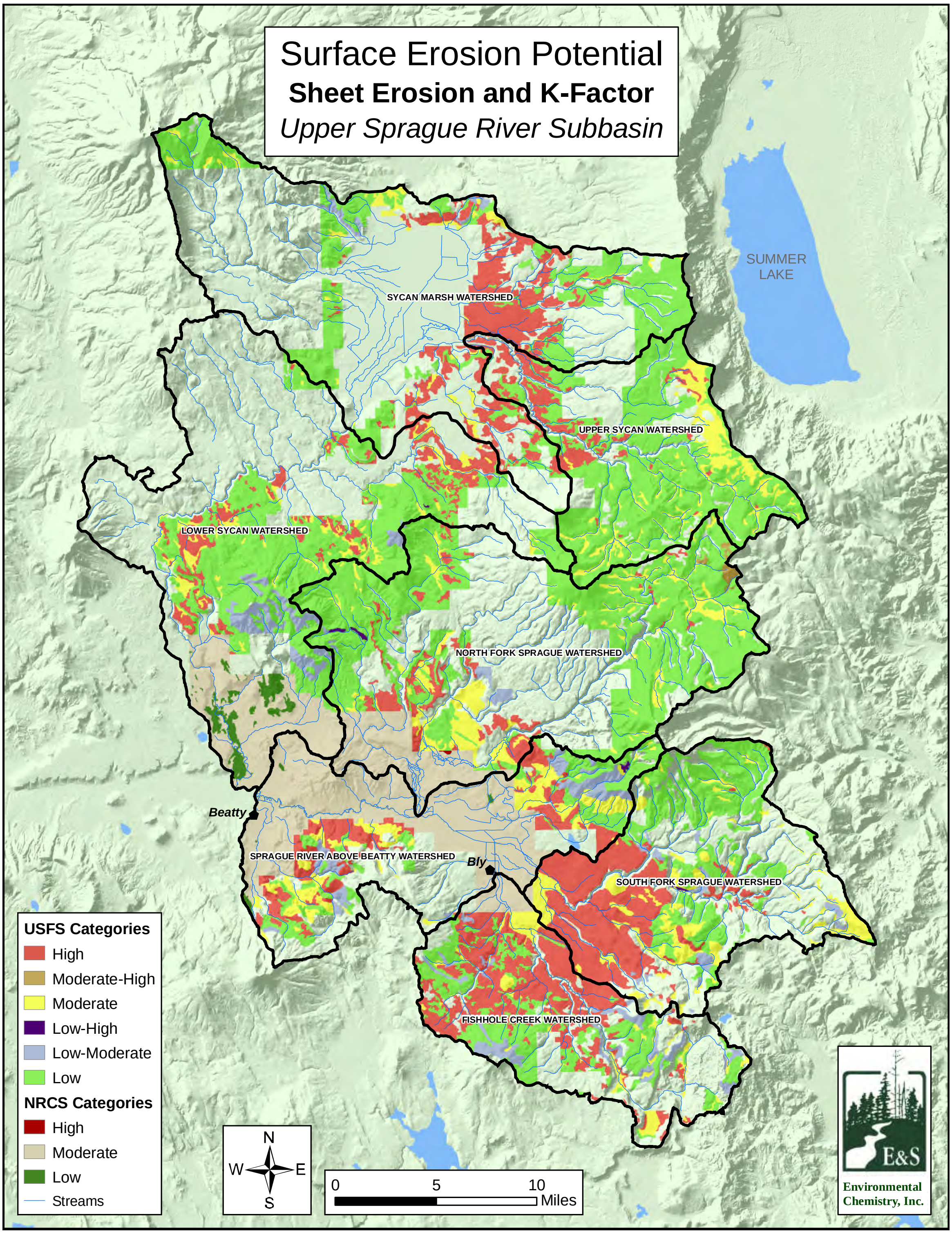
Sheet Erosion

Three sources of data on sheet erosion potential are presented here (Map 4-4; Tables 4-4, 4-5). The NRCS SSURGO data provide a "K-factor", which represents sheet erosion potential. The Fremont-Winema NF soil surveys included a classification of the potential for sheet erosion associated with each land type (Carlson 1979, Wenzel 1979).

SSURGO data can be used to evaluate the potential for sheet erosion, using the K-factor, which is defined by the US Department of Agriculture (USDA) as an erodibility factor which quantifies the susceptibility of soil particles to detachment and movement by water (USDA 2006). This factor is used in the Revised Universal Soil Loss Equation (RUSLE) to calculate soil loss by water. RUSLE is included in many watershed models to simulate soil movement.

Table 4-4. Breakdown of K-factor erosion potential classes derived from SSURGO data available within the Upper Sprague River subbasin. (Data Source: NRCS 2006b)

K-Factor Rating Class	Area (mi^2)
Low	5.3
Moderate	112.8
High	0.1
Total	118.2



Map 4-4. Sheet erosion potential of soils in the study area, as estimated by the Forest Service and NRCS. Acres of high erosion potential are mapped in red and orange tones. (Data Sources: NRCS 2006b, USFS 2005, Wenzel 1979)

Table 4-5. Surfaces soil erosion potential by watershed as determined by the Forest Service. (Source: Wenzel 1979)

Erosion Potential	Sprague River Above Beatty (mi²)	North Fork Sprague (mi²)	South Fork Sprague (mi²)	Fishhole Creek (mi²)	Lower Sycan (mi²)	Sycan Marsh (mi²)	Upper Sycan (mi²)	Total	
								mi²	%
Low	13.9	88.3	32.2	24.0	59.6	46.0	60.0	189.6	60.2
Low-Moderate	6.2	1.4	2.6	6.3	6.7	1.4		14.4	4.6
Low-High	0.1	0.3	0.2	<0.1	<0.1			0.0	0.0
Moderate	11.7	15.4	14.9	5.9	7.4	5.0	11.6	29.9	9.5
Moderate-High		1.1						0.0	0.0
High	14.2	9.3	30.1	29.7	14.5	27.1	9.6	80.9	25.7
Total	46.1	115.8	80.0	65.9	88.2	79.5	81.2	314.8	100.0

For this analysis, numeric K-factor values were classified as "Low" "Moderate" or "High" based on the ranges specified in the OWEB Manual:

- Low-< 2.0
- Moderate-2.0 to 4.0
- High-> 4.0

K-factor values are available for soils surveyed by NRCS within the Upper Sprague River subbasin. These areas are located on non-Forest Service land along the mainstem of the Upper Sprague River between Beatty and Bly. In the SSURGO database, Map Units may be defined that are comprised of more than one soil type (i.e. Map Unit 6A consists of 70 percent Calimus soils and 30 percent other soil types). The dominant soil type was used to represent the erodibility characteristics that are reflected in the K-factors presented here.

The distribution of K-factor classes across the SSURGO study area is summarized in Table 4-4. More than 95 percent of the surveyed area was classified as having moderate sheet erosion potential. Only 0.1 square miles (less than one hundredth of one percent of the area) of land was classified as having high sheet erosion potential.

Data from the Forest Service Forest Soil Resource Inventory can also be used to evaluate sheet erosion potential in a manner analogous to the analysis of SSURGO data that uses K-factor designations. The Forest Service rating is based on expected loss of surface soil by sheet erosion when all vegetative cover is removed. Factors considered in designating the ratings include soil characteristics, slope gradient and length, hydrologic characteristics of the soil and bedrock, and climate. Classes are rated as:

- Low – Little loss of soil materials is expected but some minor sheet erosion may occur.

- Moderate – Some loss of surface soil materials can be expected. Sheet erosion can be identified by the presence of some soil pedestals and observable accumulation of soil materials along the upslope edge of rocks and debris. At this level of erosion, there is a possible fertility loss.
- High – Considerable loss of surface soil materials can be expected. Sheet erosion is indicated by frequent occurrence of soil pedestals and considerable accumulation of soil materials along the upslope edge of rocks and debris. This is accompanied by a probable fertility loss.
- Severe – Large loss of surface soil material can be expected. Sheet erosion loss is exhibited by numerous soil pedestals and extensive accumulation of soil materials along the upslope edge of rocks and debris. This is accompanied by fertility loss.

Results of these analyses by Fremont-Winema National Forest are summarized in Table 4-5. About 60 percent of the study area was classified as having low sheet erosion potential, nearly 26 percent had high erosion potential, and the balance of 14% was rated as moderate (Table 4-5; Wenzel 1979).

Because the sheet erosion potential classification data from NRCS and the Forest Service do not overlap, and are intended to reflect the same general characteristics of soil erodibility, these data were combined and are presented in Map 4-4. We do not assume that the classification methods are the same. However, in both cases, they are intended to reflect general erosion potential conditions. Areas of highest sheet erosion potential are concentrated mainly in two parts of the subbasin, one in the south in the lower reaches of the South Fork Sprague Watershed and Fishhole Creek Watershed and one in the north in the Sycan Marsh Watershed and adjacent lands in the Upper and Lower Sycan Watersheds (Map 4-4).

Streambank Erosion

Stream bank erosion is generally one of the most important sources of erosion in areas of relatively low relief, as occur throughout most of the Upper Sprague River subbasin. Despite the significance of this issue, however, available data are limited. The Oregon Department of Fish and Wildlife (ODFW) included field surveys of bank erosion in conjunction with their stream habitat surveys (ODFW 2001). Observable bank erosion was quantified in each of the surveyed reaches at the time of the survey.
Bank erosion data from ODFW are presented in Table 4-6 as the percent of the streambank within each surveyed reach that was observed to be actively eroding. Little or no active bank erosion was observed along the surveyed reaches of streams within the Sprague River Above Beatty and North Fork Sprague watersheds. In contrast, bank erosion was surveyed as extensive

throughout most of the surveyed reaches in the South Fork Sprague and Sycan Marsh watersheds. Many reaches were experiencing bank erosion along half or more of the surveyed reach. It should be noted that conditions may have changed since this data was collected.

Rare events can cause significant changes in local conditions. Growth records from increment boring in trees on a terrace near Bly Campground (WLA field day) suggest that the 1964 flood may have induced significant downcutting in this stream reach.

There is no available benchmark indicating what is an "acceptable" level of bank erosion. For the purposes of this analysis, bank erosion classes have been defined as follows, based on the percentage of the streambank observed to be actively eroding:

Very High – greater than 50 percent
High – 30 to 50 percent
Moderate – 10 to 30 percent
Low – less than 10 percent

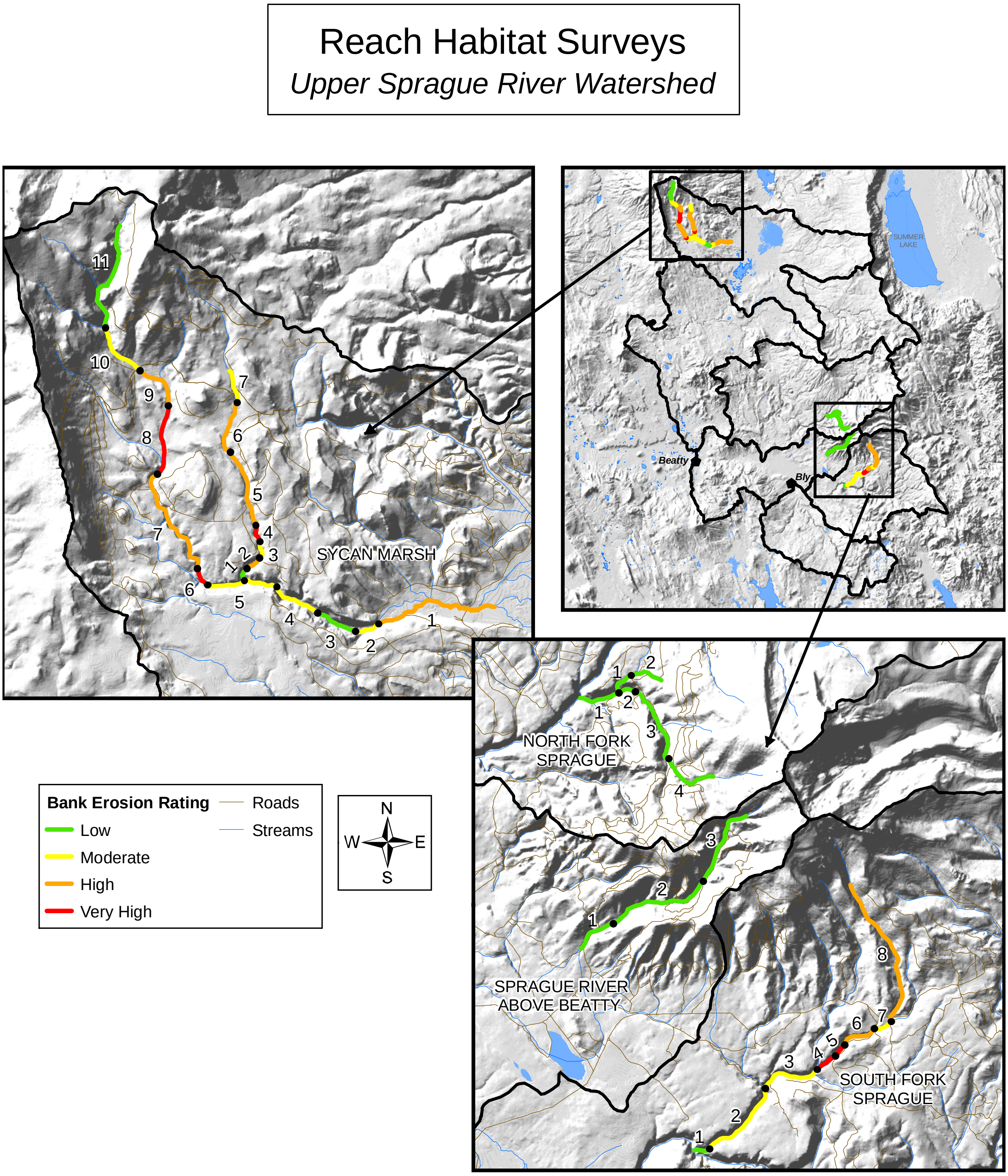
Results of this analysis are shown in Map 4-5. ODFW found that 8 percent of the surveyed reaches had Very High stream bank erosion, covering more than 50 percent of the surveyed bank area. An additional 22 percent of the surveyed streambank reaches were rated as having High bank erosion (30 to 50 percent of surveyed stream bank actively eroding; Table 4-7).

Bank stability was also evaluated in conjunction with stream surveys conducted by Fremont-Winema National Forest in the Upper Sycan Watershed (above Sycan Marsh). Within this watershed, stream banks are commonly stabilized by mountain alder, black cottonwood, quaking aspen, several species of willow, and herbaceous species (See Riparian Vegetation Chapter). Along low-gradient streams, sedges, rushes, and willow are common in some areas. Overall, the Forest Service judged bank stability to be high in that area. Individual stream reaches were found to be 74 percent to 100 percent stable, with most surveyed reaches in the 90 to 99 percent range.

It is important to note that relatively few stream reaches have been evaluated for bank erosion within the study area. However, the available data suggest that bank erosion is an important concern in some, but not all, areas within the Upper Sprague River subbasin.

Table 4-6. Bank erosion estimates from ODFW stream surveys. (Data Source: ODFW 2001)

	Reach	Stream Miles	Gradient (%)	Bank Erosion (%)
Sprague River Above Beatty				
Deming Creek	1	2.7	3.9	3.6
	2	6.8	5.6	0.0
	3	5.2	12.0	0.0
North Fork Sprague				
Boulder Creek	1	2.5	6.2	0.0
	2	1.2	6.3	0.0
	3	5.2	7.0	0.0
	4	3.6	7.0	0.0
Dixon Creek	1	1.6	17.3	0.0
	2	2.1	4.6	0.0
South Fork Sprague				
Brownsworth Creek	1	1.0	4.3	6.1
	2	5.5	3.5	15.4
	3	4.0	4.0	29.2
	4	1.4	3.7	68.7
	5	1.0	3.4	50.7
	6	2.2	3.9	48.5
	7	1.2	3.5	28.0
	8	9.8	5.2	32.8
Sycan Marsh				
Calahan Creek	1	1.0	4.9	8.3
	2	1.1	2.1	30.6
	3	1.0	2.4	24.1
	4	1.2	1.8	55.6
	5	5.0	1.7	34.9
	6	3.6	1.4	34.9
	7	2.0	3.1	25.7
Long Creek	1	8.4	0.6	35.1
	2	1.6	1.0	20.7
	3	2.7	1.9	5.6
	4	3.1	1.6	10.3
	5	4.7	1.8	20.2
	6	1.2	1.2	56.0
	7	7.4	1.4	41.5
	8	4.6	0.9	58.5
	9	3.2	1.6	33.2
	10	3.6	3.4	13.4
	11	7.2	6.5	0.9



Map 4-5. Results of ODFW determinations of the extent of streambank erosion in the stream reaches that were included in stream habitat surveys. (Data Source: ODFW 2001)

Table 4-7. Breakdown of stream length in streambank erosion classes, based on ODFW survey data. (Data Source: ODFW 2001)

Bank Erosion Rating	Length (mi)	% Total Length
Low	12.4	34.1
Moderate	13.0	35.7
High	8.1	22.3
Very High	2.9	8.0
Total	36.4	100.0

Road Erosion

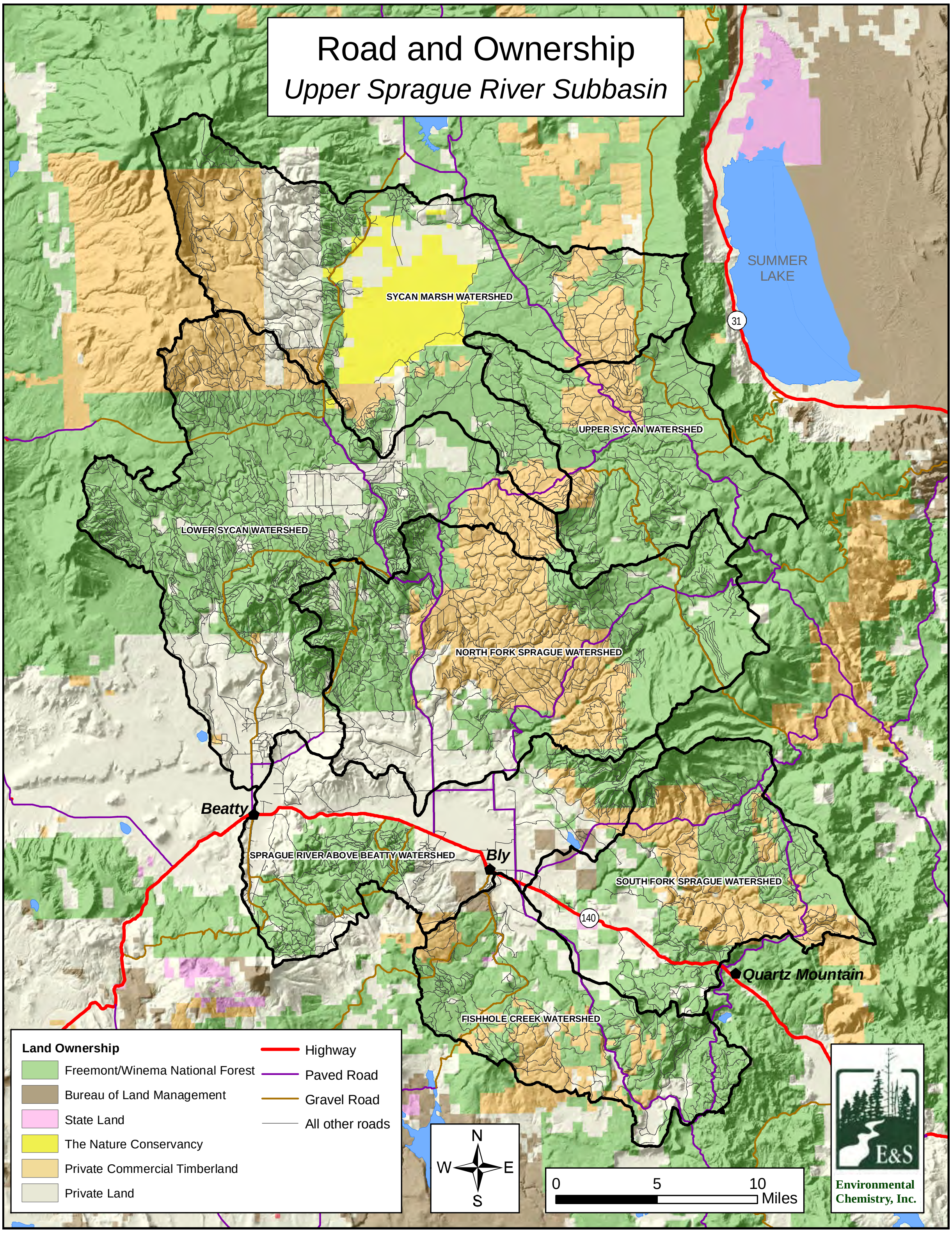
The extent, density, condition, and location of roads in a watershed can have a significant influence on erosion and the quantity and quality of sediment that is delivered to streams in the watershed. Information on roads was assembled for this assessment largely from data collected by the USFS and NRCS (see bibliography).

There are 3,500 miles of public and private roads in the Upper Sprague River subbasin, at an average road density of about three miles of road per square mile. Road density ranges from 2.4 mi/mi^2 in the South Fork Sprague Watershed to 4.3 mi/mi^2 in the Lower Sycan Watershed (Table 4-8, Map 4-6).

The extent of the effect of roads on erosion and sediment delivery to streams is determined to a large extent by the type of road surface, the amount of traffic on the road, proximity to streams or other sensitive habitat, and the level of maintenance the road receives. Also important are the slope of the cutbank and the condition of roadside ditches and culverts.

Table 4-8. Road density in the Upper Sprague River subbasin. (Data Source: USFS 2005)

Watershed	Road Length (mi)	Watershed Area (mi^2)	Road Density (mi/mi^2)
Sprague River Above Beatty	342.8	129.7	2.6
North Fork Sprague	702.1	208.1	3.4
South Fork Sprague	310.1	128.3	2.4
Fishhole Creek	266.5	101.6	2.6
Lower Sycan	992.9	231.6	4.3
Sycan Marsh	580.7	224.4	2.6
Upper Sycan	305.2	102.7	3.0
Total	3,500.3	1,126.4	3.1



Map 4-6. Distribution of roads within the Upper Sprague River subbasin. (Data Source: USFS 2006)

Analysis of road conditions in the Upper Sprague River subbasin is based on the roads analysis completed by the Fremont-Winema National Forest, which covered approximately 60 percent of the Upper Sprague River subbasin and included at least portions of all the watersheds in the subbasin. It therefore represents the condition of the majority of roads on Forest Service lands in the subbasin. The Fremont-Winema National Forest roads analysis identified four road surface materials used on roads in the forest. They are identified in Table 4-9 together with the amount of each road-surface type found in each watershed. Please note that this information pertains to publicly-owned upland areas. Less information is available for privately-owned lowlands.

The level of maintenance of roads can be an important factor in determining how much sediment travels from the road surface to the streams. The Forest Service recognizes five levels of road maintenance from level 5 (maintained for passenger car use, dust free, with a high degree of comfort [these roads may be paved]), to level 1 (maintained only for high clearance vehicles for short-term access, or scheduled to be decommissioned). The operation maintenance levels for roads within the Fremont-Winema National Forest are provided in Table 4-10.

Location of Roads

Roads Close to Streams

The location of roads in relationship to streams can be an indicator of the potential magnitude of effect the road network may have on the stream network. Map 4-7 shows areas where roads are located within 200 feet of a stream. The number of miles of gravel and dirt road within 200 feet of a stream is provided in Table 4-11. Also included in Table 4-11 is the number of stream miles within 200 feet of a road, which is perhaps more relevant to the potential effect of roads on the stream network. On average, approximately 22 percent of the streams in the Upper Sprague River subbasin are within 200 feet of a road.

Ed Bartel of Sprague River, Oregon, shares stories of successful low-tech restoration on his property using wool to hold water and tree roots, and his experience of how roads and railroads have changed the system. Ed states that "when they redid the highway, they changed it to a single culvert under the highway, so the stream is wanting to downcut and is eroding quite a bit. In addition, the nearby railroad grade channelizes the runoff and also causes downcutting and erosion as the water is carried to the Lower Sprague" (pers. comm. January 26, 2007).

Table 4-9. The amount of different types of road surface on Fremont-Winema National Forest land, by miles of road, in each watershed in the Upper Sprague River subbasin, as determined by Fremont-Winema National Forest. (Data Source: USFS 2005)

Road Surface	Sprague River Above Beatty	North Fork Sprague	South Fork Sprague	Fishhole Creek	Lower Sycan	Sycan Marsh	Upper Sycan
Aggregate	83.4	118.8	82.3	79.1	107.8	77.1	89
Improved natural material	7.6	15.3	2.5	28.8	21.3	11.4	7.8
Natural material	124.1	277.2	126.9	103.5	326.4	211.3	130.3
Surface treatment	6.2	15.4	23.7	23.8	12.7	13.5	20.1
Total	221.3	426.7	235.4	235.2	468.2	313.3	247.2
	Percent	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**
Aggregate	37.7	27.8	35	33.6	23	24.6	36
Improved natural material	3.4	3.6	1.1	12.2	4.5	3.6	3.2
Natural material	56.1	65	53.8	44.1	69.8	67.5	52.7
Surface treatment	2.8	3.6	10.1	10.1	2.7	4.3	8.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4-10. Operation maintenance level of roads (miles) in the portions of the Upper Sprague River subbasin within the Fremont portion of the Fremont-Winema National Forest. (Data Source: USFS 2005)

	Miles of Road in Each Watershed						
Operation Maintenance Level	**Sprague River Above Beatty**	**North Fork Sprague**	**South Fork Sprague**	**Fishhole Creek**	**Lower Sycan**	**Sycan Marsh**	**Upper Sycan**
1	111.4	151.1	67.2	61.8	196.2	77.7	108.9
2	84.3	208.9	134	112.7	234.3	197.3	83.4
3	20.8	51.5	11.2	37.7	24.7	29.4	34.8
4	4.9	7.9	23.0	23.0	13.0	8.9	20.1
5		7.3					
Total	221.4	426.7	235.4	235.2	468.2	313.3	247.2
	Percent of Roads in Each Watershed						
1	50.3	35.4	28.5	26.3	41.9	24.8	44.1
2	38.1	49.0	56.9	47.9	50.0	63.0	33.7
3	9.4	12.1	4.8	16.0	5.3	9.4	14.1
4	2.2	1.9	9.8	9.8	2.8	2.8	8.1
5		1.7					
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Level 1: High clearance vehicle, short-term access, or scheduled for decommissioning
Level 2: High clearance vehicle, low travel speed (5-25 mph)
Level 3: Passenger car, basic access, low travel speed, low comfort.
Level 4: Passenger car, moderate travel speed, moderate comfort.
Level 5: Passenger car, high degree of comfort, higher travel speed, may be paved.

Table 4-11. Length of road or stream within 200 feet of each other (miles). (Data Source: USFS 2005)

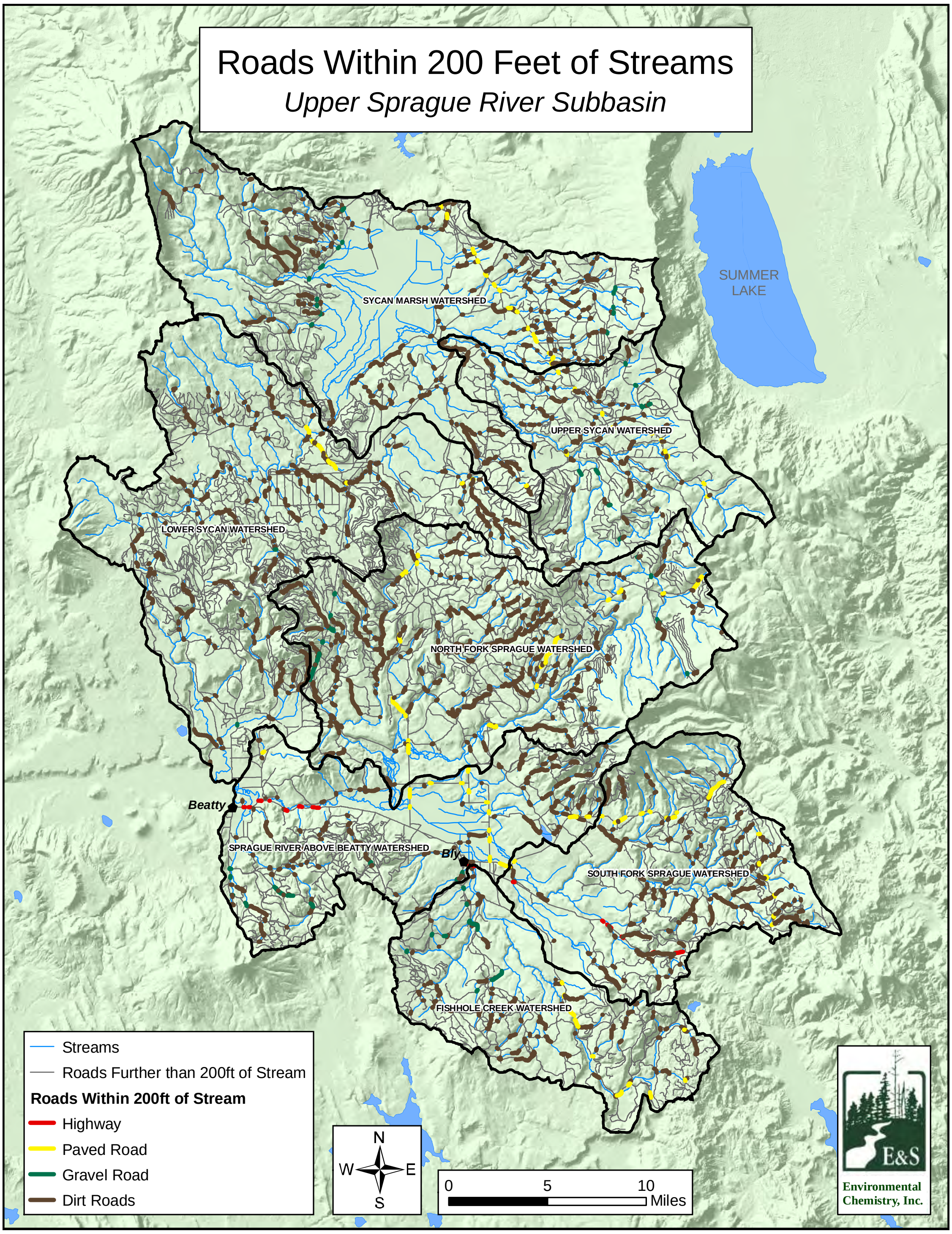
Watershed	Road Length[1]	Stream Length[2]	Percent of Total Stream Length
Sprague River Above Beatty Watershed	27.4	27.8	18.4
North Fork Sprague Watershed	77.2	71.4	27.5
South Fork Sprague Watershed	40.2	38.4	23.7
Fishhole Creek Watershed	22	21.5	21.4
Lower Sycan Watershed	50.8	46.7	23.4
Sycan Marsh Watershed	51.9	49.3	17
Upper Sycan Watershed	17.6	18.2	15.7
Total	287.1	273.4	21.4

[1] within 200 feet of stream
[2] within 200 feet of road

Table 4-12 identifies roads close to streams based on the road surface types. Highways and other paved roads generally do not contribute sediment from the road surface, although sediment from ditches and cut-banks may enter the stream system. Gravel and dirt roads may experience surface erosion, as well as ditch and cut-bank erosion, and are the most prevalent in the Upper Sprague River subbasin (Table 4-12). The North Fork Sprague Watershed contains the most miles of dirt and gravel road near streams (77.2 miles), while the Upper Sycan has the least (17.6 miles).

Table 4-12. Miles of road within 200 feet of a stream by watershed. (Data Source: USFS 2005).

	Highway	Paved Road	Gravel Road	Dirt Road	Total
Sprague River Above Beatty Watershed	1.3	2.9	2	25.4	31.6
North Fork Sprague Watershed	0	5.7	2.3	74.9	83
South Fork Sprague Watershed	1.1	3.1	0	40.2	44.3
Fishhole Creek Watershed	0.1	2.3	2.2	19.8	24.5
Lower Sycan Watershed	0	2.5	0.3	50.5	53.4
Sycan Marsh Watershed	0	2.4	1.5	50.4	54.3
Upper Sycan Watershed	0	1.4	1.3	16.3	19
Total	2.5	20.3	9.6	277.5	310.1



Map 4-7. Roads located within 200 feet of streams. (Data Source: USFS 2005)

Roads Crossing Streams

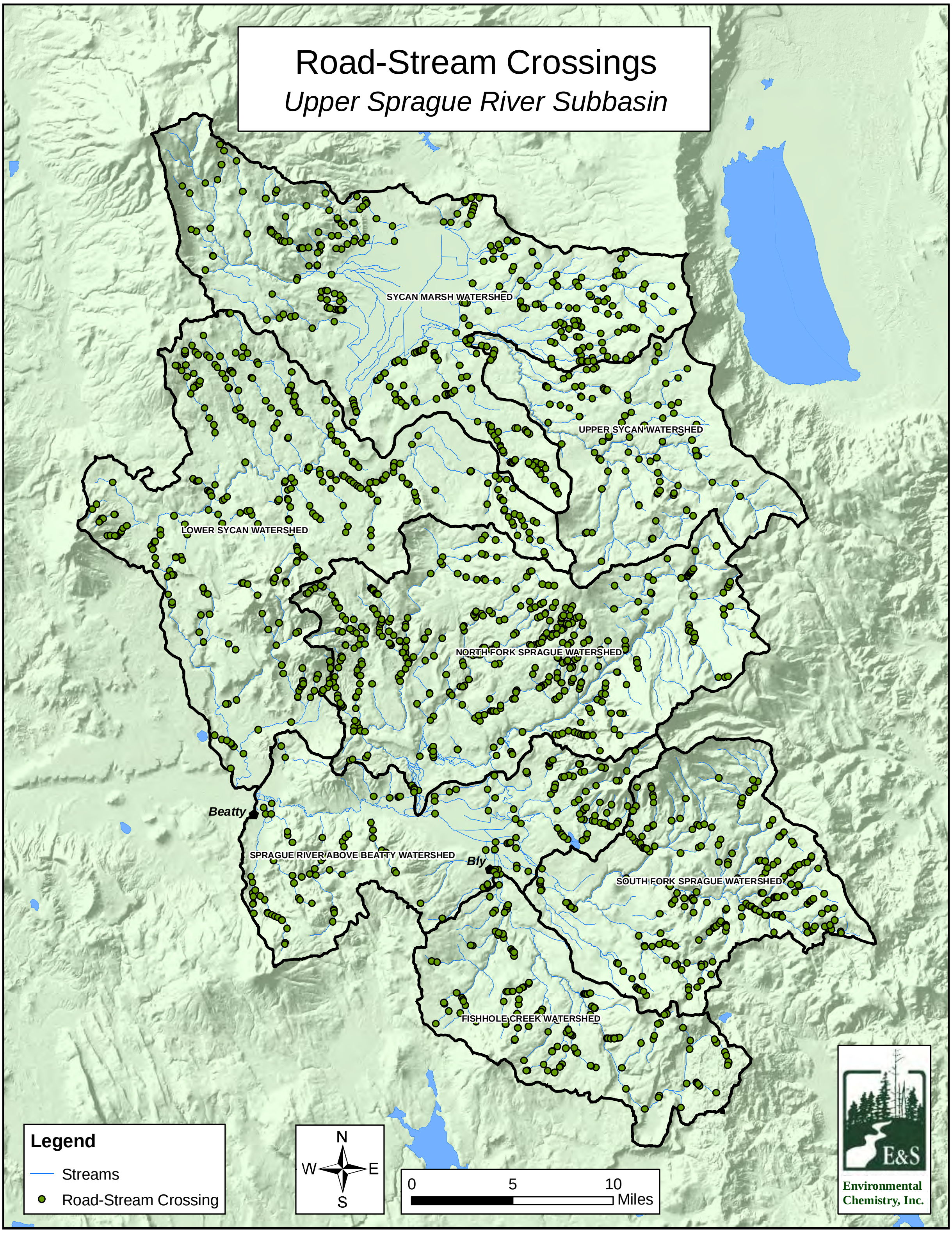
Geographic Information System (GIS) data for roads and streams were used to determine the number of locations where roads cross streams. Stream crossings were tallied where the Forest Service GIS roads coverage and GIS streams coverage intersected (USFS 2005). The number and location of stream crossings in each watershed are provided in Map 4-8 and Table 4-13. The number of stream crossings per mile of road (road/stream crossing density) ranges from 0.34 (approximately one crossing for every three miles of road) in the Upper Sycan Watershed to 0.74 (approximately one every 1.3 miles) in the South Fork Sprague Watershed. There is an average of 1.35 road crossings per mile of stream in the Upper Sprague River subbasin. The number of crossings per mile of stream ranges from 0.89 in the Upper Sycan Watershed to 1.74 in the Lower Sycan Watershed.

Table 4-13. Road-stream crossings in the Upper Sprague River subbasin. (Data Source: USFS 2005)

Watershed	Total	Density (crossings/mi of road)	Density (crossings/mi of stream)
Sprague River Above Beatty Watershed	170	0.50	1.12
North Fork Sprague Watershed	434	0.62	1.67
South Fork Sprague Watershed	229	0.74	1.41
Fishhole Creek Watershed	142	0.53	1.41
Lower Sycan Watershed	349	0.35	1.74
Sycan Marsh Watershed	346	0.60	1.19
Upper Sycan Watershed	104	0.34	0.89
Total	1,774	0.52	1.35

Roads and Erosion Potential

The effect of roads on delivery of sediment to streams can be influenced by the erosion potential of the soil, especially for roads surfaced with natural materials. The SSURGO database provides digital data based on the original 1:12,000 to 1:63,360 field survey-based soils maps, and can be used to determine the sensitivity of soils to erosion in certain areas that are of interest to resource managers. The SSURGO data for Klamath County covers a portion of the Upper Sprague River subbasin, primarily on private lands in the vicinity of Bly and Beatty. Data from this limited area were used to determine the relative abundance of soils of various erodibility classes (NRCS 2006a). The data are presented in Table 4-14. Nearly 40 percent of the soils in the area surveyed are classed as severely sensitive to road-related erosion.



Map 4-8. Road-stream crossings in the Upper Sprague River subbasin. (Data Source: USFS 2005)

Table 4-14. Soil sensitivity to road-related erosion in areas of the Upper Sprague River subbasin included in the Klamath County SSURGO database (NRCS 2006b).

	Sprague River Above Beatty	North Fork Sprague	South Fork Sprague	Fishhole Creek	Lower Sycan	Total	
Rating Class	**Area (mi^2)**	**Area (mi^2)**	**Area (mi^2)**	**Area (mi^2)**	**Area (mi^2)**	**Area (mi^2)**	**%**
Slight	18.5	3.6	0.8	0.6	8.2	31.7	27.6
Moderate	12.4	8.2	1.3	2.9	14.5	39.3	34.2
Severe	26.5	9.8			7.7	44.0	38.3
Total	57.4	21.6	2.1	3.5	30.4	115.0	100.0

Rill and Gully Erosion

Rill and gully erosion are important sources of sediment delivery to streams throughout the subbasin. Although quantitative data are generally not available, several generalizations can be made based on field observations. The soil resource inventory prepared for Fremont National Forest (Wenzel 1979) identified land types within the forest that were most prone to rill and gully erosion. Those judged to be most susceptible were rated as having extreme risk. They were characterized as having:

- steep slopes on dome-shaped uplifts;
- steep ridges and side-slopes;
- ashy soils overlying buried residual and colluvial (sloped) soils with mixed timber types. This land type typically occurs on shield volcanoes, basaltic eruptive centers, and block faults on steep lands.

Each of these high-risk land types occurs on slopes greater than 40 percent, and were rated as having extreme rill and gully erosion potential. A variety of other land types were found to be associated with high risk for gully and rill erosion. These included land types associated with such features as the following:

- old lake beds;
- volcanic features, such as cinder cones, lava tablelands, rhyolitic dome uplifts, and eruptive centers;
- alluvial and colluvial deposits, valleys, and bottomlands;
- toeslopes, benches, and footslopes where soil has accumulated by downslope movement; and
- steep ridges and sideslopes less than 40 percent.

Mass Movement of Soil

Although mass movement does not appear to have been an important source of sediment to streams within the study area, the potential exists for mass movement in some areas. Data on soil mass movement potential are only available for Fremont-Winema National Forest. Within Fremont-Winema NF, soils have been classified according to mass movement potential. None of the soils within this national forest were rated as having low stability and therefore high mass movement potential. Only some very small and localized areas were classified as having moderate stability. Eighty-seven percent of the land in Fremont-Winema NF was placed in the very stable category (Table 4-15), which indicates no evidence of failure. Some of the roads that are located on soils that are not very stable may still have no evidence of failure if constructed properly with water bars or other drainage features.

Table 4-15. Classification of the natural stability of soil, by watershed (indicating the potential for mass movement), as determined by Fremont National Forest. (Source: Wenzel 1979)

Rating Class	Sprague River Above Beatty	North Fork Sprague	South Fork Sprague	Fishhole Creek	Lower Sycan	Sycan Marsh	Upper Sycan	Total	
	mi²	mi²	mi²	mi²	mi²	mi²	mi²	mi²	%
Very Stable	35.5	83.4	67.5	55.9	80.5	71.0	69.5	463.3	87.0
Stable	9.3	26	8.3	6.5	5.2	5.3	7.8	68.4	12.8
Moderately Stable	0.1	0.3	0.2	<0.1	<0.1			0.6	0.1
Total	44.9	109.7	76	62.4	85.7	76.3	77.3	532.3	100.0

The ratings represented in this table are based on the relative stability of the mapping units as they occur in their natural state. It includes any movement or loss by all types of deep-seated failures. Types of movement include slumps, slides, rockfall, landflows, and landslips. Class designations are as follows:

- Very Stable – No evidence of failure;
- Stable – Occasional failures are observed;
- Moderately Stable – Several failures are observed;
- Unstable – Many failures are observed;
- Very Unstable – Entire area shows evidence of recent and past failures.

INFLUENCE OF HUMAN ACTIVITIES ON EROSION POTENTIAL

Human activities within the watershed can alter the natural balance between sediment sources, transport, and deposition within the stream system. It is generally not possible to specify the amount of human-induced erosion in a particular stream, given the variable nature of natural erosion processes. Furthermore, it is difficult to determine at what point human-induced erosion will actually affect an aquatic community. In general, however, the more the erosion and sediment transport processes deviate from the historical range of variability for a particular stream, the greater the likelihood of adverse effects on in-stream biota.

Changes in erosion processes have occurred as a result of land use practices since Euro-American settlement. The principal activities that have likely contributed to increased erosion were road building and logging in the uplands, and stream channel modifications in the lowlands (especially vegetation removal, channel straightening, diking, and wetland draining). Current management-related effects in the uplands are largely attributable to roads, which are subject to erosion of fillslopes, cutslopes, road surface (of unpaved roads), and ditches. Road-related erosion is probably high in the Upper Sprague River subbasin because there is a very high density of roads and many of those are adjacent to streams. In steep areas, roads increase the risk of slope failure on both the underlying slope (oversteepened and low strength) and the slope above the road (oversteepened). Drainage ditches associated with roads route surface runoff, thereby contributing increased sediment delivery if the ditches are hydrologically connected to streams (Biosystems 2003).

Alan Withers, whose family settled the 7,000 Withers Ranch in Paisley, OR in 1871, runs cattle in the Sycan. Alan shares that "the only really good stream we've got here is the one that's been fenced. It's got redband and bull trout in it. Another stream has typical erosion problems. It's been fenced for about five or six years, and you can hardly see the stream now, it's all grown up with willows and grasses" (pers. comm. January 17, 2007).

Roads provide many useful benefits, including access for timber extraction, fire suppression, and recreation. However, road construction can result in a high level of disturbance to the forest ecosystem, potentially affecting the hydrology, soil stability, fish passage, Upland habitat fragmentation, and downstream transport of material through the stream network. Road construction can expose bare soil on disturbed slopes and ditches, which are vulnerable to erosion until they become vegetated. In order to withstand traffic by log trucks and heavy vehicles, a compacted, impervious surface is created, and in some cases runoff is re-directed along roadside ditches. Roads have long been the focus of concern regarding sedimentation of streams. However, the extent of the effect depends on many factors, including road location, proximity to the stream, slope, and construction techniques. Valley bottom and mid-slope roads, especially those on steep slopes or near streams, can have great effects on sediment delivery to streams (Biosystems 2003, WPN 1999).

Road construction practices have changed significantly over the past 30 years. Improved road location, design, drainage and maintenance practices have all served to address problems associated with roads. Improved construction practices on steep slopes prevent fillslope landslides, and frequent cross-drain culverts divert road surface runoff before it reaches a stream channel. Changes in timber harvesting practices have reduced the need for roads, and road obliteration or blocking projects have reduced overall road density. Protection zones around streams and riparian buffer strips have served to mitigate negative road effects (Biosystems 2003). Continued improvement of the road system, including closure of unnecessary or problematic road segments, replacement of undersized culverts, and ongoing maintenance, will be necessary to minimize the effect of roads on sediment delivery to streams.

Ditches can potentially expand the stream network during storms. They can alter both the sediment load and the timing of delivery of runoff to the stream. Proper drainage of roads, including the use of well-designed and maintained ditches, is important to minimize the adverse effects of roads on water quality and aquatic habitat. Land management agencies and some private landowners have begun programs to minimize erosion from roads and ditches on their lands.

Logging practices changed substantially after passage of the Oregon Forest Practices Act in 1973. Practices are now required that reduce soil disturbance and retain riparian vegetation during logging operations, including riparian buffers and cable yarding on steep slopes. More recent forestry operations typically cause less erosion than previously, but effects from past practices probably persist to some extent.

Channel modifications and vegetation removal during the 19th and 20th centuries contributed to stream bank and surface erosion. The increased peak stream velocity that has resulted from channelization and diking, and reduction in the amount of wetlands has increased the erosive capability of streams within the subbasin, but by an unknown amount. In addition, the clearing of riparian vegetation has reduced the resistance of stream banks to erosion. More recently, implementation of Best Management Practices (BMPs), including many riparian fencing projects on private lands, has reduced erosion caused by agricultural practices. Riparian restoration and planting efforts should continue to improve overall bank stability conditions.

The legacy of past land use practices within the watershed is associated with erosion today, but the magnitude of effect from past land management is not known. In the uplands, human-caused erosion is probably still most strongly associated with the presence of roads, especially those in closest proximity to stream channels and on steep slopes. In the lowlands, where there is an absence of intact riparian vegetation and the continuation of land disturbing activities,excessive bank erosion will likely continue. Future sources of sediment to the stream system will continue to include legacy effects of past road construction, agricultural practices, government projects, and logging operations. In general, however, such sources will probably diminish in importance over time as problem culverts are replaced, roads are upgraded or decommissioned, and riparian vegetation is restored. Future logging and associated road building may contribute new sources of erosion, but proper road design, maintenance practices, and careful adherence to current management practices should minimize such effects (Biosystems 2003).

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CHAPTER 5. HYDROLOGY AND WATER USE

INTRODUCTION

The subjects of hydrology and water use in the Upper Sprague and Sycan watersheds are complicated because regional stakeholders are currently involved in a contested water rights adjudication. In the attempt to support their respective claims, various stakeholders have produced data and information on hydrology and water use. Some information has been produced by state and federal agencies, some has been produced by tribes, some by private consultants, and some has been compiled by citizens, landowners and advocacy groups. Because each of these entities is a claimant in the ongoing adjudication, the data they have produced is frequently disputed by entities with competing claims.

This watershed assessment is built upon the premise that differing opinions regarding natural resources issues should be respected, and given voice. It is also built upon the premise that there are many different sources of legitimate information about watershed conditions and functions, and that not all of these sources come in the form of published, peer-reviewed reports prepared by professional scientists. Given these premises, and given the pervasive influence of the adjudication on stakeholders' views with regard to hydrology and water use, the preparation of this chapter demanded a substantial additional investment of time and attention in an attempt to ensure that the information presented did not constitute an inadvertent endorsement or validation of contested information. Unless the data pertaining to a contested issue is substantial and irrefutable, we have sought to characterize the difference of opinion and the relevant data, rather than determine which opinion is correct.

GENERAL CLIMATE

The climate of the Upper Sprague River subbasin is largely determined by the prevailing air masses that move across Klamath County from the Pacific Ocean but are greatly modified when moving over the Coast Range and Cascade Mountains. Continental air masses that move down from the interior of western Canada are also a major weather factor. The resulting climate is much drier than that of western Oregon, and has more extreme temperatures, particularly in winter months. Seasonal characteristics are well defined and changes between seasons are generally gradual.

Warm days of 90 ° F or above average 15 days per year in the valleys and 5 days per year in the mountains. The average daily maximum temperatures for Klamath Falls and Chiloquin agree closely, but the average daily minimum temperatures at Chiloquin are about 6° cooler in winter and 12° cooler in summer. At the 6,500 foot level in the mountains, maximum temperatures average from 5° cooler in winter to 14° cooler in summer as compared to Klamath Falls and Chiloquin. Record temperatures in the area have ranged from –28° F at Chiloquin in 1937 to 105° F at Klamath Falls in 1911 (WRCC 2005).

At Klamath Falls, prevailing winds are southerly for November through February; westerly from March through July; and northerly during August, September, and October. Monthly wind speeds average from 4.4 miles per hour in September to 7.3 miles per hour in March. Wind conditions are calm 17 to 33 percent of the time. Conditions differ throughout the assessment area, in part due to elevation and topographic variation (WRCC 2005).

Thunderstorms average about 12 per year with an occasional severe hailstorm. Hailstorm damage, however, is rarely severe or widespread. Average yearly cloudiness is about 50 percent at Klamath Falls; 130 days are clear, 90 are partly cloudy, and 145 are cloudy. Early morning values of relative humidity average 74 to 83 percent year-round, and the afternoon low values range from 26 to 33 percent in summer and 62 to 74 percent in winter (WRCC 2005).

HYDROLOGY

Two hydrological data sets were not included in this report because of incomplete data. First, the US Geological Survey is currently conducting a study of ground water, which will characterize the ground water system and fill gaps in understanding of the ground water hydrology in the Upper Sprague River subbasin. Unfortunately, this study was still under review at the time of preparation of this assessment report. Additionally, early Department of Water Resources estimates of dewatering potential were omitted from this report because of low confidence regarding methods of estimating natural flow.

Where there is limited water availability, this can influence virtually all aspects of stream and watershed health, from water temperature and pool depth to the quality of the habitat for fish and other life forms. It affects agricultural and domestic water uses and constrains human use of the land and enjoyment of the natural resources. Furthermore, water availability concerns will almost certainly be exacerbated if climate projections are realized. Currently, most natural resource management studies do not include a discussion of climate change unless it is the direct focus of the study. However, there is substantial concern that our climate is warming and that precipitation patterns are changing (IPCC 2001, INR 2004). Such changes would be expected to have important effects on natural resource issues in the Upper Sprague River subbasin.

Current models of the effects of climate change in the Pacific Northwest suggest that maximum snowpack depth may shift to earlier in the year, resulting in earlier maximum streamflow and decreased late-summer flows.

Additional effects may include a lengthening of the growing season, longer fire season, earlier plant flowering and animal breeding, and changes in elevational plant distributions (INR 2004).

Precipitation

The Upper Sprague River subbasin lies in the semi-arid rain shadow east of the Cascade Mountains. The majority of precipitation occurs from October through March. The subbasin receives rain and snow totaling between 10 and 42 inches of precipitation each year, depending on elevation, with the highest elevations receiving the greatest depths (OCS 2006a). Winter temperatures drop below 0º F. Frost and snow may occur in all seasons at all elevations. Although summers are dry, they are characterized by intense localized convective thunderstorms.

The Upper Sprague River subbasin contains seven watersheds (USGS fifth-field) spanning several ecoregions that vary somewhat in their general hydrologic characteristics (Map 3-4). The ecoregions included in the Upper Sprague River subbasin and their hydrologic characteristics are listed in Table 5-1(EPA/Omernik 1995). The Fremont Pine/Fir Forest ecoregion is characterized by the highest amounts of precipitation, while the Klamath Juniper/Ponderosa Pine Woodland ecoregion is the driest.

Peak flows are associated with spring snowmelt and summer rainstorms for all ecoregions, although the Pumice Plateau Forest ecoregion also experiences rain-on-snow events in the spring and sometimes in the summer. Streamflows tend to be slightly higher in the winter and spring than at other times of the year for the Klamath/Goose Lake Warm Wet Basins, Fremont Pine/Fir Forest, and Klamath Juniper/Ponderosa Pine Woodland ecoregions. In the Cold Wet Pumice Plateau Basins, streamflows tend to be highest in the fall. The Pumice Plateau Forest ecoregion experiences high streamflows in both late spring and in the fall and winter for some streams. However, in all ecoregions except the Pumice Plateau Forest ecoregion, some streams experience little variation in runoff values throughout the year (Table 5-1).

There are several types and sources of precipitation information for the Upper Sprague River subbasin. Continuous precipitation records have been collected in the vicinity of the town of Sprague River, just below the Upper Sprague subbasin study area. This record includes some data gaps, but spans a sufficient time period to provide a reliable estimate of average conditions (WRCC 2006). Climatologists at Oregon State University have developed the PRISM model, which estimates average annual precipitation throughout Oregon (OCS 2006b). These data are probably best for estimating precipitation amounts. Finally, the SNOTEL program of the Natural Resource Conservation Service (NRCS) collects data on snow accumulation. There are several SNOTEL stations within the subbasin.

Table 5-1. Hydrologic characteristics of ecoregions within the Upper Sprague River subbasin. (Data Source: ONHP 1995)

Ecoregion	Code	Precipitation	Precipitation Pattern	Runoff Pattern	Peak Flow
Pumice Plateau Forest	(9e)	16 to 30 inches	Most precipitation occurs in the winter months from November to January.	Average monthly streamflows are highest in the late spring and early summer months. Some streams also experience high flow values in the fall and winter.	Primarily spring rain-on-snow, spring snowmelt and spring rainstorms; winter rain-on-snow can also produce peak flows though less commonly.
Cold Wet Pumice Plateau Basins	(9f)	20 to 25 inches	Most precipitation occurs in the winter months of November, December, and January.	Average monthly streamflows tend to be higher in fall, although some streams experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.
Klamath/ Goose Lake Warm Wet Basins	(9g)	10 to 18 inches; up to 40 inches in higher elevations.	Most precipitation occurs in the winter months, predominately in November and January.	Average monthly streamflows tend to be slightly higher in winter and spring; many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.
Fremont Pine / Fir Forest	(9h)	15 to 40 inches	Majority of the precipitation occurs during the winter and early spring months from December to April.	Average monthly streamflows tend to be slightly higher in winter and spring, although many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.
Klamath Juniper / Ponderosa Pine Woodland	(9j)	12 to 20 inches	Most precipitation occurs in the winter months, predominately in November and January.	Average monthly streamflows tend to be slightly higher in winter and spring, although many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.

Figure 5-1 presents average annual precipitation by year (WRCC 2006). Although the record extends from 1953 through 2001, we have removed years in which more than five consecutive days of data are absent in a single month, in the interest of maintaining consistency and accuracy. Average annual measured precipitation at Sprague River is 17 inches, but may be less in parts of the assessment area. Annual precipitation has been below average since 1999 with the exception of 2004 and 2006. Average monthly precipitation as measured at Sprague River is presented in Figure 5-2. December typically has the most precipitation and July has the least. Four months, November through February, account for 63 percent of annual precipitation.

The PRISM model was developed by researchers at Oregon State University (OSU) to estimate climatological conditions across the state of Oregon (Daly et al. 1994, OCS 2006b). The GIS precipitation data available from OSU for the Upper Sprague River subbasin are shown in Map 5-1. Mean annual precipitation ranges from 15 inches near Beatty to 47 inches in the upper elevations of the Sycan Marsh watershed near Partin Butte. The average annual precipitation for the watershed as a whole, as estimated by PRISM, is approximately 24 inches, but varies considerably among the constituent watersheds. The precipitation characteristics modeled by PRISM for the watersheds are provided in Table 5-2.

Winter precipitation typically falls as snow and accumulates throughout the Upper Sprague River subbasin. Snow pack data were obtained from the Natural Resource Conservation Service (NRCS 2006) for approximately the last 25 years at four SNOTEL snow survey sites near the subbasin. These are listed in Table 5-3, and shown on Map 5-2. Annual snow pack is quite variable from year to year. Table 5-4 shows the minimum, maximum, and average snow pack for the four snow survey sites. Figure 5-3 illustrates the peak annual snow pack for the period of record for the four area snow survey sites. Although the greatest amount of precipitation typically occurs in December (based on the Sprague River data), maximum snow accumulation typically occurs in February, as measured at Taylor Butte (Figure 5-4). The maximum snow accumulation for the period of record, 38.9 inches in 1993, occurred at Summer Rim the same year that maximum accumulation occurred at Taylor Butte and Silver Creek.

Ground Water

Subsurface geology in the Sprague River valley is complex, and ground water dynamics are not well understood. Studies are currently underway by the U.S. Geological Survey to attempt to clarify ground water relationships in the Sprague basin (USGS 2006). The information for the material below was taken from a report prepared in 1974 (Leonard and Harris 1974). Although conditions may have changed since that time, currently this is the best information available. Also, it provides a useful introduction to a complex issue.

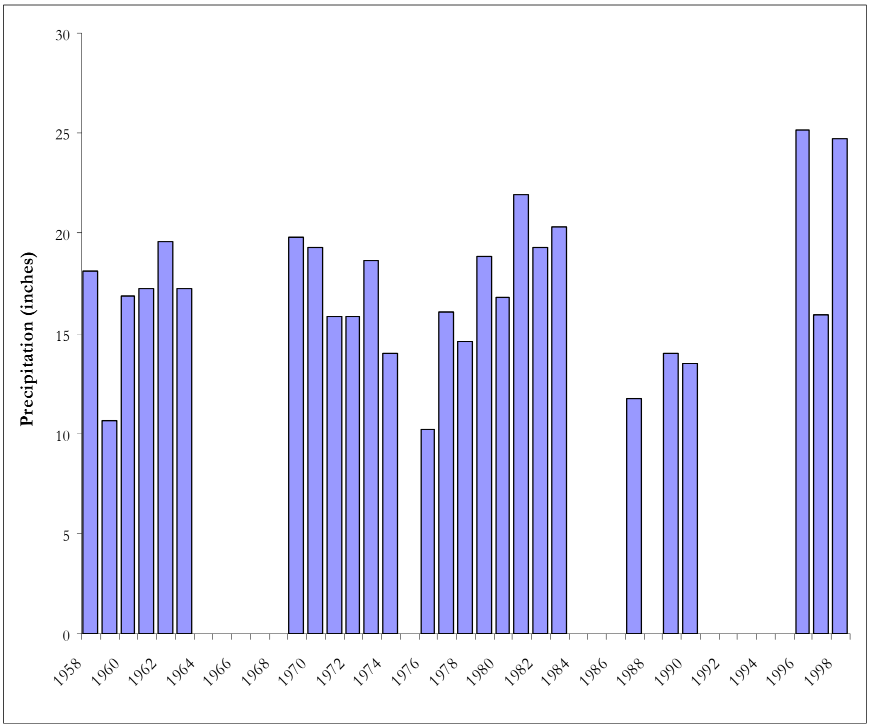


Figure 5-1. Annual precipitation measured at Sprague River, Oregon (Station 358007) from 1958 through 1998 showing long-term patterns in regional precipitation. (Data Source: WRCC 2006)

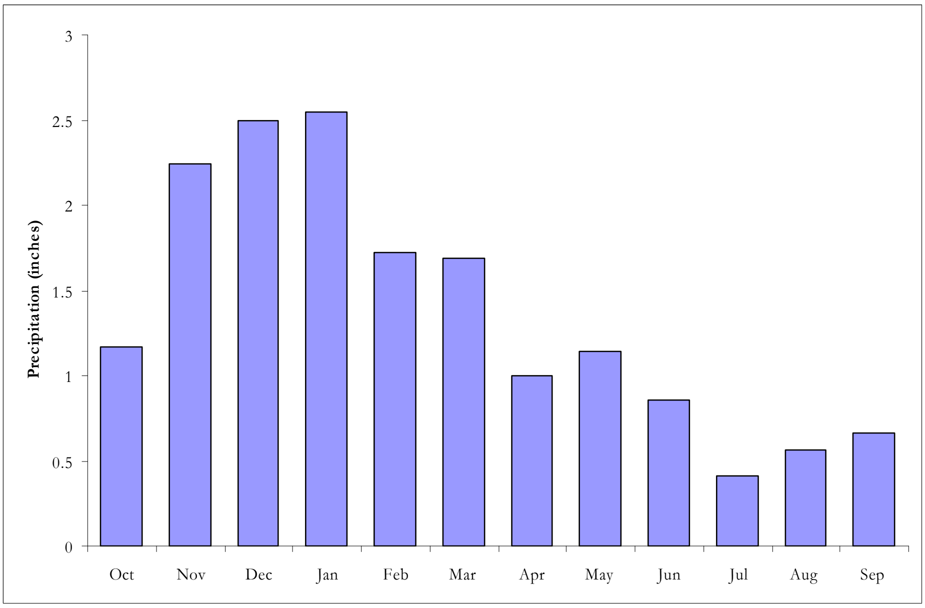
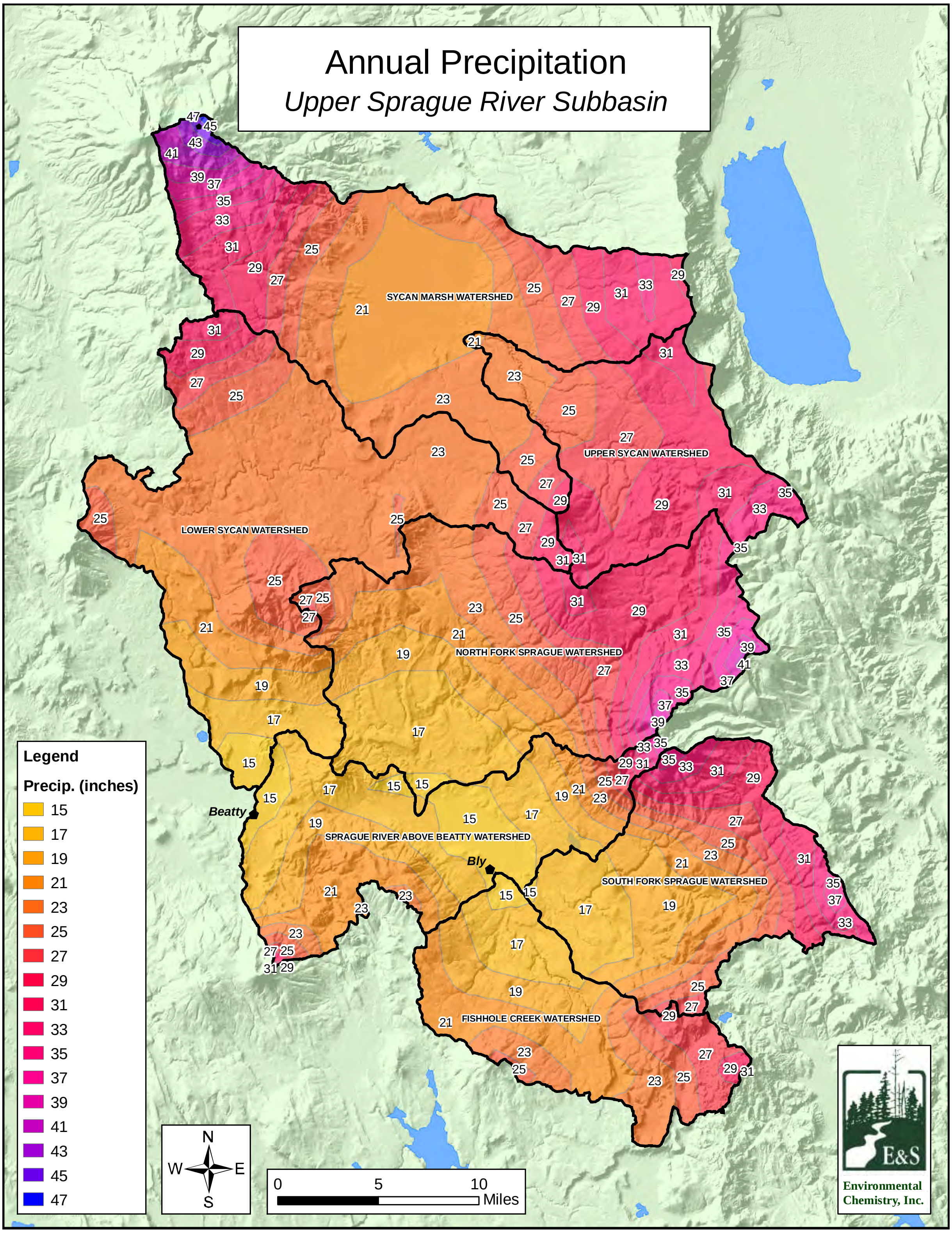
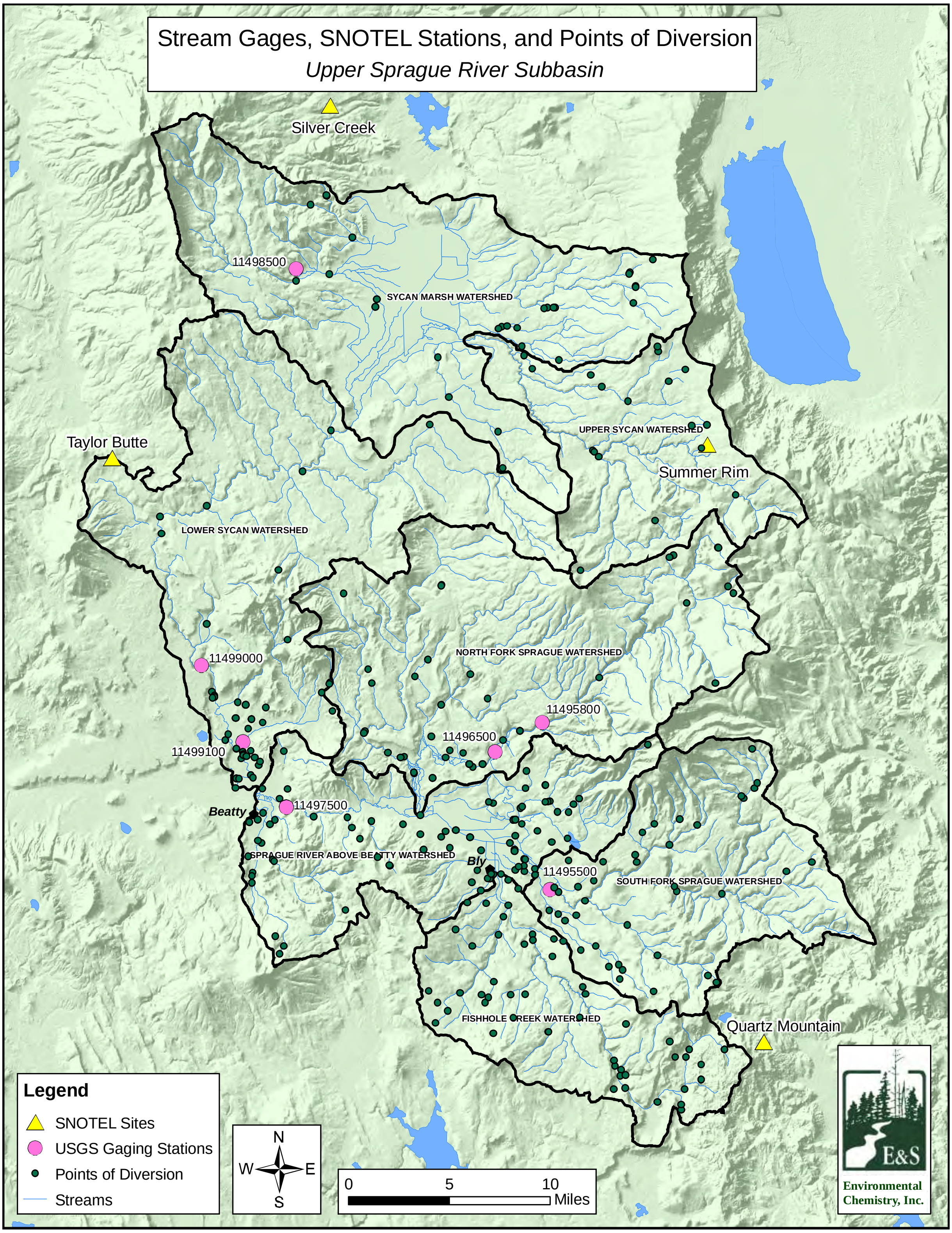


Figure 5-2. Annual distribution of precipitation as shown by average monthly precipitation at Sprague River, Oregon (Station 358007) from 1958 through 1998. (Data Source: WRCC 2006)



Map 5-1. **Modeled annual precipitation, using the PRISM model. (Data Source: OCS 2006b)**



Map 5-2. Locations of stream gages, SNOTEL stations, and points of diversion in the Upper Sprague River subbasin. (Data Sources: NRCS 2005, NRCS 2006, OWRD 2006)

Table 5-2. PRISM annual precipitation values for watersheds of the Upper Sprague River subbasin. (Data Source: OCS 2006b)

Watershed	Minimum Precip. (in.)	Average Precip. (in.)	Maximum Precip. (in.)	Minimum Elevation (ft.)	Maximum Elevation (ft.)	Area (sq. mi.)
Sprague River Above Beatty	15	19	39	4,308	8,265	129.7
North Fork Sprague	15	24	41	4,321	8,373	208.1
South Fork Sprague	15	24	37	4,360	8,166	128.3
Fishhole Creek	15	21	31	4,341	7,067	101.6
Lower Sycan	15	23	31	4,305	7,130	231.6
Sycan Marsh	21	26	47	4,967	8,127	224.4
Upper Sycan	21	28	35	5,007	7,563	102.7

Table 5-3. Snow survey sites in the vicinity of the Upper Sprague River subbasin. (Data Source: NRCS 2006)

Site Name	Site ID	Elevation	County	Land Ownership	HUC	Latitude (degrees)	Longitude (degrees)	Installed in Water Year	Site Aspect
Silver Creek	21F12S	4,900	Lake	Fremont NF	17120005	42.95	121.18	1981	-
Summer Rim	20G02S	7,100	Lake	Fremont NF	18010202	42.70	120.82	1979	N
Taylor Butte	21G03S	5,100	Klamath	Winema NF	18010201	42.70	121.40	1979	-
Quartz Mountain	20G06S	6,300	Lake	Fremont NF	18020001	42.27	120.78	1981	W

Table 5-4. Minimum and maximum snow accumulation (snow water equivalent, inches) for nearby snow survey stations. (Data Source: NRCS 2006)

Station	Minimum (year)	Maximum (year)	Average
Summer Rim	9.6 (2001)	38.9 (1983)	19.7
Taylor Butte	2.3 (1979)	15.4 (1993)	7.3
Silver Creek	4.1 (1981)	26.9 (1983)	11.7
Quartz Mountain	1.8 (2005)	17..2 (1993)	6.8

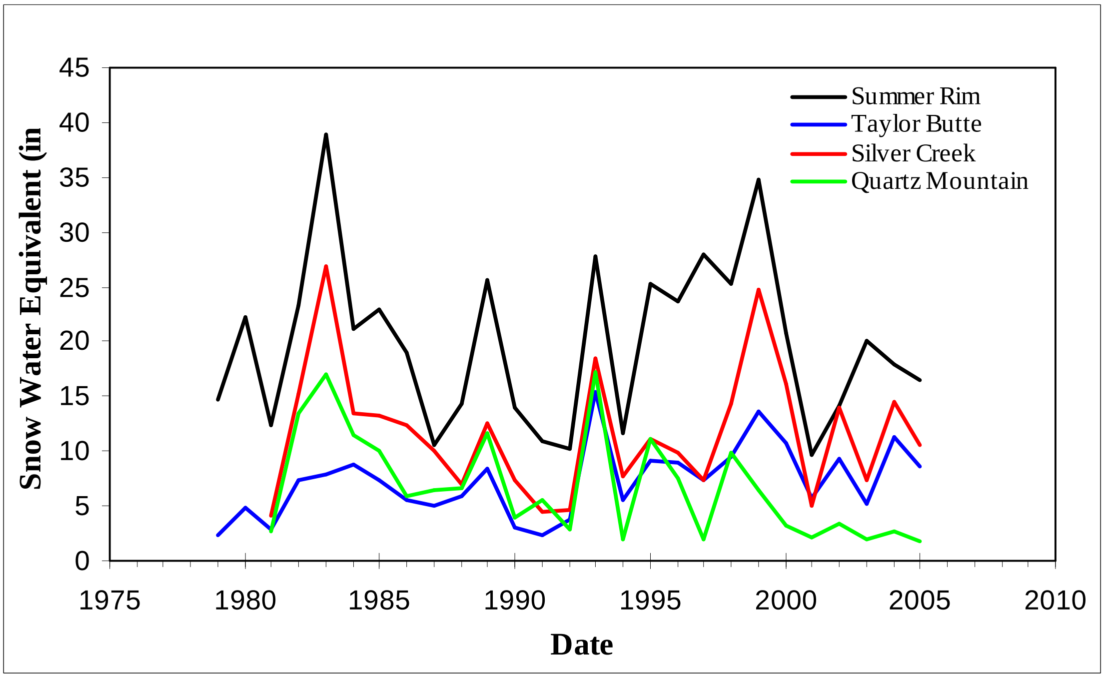


Figure 5-3. Maximum annual snow pack (snow water equivalents) at snow survey sites in the vicinity of the Upper Sprague River subbasin. (Data Source: NRCS 2006)

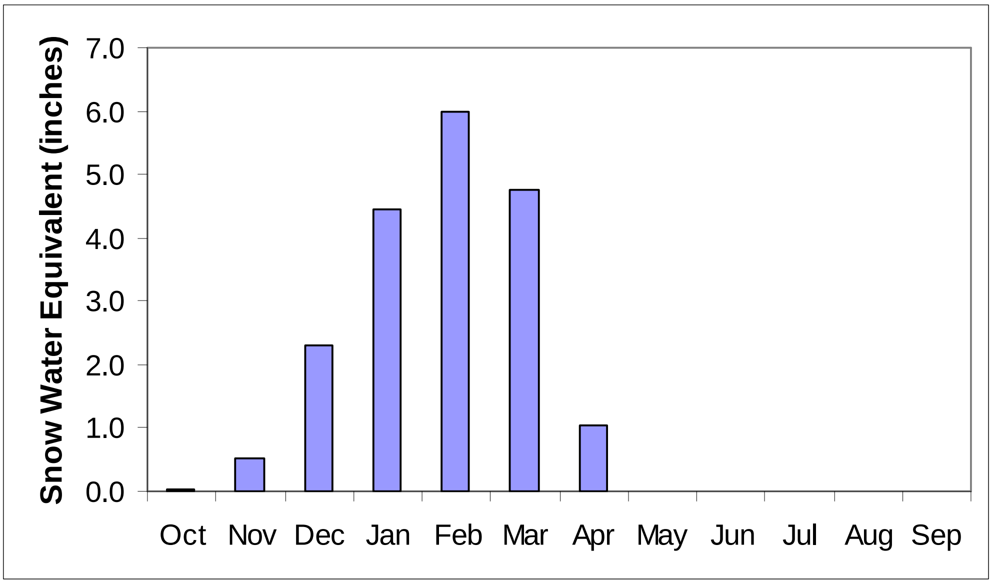


Figure 5-4. Average monthly snow pack (snow water equivalents) measured at Taylor Butte in 1979 through 2005. (Data Source: NRCS 2006)

The source of most ground water in the Klamath Basin as a whole is precipitation that falls within the basin and infiltrates into the ground, largely in the mountains. The porous pumice and fractured volcanic rocks in the mountains readily absorb precipitation and transmit it toward the lowland areas. Within the assessment area, infiltration and recharge are greatest in the headwaters to the north and east (Graham Matthews, pers. comm. 2007)

Part of the ground water occurs in a relatively shallow zone under water-table or perched conditions, and part in a deeper zone, largely under confined conditions. Ground water in the shallow zone generally moves a relatively short distance from its source before it is discharged through springs along the mountain slopes.

A large part of water that infiltrates into the ground seeps downward to deep zones and moves laterally toward and beneath the lowlands. Where favorable permeable zones for fracture are intersected by streams, some of this water is discharged into the stream by springs. The general movement of ground water in the deeper zone is from north to south and from the uplands toward the valleys. At least some of the lowlands are areas of discharge, where ground water is discharged by upward seepage from confined aquifers and through springs.

Inflow to the lowlands of the Sprague River valley is largely from the north and east, although some ground water moves toward the valley from the southeast and south. There is also a downstream component of ground water movement within the lowland area.

Artesian wells were developed in a broad area from near Beatty to the town of Sprague River and in lower Sycan River valley. Some wells are in use, some have been effected by changes in local hydrogeology, and some have been capped and are not currently being utilized. The current status of the wells was unavailable. At least 35 flowing wells existed in this area in the 1970s (Leonard and Harris 1974). The United States Geological Survey is, as of this printing, conducting studies of groundwater dynamics in the area. There is also other sources of data pertaining to wells and groundwater, which are currently unavailable due to ongoing water rights adjudication.

Along the Upper Sprague River there are ground-water discharge areas. However, seepage is not uniform, but is concentrated in a few parts of the valley. Seeps and large springs are the principal sources of discharge. Based on findings from a detailed study of the river in 1970 (Leonard and Harris 1974), the river gains about 25 cubic feet per second (cfs) from ground-water inflow in the marshy area east and north of Bly. The river also gains about 41 cfs in the constricted reach just east of Beatty, in addition to 14.6 cfs from Medicine Springs and 4 cfs from Spring Creek. In the 54 mile reach from Braymill to east of Bly, ground water inflow to the Sprague River is 124 cfs (about 90,000 acre feet per year), most of which is concentrated in a few spring areas and where the valley is constricted east of Beatty and west of the Town of Sprague River. It is also believed that groundwater pumping by irrigators contributes to surface flows in these reaches, but there is currently little data available to support this assertion. What data there is is unavailable due to ongoing litigation.

Stream Flow

The hydrology of the Upper Sprague River subbasin is unique and complex. It includes large marshes, numerous small wetlands, and springs, along with complex patterns of ground water discharge. Streamflow is supplied primarily by snowmelt and ground water, and many small streams dry up in the summer, especially in the western half of the subbasin. In other parts of the subbasin, such as in the North Fork and South Fork Sprague watersheds, streams receive substantial groundwater inputs, maintaining cool water temperatures throughout the summer and fall.

Streamflow can be influenced by precipitation patterns and amounts, snowpack development and melting, vegetation conditions, pumping of groundwater to the surface, water loss to the atmosphere through evapotranspiration (ET), and by the condition of the soil profile (freezing, etc) during precipitation events. ET includes water loss by evaporation from water bodies and the soil, and also loss from plants via transpiration.[1]

In addition to climatic limitations on the availability of water, some human activities have affected the limited water supply. These may have included ecological changes that have contributed to denser and more extensive forest ecosystems, major diking and dredging of stream channels, reduction in the amount of wetlands, construction of water impoundments, widening of stream channels, and increased water use. As of this writing, there is no data quantifying or even confirming this impact. Changes in forest age, distribution and species composition typically result in changes to the hydrologic regime, although the data pertaining to such changes in the assessment area have not been collected. . Changes to riparian areas may also have affected the hydrology of the streams. The net effect of different riparian plant communities on streamflow, in comparison to irrigated plants such as pasture grasses and hay, is not well understood. A stream system that is in proper functioning condition (PFC) can store a large amount of water in the soil and deep root systems of riparian plants in the floodplain and riparian zone. However, the rate of water loss by ET for some native plants is higher than irrigated plants. Consequently, it is difficult to state with certainty how changing the vegetation community will ultimately affect streamflow.

There are four reports available on the hydrology of the Sprague River, and at times their conclusions differ:

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[1] Plants exchange oxygen and carbon dioxide with the atmosphere through tiny pores called stomata. When stomata open to allow gas exchange, the plant also loses some water to the atmosphere through the process called transpiration.

The USGS completed an assessment of the Williamson and Sprague Rivers streamflow data using three statistical techniques: trend tests, double mass curves, and two sample tests. The trend test showed no significant increasing or decreasing streamflow trends. The double mass curve technique and the two sample test of the Sprague River annual runoff showed a significant increase in runoff for the period 1951-1996 compared to the period 1922-1950 at the Sprague River at Chiloquin gage. The climate data showed no significant difference between the two periods, suggesting the possibility of human activities as a cause of the difference in runoff between the two periods. During the past century, the cumulative effects from various land-use activities could have resulted in the observed changes in streamflow. However, they were not able to relate specific land-use activities to those changes because of the size and geologic complexity of the catchment, and to the small amount of historical land- and water-use data (Risley and Laenen 1999).

Oregon Department of Environmental Quality (2002) summarized the work by Risley and Laenen (1999), and suggested that irrigated acreage cannot explain the increase in water yields, but other associated landscape modification that accompany irrigated crop cultivation and livestock grazing may offer an explanation, such as decreased summertime evapotranspiration, increased runoff rates, reduced infiltration, and reduced riparian, floodplain and wetland water storage. The state that there was a decrease in timber harvests in the post 1950's period, therefore, it is more likely that the combined effects of hydrologic disturbance that have increased water yields in the Williamson and Sprague River subbasins are related to agricultural activities in the drainage.

To estimate the effects of agricultural development on streamflows, Bureau of Reclamation used various hydrologic models and statistical techniques to study the flows of the upper Klamath River 1949-2000. Like Risley and Laenen (1999), they found no statistically significant increasing or decreasing trends. Unlike Risley and Laenen (1999), their double mass curve results showed no significant changes, and they concluded that Sprague River streamflow is unaltered by agricultural activities (BOR 2004 and BOR 2005).

Graham Matthews and Associates 2007 in press used HEC FFA Flood Frequency Analysis to calculate flood magnitude and frequency for gages with at least 10 years of record. They used the Indicators of Hydrologic Alteration Analysis (IHA) program developed by The Nature Conservancy to analyze trends and differences in daily and peak high and low flows in the streamflow record. Their analysis agreed with the conclusion in Risley and Laenen 1999 that annual surface water flow in the Sprague River has increased since 1950.

Changes to riparian areas may also have contributed to the cumulative effect on hydrology of the streams. Degraded riparian conditions can lead to channel widening, decreased depth, channel straightening, increased gradient and stream energy, and increased erosion rates, therefore influencing water storage, aquifer recharge, flood attenuation, and late season flows (IMST 2007 in press). Healthy riparian vegetation contributes to good above ground biomass, root growth and root strength in streambanks. If the rooting strength of riparian vegetation and the surface roughness is sufficient, sediments will be deposited, not eroded (National Research Council 2002). Reduction in root mass through removal of riparian vegetation can lead to increased bank erosion and sedimentation rates (Kleinfelder et al. 1992, Michelli and Kirchner 2002, Wynn et al. 2004). If streambanks are excessively eroded, there is a loss of pore space for water storage, as well as less hydrologic connection to the frequent floodplain. There is some controversy about evapotranspiration because there is concern that the rate of water loss by ET for some native riparian-wetland plants may be higher than irrigated plants. Because of the difficulty of measuring and interpreting cause and effect with the gage data (as demonstrated by Risley and Laenen 1999), it is difficult to state with certainty how changing the riparian vegetation community will ultimately affect streamflow in the Sprague River. However, several case studies in Central Oregon and Northern California have shown that in streams flowing through wide valley bottoms with fine grained soils, riparian-wetland vegetation with strong and deep root masses interacts with the soil and water to create a narrower, deeper, more sinuous channel, and thus frequent floodflows stay connected to their associated floodplain. The pore spaces in the soils that are held together or built from sediment capture store more water than is transpired, and has led to releasing some part of the stored water over a longer period of time to the channel (Elmore, personal communication 2006).

Six USGS stream flow gages collect stream discharge (flow) data in the Upper Sprague River subbasin. They are listed in Table 5-5 and illustrated on Map 5-1. Of the six gage records, several were inadequate for the purposes of this assessment because they had few data or the record was repeatedly interrupted. For that reason, this discussion of stream flow is based largely on the stream flow records from the Sprague River near Beatty (Gage No. 11497500), the Sycan River below Snake Creek (Gage No. 11499100), and the North Fork Sprague River at Power Plant (Gage No. 11495800; OWRD 2005).

Table 5-5. Stream flow records from the Upper Sprague River subbasin. (Data Source: OWRD 2005).

Gage Number	Gage Name	Period of Record
11499000	Sycan River Near Beatty	04/1917~09/1925
11499100	Sycan River Below Snake Creek Near Beatty	10/1973~09/2003
11497500	Sprague River Near Beatty	04/1912~09/2003
11495500	South Fork Sprague River Near Bly	03/1925~09/1926
11496500	North Fork Sprague River Near Bly	04/1925~09/1926
11495800	North Fork Sprague River at Power Plant Near Bly	05/1993~09/2004

The annual cycle of discharge in streams in the Sprague River basin is offset from the annual precipitation cycle because much of the precipitation falls as snow and accumulates until spring when it melts (See figure 5-8). Peak discharge in basin streams usually occurs in the spring, well after the period of maximum precipitation. However, maximum discharge can be influenced by rain-on-snow events which can occur at any time throughout the winter and spring depending on local climatic events. Monthly flows for streams in the Upper Sprague River subbasin are illustrated in Figure 5-5. Peak flows in the North Fork Sprague River and Sprague River near Beatty typically occur in May, whereas peak flow in the Sycan River occurs in April. Minimum flow at all three gages occurs in August and September. The North Fork Sprague River exhibits a much steeper rise from low flow to peak flow than either the Sprague River near Beatty or the Sycan River, with relatively low flow persisting through March followed by a steep rise to peak flow in May. In contrast, flows in the Sprague River near Beatty and the Sycan River typically begin increasing in December and gradually increase to the peak flow. Low precipitation during the summer leads to markedly low flow in basin streams decreases precipitously after the peak and all three sites are near minimum flow by July.

Low Flow

The dependence of flow on snow melt combined with a lack of substantial summer precipitation typically results in low streamflows in the late summer. Only 15 to 17 percent of average annual flow occurs in the Sprague River near Beatty and the North Fork River at Power Plant from July through October (See Fig. 5-8). In the Sycan River below Snake Creek, only about six percent of average annual flow occurs during the same period. Minimum daily average flow during July through October is about 58 percent of normal daily flow in the Sprague River near Beatty, about 63 percent of normal daily flow in North Fork Sprague at Power Plant, and about 53 percent of normal daily flow in the Sycan River below Snake Creek for the period of record. The low flow history in the Sprague River near Beatty and Sycan River below Snake Creek is summarized in Figure 5-6. The available data show several drought cycles, with lowest flows occurring around 1955, 1981, 1994, and 2002 (OWRD 2005).

Peak Flow

Annual peak flows of streams within the Upper Sprague River subbasin can occur during winter, spring, or summer. Furthermore, peak flows can occur in response to rain, rain-on-snow, or snowmelt events. An investigation of the hydrology of the southern Cascades region, including the Upper Sprague River subbasin (WPN 1999), identified that 57 percent of all annual peak flow values recorded at the 19 flow monitoring stations in the southern portion of the East Cascades ecoregion occurred in the spring months, while 25 percent occurred during winter. Of the 19 stations, 8 showed clearly that spring peak flows were most common. While a few sporadic winter peaks

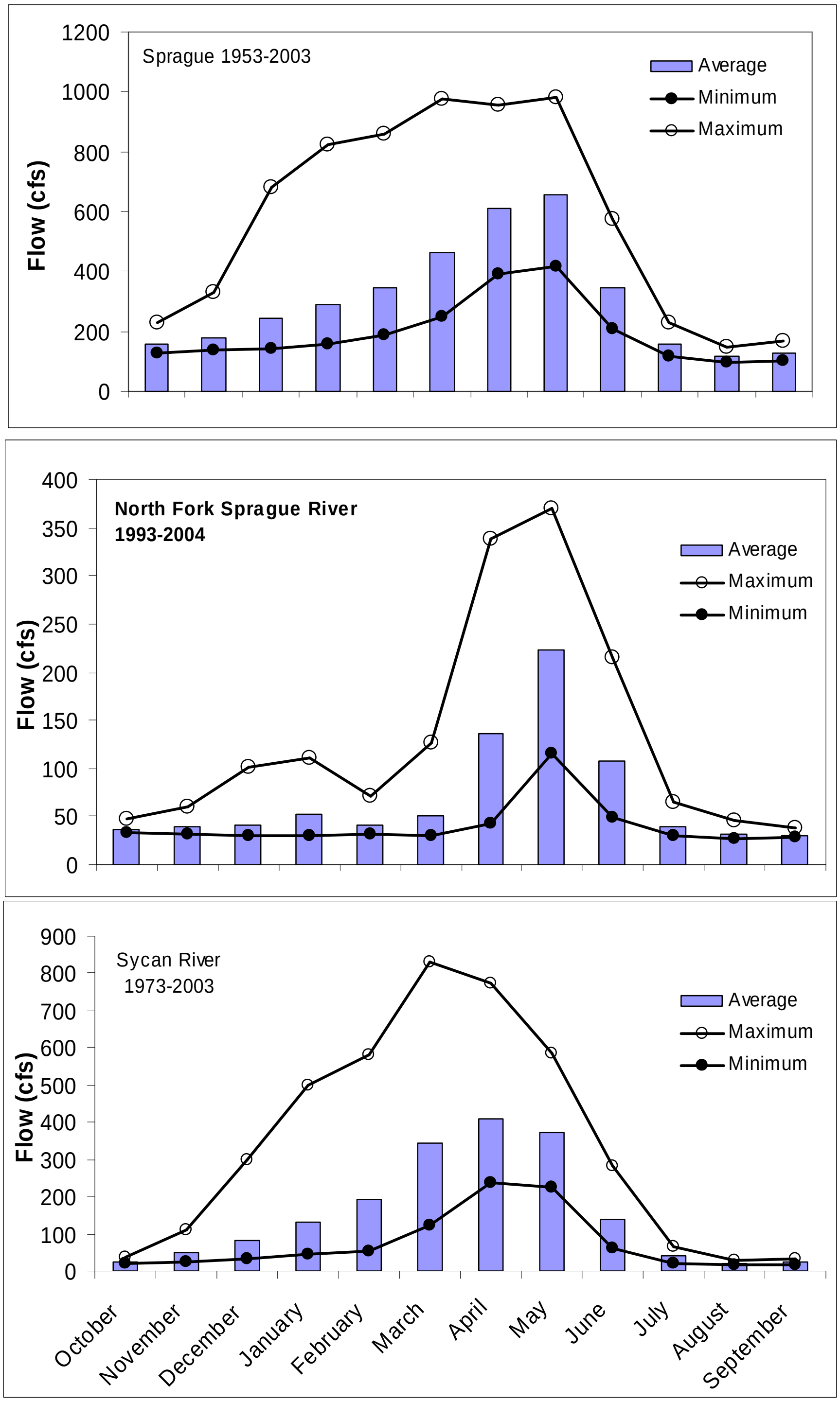
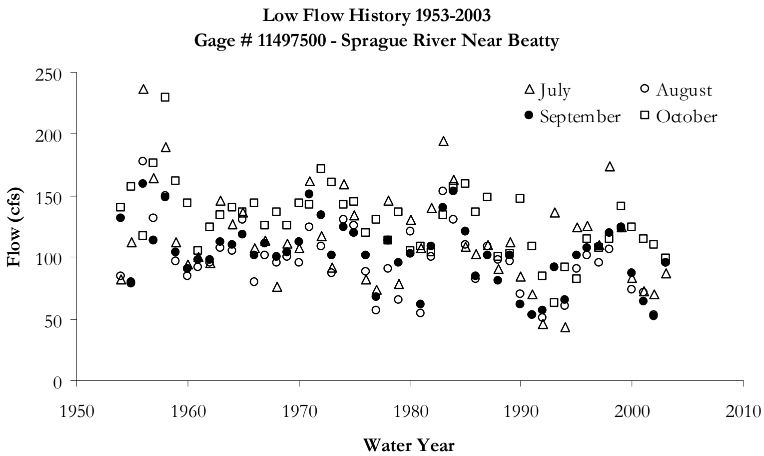


Figure 5-5. Monthly stream flow throughout the period of record in the Sprague River near Beatty (Gage 11497500, top), the North Fork Sprague River at Power Plant (Gage 11495800, center), and the Sycan River below Snake Creek (Gage 11499100, bottom). (Data Source: OWRD 2005)

occurred in the annual peak flow series at four of these 8 stations, peak flows of all magnitudes at these sites occurred almost exclusively during spring. Peak flows are usually associated with a warm spell and rain-on-snow events. Nine streamflow stations showed some sort of mix of peak flow occurrence between the winter and spring seasons. The majority of these mixed stations experienced the largest flows during the winter months. In combination, the spring snowmelt and spring rain or rain-on-snow events accounted for slightly more peak flows than did winter rain and rain-on-snow processes. Summer rainstorms were also identified as a regular producer of annual peak flows in some streams.

Peak flow patterns for the two stations with the most comprehensive flow data are illustrated in Figure 5-7. The two largest flow events recorded for the Sprague River Near Beatty, 1964 (5670 cfs) and 1997 (5720 cfs), were the result of rain-on-snow events. Flow duration curves for the Sprague River near Beatty, showing the flow that was equaled or exceeded for a given percent of time, are included in Figure 5-8 (OWRD 2005).



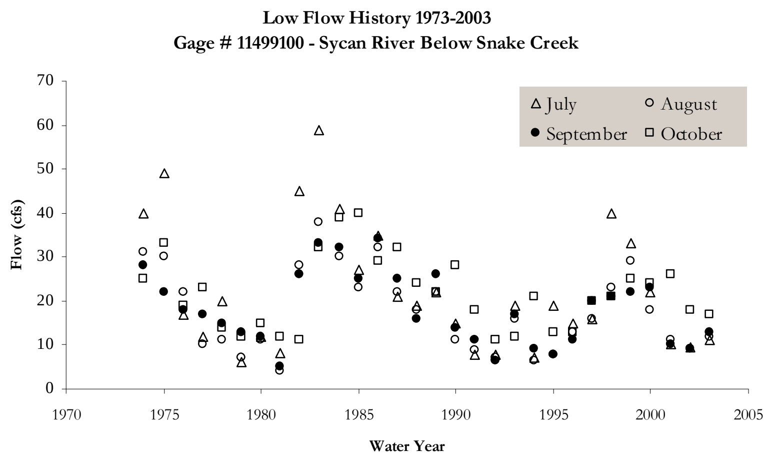


Figure 5-6. Low flow history for the period of record for the Sprague River near Beatty (top) and the Sycan River below Snake Creek (bottom). (Data Source: OWRD 2005)

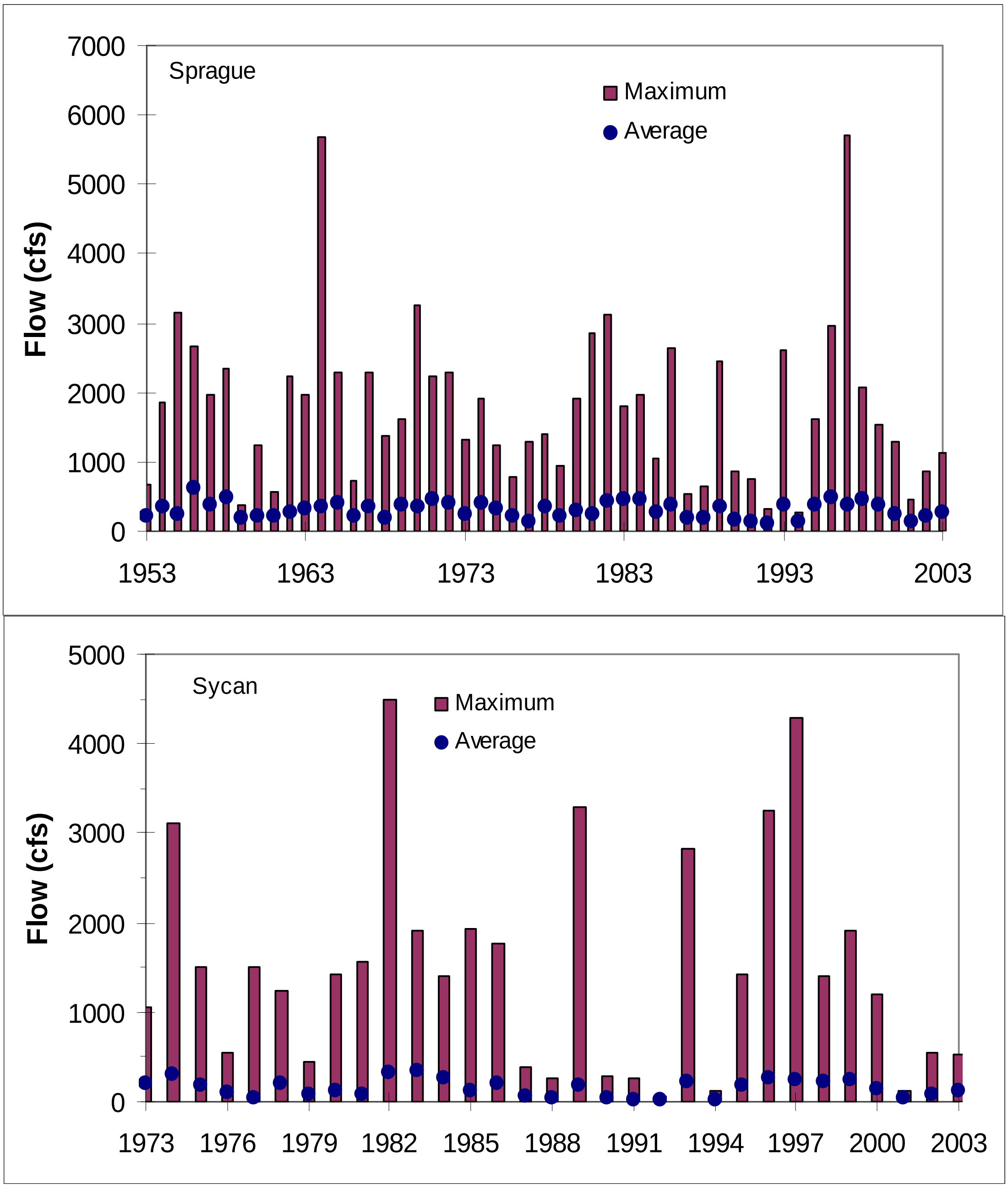


Figure 5-7. Annual peak flow measured in the Sprague River near Beatty (Gage No. 11497500, top), and in the Sycan River below Snake Creek (Gage No. 11499100, bottom). (Data Source: OWRD 2005)

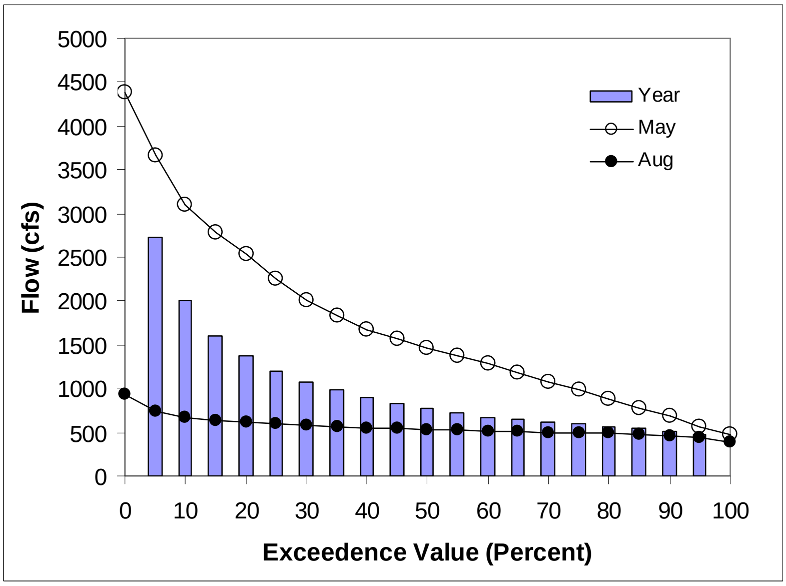


Figure 5-8. Flow duration curves for the Sprague River near Beatty for the most common high-flow month (May), low flow month (August), and the annual average daily flow. The curves indicate the flow that was equaled or exceeded for the indicated percent of time. (Data Source: OWRD 2005)

WATER USE

This section presents information on water use within the Upper Sprague River subbasin. Under Oregon law, most available water is publicly owned (Bastasch 1998). A water right entitles a person or organization to withdraw publicly-owned water for a specific type of use, for example, domestic use, livestock watering, or irrigation. The Oregon Water Resources Department (OWRD) issues water rights to both private and public users through a permitting process (Bastasch 1998). In Oregon, water rights are distributed according to the "principle of prior appropriation", which means that older water rights have priority over newer ones. If water becomes scarce during dry years, the holders of the most recently issued water rights will be the first who are required to cease withdrawing water to ensure that an adequate supply is available for the holders of more senior water rights (OWRD 2001).

Regional stakeholders are currently involved in a contested water rights adjudication. In the attempt to support their respective claims, various stakeholders have produced data and information on hydrology and water use. Because each of these entities is a claimant in the ongoing adjudication, the data they have produced is frequently disputed by entities with competing claims.

Water is withdrawn for a broad array of beneficial uses. Water is used to grow crops or forage for livestock. Towns and cities withdraw water, as do rural residents, for domestic use. Water is also required by the fish and other organisms that live in the streams. Frequently, the need for water for a multitude of beneficial uses results in conflicting opinions on how priorities should be set.

Consumptive Water Use

In this section, we summarize information regarding the maximum diversion rate permitted for consumptive use, which is available from OWRD's website (OWRD 2006). This represents the maximum potential diversion from all surface water right permits, not necessarily the amount that is actually used. The actual amount diverted for use varies seasonally and from year-to-year, and is usually less that the maximum allowed amount. Consumptive water use does not include groundwater or storage (i.e. wells or reservoirs). In-stream water rights are also excluded from these analyses because they do not entail removing water from the hydrologic system, but are discussed in the subsequent section.

Water quantity and availability within the subbasin are challenging topics without easy solutions when multiple uses compete for a finite water supply that varies widely from year to year. There can be confusion regarding water use data. Permitted flow rates for water withdrawal do not provide an accurate indication of the amount being withdrawn, which varies seasonally, because not all permit-holders use all of their allocated water. Also, much of the withdrawn water returns to the stream, and in many cases is be withdrawn again by another downstream user (Cooper 2002). Ground water pumping may augment stream flows. The effects of the timing and location of withdrawal are additional considerations.

The following water uses may not require a water right: natural springs, stock watering, salmon propagation, fire control, forest management, and rainwater collection (OWRD 2001). Groundwater uses that are usually exempt include stock watering, lawn and garden watering (less than one-half acre), and domestic water uses of no more than 15,000 gallons per day.

OWRD also approves in-stream water rights, which are rights that keep water in the stream for the benefit of fish, minimizing the effects of pollution, or maintaining recreational uses (OWRD 2001). In-stream water rights designate monthly flows, and are regulated in the same manner as other water rights. They do not guarantee that a certain quantity of water will be present in the stream, because they cannot affect a use of water with a senior priority date (OWRD 2001).

If water has been continuously used since before the establishment of water laws in Oregon in 1909, the property owner may have a "vested" water right. These uncertified rights, or "claims", can be found valid in a judicial (court) process known as adjudication. The process of adjudicating

In addition to many landowners' fears about outcomes of the adjudication, many fear changes in power rates. Butch and Rod Hadley of the Hadley Ranch in Bly, Oregon share that "our biggest damn fear is the power, because we're all pump [irrigation]. And we'll just have to quit if the rates go up the way they are talking. We can't afford an increase like that. We use sprinklers on one side, and flood [irrigation] on the other. If we get the high power rates, we'll probably junk the wheel lines and then flood instead… who knows with the rates they're talking about what will be feasible" (pers. comm. January 24, 2007).

water rights is currently underway in the Sprague River basin on lands that were formerly part of the Klamath Indian Reservation. The area outside of the former reservation is not included in the on-going adjudication process, as that area has already been adjudicated. But while most of the land under adjudication lies outside the assessment area, the adjudication will inevitably have direct and indirect impact on the assessment area. Once the adjudication process is complete, OWRD will issue water right certificates for each decreed right (OWRD 2001).

Information on water rights that have been adjudicated or permitted is available from the OWRD. OWRD provides online access to databases including the Water Rights Information System (WRIS) and the Water Availability Reporting System (WARS). Using the WRIS database, it is possible to download a list of water rights or claims for drainage basins within Oregon. However, this list may change in the Upper Sprague River subbasin as a result of the ongoing adjudication process.

A consumptive use is defined as any water use that causes a net reduction in stream flow (Cooper 2002). Oregon Revised Statute (ORS) 536.340 authorizes the Water Resources Commission to classify water for beneficial use. A classification indicates the uses for which new water permits can be issued, including domestic, municipal, irrigation, power development, industrial, mining, road construction, manufacturing, recreation, wildlife, fish, and pollution abatement. These uses are usually associated with an evaporative or transpirative loss, or the water may be withdrawn from the system (Cooper 2002).

Water uses are generally not considered to be 100 percent consumptive. Consumptive use is estimated by multiplying a consumptive use coefficient (e.g., for domestic use, the coefficient is 0.20) by the maximum diversion rate allowed for the water right. The OWRD assumes that all of the non-consumed part of a diversion returns to the stream from which it was diverted (Cooper 2002). The exception is when diversions are from one watershed to another, in which case the use is considered to be 100 percent consumptive (i.e., the consumptive use equals the diversion rate; Cooper 2002). Locations where water is withdrawn for consumptive use are referred to as points of diversion. Points of diversion are broadly distributed throughout the assessment area, although the highest density is in the lower elevations of the study area (Table 5-6, Map 5-2). According to the OWRD database, there are 391 points of diversion in the Upper Sprague River subbasin. The Sprague River Above Beatty Watershed has the most points of diversion, at 109. North Fork, Fishhole Creek, and Lower Sycan watersheds each have more than 60 points of diversion. The Upper Sycan Watershed has the least points of diversion, at 18. It should be noted, that more than one water right may be associated with a single point of diversion, so the number of points of diversion does not correspond to the total number of water rights in the subbasin.

Table 5-6. Number of points of diversion by watershed in the Upper Sprague River subbasin. (Data Source: OWRD 2006)

Watershed	Number
Sprague River Above Beatty Watershed	109
North Fork Sprague Watershed	61
South Fork Sprague Watershed	41
Fishhole Creek Watershed	65
Lower Sycan Watershed	67
Sycan Marsh Watershed	30
Upper Sycan Watershed	18
Total	391

Figure 5-9 presents the distribution of the amount of permitted surface water use for each watershed in the Upper Sprague River subbasin. Eighty-four percent of water allocated for consumptive use is from three watersheds in the Upper Sprague River subbasin (Figure 5-9). The Sprague River Above Beatty Watershed accounts for the largest proportion, at 34 percent. The North Fork Sprague Watershed is second at 27 percent, and the South Fork Sprague Watershed constitutes 23 percent. The smallest proportion of surface water is allocated for consumptive use in the Upper Sycan Watershed, accounting or less than one percent (Figure 5-9; OWRD 2006).

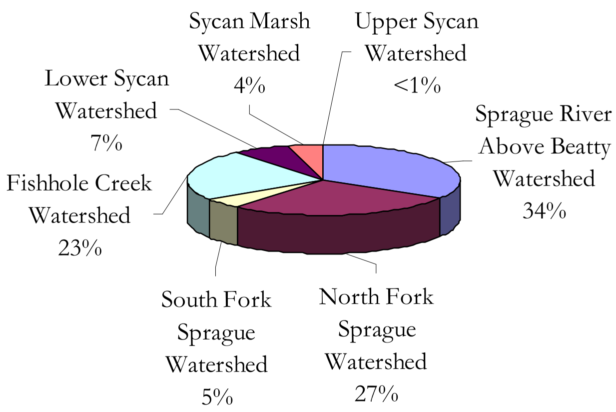


Figure 5-9. Distribution of maximum potential surface water use by watershed, based on the permitted flow rates of water rights (not including in-stream water rights). These data are not indicative of actual water use. (Data Source: OWRD 2006)

There are six major categories of water use in the Upper Sprague River subbasin: commercial, domestic, fish culture, irrigation, livestock, and road construction (Table 5-7). Irrigation accounts for the majority (85.9 percent) of the permitted water diversion in the Upper Sprague River subbasin, most of which occurs in the Sprague River Above Beatty Watershed. Livestock use is the second largest consumptive use category, accounting for 12.8 percent. Commercial, domestic, fish culture, and road construction each account for less than one percent (OWRD 2006).

In-stream Rights

Water that is withdrawn from a stream has the potential to affect in-stream habitat for aquatic organisms by changing flow or dewatering the stream. Some of the water that is removed from the channel for irrigation is permanently lost from that stream as a result of plant transpiration and evaporation. Some is returned to the stream channel. The permanent removal of water from the stream channel lowers the in-stream flows. Water can also be added to the stream channel via pumping of groundwater. Possible effects of changes to water availability include altered water quality, the creation of fish passage barriers, and altered habitat quality for aquatic organisms. Due to the issues discussed at the beginning of this chapter, we do not make an effort in this assessment to quantify either the removal of water from the system through consumptive use or any increase in water that may occur from groundwater pumping.

In-stream water rights were established by ODFW throughout much of the subbasin in 1990 to prevent additional withdrawals in order to retain water in the stream for fish and other aquatic species. Because these water rights are junior to the majority of the consumptive water rights, there is no guarantee that in-stream rights will be met. Flow of the Sprague River near Beatty falls below the designated in-stream water right for resident fish habitat only infrequently, most commonly in August (a total of 36 days in August over the period of record for the stream flow data).

All of the watersheds in the Upper Sprague River subbasin have in-stream water rights created by ODFW for anadromous and resident fish habitat, most of which were established on October 26, 1990 (OWRD 2006). These water rights are junior to the majority of water rights, which were established at a prior date, and consequently cannot guarantee that the in-stream flow will be available. The in-stream rights were established by ODFW primarily to ensure that later claims can be prevented from removing water that may adversely affect aquatic species. Additionally, although the purpose of the in-stream water rights is to protect aquatic habitat by retaining water in the stream, the flow rates of the in-stream rights are not exact, site-specific determinations of habitat requirements.

An examination of the number of days from 1953 to 2002 at the Sprague River near Beatty stream gaging station reveals that over the 49-year period, flows were less than the in-stream water right during a given month a maximum of 2.3 percent of the time (Table 5-8). However, in all months except October streamflows were lower than the in-stream water right at least once (OWRD 2005, 2006).

Table 5-7. Maximum flow of surface water that has been allocated in water rights for consumptive use, not including in-stream rights, as represented in the OWRD database. These values do not represent the actual flow of water being withdrawn at a specific time, but rather the maximum flow granted to all users based on their water rights. (Data Source: OWRD 2006)

Type of Use	Sprague River Above Beatty Watershed		North Fork Sprague Watershed		South Fork Sprague Watershed		Fishhole Creek Watershed		Lower Sycan Watershed		Sycan Marsh Watershed		Upper Sycan Watershed		Total	
	cfs	%	cfs	%	cfs	%	cfs	%	cfs	%	cfs	%	cfs	%	cfs	%
Commercial	-	-	-	-	1.80	4.95	-	-	-	-	0.33	1.18	0.30	100.00	2.43	0.37
Domestic	-	-	0.16	0.09	0.03	0.08	0.02	0.01	0.01	0.02	-	-	-	-	0.22	0.03
Fish Culture	-	-	-	-	-	-	1.00	0.65	-	-	-	-	-	-	1.00	0.15
Irrigation	206.80	91.94	164.49	92.79	23.09	63.43	107.09	69.37	43.11	95.55	27.63	98.80	-	-	572.21	85.87
Livestock	18.15	8.07	12.62	7.12	8.48	23.30	46.26	29.97	-	-	0.01	0.02	-	-	85.52	12.83
Road Construction	-	-	-	-	3.00	8.24	-	-	2.00	4.43	-	-	-	-	5.00	0.75
Total	224.94	100.00	177.27	100.00	36.40	100.00	154.37	100.00	45.12	100.00	27.97	100.00	0.30	100.00	666.38	100.00

Table 5-8. Number of days during which flow was below the in-stream water right within a given month, over the period of record, at the Sprague River near Beatty gage. The in-stream water right is owned by the State of Oregon and managed by ODFW. (Data Source: OWRD 2005, OWRD 2006)

		Days Below In-Stream Water Right	
Month	**Total # of Days**	**Number**	**Percent**
January	1,550	22	1.4
February	1,412	2	0.1
March	1,550	0	0.0
April	1,500	9	0.6
May	1,550	34	2.2
June	1,500	30	2.0
July	1,550	24	1.5
August	1,550	36	2.3
September	1,500	9	0.6
October	1,550	0	0.0
November	1,500	14	0.9
December	1,550	31	2.0

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CHAPTER 6. TERRESTRIAL VEGETATION

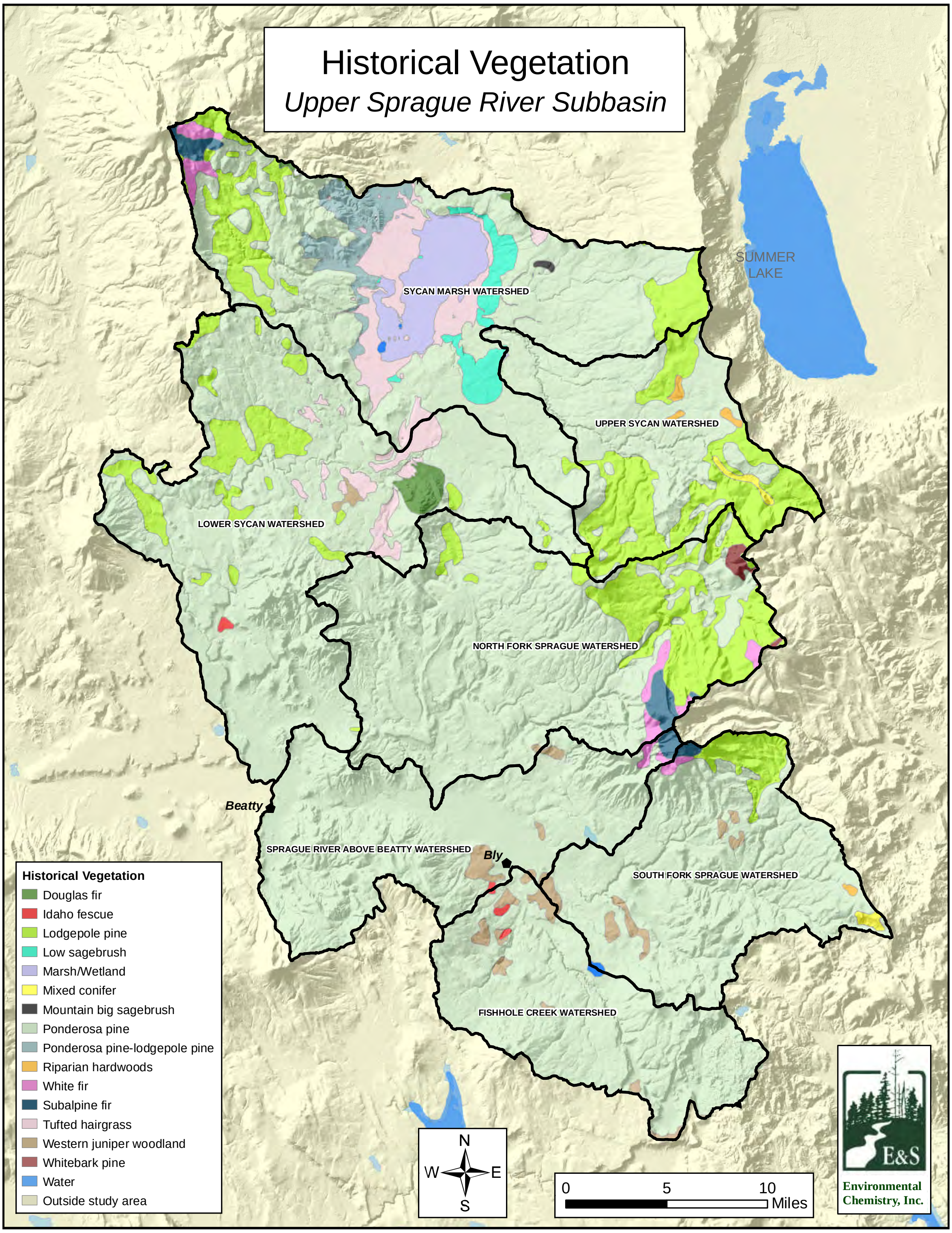
PRE-SETTLEMENT TERRESTRIAL PLANT COMMUNITIES

During the 19th and early-20th Centuries, pure stands of ponderosa pine extended widely across the Upper Sprague River subbasin (Map 6-1). It has been estimated that approximately 77 percent of the landscape was composed of this forest type (Table 6-1). Historical ponderosa pine forests were dominated by a diversity of age classes, including late-seral and old-growth stands, usually with an even-aged structure (Franklin and Dyrness 1988, USFS 1995).

Table 6-1. Nineteenth-Century landscape composition of the Upper Sprague River subbasin. (Data Source: ONHP 2002)

Landcover Type	Acres	Percent Area
Idaho fescue	708	<1.0%
Mountain big sagebrush	292	<1.0%
Low sagebrush	6,986	<1.0%
Western juniper woodland	8,210	1.1%
Ponderosa pine	557,495	77.3%
Ponderosa pine-lodgepole pine	9,014	1.2%
Lodgepole pine	87,273	12.1%
Douglas fir	3,168	<1.0%
Mixed conifer	1,372	<1.0%
White fir	5,133	<1.0%
Whitebark pine	1,073	<1.0%
Subalpine fir	4,508	<1.0%
Riparian hardwoods	1,032	<1.0%
Tufted hairgrass	20,901	2.9%
Marsh/Wetland	13,760	1.9%
Open water	436	<1.0%
Other	240	<1.0%

Ponderosa pine (*Pinus ponderosa*) existed as a climax species at low elevations and warm sites throughout the eastern Cascade Mountains (Franklin and Dyrness 1988). The species was also able to dominate stands for extended intervals in the true fir zone, where the climax fir species (e.g. white fir [*Abies concolor*] and grand fir [*Abies grandis*]) were unable to regenerate because of the frequent, low-intensity fire regime.



Map 6-1. Historical vegetation map. (Data Source: ONHP 2002)

Research suggests that fire return intervals ranged between 5 and 25 years in low elevation forests of the Upper Sprague River subbasin (USFS 1995, USFS 1999). Although lightning undoubtedly ignited many of the fires, accounts by the first white explorers of the southern Cascades give evidence of widespread fire-setting by the Klamath and Modoc tribes (Robbins and Wolf 1994).

In the forested part of the watershed

Helen Crume Smith remembers a time "when there used to be trees-big, beautiful trees- on both sides of the river. Huge Ponderosa Pines on the south side, the same way. And this time of year, summer, you could still get to the top of the mountain and you'd hit snow, because that canopy was so great that it kept the snow. And it kept water. In October, then it used to start freezing, it would rain or snow and the water would freeze and stay there. You had the canopies that kept the sun from it, and it used to be so, so fabulous" (as quoted in Frank 2006 p. 162).

The low tree densities and scarcity of true firs made pre-settlement pine stands much less susceptible to insect outbreaks and tree diseases than contemporary forests in the ponderosa pine zone (Campbell and Liegel 1996). Nevertheless, western pine beetle (*Dendroctonus brevicomis*) and pine engraver (*Ips pini*) infestations did occur during drought conditions and on poor sites (USFS 1995). Fire fuel loading was historically low in ponderosa pine forests because of the frequent fires.

At the time of European settlement, the Upper Sprague River landscape contained only minor components of lodgepole pine (*Pinus contorta*), mixed conifer, and true fir forests (Table 6-1; ONHP 2002).

Lodgepole pine was able to persist in topographic depressions and "frost pockets" where ponderosa pine could not because it is more cold-tolerant than ponderosa pine (USFS 1995). Lodgepole pine was able to co-exist within the same stands as ponderosa pine on the coarse, pumice soils common in the Sycan River Watershed. Other conifer species dominated higher elevations of the subbasin where the fire regime was characterized by less frequent, stand replacement fires.

Pre-European settlement understory plant composition and structure varied widely across forestlands according to soil type, elevation, and fire history. Franklin and Dyrness (1988) described a number of plant community associations in the ponderosa pine and lodgepole pine forest zones. In general, shrubs were a more prominent component of forest stands at higher elevations. Common understory species in ponderosa pine stands were likely big sagebrush (*Artemisia tridentate*), antelope bitterbrush (*Purshia tridentata*), and greenleaf manzanita (*Arctostaphylos patula*) (USFS 1999).

The 19th-Century landscape mosaic in the assessment area also contained a number of non-forested areas dominated by sagebrush communities, grasslands, and wetlands. However, the total acreage occupied by non-forest land cover types probably amounted to less than 10 percent of the total subbasin (Table 6-1; ONHP 2002).

CURRENT TERRESTRIAL PLANT COMMUNITIES

Mapping Methods

The distribution of different plant communities in the assessment area was mapped using data from the Oregon Gap Analysis Program. The data were derived from LANDSAT imagery originally acquired between 1991-1993 and updated in 1998 (Kiilsgaard 1999). Although the data are more than six years old, it was assumed for the purpose of this analysis that major compositional patterns of vegetation have not changed significantly during the intervening period. Alternative vegetation maps and data were considered for the analysis, but were rejected because they were only available for a portion of the assessment area (e.g. Fremont-Winema National Forest stand type data) or because their land cover classification did not distinguish between important plant communities (e.g. USGS 1992). The 1999 Oregon Gap Analysis map includes 87 different classes of land cover, of which15 types were found to occur in the assessment area.

The Oregon Gap Analysis Program land cover map was acquired for this assessment as ESRI shape files downloaded from the Oregon Geospatial Data Clearinghouse (OGAP 1998). Using ArcGIS 9, the assessment area plant community map was clipped from the statewide coverage. Acreages for each of the 15 land cover types in the assessment were calculated in ArcGIS 9 and are reported in Table 6-2.

Table 6-2. Acreage and percent subbasin area of 15 land cover types occurring in the Upper Sprague River subbasin. Gap types refer to numeric identifiers corresponding to each land cover type and are further described in Kagan et al. 1999. (Data Source: Kiilsgaard 1999)

Land Cover Name	Gap Type	Acres	Percent of Subbasin
Whitebark-Lodgepole Pine Alpine Forest	39	335	<1
Ponderosa Pine Dominant-Mixed Conifer Forest	40	102,878	14
Lodgepole Pine Forest and Woodland	44	19,700	3
Ponderosa Pine Forest and Woodland	54	221,021	31
Ponderosa-Lodgepole Pine on Pumice	59	124,916	17
Ponderosa Pine/Western Juniper Woodland	58	31,180	4
Western Juniper Woodland	61	27,000	4
Regenerating Young Forest	121	13,659	2
Sagebrush Steppe	91	68,791	10
Low-Dwarf Shrubland	93	42,098	6
Wet Meadow	114	2	<1
Palustrine Shrubland	201	58,591	8
Palustrine Emergent Wetland	203	2690	<1
Agriculture	125	8,238	1
Other		502	<1

Forests and Woodlands

Ponderosa Pine Forests

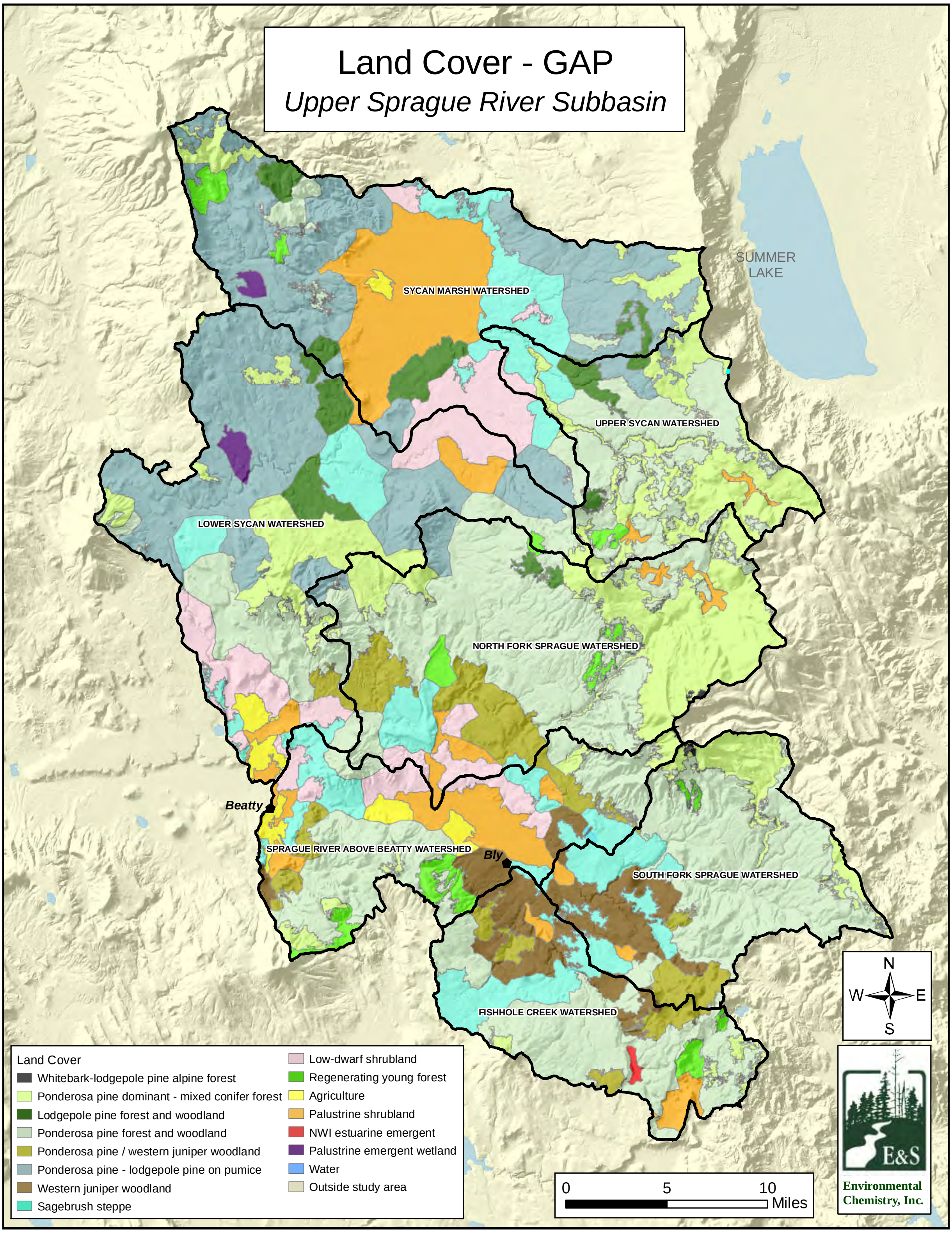
Ponderosa pine forests and woodlands are currently the most extensive plant community in the Upper Sprague River subbasin. Approximately 221,021 acres of this forest type occurs in the assessment area (Oregon Gap Analysis Program 1998). Historically, natural wildfires were frequent across ponderosa pine forests in the eastern Cascades. Although mature ponderosa pines are resistant to low-intensity fires, young pines and other species such as the true firs usually did not survive the flames. Therefore, ponderosa pine forests tended to occur in pure, even-aged stands of widely-spaced trees under the natural fire regime. At lower elevations in the subbasin, conditions are generally too hot and arid to support large trees. In such locations, stands of ponderosa pine transition into western juniper (*Juniperus occidentalis*) woodlands. The distribution of vegetation types is presented in Table 6-2 and shown in Map 6-2.

More than 50 years of effective fire suppression has allowed grand fir (*Abies grandis*), Douglas-fir (*Pseudotsuga menziesii*) and other tree species to establish in the understory of these stands, creating conditions in which ponderosa pine is unable to maintain its dominance. Selective logging has further hastened the conversion of ponderosa pine forests and woodlands to mixed conifer forest.

At higher elevations within the ponderosa pine zone, shrubs are an important component of stand structure. The most commonly associated shrub species are bitterbrush, big sagebrush, greenleaf manzanita, and snowberry (*Symphoricarpos albus*). At lower elevations, the shrub layer becomes sparser and less diverse.

Lodgepole Pine Forests

Stands of lodgepole pine are found interspersed among true fir forests at mid- to high-elevations across the assessment area. Approximately 19,700 acres of this forest type occurs in the assessment area (Table 6-2). Lodgepole pine can grow well under a wide range of site conditions; its distribution tends to follow forest fire patterns rather than environmental gradients. Lodgepole pine stands typically develop a dense, single-layer canopy structure immediately after a fire. As the forest matures, other tree species such as Douglas-fir, grand fir, and white fir become established in the understory and create an uneven multi-storied canopy structure. Eventually these other tree species replace lodgepole pine on the site until the next fire occurs. A layer of dense shrubs is often found in lodgepole pine forests. Common shrub species include mountain snowberry (*Symphoricarpos mollis*), serviceberry (*Amelanchier alnifolia*), shiny-leaf spirea (*Spiraea betulifolia*), bitterbrush (*Purshia tridentata*), and huckleberry (*Vaccinium. membranaceum, V. scoparium).*



Map 6-2. Land cover GAP map for the Upper Sprague River subbasin. (Data Source: ONHP 2002)

Whitebark-Lodgepole Pine-Alpine Forest

Whitebark-Lodgepole Pine Alpine Forests are confined to the highest elevations on Gearhart Mountain. Only 335 acres of this forest type occurs in the assessment area. Besides whitebark pine (*Pinus albicaulis*) and lodgepole pine, white fir (*Abies concolor*) and western white pine (*Pinus monticola*) are sometimes found in the overstory of these forests. Stands tend to be open or semi-closed.

Western Juniper Woodlands

Western juniper woodlands occupy a transition zone between the forested foothills of the eastern Cascades and shrub-dominated rangelands. In the assessment area, there are approximately 27,000 acres of this cover type, mostly occurring above the main stem and South Fork of the Sprague River.

Western junipers have been expanding and replacing shrub-steppe cover types since the late-1890s (Bedell et al. 1993). These new western juniper woodlands are much more dense than the original cover type and are usually dominated by trees in young age-classes.

Western juniper invasion can significantly alter the hydrological regime and plant community diversity. In addition to water use from evapo-transpiration, rainfall on a dense juniper canopy is partially intercepted and evaporates before reaching the soil. Up to 38 percent of the total annual rainfall may be intercepted by the canopy in a juniper woodland and is unavailable to other plants (Bedell et al. 1993). The subsequent reduction in shrubs and ground cover vegetation may lead to greater overland flows of water during storms and greatly increased sediment input into streams (Bedell et al. 1993).

Shrublands

Two types of shrub communities are common across the Upper Sprague River landscape: Sagebrush Steppe (68,791 acres) and Low-Dwarf Shrubland (42,098 acres). Shrublands are most extensive in the 4,200 to 5,200-foot elevation band.

The shrub layer of Sagebrush Steppe communities is always dominated by one or more of the big sagebrush species (OGAP 1998): Wyoming (*Artemisia tridentata* var. *wyomingensis*), basin (*A. tridentata* var. *tridentata*), or mountain (*A. tridentata* var. *vaseyana*) sagebrush. Shorter shrubs such as rigid sagebrush (*Artemisia rigida*), low sagebrush (*A. arbuscula*) and rabbitbrush (*Chrysothamnus viscidiflorus* and *C. nauseosus*) may also be present. Native grasses associated with Sagebrush Steppe include: Great Basin wildrye (*Elymus cinereus*), Thurber needlegrass (*Stipa thurberiana*), Indian ricegrass (*Oryzopsis hymenoides*), blue bunch wheatgrass (*Agropyron spicatum*), and Idaho fescue (*Festuca idahoensis*). However, grazing pressure and changes in the fire regime have generally shifted the understory composition of these shrub communities to include introduced species such as cheatgrass (*Bromus tectorum*), and crested wheatgrass (*Agropyron cristatum*).

Low-Dwarf Shrublands occur where soils are too shallow or rocky to support big sagebrush. Low sagebrush (*A. arbuscula*) or rigid sagebrush (*Artemisia rigida*) typically dominate these stands.

Threatened, Endangered, and Sensitive Plant Species

A number of native plant species that inhabit the assessment area face uncertain futures. Some plant populations are affected by land use practices that change their habitats, and others are at particular risk because of non-native invaders such as Canada thistle (*Cirsium arvense*). The most vulnerable species tend to be those that are naturally rare or have very particular habitat requirements. The purpose of this section is to identify the plant species in the assessment area that are currently suspected of being most at risk so that stakeholders can plan conservation actions to protect their habitats and populations.

To determine which plant species are most vulnerable in Oregon, the following lists of protected and special status species were reviewed:

- Species protected under the Federal Endangered Species Act (ESA),
- Federal Candidate Species,
- Federal Species of Concern,
- State Threatened & Endangered Species,
- State Sensitive Species, and
- Oregon Department of Agriculture lists of protected plants

Plant species that occurred on any one of these lists were then checked as to the probability that they are present in the assessment area. For this task, geographic range maps were reviewed, as well as plant reference guides, locality records, interviews with local experts, and online databases. The review resulted in a list of 5 species with special conservation status that may be likely to occur in the assessment area (Table 6-3). A short description of each species is provided below.

Table 6-3. Plant species that have special conservation status and are likely to occur in the Upper Sprague River subbasin. (Data Source: ONHP 2002)

Scientific Name	Common Name	Federal Status[1]	State Status[2]
Mimulus evanescens	Disappearing monkeyflower	SOC	SC
Astragalus peckii	Peck's milk-vetch		LT
Botrychium pumicola	Pumice grape-fern		LT
Eriogonum prociduum	Prostrate buckwheat	SOC	SC
Penstemon glaucinus	Blue-leaved penstemon	SOC	

[1] Federal Status: SOC=Species of Concern
[2] State Status: LT=Listed State Threatened; SC= Sensitive-critical

Peck's Milkvetch (*Astragalus peckii*)—A rare legume endemic to the central Oregon Cascades. Peck's milkvetch grows on sandy or pumice soils (Hitchcock and Cronquist 1973). The species is associated with open-canopy lodgepole pine forest and sagebrush or bitterbrush shrublands between 3,000-6,000 ft elevation (ODF 1995). Peck's milkvetch has been observed on U.S. Forest Service lands in the assessment area (S. Malaby pers. comm., September, 2005).

Pumice Grape-Fern (*Botrychium pumicola*)—A rare, fern-like plant that is endemic to the eastern Cascades of Oregon. Pumice grape-fern was originally believed to be restricted to the treeless alpine zone, but has more recently been discovered on dry, pumice gravels in lodgepole pine woodlands above 5,000 ft elevation (ODF 1995). There are no recorded observations of the species from the Upper Sprague River subbasin. However, pumice grape-fern has been found at many sites in northern and western Lake County (OFP 2005). It is possible that the species exists at high elevations in the assessment area. A federal conservation plan for pumice grape-fern has been implemented on the Fremont-Winema National Forest and Prineville District of the Bureau of Land Management (Hopkins et al. unknown date)

Blue-leaved Penstemon (*Penstemon glaucinus*)—Associated with ponderosa pine and whitebark-lodgepole pine forests at middle to high elevations, usually found in sandy, volcanic soils; often on rocky ridgetops. The species seems able to colonize disturbed areas such as slash burn piles and other areas cleared of vegetation (Meinke 1995a). It may benefit from prescribed fire in areas where woody debris has accumulated due to past fire suppression. Blue-leaved penstemon has been found at many sites in the assessment area (ONHIC 2005).

Ephemeral (Disappearing) Monkeyflower (*Mimulus evanescens*)—Associated with western juniper-bluebunch wheatgrass plant communities, ephemeral monkeyflower is found along streams and drying creekbeds. The species is considered extremely vulnerable to grazing and has disappeared from much of its former range (Meinke 1995b). Ephemeral monkeyflower has not been found in the Upper Sprague River subbasin, but there are three known localities only a few miles south of the southern boundary (OFP 2005).

Prostrate Buckwheat (*Eriogonum prociduum*)—Occurs on basalt flows and barren hillslopes above 4,200 ft elevation. There are no recorded observations of prostrate buckwheat from the Upper Sprague River subbasin. However, the species has been recorded at many localities less than 50 miles from the assessment area (OFP 2005).

Effects of Human Activities on Plant Communities

Management of terrestrial vegetation influences water quality in a variety of ways, especially via erosional processes and effects on water quantity, each of which was discussed previously. An additional upland environmental concern is the introduction of invasive non-native plant species. This problem is generally most severe in disturbed soils. Control of non-native plants is a serious challenge, and successful control typicallyl requires substantial effort over a long period of time.

Vegetation patterns within the Upper Sprague River subbasin have changed substantially from past conditions. In the uplands, extensive late-successional ponderosa pine forests, interspersed with early- to mid-successional forests and openings created by natural disturbance, have largely been replaced by much more homogeneous young forests. In lowland areas, the former mix of forests, wetlands, and prairies has largely been replaced by agricultural land, with some urban and rural residential development. These changes have contributed, by an unknown amount, to the limited water availability currently experienced in the subbasin.

The US Forest Service provided the following conclusions regarding changes to the forest in the Upper Sycan Watershed Analysis (USFS 1999). The same general historical chronology of environmental change likely occurred throughout much of the forested area of the Upper Sprague River subbasin.

- Prior to the era of Euro-American settlement, much of the forested area of the Upper Sprague River subbasin was dominated by open stands of large ponderosa pine;
- Extensive timber harvesting over the past century has made significant changes to the forest;
- Landscape patterns of species composition and stand structure are noticeably different today than at the time of Euro-American settlement;
- Insect outbreaks led to high levels of tree mortality in the late 19^{th} and early 20^{th} centuries, which provided an added urgency to timber harvest for those worried about lost merchantable timber;
- Insects outbreaks in the 20^{th} century may have been related to changes in the forest structure associated with the preceding half-century of fire suppression and logging;
- Decades of fire suppression have been associated with a decline in the extent of native grasses that co-evolved in the presence of frequent, low-intensity fire;
- Fire suppression and timber harvesting have created a forest characterized by dense stands with weakened overstories and high fuel levels; and
- Recent timber harvesting activities in many areas of the subbasin have been focused on reducing fuel loading and vulnerability to insects and disease.

Existing problems in the forests of the Upper Sprague River subbasin are largely related to resource management practices of the past, especially logging and fire suppression. Current efforts to improve forest health are expected to develop benefits slowly, over many decades.

Since the early 1900s, the frequent and low-intensity fires that once maintained vast open ponderosa pine forests have been suppressed, allowing a high density of undergrowth to develop. Historically, the ponderosa pine forests of the region were characterized by large trees, an open understory, and less brush than is evident today.

Fire suppression has also been associated with expansion of juniper into areas where juniper was not present before. In the past, frequent fires would have kept junipers restricted to sites of poor soils, such as rocky hillsides and ridges. Unless the natural fire regime is restored, juniper encroachment into many riparian areas is likely to continue. Effects of juniper encroachment may include soil nutrient loss, reduced water storage, increased runoff, and erosion.

According to the US Forest Service's Upper Sycan Watershed Analysis, three non-forested plant associations are declining, four are increasing and two are stable. Hairgrass-sedge-moist meadow, sedge-wet meadow, and big sagebrush-bunchgrass are all becoming less common in the Upper Sycan Watershed. Although comparable data are unavailable in other areas of the Upper Sprague River subbasin, anecdotal evidence suggests that the same patterns may be occurring throughout the subbasin.

Natural disturbances generally do not produce extensive areas of uniform effect (Turner et al. 1998), but rather create complex patterns of heterogeneous landscape in which disturbance effects range from severe to none. Even very large fires typically leave some stands unburned due to wind shifts and natural fire breaks (Turner and Romme 1994, Young and Sanzone 2002). The mosaic of habitat created by differential disturbance has important influences on biotic structure, diversity, and ecosystem function. These influences are important for vegetation development and for developing appropriate management guidelines (Young and Sanzone 2002). The effects of natural disturbance are modified by the frequency, intensity, extent, and duration of the disturbance events. Such factors are important regardless of the type of disturbance, including fire, flood event, insect infestation, etc.

A certain minimum amount of intact habitat is required to maintain population viability of native species within the landscape. For example, populations are unlikely to persist where patches of intact habitat are smaller than the home range of the species. In addition to habitat area, the spatial pattern in habitat availability is also important. Both natural processes (e.g., fire, windthrow) and anthropogenic activities (urbanization, agricultural development, silviculture) have influenced the size and distribution of habitat patches within the Upper Sprague River subbasin. The interactions between natural disturbance and disturbance due to management practices largely determined the risk of species loss. Species that became isolated as a result of fragmentation and were also restricted to particular habitat types have tended to be most vulnerable to extirpation (Young and Sanzone 2002).

Noxious and exotic plants are in many cases a serious problem in the assessment area, and will continue to exist in the Upper Sprague River subbasin. This problem is, and will continue to be, most pronounced in roadside, agricultural, urban, timber harvest and other disturbed areas. Many of the exotic plants require high amounts of sunlight to grow rapidly and reproduce. While these plants are a concern, particularly in reforestation efforts, they are not considered to be a long-term threat to the integrity of the forest ecosystem because they quickly disappear when overtopped by other vegetation. Effects of noxious plants are expected to be more severe in wetlands and pasturelands. In such areas, noxious plants can have major effects on forage quality, quantity, and plant species diversity.

Extensive industrial logging began in the Upper Sprague River subbasin with completion of the railroad to Quartz Pass by the Ewauna Box Company in 1929 (USFS 1995). During the earliest period of logging, timber companies harvested only the most valuable trees (large-diameter ponderosa pine in the eastern Cascades), leaving many trees standing. Early logging practices also generated levels of downed woody debris greatly in excess of historical volumes under the frequent, low-intensity fire regime (Campbell and Liegel 1996). Steam-powered yarding machines and railroad engines frequently ignited logging slash, causing intense, stand-replacement fires. As a result of early tree harvesting and the altered fire regime, the volume of ponderosa pine saw timber in the assessment area was greatly reduced, while overall stocking levels (tree density) increased dramatically (USFS 1999). Climax species such as white fir and grand fir were able to establish in much greater densities in the wake of the fires.

Commercial harvesting began on the Fremont National Forest during the 1950s (USFS 1995). Effective fire control was also established on federal and private timberlands during this period. Fire suppression led to increased fuel loadings, more widespread mixed-species (ponderosa pine-dominant) stands, and a general change from even-aged to uneven-aged forest structure.

Pine and mixed conifer forests became highly susceptible to insect outbreaks and tree diseases as a result of the changes in stand composition and structure. In ponderosa pine forests, western pine beetle, mountain pine beetle (*Dendroctonus valens*), and the pine engraver are the most serious insect pests. Mixed conifer stands became infested with the same insects affecting pine forests, as well as the fir engraver beetle (*Scolytus ventralis*) and several other pests associated with Douglas-fir and true fir. Annosus root disease (*Heterobasidion annosum*) and Armillaria root disease (*Armillaria ostoyae*) are the most serious tree pathogens in the assessment area. These diseases cause significant levels of tree mortality. Dwarf mistletoe (*Arceuthobium* spp.) lowers the productivity of ponderosa and lodgepole pine forests. Treating these forest health issues has been the principle objective of stand management on private and public forests in the region for the last 25 years (USFS 1995, USFS 1999).

Historically, western junipers were confined to pumice sands and rock outcrops (Bedell 1993). Juniper woodlands were typically comprised of ancient trees (western junipers can live more than 800 years) spaced widely apart. However, junipers have been expanding and replacing shrub-steppe cover types since the late-1890s (Bedell et al. 1993). Most of the invasion has been into areas previously dominated by mountain big sagebrush (*Artemesia tridentata* var. *vaseyana*). The reasons for the shifting distribution are unclear, but are generally believed to be related to over-grazing, fire suppression, or climate change (Miller and Rose 1995). These new western juniper woodlands are much more dense than the original cover type and usually are dominated by trees in young age-classes.

The first livestock ranches were established in the Upper Sprague River subbasin by the 1860s (USFS 1999). Livestock numbers were unregulated during the early period. By 1910, there were 110,000 sheep and 26,000 cattle (equivalent to 450,000 animal unit months [AUMs]) grazing across the Fremont National Forest. In comparison, during the 1990s permitted AUMs were less than 75,000, or one-sixth that level (USFS 1999).

Today, many Sprague and Sycan ranchers have altered their land management practices to benefit the native plant communities. Alan Withers on the Sycan shares how he operates on the "graze well" principle, saving a lot of grass and rotating their pasture use. He states, "That's been good for the country. It makes the grass stronger, it makes our cattle healthier. That's the principle that we really operate on: save the land and the grass and make it as productive as you can that way" (pers. comm. January 17, 2007). In addition, the Valladao's who possess 897 acres for a cow-calf operation in Bly, OR focus on management for maximum plant communities. The Valladao's rest the upland areas of their ranch. They irrigate 603 acres for grazing 261 cows and replacement heifers. They also graze 90 acres of drylands, mostly sage. It has taken 20 years to get the maximum grazing capacity while factoring in the requirements of the land. When the Valladao's started in 1986, the cows were 350-400 pounds at market. Today, the average weaning weight is 125 pounds more, 375-525 pounds (pers. comm. December 22, 2006). The Topham's Flying T Ranch has also undertaken a huge noxious weed eradication program to restore native plant diversity on their property. Between changing grazing practices to improve clover diversity, juniper eradication, and proper forest management, they have had an extremely positive effect on the plant communities existing there (pers. comm. December 13, 2006).

Fire suppression has also altered non-forest plant communities in the subbasin. Areas once dominated by perennial bunch grasses such as tufted hairgrass (*Deschampsia caespitosa*), have transitioned to shrublands. It has been estimated that 60 to 70% of the shrub/steppe communities were maintained in early-seral condition under the pre-settlement fire regime, but these communities have succeeded to late-seral shrublands with little of the herbaceous understory remaining (USFS 1999).

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CHAPTER 7. RIPARIAN AREAS

INTRODUCTION

Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence). Riparian areas are adjacent to perennial, and intermittent, streams, lakes and estuarine-marine shorelines. This a good working definition of riparian areas as defined by the National Research Council (National Academy of Sciences, 2002).

High quality riparian vegetation improves stream health and the sustainability of values such as fish and wildlife habitat, livestock forage, and aesthetics. It provides:

- rooting strength to prevent bank erosion which can fill gravel beds with fine sediment
- roughness for dissipating energies of water
- filtering of runoff from adjacent lands of erosional sediment, nutrients, and bacteria
- water storage and aquifer recharge
- shading necessary to retard heating and help maintain cooler water temperatures
- the source for large woody debris in higher gradient reaches that dissipates energy and helps retain spawning gravels, contributes to pool formation, provides critical in-stream structure, and helps moderate summer water temperature

During the course of this assessment, three main methodologies have been used to gather and interpret information about riparian conditions and function. Each methodology has its own benefits and shortcomings, but together they can provide us with information that will be useful in prioritizing and planning improvements.

First, Proper Functioning Condition (PFC) and "Greenline" (Winward 2000) have been used to assess site-specific conditions on privately-owned ranch properties. This site-specific approach has been enormously useful, due mainly to the wide variability in riparian conditions and function within the assessment area. Larger-scale methods can provide helpful general information and necessary context but, as has been mentioned previously in this document, restoration planning and project development must be rooted in more detailed site analysis. The first section of this chapter summarizes this approach, as well as other recent site specific analyses that have occurred within the assessment area.

The second methodology involved visual analysis of aerial photographs, classifying vegetations types by interpreting color, texture, and topography. This a common approach used in regulatory contects, and a necessary one given the large size of the assessment area, but it has significant limitations, including the following:

- Artificially establishes width of riparian zone, which naturally fluctuates a high degree from the assumed 75 feet width.
- Over- or underestimates the actual acreage of the natural riparian area. This inaccuracy makes it impossible to compare acreage of riparian areas in different reaches and present a meaningful result.
- Misclassifies the vegetation classes for the riparian area. The vegetation classes of the natural riparian area should be wetland plant communities. Instead by setting an artificial boundary, many upland plant communities have been erroneously included in the vegetation classes for the riparian area. For example, conifers such as ponderosa pine are upland species, not wetland species.

Because of these limitations, this supplementary information is located with other reference material at the end of the document (See Appendix C).

The third approach is based on a dataset collected using Light Detection and Radar (LIDAR) technology. This dataset provided information about vegetation heights in riparian areas, which can help clarify where taller woody vegetation species are present However, LIDAR does not allow us to distinguish between low vegetation heights resulting from poor riparian conditions, and low vegetation heights resulting from very stable but low-growing sedge/rush communities. The third section of this chapter summarizes the LIDAR information, and includes samples of the graphic results of the dataset.

PFC, GREENLINE, AND SITE-SPECIFIC METHODS

There are many methods for assessing condition and trend in the riparian area. Two methods that have been used in the Upper Sprague include *Monitoring the Vegetation Resources in Riparian Areas* (Winward, 2000) and *Riparian Area Management: A User Guide to Assessing Proper Functioning Condition* *and the Supporting Science for Lotic Areas* (Prichard 1998). Both methods rely heavily on the riparian vegetation to define and assess the condition and extent of the riparian area.

Proper Functioning Condition (PFC) is described as *meeting the minimum conditions for a riparian area to function properly* (Prichard 1998). It is based on the physical processes and attributes of streams that make it possible for them to more easily maintain their dimension (channel shape), pattern (sinuosity), and profile (gradient) on the landscape. The PFC Technical Reference, defines riparian areas that are functioning properly as having adequate vegetation, landform, or large woody debris present to:

- dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload, and aid floodplain development;
- improve floodwater retention and groundwater recharge;
- develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and
- support greater biodiversity (Prichard 1998).

The methods include both native and non-native vegetation in their assessment of the riparian areas. Native plants are plants which are indigenous to the area and would naturally occur in the given habitat. Non-native plants are plants that have been introduced to the area and would not naturally occur there. Non-native plants may include, but is not limited to, weeds.

Riparian Ecological Type Classification and Scorecard Guides

Contributors include: Gregg Riegel, Area Ecologist, Area Ecology Program;David Baker, Riparian Ecologist, Area Ecology Program; Dave Weixelman, PSW Regional Range Ecologist, Desi Zamudio, Soil Scientist, Fremont-Winema NF and Lakeview BLM; Karen Zamudio, Ecologist Fremont-Winema NF; Barbara Machado, District Hydrologist, Lakeview BLM.

The Riparian Field Guide for south central Oregon was developed from 395 permanent plots established from 1995 to 2002 on Fremont National Forest and Lakeview District BLM lands. The Guide is a classification of ecological types and scorecards for ecological status. Ecological types are classified as combinations of vegetation community, soil type and landform. Plots were sampled intensively to provide comprehensive vegetation, soil and geormorphic data for analysis in the classification. The data, which includes GIS plot locations, is available through the Area Ecology Program. The Field Guide is in its final draft stage prior to review and publication. Currently the draft guide is being used for mapping and monitoring by both the Fremont National Forest and Lakeview BLM (as shown below)

Lakeview BLM is using the guide to assess ecological type and condition of riparian areas in their watershed mapping project. They have contracted with John Ritter, Oregon Institute of Technology, to develop an interactive database to automate the classification and scoring process from field data.

Fremont-Winema NF is using the guide for several assessments and monitoring programs:

1. Effectiveness Monitoring for the Programmatic Biological Opinion for Listed Suckers and Bull Trout.
2. Range Analysis
3. Water Quality Implementation Plan Effectiveness Monitoring
4. Forest Plan Monitoring Report

In 2001 a field test of the initial draft version of the classification and scorecards was used to map the riparian areas of the Upper Sprague river watershed in the Fremont National Forest. The mapped areas included the Sycan River from its headwaters to the private lands upstream of Sycan Marsh and its tributary Paradise Creek, the North Fork Sprague River from its headwaters to US Timber land south and downstream from Sandhill Crossing and its tributaries Cold Creek and Dead Cow Creek, and the South Fork Sprague River from its headwaters to 1 mile downstream from Grouse Prairie near its confluence with Jack Creek. A few sites were mapped on Fishhole Creek below Middle Fishhole. Additional riparian plots were collected that year and a second draft classification was applied to the map units. In 2002 plot sampling was completed and a final draft classification completed in 2006, and applied to the map units. While plant lists do not exist for individual polygons or map units, representative plant lists and soil/landform attributes are available for the ecological types in the classification used to name the map units. Plant lists and soil/landform data is also available for sampling plots (above) that are located in, but independent of, the map unit polygons and polylines.

A separate classification of riparian areas was done in 1987 by Bernard Kovalchik (Riparian Zone Associations of Deschutes, Ochoco, Fremont, and Winema National Forests, R6 ECOL TP-279-87). Data from this classification has been included in the larger document Riparian and Wetland Vegetation of Central and Eastern Oregon (Crowe, Kovalchik and Kerr, 2004). A map layer showing the approximate location of Kovalchik's plots is available through the Area Ecology Program.

This completed riparian vegetation classification will be combined with other classification projects planned for the summer of 2007.

The goal is to complete the classification of riparian vegetation communities to develop a complete for the Sprague, Wood, and Sycan Rivers and tirbutaries. Besides the work listed above the additional references that also gives us an idea of what the Riparian Community Type Classifications might be are found in the documents Humbolt and Toiyabe National Forests, Nevada and eastern California (Manning and Padget 1995) and Riparian Plant Community Classification, West Slope, Central and Southern Sierra Nevada, California (Potter 2005). The vegetation communities summarize an association of plants based on the soils and the dominant plant species. Characterizing the vegetation communities allows different riparian areas to be easily compared, as the characterization is a generalization of the plants presence and ignores small amounts of variation in plant species presence.

Another very useful classification of plants was conducted by the US Fish and Wildlife Service (Reed 1988). This classification established five basic categories of indicator status" reflecting different frequencies of occurrence in wetlands: l) obligate (OBL; >99% of time in wetlands), 2) facultative wetland (FACW; 67-99% in wetlands), 3) facultative (FAC: 34--66%), 4) facultative upland (FACU; 133%), and 5) upland (UPL; < 1%). The latter species were typically not recorded on the regional and national lists as the lists represent plants occurring in wetlands; some UPL species appear on the lists because they occur in wetlands >I% of the time in one region of the country or simply to show that they had been reviewed. For the "facultative" type species, a + (plus) or a -(minus) representing the higher or lower end of the range of occurrence in wetlands was assigned to species where there were differences in opinions among the reviewers and/or regional panel members (Reed 1988). No indicator (N!) was assigned to species with insufficient information available to project their indicator status, whereas species designated with not available (NA) were those where differences among reviewers could not be resolved. A supplemental list was produced in 1993 for the northwest region (Reed, et.al. 1993).

While these categories seem overly detailed, this classification system is easy to use. Once a plant species is identified, the plant species is looked up in the classification tables and the indicator status is ascertained. The riparian area would contain primarily obligate, facultative wetland, and facultative plant species. Once the transition has been made to mostly facultative upland or upland plants, then that is the edge of the riparian area and beginning of the upland area.

Riparian Process, Function and Management

There are many roles served by the aquatic ecosystem in the Upper Sprague River subbasin that includes providing habitat for a diverse group of plants and animals. Riparian plants provide shade to the stream, helping to prevent water from warming. In addition, many species of riparian plants play a role in retaining water received from the hillslopes. Especially important in this regard are a variety of sedges, rushes, grasses, shrubs such as thinleaf alder and willow, and deciduous trees such as black cottonwood. By slowly releasing water from their sponge-like root systems, sedges and other deeply-rooted plants help to augment flows during the late summer and early fall. Additional cool water, especially in the late summer, is beneficial to many fish species. Improved riparian areas, when grazed properly, can also provide important livestock forage.

In some cases, improved management leads to the establishment of reed canarygrass (*Phalaris arundinacea* L.) because it is a very aggressive plant and it already has a strong presence in the catchment/watershed. Most people consider it non-native to eastern Oregon. While possibly native to North America, European cultivars have been widely introduced for use as hay and forage on the continent; there are no easy traits known for differentiating between the native plants and European cultivars. The species grows so vigorously that it is able to inhibit and eliminate competing species. Since it often forms persistent monocultures, it does pose a challenge to establishing native sedges and rushes. The root mass of reed canarygrass is intermediate between the strong, deep roots of native sedges and rushes, and the less strong and deep roots of most pasture grasses and Kentucky bluegrass. In addition, the root masses of Reed canarygrass can provide a measure of functionality even though they are not considered native.

Ongoing research has shown management like livestock grazing and establishment of shade can keep reed canarygrass in check, or at least slow its spread, so that it does not become a monoculture. However currently t we do not have the technology to eliminate it totally while protecting functional attributes of stream and river systems. If reed canarygrass becomes a monoculture along a riparian-wetland area, the loss of a diverse composition of plants and the intermediate root mass would cause the area to have less stability than otherwise expected.

The methods outlined above can be applied on a site by site basis. The methods provide detailed information that can be used to determine the condition and extent of the riparian area in a given location. Furthermore, if applied repeatedly over time the methods will provide a picture of the riparian area trends. For example, is the riparian area increasing or decreasing in width?

While the methods are useful on a site specific basis, a series of proper functioning assessments and Greenline transects across the watershed assessment area would provide generalizations for the riparian area in the entire assessment area. The assessments and transects would need to be visited at intervals of one to 5 years, depending on observed change, to establish the short and long term trends over time.

Table 7-1. Major indicator shrubs and herbs in riparian zones on national forests in central Oregon. (Source: Kovaichik et al. 1988).

Forbs		Grasses	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Arrowleaf groundsel	*Senecio triangularis*	Blue wildrye	*Elymus glaucus*
Bog saxifrage	*Saxifraga oregana*	Bluejoint reedgrass	*Calamagrostis canadensis*
California falsehellebore	*Veratrum californicum*	Cusick bluegrass	*Poa cusickii*
Claspleaf twistedstalk	*Streptopus amplexifolius*	Kentucky bluegrass	*Poa pratensis*
Common horsetail	*Equisetum arvense*	Tufted hairgrass	*Deschampsia cespitosa*
Elephanthead	*Pedicularis groenlandica*		
Gray licoriceroot	*Ligusticum grayii*		
Hooded ladies-tresses	*Spiranthes romanzoffiana*		
Monkshood	*Aconitum columbianum*		
Queencup beadlily	*Clintonia uniflora*		
Rosy twistedstalk	*Streptopus roseus*		
Sweetscented bedstraw	*Galium triflorum*		
White trillium	*Trillium ovatum*		

Shrubs		Sedges and Rushes	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Bearberry	*Arctostaphylos uva-ursi*	Aquatic sedge	*Carex aquatilis*
Bebb willow	*Salix bebbiana*	Beaked sedge	*C. rostrata*
Big sagebrush	*Artemisia tridentata ssp. vaseyana*	Bigleaf sedge	*C. amplifolia*
Bog birch	*Betula glandulosa*	Black alpine sedge	*C. nigricans*
Bog blueberry	*Vaccinium occidentale*	Brewer sedge	*C. breweri*
Booth willow	*Salix boothii*	Green-fruited sedge	*C. interrupta*
Common snowberry	*Symphoricarpos albus*	Holm's sedge	*C. scopulorum*
Coyote willow	*Salix exigua ssp. exigua*	Inflated sedge	*C. vesicaria*
Douglas-hawthorn	*Crataegus douglasii*	Nebraska sedge	*C. nebraskensis*
Douglas spiraea	*Spiraea douglasii*	Short-beaked sedge	*C. simulata*
Drummond willow	*Salix drummondiana*	Sitka sedge	*C. sitchensis*
Eastwood willow	*Salix eastwoodiae*	Slender sedge	*C. lasiocarpa*
Geyer willow	*Salix geyeriana var. geyeriana*	Widefruit sedge	*C. eurycarpa*
Geyer willow	*Salix geyeriana var. meleiana*	Woolly sedge	*C. lanuginosa*
Lemmon willow	*Salix lemmonii*	Creeping spikerush	*Eleocharis palustris*
Mountain alder	*Alnus incana*	Few-flowered spikerush	*E. pauciflora*
Pacific willow	*Salix lasiandra var. lasiandra*	Baltic rush	*Juncus balticus var. balticus*
Prickly currant	*Ribes lacustre*	Drummond rush	*J. drummondii*
Pyramid spiraea	*Spiraea pyramidata*	Nevada rush	*J. nevadensis var. columbianus*
Red mountainheath	*Phyllodoce empetriformis*	Nevada rush	*J. nevadensis var. nevadensis*
Scouler willow	*Salix scouleriana*	Small-fruit bulrush	*Scirpus microcarpus*
Silver sagebrush	*Artemisia cana*		
Sitka willow	*Salix sitchensis*		
Undergreen willow	*Salix commutata*		
Vine maple	*Acer circinatum*		
Whiplash willow	*Salix lasiandra var. caudata*		
Yellow willow	*Salix lutea complex*		

Individual landowners have already begun to develop relationships with the Working Lands Alliance to establish Greenline transects on their property and conducted proper functioning assessments. With these assessments in hand the landowner can make management changes and conduct restoration activities to positively influence the riparian area trends. A positive influence could be widening the riparian area or improving riparian vegetation. These changes can still be compatible with land use activities, including agriculture. Potential management strategies are summarized in *Riparian Areas—Functions and Strategies for Management* (National Academy of Sciences, 2002).

Riparian Assessment Studies

Many different agencies and organizations have conducted riparian assessments within the watershed assessment area. Below is a partial summary of completed and ongoing riparian assessments. It is important to recognize this is just a partial list and it is beyond the scope of this document to present and summarize a complete list.

- US Forest Service has conducted riparian area assessments and classification for many river reaches within their ownership in the assessment area. The Forest Service used proper functioning condition methods in their assessment.
- Klamath Tribe LIDAR data set: a collection of maps with very detailed aerial imagery of the riparian area. The data set needs to be analyzed and a model developed to use the classification information, sediment budget data, and channel geometry to better estimate recovery times.
- The Nature Conservancy is conducting on-going studies on the effects of grazing and riparian conditions in the Sycan Marsh.
- Klamath Tribes are conducting a geomorphology study of the main stem of the Sprague River. This study is not yet completed.
- A Vegetation Classification study is currently being conducted by Tamzen Stringham, Al Winward, and Wayne Elmore (funded by NRCS).
- Chris Massengill is conducting a study on the colonization of point bars and banks.

Fremont-Winema National Forest Evaluation of Riparian Conditions

The following information is from the Fremont-Winema National Forest. It indicates the condition and trends of riparian areas in publicly-owned areas within the Upper Sprague/Sycan area:

Three long term monitoring sites in the Upper Sprague/Sycan watersheds were selected in 1997 as key areas to monitor effects of different grazing strategies on riparian habitat conditions. A variety of parameters were sampled at these key reaches between 1997 and 2006 (Tables 7-2 – 7-5).

Proper functioning condition assessments were made by interdisciplinary teams when the monitoring sites were established. The sites were reevaluated in 2005 using the same PFC worksheets however the make up of the team was different. PFC is not recommended as a monitoring method however it was adopted as part of the monitoring scheme for the Forest's Grazing Biological Opinion. (Tables 7-2 and 7-4)

Greenline transects (USFS, 1992) from monumented starting points were read in 1997. No ecological status or bank holding capacity has been assigned to Kovalchick's 1987 plant associations (Riparian Zone Association Guide for the Deschutes, Ochoco, Fremont and Winema National Forests) so evaluation using Winward methods was not possible. An attempt was made by the Forest Service Ecologist, Karen Zamudio, to evaluate the percentage of the greenline with appropriate late seral riparian plant communities for the site. (Tables 7-2 and 7-4)

The Forest Service Region 6 Ecology Program has been in the process of developing riparian scorecards for the Fremont National Forest and Lakeview Bureau of Land Management for the last decade. Transects were established on the floodplains at these three sites in 1997 or 2003 and in case of N. Fork Sprague River also on the stream terrace. Transects were reread in 2006 and scored in relation to plant species composition, rooting depth and density, and bare soil ground cover (BSGC) found on late seral/highly functioning sites within the same ecological type measured on the Forest. The results give riparian ecological status (function) ratings of high, moderate or low similarity to potential. (Tables 7-2 and 7-4)

Woody species counts (USFS, 2000) along a belt transect were made in 1997 and 2002 at the N. Fork Sprague site and at the Coyote Creek site. Changes in number, species and size classes of riparian shrubs were evaluated. (Tables 7-2 and 7-4)

Bank stability was recorded using Ochoco bottomline survey methods in 1997 and 2002 for N. Fork Sprague and Coyote Creek sites. (Tables 7-3 and 7-5)

Ten channel cross sections were surveyed at each of the three sites; two sites were resurveyed in 2002. (Tables 7-3 and 7-5)

Hourly stream temperatures at all three sites were monitored through the 2005 field season. Results are compared to values used for specific fish species. (Tables 7-3 and 7-5)

Sprague Watershed

Swamp Creek: (T35SR13ES1) This reach is associated with springflow and some seasonal runoff and is tributary to Fivemile Creek and the North Fork of the Sprague River. It has seen some improvement in riparian conditions over the decade. In 1996 the reach was rated as Functional-At-Risk with non-apparent trend. In 2005 it was rated at Proper Functioning Condition. Surprisingly, data from the ecological status transects show a reduction in ecological status due to reduced rooting depth. This could be due to a recording error. The density of roots was not recorded in 2003 but was assumed to be in the same category as that measured in 2006. Grazing use on the Five Mile Allotment has changed over the decade. Cattle grazing is permitted from 5/21 to 9/10. Cattle used the Swamp Creek reach area early in the season, prior to 7/15. In 2001 Swamp Creek was fenced into a riparian pasture (Foster Field). Use continued in 2001 and 2002. Since 2003 the new riparian pasture has been effectively excluded from grazing.

North Fork Sprague River: (T34SR16ES19) This reach of the Sprague River is located downstream of Fuller Walker and Lee Thomas Exclosures in the Sprague River Riparian Pasture. Ecological Status has shown very little change despite efforts to improve grazing management in the Paradise Creek Allotment. The floodplain is in low ecological status and the terrace is in high ecological status. Grazing on willows remains an issue in this reach. The riparian pasture was separated from the South pasture in 1995 and rested until 1998. Grazing on the entire allotment is permitted from 7/1 to 9/30. The riparian pasture is generally grazed early in the season each year to avoid grazing willows and provide time for regrowth on greenline vegetation after the grazing season. The permittees have been careful to not exceed the 6" stubble height requirements, leaving much more forage on the floodplain than the use standards allow. Despite this management the floodplain is having difficulty improving ground cover and rooting depth. A shallow gravel layer is restricting roots to a certain degree, but with higher vigor, the species of plants present should break through this layer.

Coyote Creek: (T31SR13ES22) Located in a seldom-grazed portion of the Silver Creek Pasture of the Foster Butte Allotment this reach is critical habitat for Bull Trout. The utilization standard is set at 20% and the season of use is 5/16 to 6/15. It is rated in Properly Functioning Condition however ecological status remains low. Beaver have played a significant role in this reach in the past but appear to be absent currently. This reach may be in a drying phase of the cycle between beaver flooding. Seedling lodgepole pine are abundant. Conditions are not related to grazing.

Table 7-2. Effectiveness monitoring results for riparian areas within the North Fork Sprague River Action Area. (Data Source: USFS 2007)

Stream	*PFC (Reach ID)1*	*Greenline 1997*	*Scorecard2002*	*Scorecard 2006*	*Woody Species Regeneration (1997 to 2002)*
Swamp Cr	1996 – ARNA 2005 – PFC (ID1048)	25% desired riparian spp., 72% undesired riparian spp, and 3% bare bank	2003 Floodplain (Mod) Veg – mod BSCG – low RD – mod	2006 Floodplain (Low) Veg – mod BSCG – low RD – low	Not re-read in 2002
NF Sprague R	2005 – PFC (ID3032, at site) 1997 – ARUT 2005 - PFC (ID3026, DS ¼ mile)	86% desired riparian spp., 9% undesired riparian spp, 5% non-vegetated	2002 Floodplain (Low) Veg - mod BSGC – low RD – low 2002 Terrace (High) Veg - mod BSGC - high RD – high	2006 Floodplain (Low) Veg - mod BSGC – low RD – low 2002 Terrace (High) Veg - mod BSGC - high RD – high	Willow continue to be hedged. Willow regeneration is occurring, but they are not being recruited into the large size class

Table 7-3. Effectiveness monitoring results for fish habitat conditions within the North Fork Sprague River Action Area. (Data Source: USFS 2007)

Stream	*Bank Stability (1997 to 2002)*	*Cross Sections (1997 to 2002)*	*Stream Temp. (ºC, 7-day max moving avg)*	*ID Review*
Swamp Cr	No data	Stable	17.8 (2005)	Upward
NF Sprague R	Stable	Stable	23.1 (2005)	Upward

Table 7-4. Effectiveness monitoring results for riparian areas within the Sycan River Action Area. (Data Source: USFS 2007)

Stream	*PFC (Reach ID)1*	*Greenline 1997*	*Scorecard 2003*	*Scorecard 2006*	*Woody Species Regeneration (1997 to 2002)*
Coyote Cr	2005 – PFC (ID4001)	No data	2003 Floodplain (Low) Veg – low BSGC – mod RD – low	2006 Floodplain (Low) Veg – low BSGC – mod RD – low	Small willows increased in number

Table 7-5. Effectiveness monitoring results for fish habitat conditions within the Sycan River Action Area. (Data Source: USFS 2007)

Stream	*Bank Stability (1997 to 2002)*	*Cross Sections (1997 to 2002)*	*Stream Temp. (ºC, 7-day max moving avg)*	*ID Review*
Coyote Creek	Stable	Not enough time to assess trend	19.3 (2005)	Undetermined, needs more time

Table 7-6. Fremont-Winema National Forest Service Proper Functioning Condition monitoring results.

Stream Name	Reach Number	Location	PFC Rating 1	Rating Date 1	PFC Rating2	Rating Date 2
Coyote Creek	4001	T31SR13ES22			PFC	8/29/2005
North Fork Sprague	3032	T34SR16ES19			PFC	8/25/2005
North Fork Sprague	3026	T34SR15ES24	FAR/U		PFC	8/25/2005
Yaden Creek	1057	T35SR15ES31	FAR	8/7/1997	FAR	7/19/2005
Sycan River	1054	T34SR11ES12	FAR/U	8/14/1997	PFC	7/19/2005
Reservoir Creek	1045	T35SR14ES19	FAR/U	8/21/1997	FAR/U	7/19/2005
Long Creek	1044	T37SR15ES2	FAR	8/7/1997	FAR	2004
Deming Creek	1040	T37SR15ES18	FAR/U	8/21/1997	FAR/U	7/14/2005
Beer Garden Spring	1031	T37SR16ES19	FAR/U	8/21/1997	FAR/U	7/14/2005
Paradise Creek	1030	T37SR15ES35	FAR/U	9/23/1997	FAR	9/27/2005
Paradise Creek	1029	T38SR15ES1	FAR	9/23/1997	FAR/D	9/27/2005
Picket Flat	1028	T38SR15ES20	FAR/U	9/10/1997	FAR/D	9/27/2005
Fishhole Creek	1024	T38SR15ES15	FAR/U	8/21/1997	PFC	8/23/2005
Brown Creek	1023	T37SR13ES5&6	FAR/U	9/11/1996	FAR	8/23/2005
Pole Creek	1014	T37SR14ES33	NF	9/19/1996	PFC	5/19/2005
Longbranch Creek	1011	T39SR15ES7	FAR/U	9/24/1996	FAR/U	9/13/2005
Swamp Creek	1048	T35SR13ES1	FAR	8/12/1997	PFC	7/14/2005
PFC - Proper Functioning Condition, TR 1737-15,1998 Methodology						
FAR - Functioning at Risk, FAR/U Functioning at Risk with Upward Trend, FAR/D Functioning at Risk with Downward Trend						
NF - Non Functioning						

LIDAR-BASED VEGETATION HEIGHT ANALYSIS

In order to identify mature riparian vegetation, and to provide a screening-level analysis of some of the likely locations for ecologically-important willow, alder, and cottonwood stands along the mainstem of the Upper Sprague River, we analyzed this zone using recent Light Detection and Ranging (LIDAR) data.

LIDAR is a remote sensing technique that measures the vertical height of the land and vegetation canopy surfaces using a laser mounted to an aircraft. LIDAR data provide information from which vegetation canopy height can be determined. In 2004, the Klamath Tribes commissioned the collection of LIDAR data for the length of the mainstem of the Sprague River and lower reaches of the Sycan, North Fork and South Fork Sprague rivers (Figure 7-1). These data were analyzed for this project in the Upper Sprague River subbasin, upstream from the confluence of the Sycan and Sprague rivers.

Methods

Using a Geographic Information System (GIS), we analyzed two LIDAR data sets: one representing the ground surface, and another representing the upper surface of the plant canopy. Example digital images created from aerial views of two of the analysis areas are depicted in Figures 7-2 and 7-3. The images in Figure 7-2 were taken just east of Bly along the Sprague River (see Map 1 on Figure 7-4). The images in Figure 7-3 were taken further upstream (see Map 2 on Figure 7-4). These digital images shown in Figures 7-2 and 7-3 depict the surface elevation of the ground (upper panel) and of the vegetation canopy (lower panel). By calculating the difference between the two data sets, we created a new vegetation height data layer. This layer was classified into five height categories (Table 7-7) which are mapped on Figures 7-4 and 7-5. The 0.0 to 0.3 meter height class (mainly pasture grasses, sedge/rush communities, and/or bare ground) is not shown on the maps because it dominates the majority of the analysis area, and by making it transparent it is possible to see the underlying aerial photo. However, it is important to note that the vegetation in all areas that are not classified in Figures 7-4 and 7-5 (which comprises 85.6% of the upper reaches of the analysis area) is less than 0.3 meters in height. It is also important to note that this low vegetation height does not necessarily indicate degraded or non-functioning riparian areas, because in many cases highly stable but low-growing sedge/rush communities represent optimum potential for the site.

Results

In the analysis area, there were two zones in which there were significant areas of riparian vegetation taller than 0.3 meters. Each was divided into two mapping areas for constructing the maps shown in Figures 7-4 and 7-5. The inset in Map 2 shows the sections of the Sprague River and South Fork

Sprague River that are represented in Maps 1 through 4. The first class is 0 to 0.3 meters (0 to 1 foot). This category represents bare ground, short grass, or sedge/rush communities. The second class is 0.3 to 2 meters (1 to 7 feet), most likely represents willow and other shrubs. The third class is 2 to 4 meters (7 to 13 feet). It also is likely to be dominated by willow, but may include young alder or cottonwood. The 4 to 8 meter class (13 to 26 feet) is most likely dominated by alder, cottonwood or small conifers. Finally the greater than 8 meter class represents tall alder, cottonwood, or conifers.

Discussion

The purpose using the Lidar data was to provide an initial screening to identify riparian stands of shrubs, such as willows, and riparian forest stands, such as cottonwood and conifer stands. The only region for which Lidar data were available in the subbasin was along the mainstem Sprague River and lower tributaries. Most of the region analyzed is characterized by riparian zones having low vegetation (< 0.3 meters). Only four analysis areas of a few miles each of stream length actually contained any appreciable amount of riparian vegetation taller than 0.3 meters.

We were unable to distinguish from the Lidar data between conifer tree species and hardwood tree species. Although height classes cannot alone provide a reliable indication of the species or plant community present, the 4 to 8 meter and greater than 8 meter classes are more likely to be cottonwood or coniferous, since most willow species do not attain such heights.

Nonetheless, the vegetation height classification quickly divides vegetation in the riparian zone into several distinct zones, and through careful observation of the moist valley floor it is possible to identify stands that have a high probability of containing large deciduous trees, and other zones of extensive willows. A rapid field verification effort could quickly provide a significant amount of additional information regarding the species composition of riparian vegetation within the relatively few portions of the analysis area in which it is well-developed.

The greatest concentration of riparian vegetation taller than 8 meters was found in the eastern portion of the area covered by Map 1 (Figure 7-4). Somewhat taller riparian vegetation was found along some portions of the South Fork Sprague River shown in Maps 3 and 4 (Figure 7-5).

It is very important to note that vegetation height, while it indicates the presence/absence of larger deciduous trees and shrubs, does not necessarily give an accurate indication of the stability and function of riparian areas. In many such areas, optimum site potential is characterized by sedge/rush communities, which have low height but, in some cases, resiliency approaching that of anchored rock.

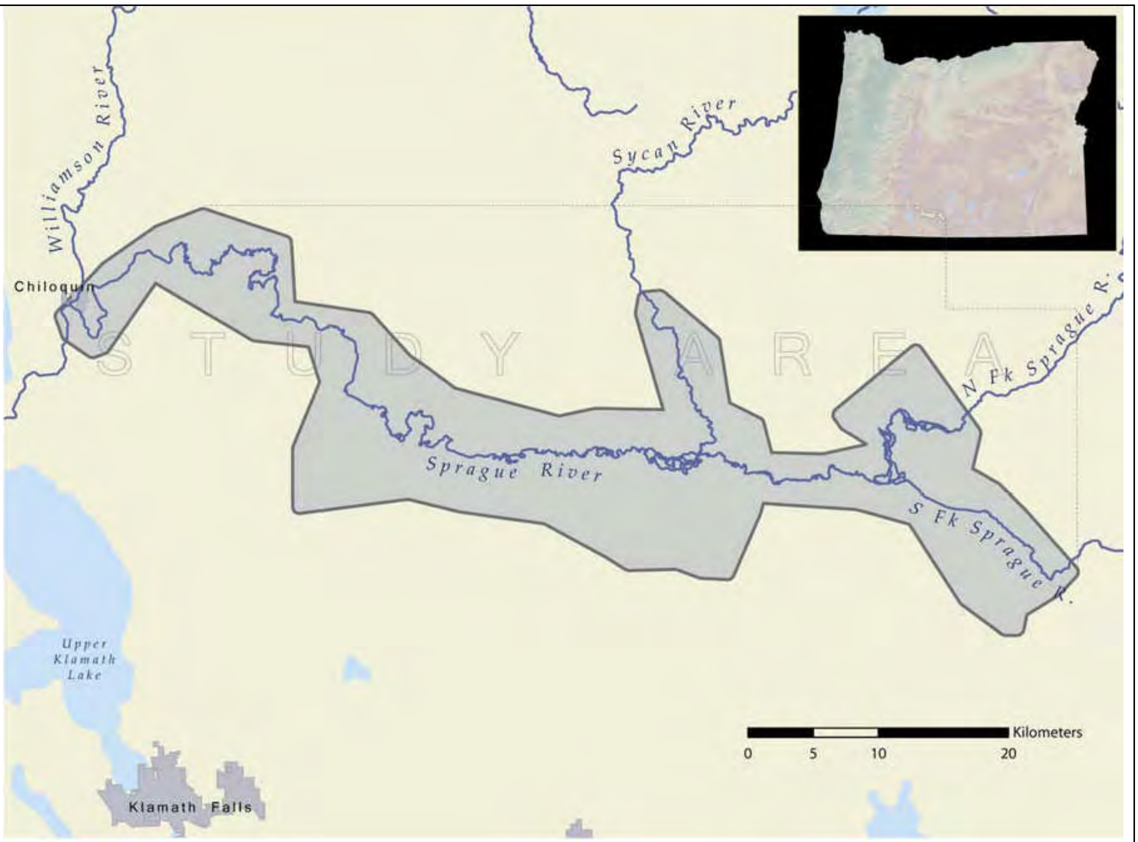


Figure 7-1. Extent of LIDAR data collection in the Sprague River Basin. (Data Source: Watershed Sciences 2005)

Table 7-7. Distribution of riparian vegetation height classes within the analysis areas. (Data Source: Watershed Sciences 2005)

Height Class (meters)	Lower Reaches		Upper Reaches	
	Area (acres)	%	Area (acres)	%
0 - 0.3	229.7	85.6	69.0	79.1
0.3 - 2	20.5	7.6	8.0	9.1
2 - 4	8.6	3.2	3.7	4.3
4 - 8	4.2	1.6	2.7	3.1
> 8	5.4	2.0	3.8	4.3
total	268.5	100.0	87.2	100.0

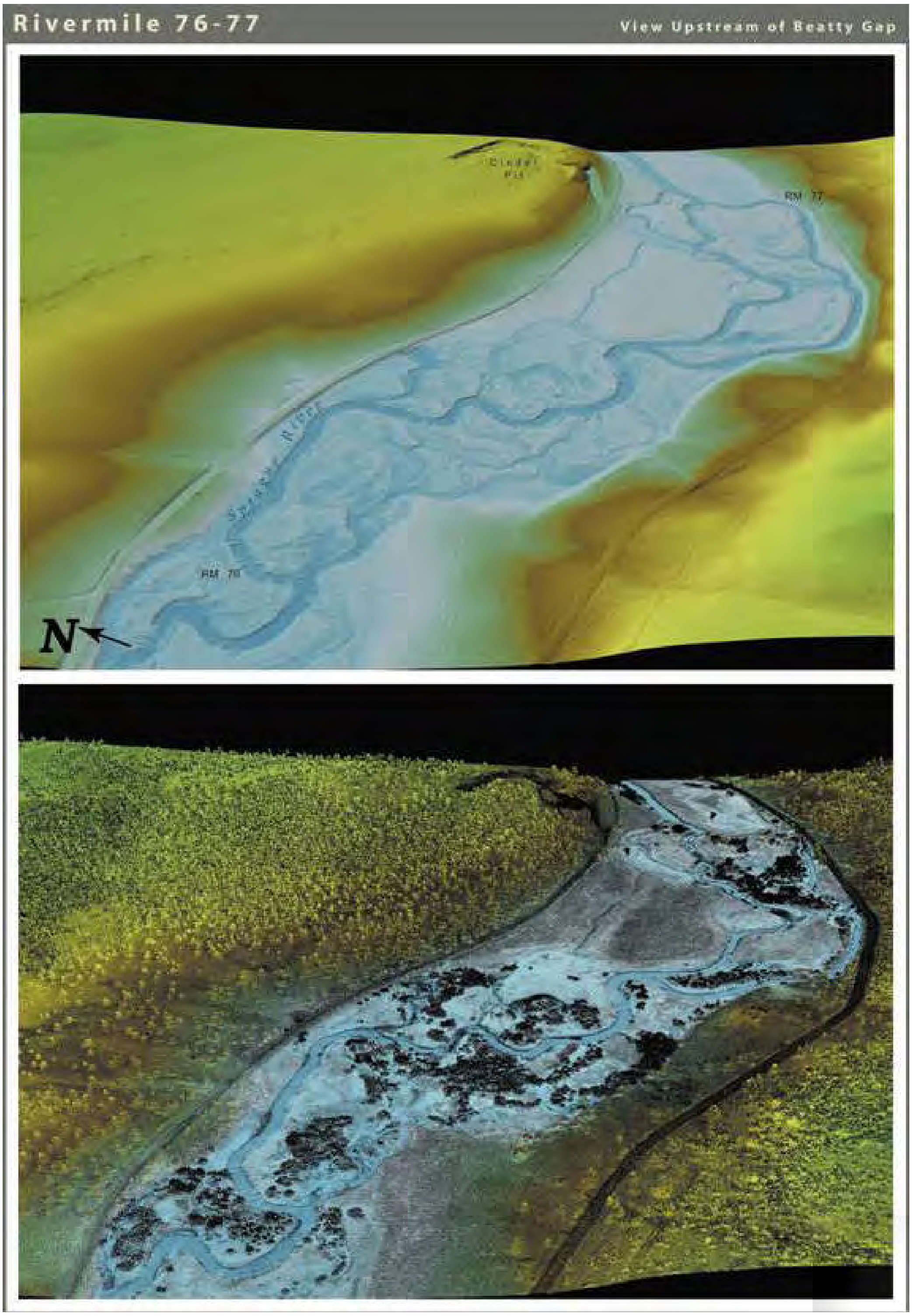


Figure 7-2. **Digital images of the ground surface (upper panel) and vegetation canopy (lower panel) in the area covered by Map 1 (Figure 7-4). (Data Source: Watershed Sciences 2005)**

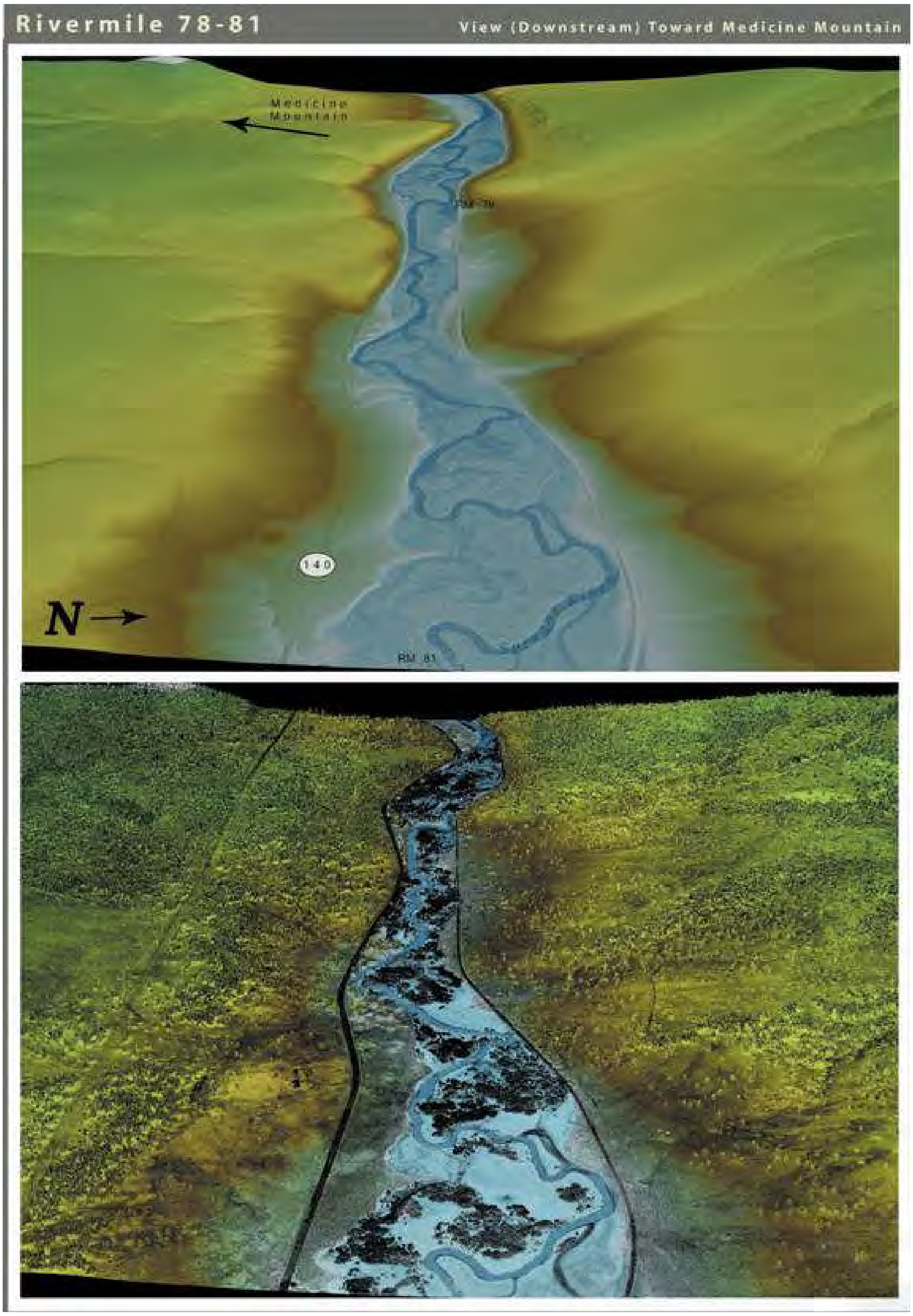
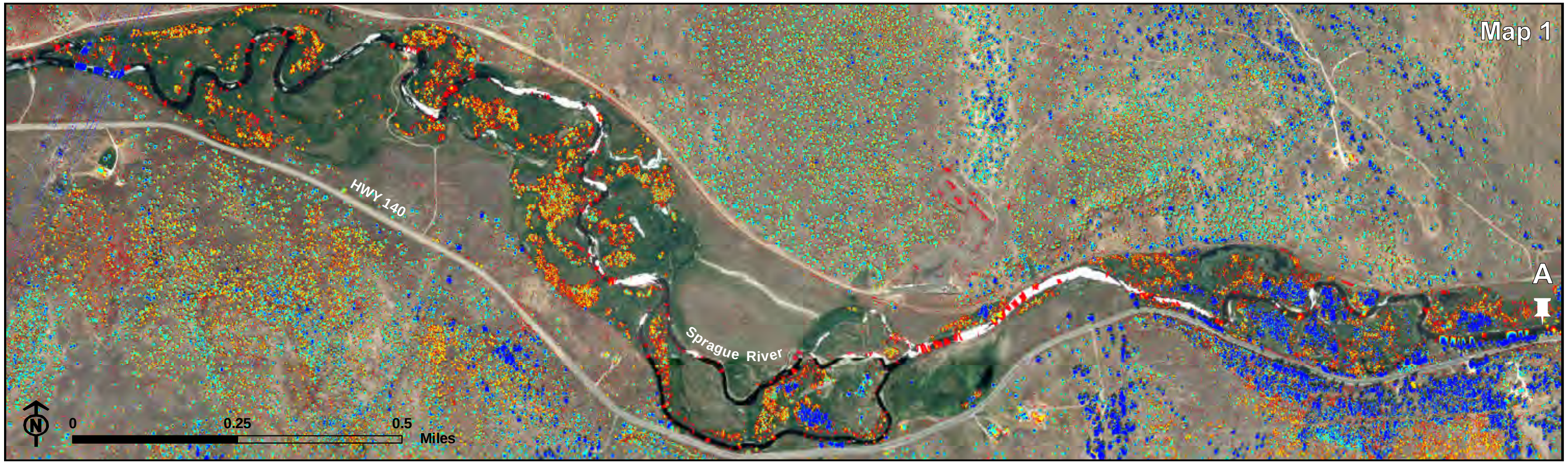


Figure 7-3. **Digital images of the ground surface (upper panel) and vegetation canopy (lower panel) in the area covered by Map 2 (Figure 7-4). (Data Source: Watershed Sciences 2005)**



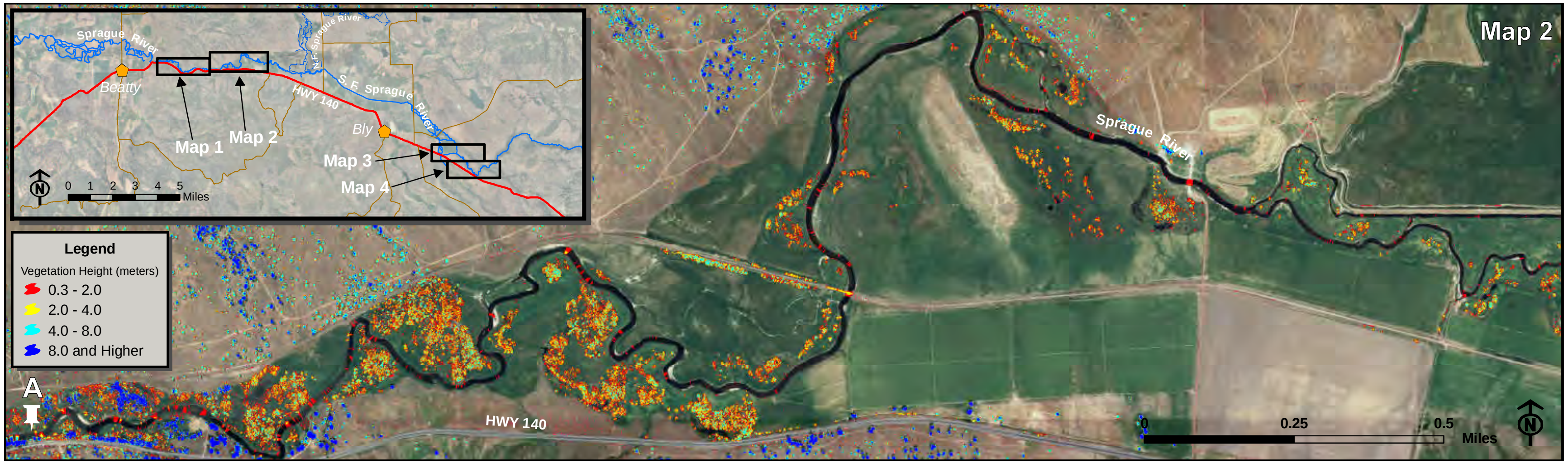
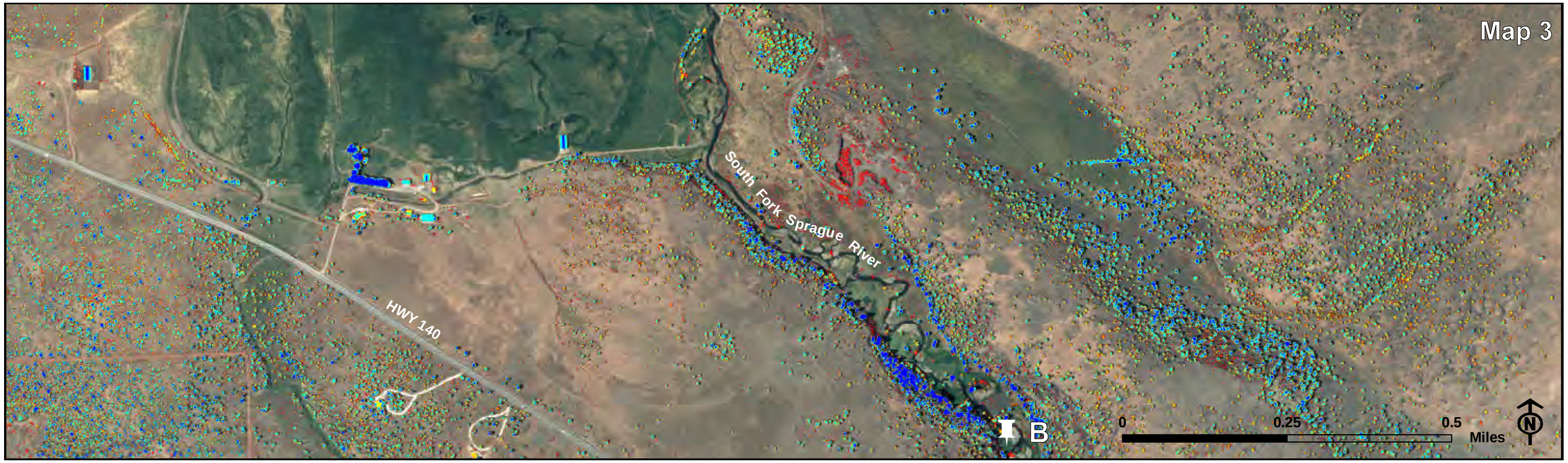


Figure 7-4. Digital images of vegetation height superimposed on aerial photos of sections of the Sprague River mainstem.



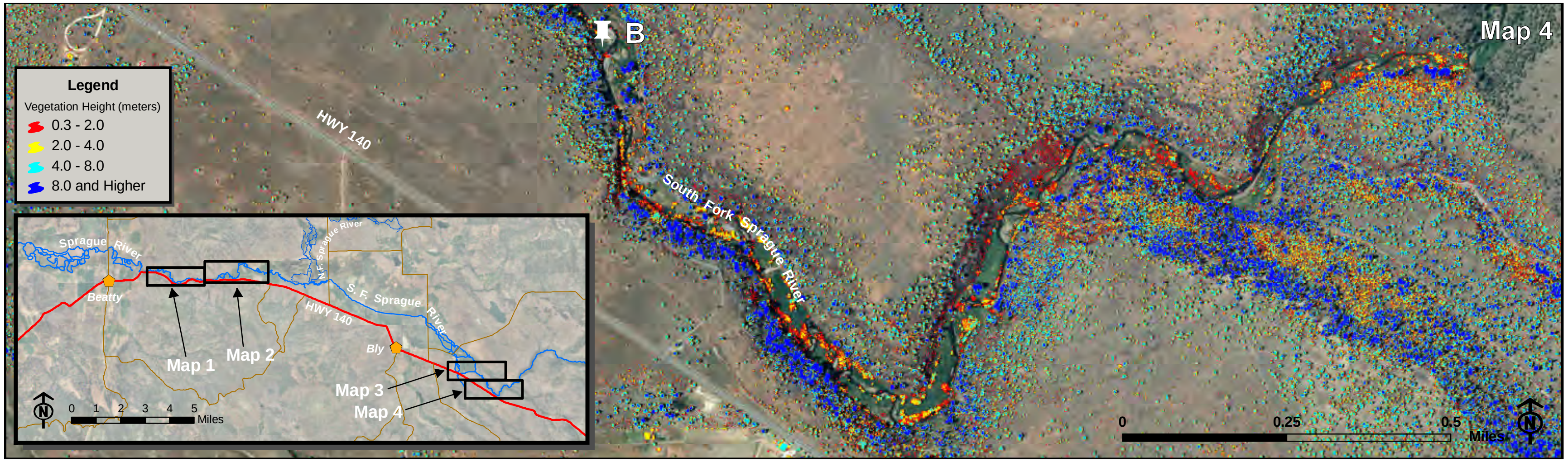


Figure 7-5. Digital images of vegetation height superimposed on aerial photos of sections of the South Fork Sprague River.

SUMMARY: CHANGES IN RIPARIAN FUNCTION

It is very difficult to accurately assess the changes to the riparian area within the assessment area. The best estimates of historic or reference conditions are marginal. The estimates are taken from limited historic photographs, historic manuscripts, personal memories and site evidence. This assessment attempts to summarize these changes and causes, but it is not an exact representation of past conditions rather a best guess given the data available.

A major change to the riparian area was the US Army Corps of Engineers diking and dredging of the main stem of the Sprague River during the mid-1900's. The diking created upland dikes where the riparian vegetation should and once existed. Due to the higher elevation of the dikes compared to the original bank level, the dikes do not have the appropriate wetland hydrology to support riparian or wetland vegetation. The higher dikes also keep the Sprague River from flooding over its natural flood plain in average flood events.

Current riparian conditions in the Upper Sprague River subbasin are different than they were historically but it is not possible to quantify the changes that have occurred. Riparian habitat has changed in comparison to the past. Historical timber harvesting, channelization, diking, agricultural practices, and urbanized type development may have removed some of the riparian forest up to the stream channel.

Willow and hardwood vegetation may have been more prevalent in the past, especially in the lower elevation portions of the subbasin now dominated by wetland-sedge-wet pasture and meadow-grass-pasture vegetation types. There is still a debate within the scientific community as to how much willow cover existed within the assessment area in the past.

Some of the existing concerns with water quality and in-stream habitat quality within the Upper Sprague River subbasin may be associated with the condition of the riparian vegetation. Such deficiencies in riparian habitat quality may occur subbasin-wide, but are most pronounced along lower-elevation mainstem stream reaches. Efforts to restore riparian condition should consider the plant species that are characteristic of this habitat.

A listing of native forbs, grasses, sedges, rushes, and shrubs that are characteristics of, and expected to occur in, riparian areas in central Oregon is provided in Table 7-1. It is expected that most, but perhaps not all, of these plant species might occur in riparian areas of the Upper Sprague River subbasin. It is important to assess site potential prior to replanting riparian vegetation.

The process of recovering riparian function will be gradual, and will require working with all private and public stakeholders throughout the subbasin. Efforts to maintain and or improve riparian areas will require finding the methodology that best fits each situation. If the solution is does not fit the entire operation, is easily maintained, and profitable over time it will be difficult to maintain at the basin scale over time. This includes the management of livestock grazing, fencing, and restoration of native streamside plant communities. These practices and others will, over time, restore riparian function resulting in improved water storage capacity, bank stability, stream shading, and recruitment of large woody debris where potential exists. Such improvements are expected to occur over time frames of a few years to many decades.

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CHAPTER 8. WETLANDS

INTRODUCTION

Wetlands constitute an important aspect of watershed systems within watersheds. This is also true within the in Upper Sprague River subbasin, especially the Sycan Marsh and Sprague River Above Beatty watersheds. Wetlands serve many functions related to water quantity and quality and provide habitat for a diversity of plant and animal species. Historically, wetlands were present in much of the subbasin, controlling water flow rates, filtering pollutants, trapping sediments, and sustaining food webs. They kept high flows from getting too high, thereby controlling downstream bank erosion. They kept low flows from getting too low, thereby maintaining cool water temperatures with adequate dissolved oxygen. Many of the concerns with watershed condition are at least partly due to changes that have occurred in these critical wetland systems. The systems are complex, making it difficult to allocate condition changes to different causes including time, nature, and human intervention.

NWI AND WETLAND DELINEATION

The information in this chapter addresses wetlands at a large scale through use of the National Wetland Inventory (NWI). While the NWI is informative, it does have limitations. The NWI was assessed using aerial photography and color variations to identify wetlands. The NWI was not ground-truthed, and therefore will not accurately represent what is found at specific sites.

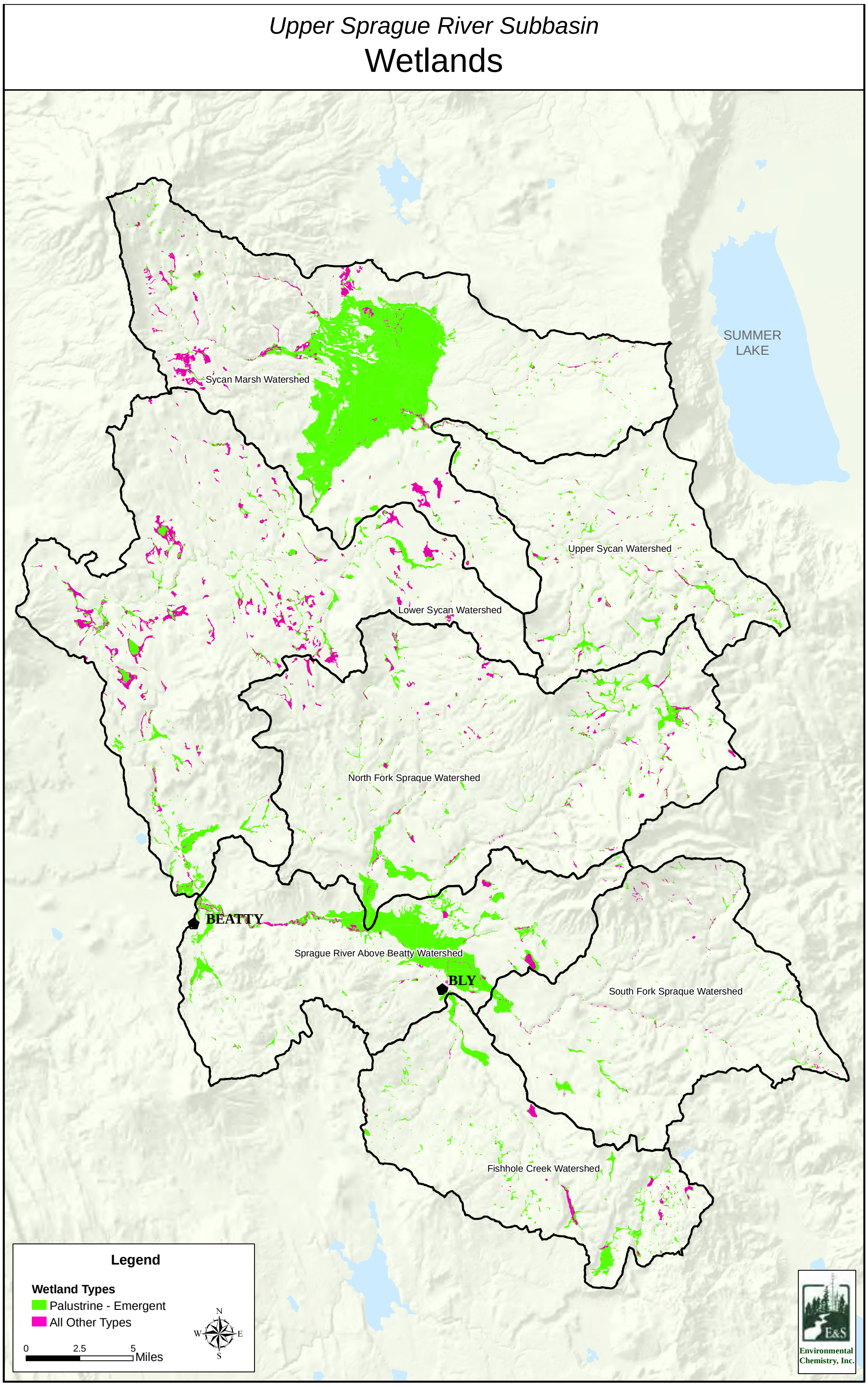
Maps of wetlands compiled by the NWI do not always agree with the actual appearance of the landscape on the ground because wetland areas are frequently converted to other uses. Classification of land as wetland is not necessarily dependent on current use, but on the characteristics of the soil, the seasonal hydrology, and the plants that would grow there in the absence of local disturbance. Figure 8-1 shows the boundary of NWI wetlands superimposed on an aerial photo of an area just north of Bly showing current land use.

The NWI does not distinguish between "natural" and "irrigated" wetlands. A natural wetland is defined as a wetland which would display wetland characteristics under natural hyrdrologic conditions. Whereas, an irrigated wetland displays wetland characteristics due to irrigation water, not natural hyrdrology. In some cases these wetlands may be the same. That is, some wetlands may be natural, but currently irrigated. The NWI classifies both natural and irrigated wetlands as wetlands. This potentially inflates the area of natural wetlands, if one considers all NWI wetlands as natural wetlands.

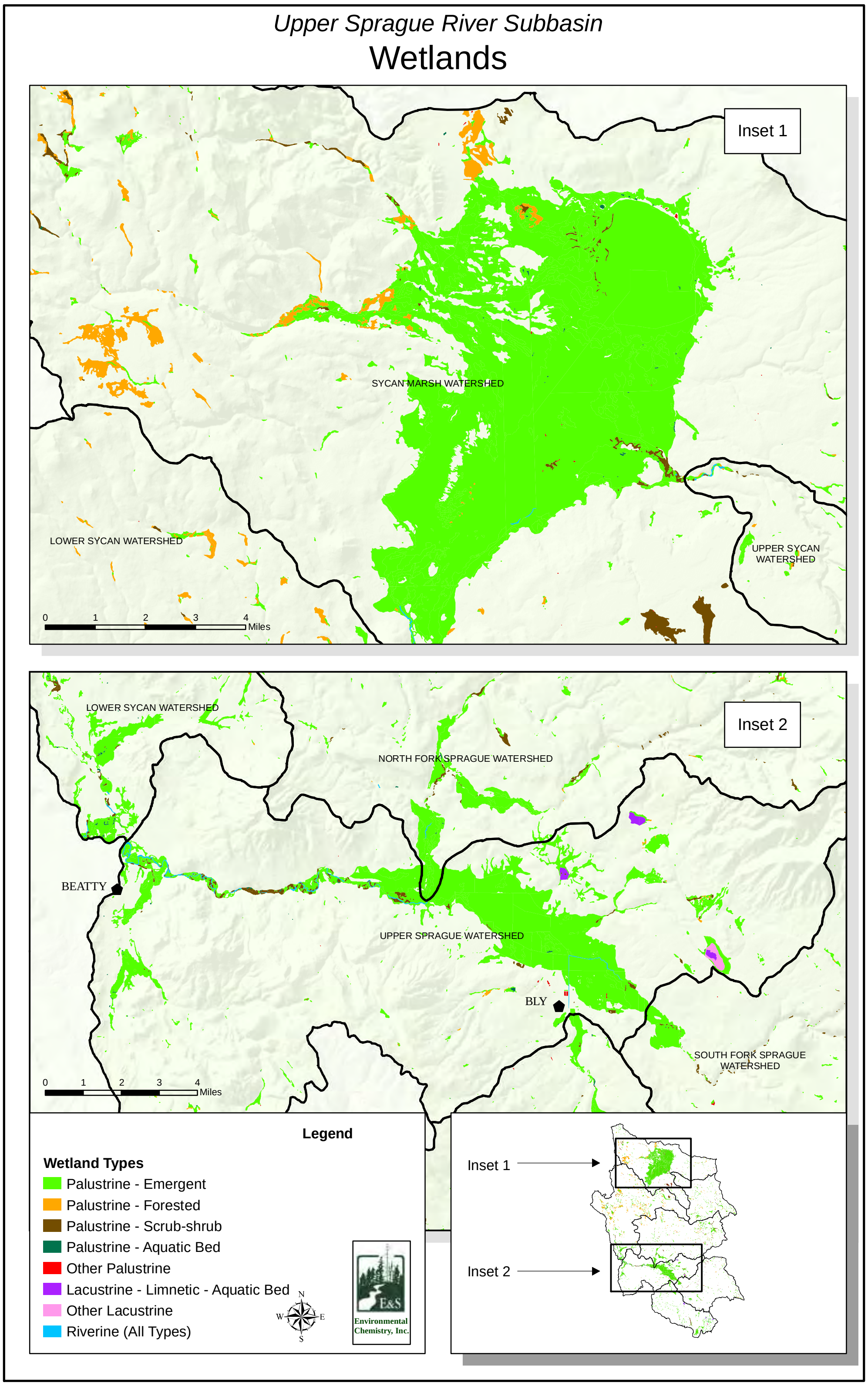
NWI is the first step in determining the existence of wetlands. After the NWI is consulted, a site visit needs to occur. During this site visit a detailed wetland determination and delineation would occur. A wetland determination would indicate if a wetland is indeed present. A wetland can be defined in many different ways, but the legal definition provided by the State of Oregon is as follows: *The wetland definition is identical to the federal definition* (ORS 196.800(16)). The federal definition presented by Army Corps of Engineers (33 CFR 328.3) and the Environmental Protection Agency (40 CFR 230.3) is: "Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalance of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." While the definitions present legal basis for wetlands, US Fish and Wildlife Service has developed a user-friendly definition that is more applicable to the landowner within this watershed area.

US Fish and Wildlife Service developed a nonregulatory, technical definition that could have several uses, ranging from wetland conservation to scientific investigations. This definition emphasizes three important attributes of wetlands: (1) hydrology--the degree of flooding or soil saturation; (2) vegetation--plants adapted to grow in water or in a soil or substrate that is occasionally oxygen deficient due to saturation (hydrophytes); and (3) soils--those saturated long enough during the growing season to produce oxygen-deficient conditions in the upper part of the soil, which commonly includes the major part of the root zone of plants (hydric soils) (Cowardin and others, 1979; Tiner, 1991). To supplement this definition and to help identify wetlands, the US Fish and Wildlife Service prepared a list of wetland plants (Reed, 1988). In addition, the Soil Conservation Service developed a list of hydric soils (US Soil Conservation Service, 1991).

If a wetland is present, then the next step is to delineate the wetland. The delineation process would be conducted according to the guidelines in the following documents: *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987) (1987 Manual); the *Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (USACOE, 2006) (Arid West Supplement); *Minimum Standards of Acceptance of Preliminary Wetland Delineations, November 30, 2001* (USACOE, Sacramento District, 2001); and Oregon Department of State Lands (DSL) regulations, permitting requirements, and agency guidance pertaining to DSL *Administrative Rules for Wetland Delineation Report Requirements and for Jurisdictional Determinations for the Purpose of Regulating Fill and Removal within Waters of the State* (OAR 141-090-0005 through 0055), including DSL's *Wetland Delineation Report Guidance, July 2005* (DSL and EPA, 2005). While these documents provide a plethora of details, simply put the delineation would be conducted by assessing paired sample plots (one within the wetland and one outside). At each sample plot soils, hydrology and vegetation would be assessed. If these three factors met the criteria for a wetland in one plot but not the other, then the wetland boundary would be established at this location.



Map 8-1. **Wetland distribution within the Upper Sprague River subbasin, based on NWI data (USFWS 1981). All wetland types, except palustrine, have been grouped together on this map, because individually they are too small to be clearly visible. See Map 8-2 for greater resolution for the areas that contain the greatest densities of wetland.**



Map 8-2. **Detailed depiction of wetland distribution in the portions of the Upper Sprague River subbasin that exhibit the greatest wetland abundance. (Data Source: USFWS 1981)**

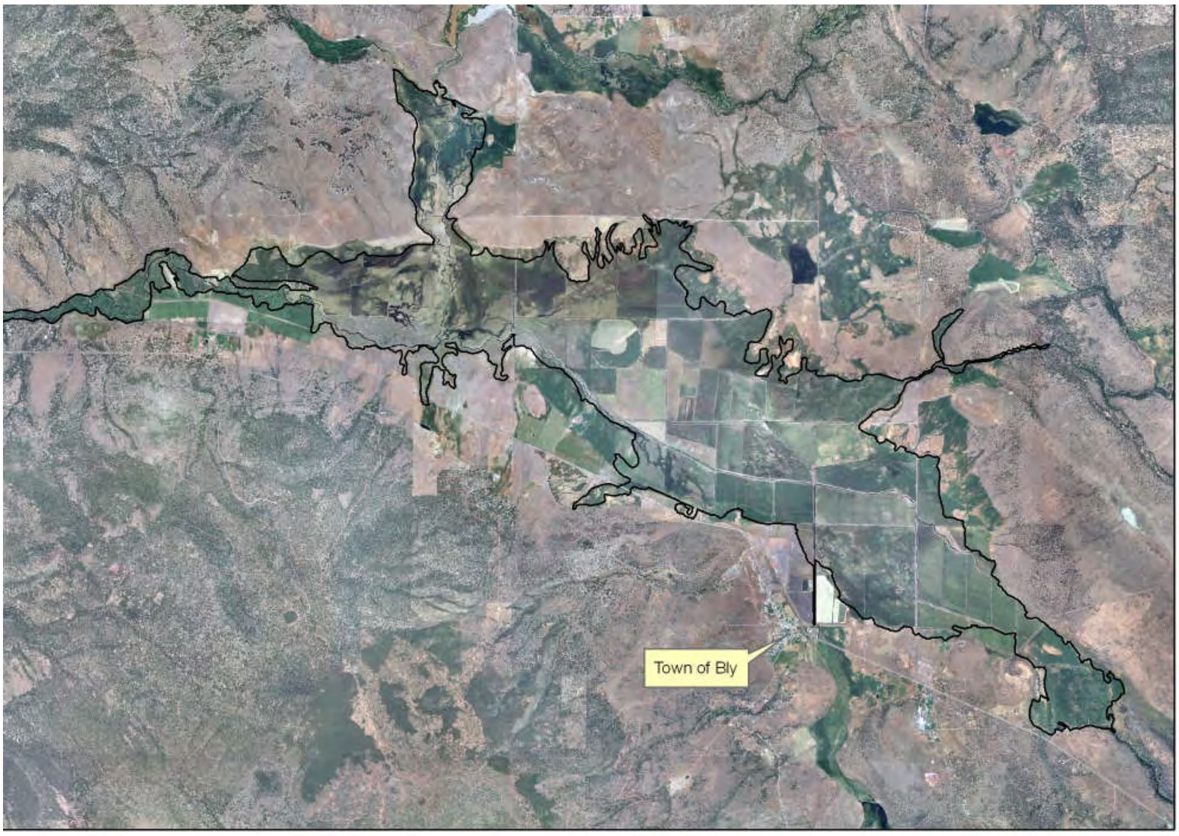


Figure 8-1. Aerial photography depicting NWI designated wetlands (black lines). (Data Sources: ODSL 2005, USFWS 1981)

It is important to make the distinction between natural and irrigated wetlands. When restoring wetlands, it is important to recognize if the wetland is historic and natural or a more recent wetland caused by irrigation water applied during the past century. Regulatory agencies for wetlands (Army Corps of Engineers and Oregon Department of State Lands) view natural and irrigated wetlands differently. The natural wetlands are regulated, whereas the agencies due not have jurisdiction over most irrigated wetlands. Regulatory implications are important for restoration activities, as this will determine when permits and mitigation activities are needed.

The Army Corps of Engineers and Oregon Department of State Lands have regulatory prevue over most natural wetlands. The job of these agencies is to ensure there is no net loss of wetland acres. If a project or management change is going to affect a wetland area through adding material or removing material, permits may be required from these agencies. Typically, the permit required is a removal-fill permit. The agencies' websites have forms and information for these permits. To obtain a removal-fill permit, one must conduct a wetland delineation, map the extent of the wetland, fill out permit forms and provide a mitigation plan. The agencies will provide concurrence for the wetland delineation.

If the wetland area has materials filled or removed from it, then a mitigation plan will be needed. A mitigation plan can propose three actions to off-set the impacts of the activity: enhance, create or restore a wetland. These actions may be conducted at the same site as the activity or in similar nearby areas. It is important to note that although the proposed activity may have beneficial long-term impacts on habitats, water quality, or other resources, a permit and mitigation plan may still be required. The permit and mitigation plan will have to be approved by both regulatory agencies prior to commencement of proposed activity.

WETLAND TYPES

Wetlands contribute to watershed health, including water quality improvement, filtration, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat. Because of the importance of these functions, wetlands are regulated by both state and federal agencies.

The 1999 Oregon Gap Project vegetation map distinguishes three types of wetlands in the Upper Sprague River subbasin: palustrine shrublands, palustrine emergent communities, and wet meadows. However, for this assessment wetlands were organized using the much more detailed Cowardin classification system (Cowardin et al. 1979). In the Cowardin classification wetlands are identified by "system," "subsystem," and "class" (Figure 8-2). The Cowardin classification system was chosen because it provides a more detailed description of the wetland types (more division of wetlands). The Cowardin system is also consistent with the regulatory agencies, Oregon Department of State Lands and US Army Corps of Engineers, definition and jurisdiction of wetland types.
Wetlands present in the Upper Sprague River subbasin were identified and located using the National Wetlands Inventory (NWI) dataset produced by the US Fish and Wildlife Service (USFWS). The NWI database was created by interpretation of aerial photos. NWI data were available for the entire Upper Sprague River subbasin, based on aerial photo imagery collected by USFWS in 1981. No newer datasets were available in 2007 for this area. It is acknowledged that wetland acreages and locations have changed since 1981, but this is the best general data available at this time. All sites should be investigated on a site specific basis to verify the presence or absence of the NWI wetlands.

Delineating wetlands through photointerpretation alone can result in data inaccuracies. The NWI program does not attempt to characterize every individual wetland in any given watershed. The information presented with this dataset is limited in resolution by the map/photo scale and wetland delineation practices. The NWI uses a target map unit as an estimate of the smallest wetland area that it attempts to map for a given land cover type and photo scale. Forested wetlands, for example, are more difficult to discern from an aerial photograph than wetlands that exist on a treeless prairie. Furthermore, data generated from color infrared photography are typically more accurate than data generated from black and white images (USFWS 1981).

It is likely that not all wetlands within the subbasin were mapped during the NWI process, and some mapped parcels may not meet the requirements of state or federal jurisdictional wetlands. The data in this assessment do not represent exact wetland boundaries such as would be obtained through a formal, on-site wetland survey and delineation. These data are best used as a screening tool to determine large-scale characteristics of general wetland types, rather than to evaluate individual wetland parcels.

Palustrine

The majority of the wetlands found in the Upper Sprague River subbasin, and throughout the state of Oregon, are palustrine. Palustrine wetlands are defined as non-tidal wetlands dominated by trees, shrubs, and persistent emergent vegetation (Mitsch and Gosselink 1993; Cowardin et al. 1979). Palustrine wetlands include the vegetated wetlands that are traditionally called marsh, swamp, bog, fen, and prairie wetlands. Small intermittent or permanent ponds are also considered palustrine (Cowardin et al. 1979). In many instances, palustrine wetlands are found in floodplains, adjacent to lakes, or isolated in the subbasin.

The composition and structure of the palustrine emergent plant community largely depends upon the water depth and duration of inundation, but all palustrine emergent wetlands are dominated by herbaceous species and grasses. Woody plant species only occur as individual plants or in small clusters. In areas subjected to relatively prolonged flooding, cattail (*Typha latifolia*), several bulrush species (*Scirpus* spp.), and burreed (*Sparganium emersum* and *S. eurycarpum*) are typical. In slightly drier areas, sedge (*Carex* spp.) and rush (*Juncus* spp.) dominate the plant community. Common grasses (both native and non-native) in emergent wetlands are blue wildrye (*Elymus glaucus*), tufted hair grass (*Deschampsia caespitosa*), bluejoint reedgrass (*Calamagrostis canadensis*), reed canary grass (*Phalaris arundinacea*), American sloughgrass (*Beckmannia syzigachne*) and northern mannagrass (*Glycera borealis*).

Lacustrine

Lacustrine wetlands include lakes and ponds and their margins. They generally contain less than 30% vegetative cover, which might include trees, shrubs, persistent emergent vascular plant species, emergent mosses and lichens. They can be either limnetic (greater than 2 meters in depth) or littoral (from shore to 2 meters in depth). Lacustrine waters may be tidal or non-tidal, but ocean-derived salinity is always less than 0.5 parts per thousand (Cowardin et al. 1979).

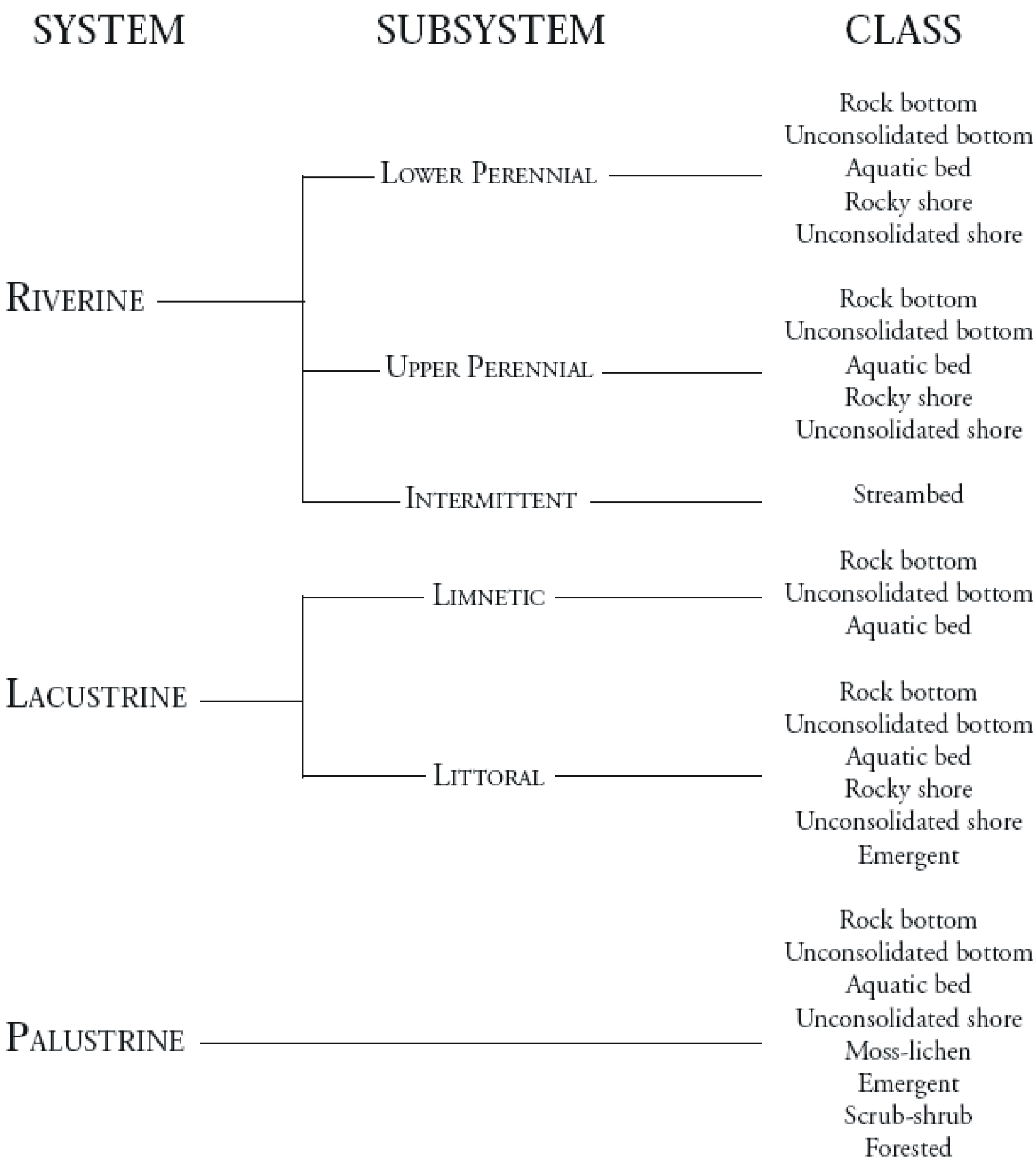


Figure 8-2. The Cowardin wetland classification system of wetlands present in the Upper Sprague River subbasin (Cowardin et al. 1979).

Riverine

Riverine wetlands include all of the wetlands that exist within the stream channel, except for those that are dominated by vegetation. Riverine wetlands are characterized by flowing water, and they are often found directly adjacent to palustrine wetlands that are located in the river's floodplain (Cowardin et al. 1979). Subsystems of riverine wetlands include:

- Lower perennial - flow through the system is continuous with a low gradient
- Upper perennial - flow through the system is continuous with a high gradient
- Intermittent - water only flows through the system during part of the year
- Tidal - low gradient, and the water velocity fluctuates under tidal influence (Cowardin et al. 1979, Mitsch and Gosselink 1993).

UPPER SPRAGUE RIVER SUBBASIN WETLAND STATISTICS

Wetlands cover 60,485 acres (9.5 percent) of the Upper Sprague River subbasin, based on NWI data from 1981. Most of the wetland area in the subbasin (49,477 acres) is classified as palustrine emergent wetland. This wetland type is distributed across the entire assessment area. The breakdown of wetland types found within the subbasin is shown in Table 8-1. Wetland area within each watershed is given in Table 8-2. It should be noted that open water is not considered a wetland and should be excluded from the wetland acreages. The largest amount of wetland area is located in the Sycan Marsh Watershed, which contains 27,349 acres of wetland. The South Fork Sprague Watershed contains the least wetland area with 1,470 acres. Table 8-3 shows a breakdown of the primary wetland types, along with their acreages and percentages, which were identified in the Upper Sprague River subbasin from the NWI data.

WETLAND SUMMARY BY WATERSHED

Sprague River Above Beatty Watershed

This watershed includes 11,095 acres of wetlands, constituting 13.4 percent of the watershed area in the subbasin. This watershed contains the greatest diversity of wetlands found in the Upper Sprague River subbasin with 10 of the 14 total wetland types present. Most of the wetland area in this watershed is located around the South Fork of the Sprague River, beginning at the confluence with the North Fork and extending upstream to the headwaters (Map 8-1). Palustrine emergent wetlands account for 90.8 percent (10,075 acres) of the wetlands found in this watershed. The acreages of the other wetland types are relatively small; that is, nine percent of 11,000 acres for a total of about 1000 acres of non-palustrine wetlands. This watershed has the only lacustrine littoral unconsolidated shore wetland (96 acres) found in the Upper Sprague River subbasin. It is located on an unnamed tributary to the east of the South Fork Sprague River, approximately five miles upstream of the confluence with Fishhole Creek.

North Fork Sprague Watershed

There are 6,081 acres of wetland in the North Fork Sprague Watershed. Palustrine emergent is the primary wetland type, accounting for 79.9 percent (4,859 acres) of the wetlands located in this watershed. Most of this wetland area is located just upstream from the confluence with the South Fork Sprague River. Other palustrine emergent wetlands are found at the headwaters of the North Fork Sprague River in the northeastern portion of the watershed (Map 8-2), Palustrine forested wetlands account for 12.0 percent (730 acres) of the wetlands in this watershed. They are distributed throughout the watershed along the headwater streams. This wetland plant community is characterized by dense, tall shrubs and often dominates riparian areas along low-gradient, meandering streams.

A small area of lacustrine littoral aquatic bed wetland (22 acres, < 1.0 percent) is found on an intermittent stream approximately 7.5 miles directly north of the watershed outlet. This is the only acreage of this wetland type found in the Upper Sprague River subbasin.

South Fork Sprague Watershed

This watershed has the least amount of wetland area at 1,470 acres (1.8 percent of the watershed). Most of the wetlands that are present are palustrine emergent (83.2 percent, 1,222 acres),the majority of which are located along the South Fork Sprague River near the confluence with the North Fork Sprague River. Additional palustrine emergent wetlands are located around tributary streams in the southern portion of the watershed.

Palustrine scrub-shrub wetlands can be found dotted along the length of the South Fork Sprague River, as well as along headwater streams in the upper reaches of the watershed. They constitute 12.3 percent (180 acres) of the wetland acreage in the watershed.

Fishhole Creek Watershed

Wetlands in this watershed cover 2,932 acres (4.5 percent of the watershed), most of which are located adjacent to Fishhole Creek, which flows into the South Fork Sprague River. Palustrine emergent wetlands account for 82.7 percent (2,424 acres) of the wetlands in this watershed and are located in both the headwaters and close to the watershed outlet.

This watershed has the only acreage of lacustrine littoral emergent wetland (28 acres) which surrounds a 71.0 acre lacustrine limnetic aquatic bed (lake). These features are located along the northeastern boundary of the watershed and form the headwaters of a tributary stream to Fishhole Creek.

Rodney Todd, Fishhole Creek property owner since 1980, believes wetlands of the Fishhole Creek Watershed were damaged by year-round grazing use of early Rodney settlers who didn't have other wintering grounds. He believes "this is what exacerbated erosion, and they probably inadvertently made the problem worse with the rock structures they used to try and help it. Their problem was not about getting water on the meadows, but getting the water off. It was too wet. Back then, they were trying to drain the meadows to make hay, they opposite of what we're doing now, trying to rewater and irrigate. The records I have also show a steady decline in willows and beaver in these wetlands" (pers. comm. January 23, 2007).

Lower Sycan River Watershed

The primary palustrine wetlands found in this watershed include both emergent and forested. Of the 9,436 total acres of wetland, just over half (4,886 acres) are palustrine emergent and 39.5 percent (3,723 acres) are palustrine forested. A large (448 acre) palustrine emergent wetland is present along Snake Creek, just upstream from its confluence with the Sycan River. Other areas of this wetland type can be found distributed throughout the watershed. The palustrine forested wetlands that are present are mainly located in the upper reaches of the watershed along streams tributary to the Sycan River.

Sycan Marsh Watershed

This watershed has the most wetland acreage in the Upper Sprague River subbasin. The 27,349 acres of wetlands make up 19.0 percent of this watershed, with 24,337 acres (89.0 percent) existing as palustrine emergent wetlands and 2,200 acres (8.0 percent) as palustrine forested. The Sycan Marsh is located in the center of the watershed along the northern edge of the Sycan River (Map 8-2). Sycan Marsh is the predominant wetland feature in the subbasin. The roughly 25,000 acre marsh consists of predominantly palustrine emergent wetlands.

Upper Sycan River Watershed

This watershed has a limited area of wetland (2,123 acres, 3.2 percent of the watershed). The palustrine emergent wetlands that comprise 78.8 percent (1,674 acres) of the wetland area found in this watershed are mainly in the higher elevation headwaters of the Sycan River. Palustrine forested wetlands make up an additional 11.9 percent (253 acres) of this watershed.

Table 8-1. Wetland type, acreage, and percent distribution identified in the Upper Sprague River subbasin, calculated from USFWS (1981) NWI data.

Wetland Type	Wetland Area (acres)	% of Total Wetland Area
Palustrine emergent	49,477	81.8%
Palustrine forested	7,005	11.6%
Palustrine scrub-shrub	2,507	4.1%
Lacustrine limnetic aquatic-bed	277	0.5%
Palustrine aquatic-bed	214	0.4%
Other[1]	1,005	1.7%
TOTAL	60,485	

[1] "Other" wetlands include: lacustrine limnetic unconsolidated-bottom, lacustrine littoral emergent, lacustrine littoral unconsolidated-shore, palustrine unconsolidated-shore, riverine intermittent streambed, riverine lower-perennial aquatic-bed, riverine upper-perennial unconsolidated-bottom, riverine upper-perennial unconsolidated-shore.

Table 8-2. Total wetland area in each watershed within the assessment area. (Data Source: USFWS 1981, calculated by E&S Environmental).

Watershed Name	Wetland Area (acres)	Watershed Area (acres)	% of Watershed Area Existing as Wetland
Sprague River Above Beatty	11,095	82,996	13.4%
North Fork Sprague	6,081	133,156	4.6%
South Fork Sprague	1,470	82,122	1.8%
Fishhole Creek	2,932	65,015	4.5%
Lower Sycan	9,436	148,248	6.4%
Sycan Marsh	27,349	143,623	19.0%
Upper Sycan	2,123	65,727	3.2%
Total	60,485	720,887	8.4%

Table 8-3. Acreage of wetland types found within each watershed. (Data Source: USFWS 1981, calculated by E& S Environmental).

Wetland Type	Sprague River Above Beatty Watershed		North Fork Sprague Watershed		South Fork Sprague Watershed		Fishhole Creek Watershed		Lower Sycan River Watershed		Sycan Marsh Watershed		Upper Sycan Watershed	
	Area (acres)	%	Area (acres)	%	Area (acres)	%	Area (acres)	%	Area (acres)	%	Area (acres)	%	Area (acres)	%
Lacustrine Limnetic Aquatic Bed	124	1.1%	0	0.0%	0	0.0%	152	5.2%	0	0.0%	0	0.0%	0	0.0%
Lacustrine Littoral Aquatic Bed	0	0.0%	22	0.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Palustrine Aquatic Bed	27	0.2%	13	0.2%	12	0.8%	81	2.8%	29	0.3%	49	0.2%	4	0.2%
Palustrine Emergent	10,075	90.8%	4,859	79.9%	1,222	83.2%	2,424	82.7%	4,886	51.8%	24,337	89.0%	1,674	78.8%
Palustrine Forested	39	0.4%	730	12.0%	52	3.5%	9	0.3%	3,723	39.5%	2,200	8.0%	253	11.9%
Palustrine Scrub-Shrub	320	2.9%	392	6.5%	180	12.3%	199	6.8%	511	5.4%	725	2.6%	181	8.5%
Other	509	4.6%	87	1.4%	4	0.3%	67	2.3%	287	3.0%	39	0.1%	12	0.6%
Total	11,095		6,081		1,470		2,932		9,436		27,349		2,123	

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CHAPTER 9. CHANNEL CHARACTERISTICS

STREAM ENERGY

General features of stream and river systems reflect the long-term constraints of geology, landform, climate and resultant vegetation patterns. During landscape evolution, stream characteristics such as drainage density, stream order, and the longitudinal channel profile develop from the interaction of runoff and stream sediment transport processes.

Channels undergo many subtle and not easily detected changes from season to season, year to year. A riffle may scour during the high flow and immediately backfill as flow decreases. To the casual observer, no change has occurred. Channel changes are a part of the natural equilibrium in stream dynamics. Recognizing that channels are constantly changing with scour and fill, to aggrade and degrade, with bankcuts and deposits, both the immediate and long-term effects need to be considered. Knowledge of stream dynamics and energy dissipation is fundamental for understanding how channels change.

Precipitation that falls on a catchment is forced by gravity along a downward path toward the ocean with a certain amount of potential energy that will be dissipated in transit. The water's initial elevation above sea level determines the total amount of potential energy available to do work. Once the water heads downstream, the potential energy is converted to kinetic energy. Some kinetic energy is utilized for sediment transport, bed scour, and bank erosion, but more than 95 percent is ultimately consumed as heat loss during turbulent mixing within the main flow as well as along channel margins (Morisawa 1968).

At a given location along a stream, the availability of energy to do work depends upon the time-rate loss of potential energy (Bagnold 1966) or total stream power. Unit stream power can be defined as the time-rate loss of potential energy per unit mass of water. In this equation the energy slope of flowing water is often assumed to be approximated by channel gradient. The unit stream power concept is important because it provides a basis for understanding the erosive capability of flowing water in open channel systems. Channels that are steep, straight, with hydraulically "smooth" banks and beds, uniform in cross-section, and of large hydraulic radius will be associated with relatively high unit stream powers. But, the unit stream power of the channel sections can be reduced in several ways.

A stream channel that changes from being relatively deep and narrow to being shallower and wider (i.e., increase in width/depth ratio) may experience a concurrent loss of pools which often provide important instream habitat for fish. Because bed shear stress would be increased in a wide, shallow cross-section, such channels would have relatively high potential for bedload transport and bank erosion, and would generally be characterized as unstable.

Channels with these types of cross-sections occur naturally but can also be the result of increased sediment loads, increased peak flows, decreased riparian vegetation (particularly woody species), mechanical damage to streambanks (by heavy equipment, livestock trampling, or ice flows), or some combination of these factors. More detailed discussions of stream hydraulics and sediment transport can be found in Leopold et al. 1964, Bagnold 1966, Morisawa 1968, Dunne and Leopold 1978, and Richards 1982.

CHANNEL MORPHOLOGY

Methods to characterize small stream channel morphology generally use some expression of width and depth. However, channels are not uniform in their cross-sectional shape and any width-to-depth measurement is only a relative index to the actual channel shape (Park 1977). Channel morphology is related to a large number of interacting variables so the expected width or depth of a particular stream reach cannot easily be predicted. In general, width usually increases faster than depth downstream. Some have considered using width/depth ration as a dimensionless index of channel morphology and useful to compare upstream and downstream reaches. Due the complex nature of the interactions in the stream channel comparisons of width/depth should only be made for streams of equal order or drainage area.

Any attempt to characterize stream channel morphology must recognize its three-dimensional aspects. Even though average widths and depths can generally index the amount and quality of instream habitat (Beschta and Platts 1986), longitudinal variability in width and depth is also important. One stream may express a uniform depth and width and have insignificant amounts of fish-rearing habitat. Yet, in another segment of the same stream with essentially the same average width and depth, but formed so that there are shallow riffle sections that are interspersed with deep pools and overhanging banks, may have relatively abundant rearing habitat. The patterns of variations in width, depth, and channel morphology are not entirely random, but are often grouped so as to provide a hierarchical structure to a stream system (Frissel, et al. 1985). Even though alluvial channels do not have fixed spacing of pools and riffles, nearly 90 percent of the pool-riffle sequences may consist of channel reaches 3 to 9 widths in length. Where bed and bank characteristics are controlled by large roughness elements the expected size and spacing of morphological features may be more variable.

Schumm's (1977) complex response concept identifies several expected changes in channel morphology by stream systems undergoing changes in flow or sediment availability. Increased high flows tend to increase channel width and depth. Increased sediment availability and transport tend to increase width, steepen gradient by decreasing sinuosity, and decrease depth. If a channel is undergoing widening, it may be responding to increases in flow, increases in sediment availability, some other factor (such as loss of streamside vegetation), or a combination of all of these.

Pools

Pools are a major stream habitat for most fish. Salmonids often require backwater or dammed pools with water moving at low velocities to survive harsh winter conditions. Elser (1968) and Lewis (1969) demonstrated that deep, slow velocity pools with large amounts of overhanging cover support the highest and most stable fish populations. Platts (1974) found that high-quality pools also supported the highest fish biomass. In the South fork Salmon River drainage of Idaho, pool quality was an important factor accounting for explained variation in total fish numbers. High-quality pools alone, however, do not make the fishery. Pools of all shapes, sizes and quality are needed. Young-of-the-year need shallow, low-quality pools that other fish will not use. Increased growth allows them to eventually compete, without undue predation, in the higher quality pools, which have better food supplies and winter rearing habitat.

Pools generally result from localized scour during moderate to highflows. The fact that a pool has formed indicates that the location is one of intense turbulence and energy dissipation during high flows. In many instances, subtle changes in channel dimensions or roughness may be sufficient to initiate pool formation and maintain pools over time (Keller and Melhorn 1973). The narrowing of channel banks can cause a converging of flow lines and acceleration of water; the gain is kinetic energy ultimately dissipated as turbulence along the bottom of a downstream pool. Although pools may form in this manner along straight reaches of a stream, they are more commonly formed at bends where flows are deflected by channel banks, turbulence is intense, and the bed is erodible. They can also be formed by large roughness elements; for instance, water flowing over a log partially or wholly buried in the bed, boulders or bedrock outcrop may create a pool immediately downstream. The size, frequency, distribution and quality of pools in a stream depend upon the mechanisms of formation and other characteristics such as size of channel substrates, erodibility of banks, size of obstruction, and depth of flow.

Riffles

Riffles, seen during periods of low flow, when substantial portions of the channel bed may become exposed or have relatively shallow water flowing over it, are remnant channel features formed at higher flows and are major storage locations of bed material. In a meandering stream, riffles are ideally located between successive pools at the inflection point of the thalweg. Their form represents a balance between the frequency and magnitude of flows, sediment transport, and other channel characteristics such as obstructions, bank erosion, or deposition. Keller and Melhorn's (1973) description of diverging flows may be an important mechanism of formation, though other mechanisms undoubtedly exist. As water moves out of a highly turbulent pool during high flow, it encounters a lower effective slope, hence reduced stream power, and may deposit coarse bedload sediment in transport. As the water continues to pass over the riffle, it accelerates until again expending most of its kinetic energy, as turbulence, at the next pool

THEORY AND FIELD METHODS

The ability of scientists and resource managers to provide for the most efficient channel form should be based on specific conditions of the fluvial system. There are few generalizations drawn from scientific studies of channel form that can be useful in practical problems of river restoration or maintenance. Width is the morphologic parameter most easily altered by the river. If the river is deprived of some of its natural discharge, it will narrow its channel. Bank erosion usually will follow unusual or unnatural alteration in sediment supply or a change in water-sediment relation. An alteration in channel gradient (slope) is the most disruptive to the natural equilibrium. The increase in gradient is the main reason channel straightening or channelization is so destructive to river systems. Also, river curves provide an essential source of hydraulic resistance necessary for equilibrium.
To develop maintenance and restoration objectives, a procedure might in principle, include the following steps. Inspect the channel upstream and downstream of the reach exhibiting problems. Inspect nearby or similar valleys that appear more natural. Choose a reach of a natural river, which appears to represent the condition of the problem channel before it was disturbed or disrupted.

Carefully consider the principle morphological features of the river channel that must be retained or restored. First, the slope or gradient of the channel must be the same as it is in the natural or undisturbed reach of the river. The deviation from this natural slope, as with drop structures or grade control, is the clearest reason that the channel may be making additional adjustments.

The second imperative is channel width. The width must represent the bankfull dimension such that when the normal bankfull discharge is exceeded, the water will overflow onto a flood plain of much greater width. This means that both width and depth at bankfull must be considered and an overflow area provided for greater discharges.

If a river curves or meanders present in the undisturbed reaches have been eliminated or importantly changed in the disturbed area, they must be reinstalled by physically constructing them. The layout of curves is the principle way the desired gradient is maintained or restored. No natural channel is straight, so the restoration of curves of appropriate size and shape is a main element in river restoration. The bed elevation should vary, in that pools occur in the curved reach and shallower zones in the crossovers.

The dimension of width, depth, meander length, radius of curvature, slope, and other features have been published for many regions in the United States. These dimensions can be used as a rough check on those measured in undisturbed reaches of the river in question.

By observing a river it should be obvious that a grade control structure flattens the channel gradient upstream for only a short distance and intrudes an unnatural-anomaly into the fluvial system. Such an anomaly will be attacked by the flow and, given time, will be eliminated. It will ultimately be destroyed by undercutting, by lateral erosion of the abutments, by scour hole erosion at the toe, or by some combination of these.

If a reach of channel is suffering unusual bank erosion, downcutting of the bed, aggradation, change of channel pattern, or other evidence of disequilibrium, a realistic approach to amelioration of these problems should be based on restoring the natural combination of dimension and form characteristics of similar channels in quasi-equilibrium. These characteristics include appropriate values of width, gradient, pool and riffle sequence, length, radius, amplitude of curves and meanders, and hydraulic roughness.

CHANNEL CLASSIFICATION

Stream channel characteristics such as width, depth, or number of pools in a section of stream are determined by many factors, including topography, geology, hydrology, and climate. Additionally, vegetation conditions and the history of disturbance, such as floods, fires, landslides, road-construction, channel modification, or livestock and timber management practices may influence stream channel conditions. High in the watershed, slopes are steep, and the rapid streamflows readily erode sediment, gravel and rocks from the banks and bed. Lower in the watershed, streams often meander across the valley bottom and may divide into multiple channels. These features may provide stream channel characteristics that respond predictably to natural and human-caused modifications and may be classified into channel habitat types (CHTs). Classifying current CHTs in the watershed helps to (1) evaluate basin-wide stream channel conditions, (2) understand how land use activities may have affected the channel form, and (3) predict how different channels may respond to particular restoration efforts (WPN 1999). Ultimately, changes in watershed processes will affect channel form and produce changes in habitat for fish and other organisms.

Channel responses to changes in ecosystem processes are strongly influenced by channel confinement and gradient (Naiman and Bilby 1998). Classifying stream channels in the watershed may help identify which stream segments are most affected by disturbances, and which segments are most likely to respond favorably to restoration activities. As an example, more confined, higher gradient streams may provide little response to restoration efforts.

In-channel structures and activities associated with human activities such as ditching and streambank stabilization (for example with riprap) and flood control can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream channel. These changes can ultimately alter community composition of in-stream aquatic biota.

Identification of channel modification activities can help in the determination of the likely effects of human-caused channel disturbances on channel morphology, aquatic habitat, and hydrologic functioning.

Unfortunately, not much data exist regarding the specific locations of channel modifications and historical channel disturbances. We present information in this section based on existing relevant data, but many sources of channel modification are undocumented.

The key questions we will address in this chapter include:

1. What are the channel habitat types?
2. What are the changes in watershed conditions?
3. What are the major modifications to channel morphology?

Designation of Channel Habitat Types

Stream segments were separated into channel habitat type categories using the Rosgen methodology (Rosgen 1996), rather than by the Oregon Watershed Enhancement Board (OWEB) protocols. The Rosgen approach was selected because of the large spatial extent of the assessment area and to maintain consistency with previous assessment efforts in the Klamath Basin. A Level I Rosgen classification was conducted based on aerial photos, digital elevation models, and topographic maps, and verified from US Forest Service data gathered in the field. The Rosgen Level I classification provides a general view of conditions in the subbasin, but is insufficient for site-specific planning. An intensive field-based analysis of channel conditions is beyond the scope of a watershed assessment, but may be desirable at selected locations in the future.

CHT categories were based on stream geomorphic structure, including stream gradient, channel size, and channel pattern. Topography in the Upper Sprague River subbasin is characterized by moderate to steep-gradient uplands that move quickly into low - gradient lowlands. Low gradient streams with extensive floodplains tend to be especially sensitive to the effects of watershed disturbance (see Figure 9-1 and Figure 9-2).

Type Aa+ Channels

Rosgen Type Aa+ channels are confined, very steep gradient streams (greater than 10 percent) found in the headwaters of the stream network. During high flows, the stream may appear as a torrent or waterfall. Type Aa+ channels typically have a step/pool morphology with chutes, debris flows, and waterfalls.

Type A Channels

Type A channels are similar to Type Aa+, but are found on slightly less steep gradients. These channels have similar landform characteristics, and gradients ranging from 4 percent to 10 percent. Type A channels are often small streams high in the stream network, although sections of Type A may be found along larger streams, as well (see Figure 9-3).

Type B Channels

The B channel designation includes streams having moderately steep to gently sloped channels, with low rates of aggradation and streambank erosion. Type B channels are moderately entrenched (see Figure 9-4).

Type C Channels

Type C stream segments have low-gradient channels, with generally less than 2 percent slope. They are frequently found in valleys formed by alluvial deposits. Type C channels characteristically meander across the valley floor, and form point-bars on inner bends (see Figure 9-5).

Type D Channels

Type D channels are shallow, wide, and braided, with active bank erosion. They are low-gradient and often include multiple channel systems.

Type DA Channels

Type DA channels are low-gradient, multiple channel systems, which are generally stable and deep relative to channel width.

Type E

Type E/F stream segments are characterized by a gentle gradient, similar to Type C, but Type E streams are narrower and deeper than Type C streams, and are more stable (see Figure 9-6).

F Channels

Type F streams are entrenched meandering streams that are not stable, continually eroding, depositing sediment, and gradually re-establishing a functional floodplain. In the absence of severe disturbance to the stream system, Type F streams may transition to Type E as they become stable (see Figure 9-7).

Ditched Channels

In addition to the Rosgen channel classifications; there were channels that have been redirected through ditches.

Table 9-1. Rosgen channel type descriptions for the Upper Sprague River subbasin. (Data Source: Rosgen 1996; WPN 1999).

Rosgen Channel Type	Comparable OWEB Stream Type(s)	General Description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features
Aa +	VH SV	Very steep, deeply entrenched, debris transport streams.	< 1.4	< 12	1.0 to 1.1	>0.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with/deep scour pools; waterfalls.
A	SV BC MV MH	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	< 1.4	< 12	1.0 to 1.2	0.04 to 0.10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology.
B	MH MM	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	> 12	> 1.2	0.02 to 0.039	Moderate relief, colluvial deposition and/or residual soils. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate with occasional pools.
C	LM FP1 FP3	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains	> 2.2	> 12	> 1.4	< 0.02	Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology.
D	AF FP2	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	N/A	> 40	n/a	< 0.04	Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply.
DA	LM LC	Multiple channels that are narrow and deep with expansive well vegetated floodplain and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks.	> 4.0	< 40	Variable	< 0.005	Broad, low-gradient valleys with fine alluvium and/ or lacustrine soils. Multiple channels controlled geologically creating fine deposition with well-vegetated bars that are laterally stable with broad wetland floodplains.

Table 9-1. Continued.

Rosgen Channel Type	Comparable OWEB Stream Type(s)	General Description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features
E	FP1	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	> 2.2	< 12	> 1.5	< 0.02	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratio.
F	LC	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	< 1.4	> 12	> 1.4	< 0.02	Entrenched in highly weathered material. Gentle gradients, with a high W/D ratio. Meandering, laterally unstable with high bank-erosion rates. Riffle-pool morphology.
G	MC MM	Entrenched "gulley" step/pool and low width/depth ratio on moderate gradients.	< 1.4	< 12	> 1.2	0.02 to 0.039	Gulley, step-pool morphology with moderate slopes and low W/D ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e. fans or deltas. Unstable, with grade control problems and high bank erosion rates.

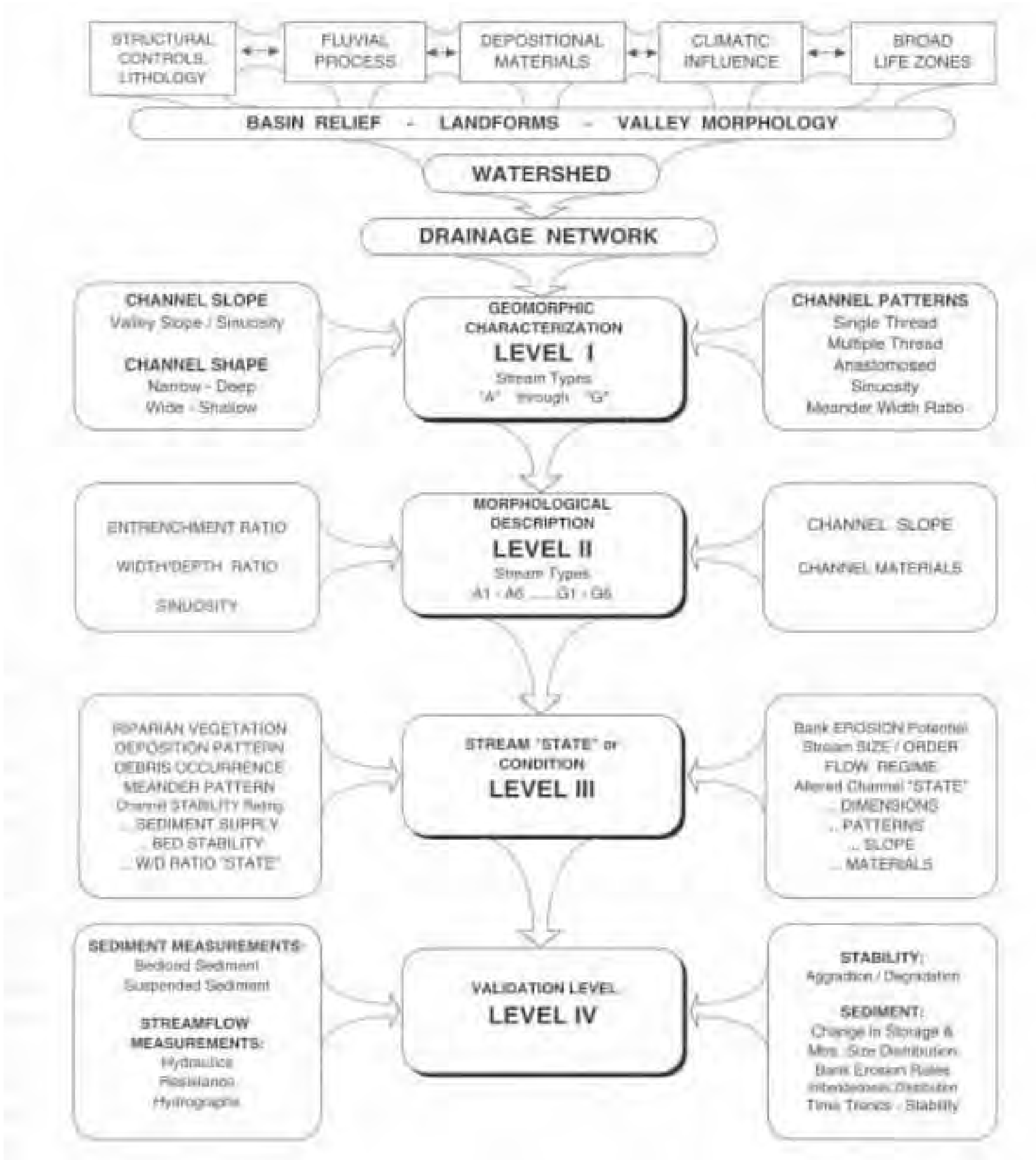


Figure 9-1. Rosgen Assessment Methodology. (Source: Rosgen 1996.)

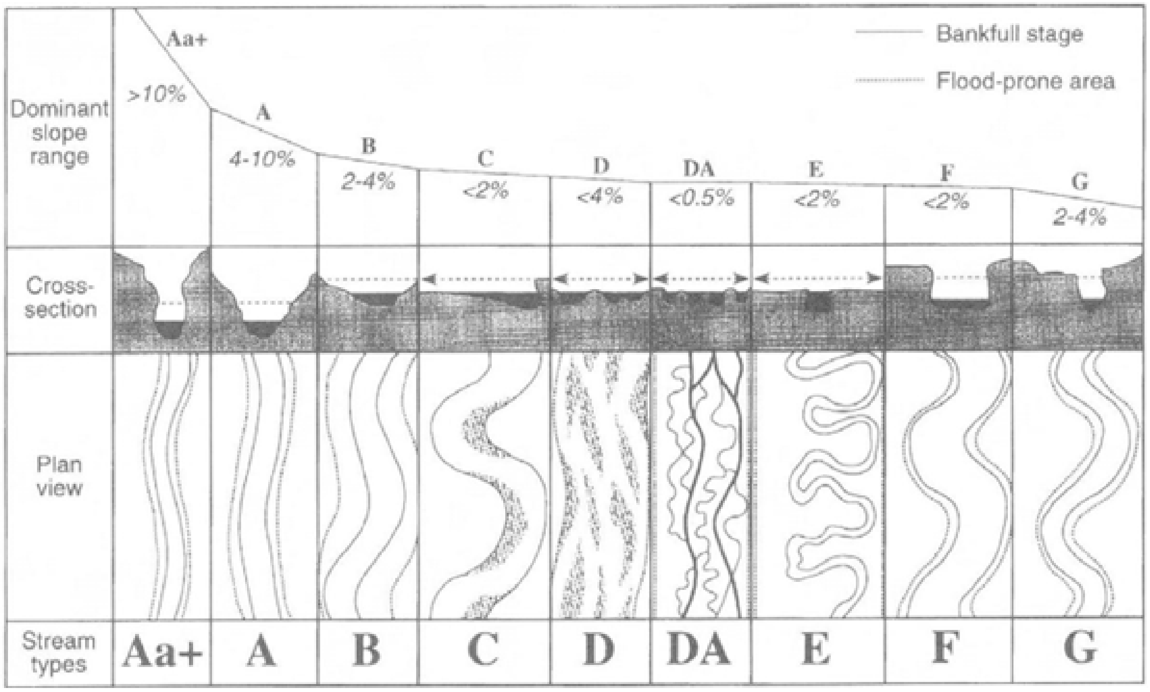


Figure 9-2. Rosgen Channel Classes. (Data Source: Rosgen 1996.)

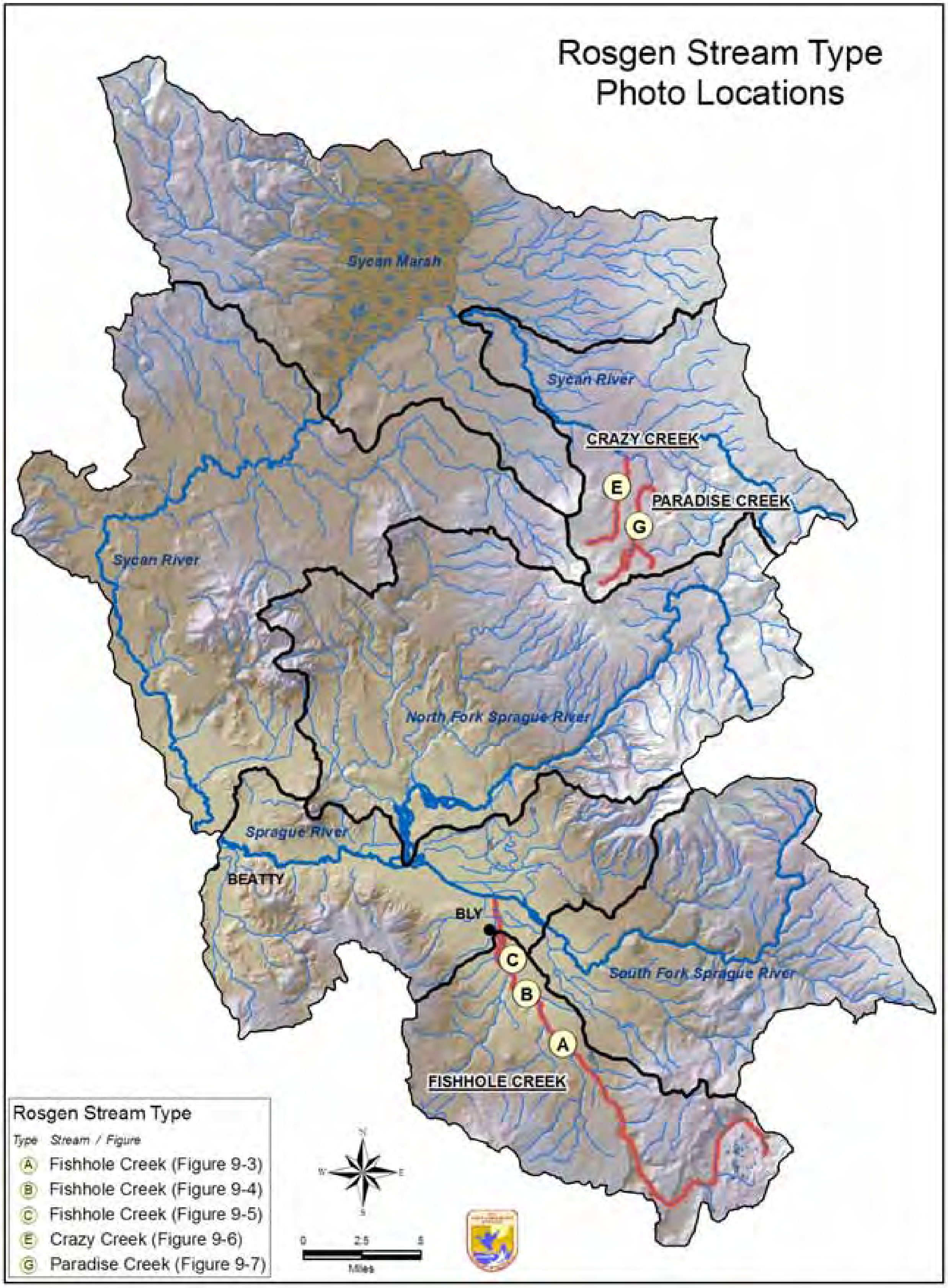
Figure 9-3. Example of Rosgen channel type A along Fishhole Creek. (Source: S. Mattenberger, USFWS.)

Figure 9-4. Example of Rosgen channel type B along Fishhole Creek. (Source: S. Mattenberger, USFWS.)

Figure 9-5. Example of Rosgen channel type C along Fishhole Creek. (Source: S. Mattenberger, USFWS.)

Figure 9-6. Example of Rosgen channel type E along Crazy Creek. (Source: S. Mattenberger, USFWS.)

Figure 9-7. Example of Rosgen channel type F along Paradise Creek. (Source: S. Mattenberger, USFWS.)



Map 9-1. Rosgen stream type photo locations. (Source: B.J. Brush, USFWS.)

Modifications to Stream Channel Conditions

Reservoirs

Modifications to the stream channel in the form of dams and reservoirs can affect not only the impoundment area, but also downstream channel morphology, water quality, and fish habitat and passage. Several reservoirs exist in the headwater reaches of the Upper Sprague River and are present in the Fishhole Creek, North Fork Sprague, South Fork Sprague, and Sprague River above Beatty Watersheds (Table 9-2).

All of the reservoirs in the Fishhole Creek Watershed are located in the headwaters of the drainage area along Fishhole Creek itself or its tributaries. They are all of moderate size, ranging from about 22 to 62 acres.

O'Connors Puddle Reservoir is the only reservoir located at the headwaters of Reservoir Creek in the North Fork Sprague Watershed. Since this reservoir is located at the origination of the creek, it does not pose any threats to fish passage.

The Sprague River above Beatty Watershed contains four reservoirs. Campbell reservoir, located on a tributary to Deming Creek, is the largest in the subbasin (206.6 acres). Hyde and Obenchain Reservoirs are two moderately sized reservoirs located within the Fritz Creek subwatershed. Whitmore Reservoir is relatively small (10.6 acres) and located on a tributary stream to the South Fork Sprague River to the west of Bly.

Splash Dams & Stream Cleaning

Splash dams have been used throughout the watershed. The history of stream cleaning is somewhat unclear. It is certain that this practice has been used on both public and private lands in the Upper Sprague River subbasin. Logs were never transported by any of the streams due to low levels of streamflow (M. Lugus, General Manager, Timber Resources Services, pers. comm., 2006).

Stream Widening and Encisement

There are stream channels throughout the Upper Sprague River subbasin that have experienced substantial channel modification associated with erosional activities related to gullying, stream incisement, and channel widening. Such changes to the channel morphology have been caused or exacerbated by a variety of human activities in past decades to centuries. These have included over-grazing, beaver trapping, removal of riparian vegetation, land clearing, wildfires, and loss of wetlands. Data are not available, however, with which to specify the locations or severity of such changes. Nevertheless, the impacts on stream structure and function are important. In particular, such changes to the channel morphology are often associated with increased sedimentation of spawning gravels, increased water temperature, and diminished riparian function.

Table 9-2. Reservoir distribution in the Upper Sprague River subbasin.

Watershed	Reservoir Name	Area (acres)
Sprague River Above Beatty	Campbell Reservoir	206.6
	Obenchain Reservoir	71.2
	Hyde Reservoir	29.4
	Whitmore Reservoir	10.6
	Unamed Reservoir1	3.0
	Unamed Reservoir2	3.5
	Unamed Reservoir3	1.7
North Fork Sprague	O'Connors Puddle Reservoir	33.9
South Fork Sprague	Little Reservoir Number One	0.2
	Little Reservoir Number Three	1.7
	Little Reservoir Number Five	3.0
	Little Reservoir Number Six	1.2
Fishhole Creek	Holbrook Reservoir	61.8
	Big Swamp Reservoir	36.8
	Lofton Reservoir	41.5
	Lapham Reservoir	21.7
Total		527.8

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CHAPTER 10. WATER QUALITY

INTRODUCTION

The purpose of the water quality assessment is to complete a screening level analysis of water quality that will identify obvious areas of water quality impairment by comparing selected measurements of water quality to certain evaluation criteria. The screening level analysis uses existing data obtained from a variety of sources. The assessment does not include statistical evaluation of seasonal fluctuations or trends through time, and does not evaluate specific sources of pollution through upstream-downstream comparisons.

The first step of the analysis identifies beneficial uses of the water that are sensitive to adverse changes in water quality. The second step establishes the evaluation criteria. The third step examines the existing water quality data in light of the evaluation criteria available. Conclusions can then be made about the presence of known water quality problems in the watershed, and whether or not additional studies are necessary.

Although there are many parameters that indicate the water quality of a stream, this assessment will focus on seven that are most often measured, and that may have the most direct effect on aquatic organisms: temperature, dissolved oxygen, pH, nutrients, bacteria, turbidity, and chemical contaminants. Evaluation criteria have been determined by regulatory entities based on values of these parameters that are generally protective of aquatic life. Some other aspects of water quality, such as fine sediment, are dealt with in other sections.

Protection of water quality in Oregon is based on water quality standards developed by the Oregon Department of Environmental Quality (ODEQ). Standards are the benchmarks that indicate if water quality is sufficient to protect designated beneficial uses. When a water body meets the standards, the beneficial uses of the water body are protected. By ODEQ definition, a water quality standard is composed of: (1) designated uses of a waterbody which set the water quality goals of a waterbody (e.g. resident fish and aquatic life, water contact recreation); (2) water quality criteria that define the minimum conditions necessary to achieve the designated uses – these can be numeric, a specific temperature value for example, or narrative, stating, for example, that the water should not have oil slicks, or objectionable color or odor; and, (3) antidegradation policy that prevents existing water quality from degrading unless specific circumstances apply. The antidegradation policy complements the use of water quality criteria. While criteria provide the absolute minimum values or conditions that must be met in order to protect designated uses, the antidegradation policy offers protection to existing water quality, including instances where that water quality equals or is better than the criteria.

BENEFICIAL USES

The Clean Water Act requires that water quality standards be set to protect the beneficial uses that are present in each water body. Beneficial uses for the purpose of water quality regulation are determined by ODEQ for each of 19 river basins. The Upper Sprague River subbasin is included in the Upper Klamath Basin. Beneficial uses for the Upper Klamath Basin are given in Oregon Revised Statute 340-41-0180, and include:

X Private domestic water supply[1]
X Industrial water supply
X Irrigation
X Livestock watering
X Fish and aquatic life[2]
X Wildlife and hunting
X Fishing
X Boating
X Water contact recreation
X Aesthetic quality
X Hydro power
X Commercial navigation and transportation

The water quality requirements to meet these uses differ. For example, the requirements for domestic water supply may be more stringent in some aspects than those for livestock watering. Frequently, the most sensitive beneficial use is considered when making decisions regarding designation of a water body as water quality limited. Federal law requires that the most sensitive beneficial use be protected. The state implements this requirement through the state water quality standards. The underlying assumption is that if the water body meets the criteria for the most sensitive use, it will meet criteria for other uses as well. For most of the Upper Sprague River subbasin, the most sensitive beneficial use would be fish and aquatic life.

POLLUTANT SOURCES

Point Sources

The Clean Water Act regulates discharge of waste to surface water. In order to discharge any waste, a facility must first obtain a permit from the State. ODEQ issues two primary types of discharge permit. Dischargers with Water Pollution Control Facility (WPCF) permits are not allowed to discharge to a water body. Industries, municipal wastewater treatment facilities, fish hatcheries, and similar facilities typically have National Pollutant Discharge Elimination System (NPDES) permits. Most WPCF

[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.
[2] Fish use designations for this basin are presented in ORS 340-41-0180. The following fish use designations pertain to the Upper Sprague River subbasin. Bull Trout – Long Creek, Coyote Creek, above Sycan Marsh, Skull Creek and the headwaters of the Sycan River, the Upper Reaches of North Fork Sprague River and South Fork Sprague River, and their tributaries. There is a short segment of the North Fork Sprague River designated core cold water habitat. The remainder of the river segments in the Upper Sprague River subbasin are designated as redband trout or Lahontan cutthroat trout use.

permits are issued for on-site sewage disposal systems. Holders of NPDES permits are allowed to discharge wastes to waters of the state, directly or indirectly, but their discharge must meet certain quality standards as specified in their permits. There are no dischargers with NPDES permits in the Upper Sprague River subbasin. The Bly sanitary district holds WPCF permits but is not allowed to discharge to any surface water.

Nonpoint Sources

The largest current source of pollutants to Oregon's waters is not point sources such as factories and sewage treatment plants, but rather comes from surface water runoff, often called "nonpoint source" pollution (ODEQ 2002, 2006). Rainwater, snowmelt, and irrigation water flowing over roofs, driveways, streets, lawns, agricultural lands, construction sites, and logging operations carry more pollution, such as nutrients, bacteria, and suspended solids, than discharges from industry (ODEQ 2002, 2006).

Land use can have a strong influence on the quantity and quality of water flowing from a watershed. An undisturbed watershed with healthy native vegetation in and along waterways and a diversity of habitats on the uplands typically provides clean water that supports the desirable beneficial uses of the waterway. As the watershed is affected by logging, agriculture, urban development, or other disturbances, the water quality in the waterways can become degraded. The percent of land area of the Upper Sprague River subbasin in various categories is shown in Table 10-1.

The most prominent type of land use in the Upper Sprague River subbasin is forestry, with little land in developed areas. This suggests that water quality problems associated with toxic industrial chemicals may be of relatively little importance while problems associated with sediment, turbidity, temperature, and possibly bacteria are likely to be more important. To the extent that herbicides and pesticides are used in forestry and agriculture operations, these compounds may assume greater importance. In the Sprague River dissolved oxygen total maximum daily load (TMDL; ODEQ 2002), ODEQ identifies forestry, agriculture, transportation, rural residential, and urban as existing nonpoint sources in the subbasin.

EVALUATION CRITERIA

The evaluation criteria for this watershed assessment are based on the Oregon Water Quality Standards for the Upper Klamath Basin (OAR 340-041-0001 to 340-041-0350) and on literature values where there are no applicable standards, as for example, for nutrients (WPN 1999). The evaluation criteria are not identical to the water quality standards in that not all seasonal variations are included. The evaluation criteria are used as indicators that a possible problem may exist. The criteria are listed in Table 10-2.

Table 10-1. Land cover types in the Upper Sprague River subbasin. (Data Source: USGS 1992)

Land Cover Type	Acres	Percent of Total
Open Water	730	0.1
Low Intensity	26	<0.1
Commercial/Industrial/Transportation	182	<0.1
Bare Rock/Sand/Clay	320	<0.1
Quarries/Strip Mines Gravel Pits	24	<0.1
Transitional	2,960	0.4
Deciduous Forest	260	<0.1
Evergreen Forest	483,605	67.1
Mixed Forest	474	<0.1
Shrubland	136,193	18.9
Grasslands/Herbaceous	35,215	4.9
Pasture/Hay	13,990	1.9
Row Crops	315	<0.1
Small Grains	1,144	0.2
Urban/Recreational Grasses	0	0
Woody Wetlands	2,651	0.4
Emergent Herbaceous	42,770	5.9
Total	720,859	100

The water quality evaluation criteria are applied to the available data by noting how many, if any, of the water quality data exceeded the criteria. If sufficient data are available, a judgment is made based on the percent exceedence of the criteria as shown in Table 10-3. If insufficient, or no, data were available, this is noted as a data gap to be filled by future monitoring. If any water quality constituent is rated by ODEQ as "moderately impaired" or "impaired" using these criteria, water quality in the stream reach in question is considered impaired for the purposes of the assessment. In the case of the Upper Sprague River subbasin, such decisions have already been made for some stream segments and some parameters.

WATER QUALITY LIMITED WATER BODIES

Sometimes, applying the best available treatment technology to all the point sources in a basin does not bring the stream into compliance with water quality standards. Under this circumstance, if all practicable measures have been taken to improve water quality by controlling discharges, the water body is declared by ODEQ to be "water quality limited" as required by the Clean Water Act section 303(d). Water bodies on the "303(d) list" must be analyzed to determine the total amount of pollutant that can be accommodated by the stream (the TMDL). The load is then allocated to all

Table 10-2. Water quality criteria and evaluation indicators. (WPN 1999)

Water Quality Attribute	Evaluation Criteria
Temperature	Core cold water habitat: The seven-day-average maximum temperature may not exceed 16.0° C (60.8° F); Lahontan cutthroat trout or redband trout: The seven-day-average maximum temperature may not exceed 20.0° C (68.0° F); Bull trout spawning and juvenile rearing: The seven-day-average maximum temperature may not exceed 12.0° C (53.6 ° F).
Dissolved Oxygen	For water bodies identified as active spawning areas the following criteria apply during the applicable spawning through fry emergence: (a) The dissolved oxygen may not be less than 11.0 mg/L. However, if the minimum intergravel dissolved oxygen, measured as a spatial median, is 8.0 mg/L or greater, then the DO criterion is 9.0 mg/L; Cold-water aquatic life: the dissolved oxygen may not be less than 8.0 mg/L as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 8.0 mg/L, dissolved oxygen may not be less than 90 percent of saturation.
pH	Estuarine and fresh waters: 6.5-8.5.
Nutrients	Total phosphorus, 0.022 mg/L Total nitrate, 0.38 mg/L
Bacteria	(a) Freshwaters and estuarine waters other than shellfish growing waters: (A) A 30-day log mean of 126 *E. coli* organisms per 100 milliliters, based on a minimum of five (5) samples; (B) No single sample may exceed 406 *E. coli* organisms per 100 milliliters.
Turbidity	2.34 NTU, 50 NTU maximum
Organic Contaminants	Any detectable amount
Metal Contaminants	Arsenic, 0.190 mg/L Cadmium, 0.0004 mg/L Chromium (hex), 0.011 mg/L Copper, 0.0036 mg/L Lead, 0.0005 mg/L Mercury, 0.000012 mg/L Zinc, 0.0327 mg/L

Table 10-3. Criteria for evaluating water quality impairment. (Source: WPN 1999)

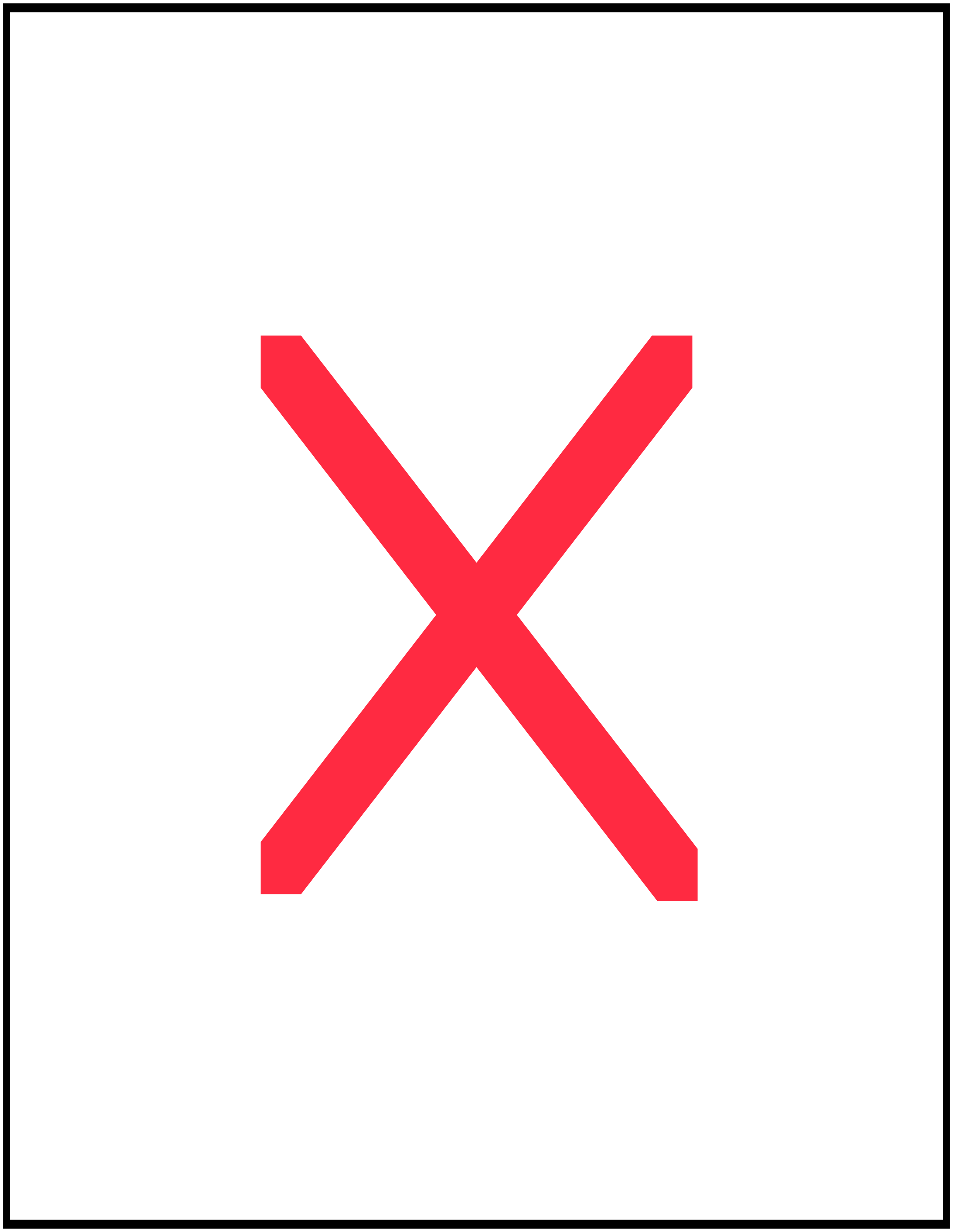
Percent of Data Exceeding the Criterion	Impairment Category
Less than 15 percent	Not impaired
15 to 50 percent	Moderately impaired
More than 50 percent	Impaired
Insufficient data	Unknown

the dischargers, including nonpoint. Dischargers must then take the steps necessary to meet their allocated load. Once a TMDL and waste load allocation is completed, the water bodies to which it applies are removed from the 303(d) list. The water quality limited stream segments in the Upper Sprague River subbasin are listed in Table 10-4, and illustrated in Map 10-1. These streams do not appear on the 2002 303(d) list because a TMDL was completed in 2002 (ODEQ 2002).

Most of the streams on the list are included because they did not meet the previous water quality standard for temperature for salmonid rearing (17.8ºC, 64ºF). A new temperature standard has been adopted for waters designated as redband trout habitat (20ºC, 68ºF) since completion of the TMDL and

Table 10-4. Water quality limited water bodies in the Upper Sprague River subbasin. (Source: ODEQ 1998)

Water Body	Segment	Constituent
Boulder Creek	Mouth to Headwaters	Temperature
Brownsworth Creek	Mouth to Hammond Creek	Temperature
Brownsworth Creek	Hammond Creek to Headwaters	Temperature
Buckboard Creek	Mouth to Headwaters	Temperature
Calahan Creek	Mouth to Hammond Creek	Temperature
Coyote Creek	Mouth to Headwaters	Temperature
Deming Creek	Campbell Reservoir Diversion to Headwaters	Temperature
Deming Creek	Mouth to Campbell Reservoir Diversion	Temperature
Fishhole Creek	Mouth to Headwaters	Temperature
Fivemile Creek	Mouth to Headwaters	Temperature
Leonard Creek	Mouth to Headwaters	Temperature
Long Creek (Sycan Marsh)	Sycan Marsh to Calahan Creek	Temperature
Paradise Creek	Mouth to Headwaters	Temperature
Pothole Creek	Mouth to Headwaters	Temperature
Sprague River	Mouth to North/South Fork	pH
Sprague River	Mouth to North/South Fork	Dissolved Oxygen (DO)
Sprague River	Mouth to North/South Fork	Temperature
Sprague River North Fork	Mouth to Dead Cow Creek	Temperature
Sprague River South Fork	Mouth to Camp Creek	Temperature
Sycan River	Mouth to Rock Creek	Temperature



Map 10-1. Water quality limited streams in the subbasin. (Data Source: ODEQ 2003)

Water Quality Management Plan (WQMP) in 2002 as a result of better understanding of the temperature tolerance of redband trout.

It should also be mentioned that, in addition to the overall WQMP, there has been a state-led process oriented toward addressing agricultural water quality issues. This process is driven by Oregon Senate Bill 1010, and includes the involvement of a Local Advisory Committee made up of interested stakeholders. This Agricultural Water Quality Plan has been included as a component of the overall WQMP and the TMDL.

Although the 303(d) list identifies water bodies that are known not to meet current water quality standards, the list is not necessarily a complete indicator of water quality in a particular basin. For many stream segments, there are not enough data to make a determination. In addition, the 303(d) listing is tied to the total amount of monitoring done, which is influenced by the number of special monitoring studies completed by ODEQ. Because special studies are frequently concentrated where water quality degradation is a concern, the list is weighted toward poorer quality waters. Consequently, the ODEQ has developed the Oregon Water Quality Index (OWQI) as a water quality benchmark that is keyed to indicator sites monitored regularly by ODEQ.

The OWQI is a single number that expresses water quality by integrating measurements of eight water quality variables (temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia+ nitrate nitrogen, total phosphorus, total solids, and fecal coliform).

No regular ODEQ monitoring site is located in the Upper Sprague River subbasin. The OWQI for waters above Upper Klamath Lake is based on a site in the Williamson River near the Williamson River Store at river mile (RM) 4.6. The Williamson River subbasin contributes approximately 50 percent of the inflow to Upper Klamath Lake.

Moderately high concentrations of total phosphates and biochemical oxygen demand are present at RM 4.6 on the Williamson River during various seasons. A high percentage of total phosphates is thought to be caused by erosion of soils that are naturally high in phosphorous. The availability of phosphorus allows the production of algae, plankton, and aquatic plants. These in turn consume oxygen as they respire or decay, increasing the biochemical oxygen demand. High pH values have been detected during the summer season. Water quality at this site in the Williamson River is better than the other sites monitored in the Klamath Basin, all of which are below Upper Klamath Lake. On the average, OWQI scores for the Williamson River site are good in the summer and excellent in the fall, winter, and spring, and based on the limited data available, water quality appears to be improving (Mrazik 2005).

WATER QUALITY DATA

Water quality data collected by ODEQ in the Upper Sprague River subbasin were retrieved from the ODEQ LASAR database (ODEQ 2005). Eleven sites in the Upper Sprague River subbasin have been sampled for water quality by ODEQ. Additional sites have been sampled by the Klamath Tribes and the Fremont-Winema National Forest. The sites are listed in Table 10-5 and shown on Map 10-1. ODEQ samples were collected on seven separate days; August 17-19, 1999, May 2, 2000, August 22-23, 2000, and September 17, 2002 (one sample). Summary information for the 12 constituents that were measured is provided in Table 10-6.

The Natural Resources Department of the Klamath Tribes has an active program of water quality monitoring in the Upper Sprague River subbasin. In addition to detailed temperature monitoring, they collect information on a variety of water quality constituents.

The Fremont-Winema National Forest has collected a considerable set of hourly temperature data from a number of sites throughout the Upper Sprague River subbasin. A summary of their data is presented in Table 10-7.

ODEQ, in response to the requirements of the Clean Water Act has completed a TMDL and Water Quality Management Plan for the Upper Klamath Lake watershed (ODEQ 2002) that incorporates and analyzes much of the data collected in the Upper Sprague River subbasin.

WATER QUALITY CONSTITUENTS

Temperature

Many of the stream segments in the Upper Sprague River subbasin are water quality limited for temperature based on the 1998 303(d) list (Map 10-1), although they do not appear on the 2002 303(d) list, having been removed following completion of the Upper Klamath Lake Drainage TMDL. A new water temperature standard that recognizes the special adaptation of redband trout and permits a higher temperature has been adopted for waters supporting redband trout use[3] since the completion of the TMDL. Figure 10-1 shows the seven-day-average maximum of hourly temperature data collected by the USFS at several sites in the Upper Sprague River subbasin. These data suggest that streams in the Upper Sycan and Sycan Marsh

[3] OAR 340-41-0028: "Temperature.

(4) Biologically Based Numeric Criteria. Unless superseded by the natural conditions criteria described in section (8) of this rule, or by subsequently adopted site-specific criteria approved by EPA, the temperature criteria for State waters supporting salmonid fishes are as follows:
(e) The seven-day-average maximum temperature of a stream identified as having Lahontan cutthroat trout or redband trout use on subbasin maps and tables set out in OAR 340-041-1010 to OAR 340-041-0340:…Figure 180A,…may not exceed 20.0 degrees Celsius (68.0 degrees Fahrenheit);…."

Table 10-5. Sites in the Upper Sprague River subbasin sampled for water quality by ODEQ, USFS, and KNRD.

Station ID	Station Description	Latitutude	Longitude	Organization[1]
31017	SF Sprague River upstream of Corral Creek	42.4556	-120.7786	USFS
26580	Sycan River upstream of Boulder Creek	42.6597	-120.7819	USFS
26571	NF Sprague River, Lee Thomas crossing	42.6039	-120.8467	USFS
26572	Paradise Creek	42.6917	-120.8919	USFS
31000	Fishhhole Creek upstream of Briggs spring	42.2336	-120.9097	USFS
26569	Fishhole Creek upstream of Briggs spring	42.2344	-120.9119	USFS
26567	Sycan River Pikes Crossing	42.6981	-120.9328	USFS
26568	Fishhole Creek	42.3044	-120.9547	USFS
31213	Lower Fishhole Creek	42.3044	-120.9547	USFS
26576	SF Sprague River picnic area	42.3694	-120.9653	USFS
21564	SF Sprague River at Sprague River Campground, Hwy 140	42.3709	-120.9681	ODEQ
SR0050	SF Sprague at Picnic Area	42.3761	-120.9694	KNRD
26965	Fishhole Creek	42.3229	-120.9859	ODEQ
SR0040	NF Sprague at 3411 Road	42.4396	-121.0056	KNRD
28148	NF Sprague River at 3411 Road	42.4970	-121.0056	USFS
26570	NF Sprague River at "the Elbow"	42.4967	-121.0058	USFS
31001	NF Sprague River elbow	42.4967	-121.0058	USFS
21563	NF Sprague River upstream of "The Elbow"	42.4986	-121.0115	ODEQ
21532	SF Sprague River at Dairy Creek Road	42.4168	-121.0146	ODEQ
28150	SF Sprague River at Campbell Road Bridge	42.4153	-121.0162	USFS
28154	Sprague River at Lone Pine Bridge	42.4153	-121.0162	USFS
21568	Fishhole Creek at Hwy 140 upstream of Bly, OR	42.3969	-121.0322	ODEQ
28151	SF Sprague River at Ivory Pine Road Bridge	42.4396	-121.0944	USFS
SR0140	S.F.Sprague at Ivory Pine Road	42.4396	-121.0944	KNRD
28149	NF Sprague River at Ivory Pine Road Bridge	42.4853	-121.0946	USFS
SR0150	N.F.Sprague at Ivory Pine Road	42.4853	-121.0946	KNRD
21533	SF Sprague River at Ivory Pine Road	42.4396	-121.0949	ODEQ
21530	NF Sprague River at Ivory Pine Road	42.4837	-121.0972	ODEQ
21531	NF Sprague River at Campbell Road	42.4554	-121.1145	ODEQ
SR0120	Five Mile Creek	42.5431	-121.1203	KNRD
21534	Sprague River Near Hwy 140 Milepost 45	42.4410	-121.1836	ODEQ
SR0130	USGS Gage	42.4481	-121.2366	KNRD
28152	Sprague River at Beatty Gap	42.4478	-121.2366	USFS
21562	Sprague River at Hwy 140 Public Access Gage Station	42.4467	-121.2381	ODEQ
SR0060	Sprague River at Godowa Road	42.4604	-121.2699	KNRD
30996	Lower Calahan meadow	42.8744	-121.2714	USFS
21565	Sycan River at Drews Road	42.4856	-121.2778	ODEQ
31018	Lower Long meadow	42.8675	-121.2956	USFS
26579	Sycan River coyote bucket	42.5739	-121.3358	USFS
31022	Sycan River coyote bucket	42.5739	-121.3358	USFS
31021	Sycan River upstream of Teddy Powers meadow	42.6589	-121.3478	USFS
26578	Sycan River upstream of Teddy Powers meadow	42.6572	-121.3481	USFS
28156	Sycan River at Elde Flat	42.6106	-121.3487	USFS
SR0070	Sycan River at Drews Road	42.4857	-121.3487	KNRD
30993	Sycan River downstream of Teddy Powers meadow	42.6289	-121.3594	USFS
26577	Sycan River downstream of Teddy Powers meadow	42.6289	-121.3611	USFS
SR0080	Sprague River at Lone Pine	42.3302	-121.6176	KNRD
SR0100	Trout Creek	42.4873	-121.6218	KNRD
SR0090	Sprague River at Power Plant	42.7678	-121.8419	KNRD

[1] ODEQ – Oregon Department of Environmental Quality; USFS – U.S. Forest Service; KNRD – Klamath Tribes Natural Resources Department

Table 10-6. Summary of water quality data collected by ODEQ in the Upper Sprague River subbasin in August 1999 and August 2000. (Data Source: ODEQ 2006)

Parameter	Number of Observations	Minimum	Maximum	Mean	Median
Ammonia (mg/L)	47	<0.02	0.03	0.02	<0.02
Dissolved Orthophosphate (mg/L)	47	0.018	0.240	0.049	0.039
E. Coli (CFU/100 ml)	47	2	500	129	88
Fecal Coliform (CFU/100 ml)	47	2	650	166	94
Field Dissolved Oxygen (mg/L)	45	7.0	11.0	8.8	8.8
Percent Saturation Field Dissolved Oxygen (%)	45	82.0	144.0	105.6	104.0
Field pH	47	7.6	8.8	8.1	8.0
Field Temperature (°C)	47	5.6	22.0	17.3	18.2
Field Turbidity (NTU)	47	1.0	18.0	5.4	3.9
Nitrate/nitrite as N (mg/L)	47	0.005	0.039	0.010	0.005
Total Phosphorus (mg/L)	47	0.04	0.34	0.08	0.07
Total Suspended Solids (mg/L)	47	1.0	22.0	4.4	3.0

watersheds may meet the criteria for redband trout, but not for bull trout, while streams in the Lower Sycan Watershed do not currently provide conditions that fully support redband trout. The sites in the Sprague River Above Beatty and South Fork Sprague watersheds have relatively few instances of temperature higher than the evaluation criteria, suggesting marginal support for the beneficial use, but Fishhole Creek and North Fork Sprague watersheds do not appear to fully support conditions suitable for redband trout. Riparian area management and re-vegetation measures are proposed in the Upper Klamath Lake Drainage WQMP (ODEQ 2002) to bring these areas into compliance with relevant criteria. Since the WQMP was published there have been many accomplishments with regard to implementing the recommendations of the plan.

Dissolved Oxygen

Information for evaluation of dissolved oxygen comes primarily from data collected by the Klamath Tribes in 2001 through 2005, plus data collected by ODEQ on three days in August 1999 and three days in August 2000. The total number of samples collected by all agencies for a variety of water quality constituents is provided in Table 10-9. Of the 23 sites in the Upper Sprague River subbasin for which water quality constituent concentration measurements were available, only eight had more than 10 values.

Table 10-7. Summary statistics for hourly streamwater temperature (°C) data collected in 2001 and 2002 at various locations in the Upper Sprague River subbasin. (Data Source: USFS 2006)

Location	N	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Mean	CV
Sycan River Pikes Crossing	7,716	-0.4	10.1	12.6	16.5	24.8	13.0	0.4
Lower Calahan meadow	3,284	-0.1	6.0	8.2	11.0	18.5	8.6	0.4
Lower Long meadow	3,284	-0.1	6.2	8.5	11.6	19.6	8.9	0.4
Sycan River upstream of Teddy Powers meadow	5,883	2.3	12.0	16.3	19.7	25.6	15.6	0.3
Sycan River downstream of Teddy Powers meadow	5,882	1.8	12.7	17.0	20.5	28.4	16.5	0.3
Sycan River coyote bucket	5,881	1.5	11.9	16.0	19.7	29.7	15.8	0.4
Sycan River at Elde Flat	567	13.8	18.4	20.6	23.1	27.8	20.7	0.2
SF Sprague River at Campbell Road Bridge	1,009	14.1	17.1	19.9	21.9	26.2	19.7	0.1
SF Sprague River at Ivory Pine Road Bridge	1,608	11.0	17.2	19.7	22.7	29.1	20.0	0.2
Sprague River at Beatty Gap	1,607	13.2	17.0	18.2	19.9	23.2	18.4	0.1
Sprague River at Lone Pine Bridge	1,632	14.9	19.0	20.8	22.5	26.1	20.7	0.1
Fishhole Creek upstream of Briggs spring	6,673	0.6	12.3	15.8	19.6	29.2	15.9	0.3
Lower Fishhole Creek	3,643	1.4	12.1	15.9	19.7	29.5	15.8	0.4
NF Sprague River elbow	2,232	2.6	7.2	9.3	11.3	16.5	9.3	0.3
NF Sprague River, Lee Thomas crossing	3,357	-0.2	6.9	10.2	14.6	22.4	10.8	0.5
SF Sprague River picnic area	3,668	3.2	12.6	15.8	19.3	25.8	15.8	0.3
SF Sprague River upstream of Corral Creek	2,275	2.3	5.3	6.5	8.2	13.0	6.9	0.3

Dissolved oxygen data collected in the Upper Sprague River subbasin are presented in Figure 10-2. For dissolved oxygen at all sites combined, 16 percent of the samples were less than the evaluation criterion of 8.0 mg/L for cold water species. These values suggest that streams in the Upper Sprague River subbasin are not impaired with respect to dissolved oxygen for cold water fish habitat considering that portions of the subbasin are at elevations that might preclude attainment of these concentration values. For all sites combined, during the months of January, February, and March when trout spawning is most likely, 48 percent of dissolved oxygen values were less than 11.0 mg/L. This suggests that at least portions of the subbasin might be impaired for salmonid spawning with respect to dissolved oxygen. Care must be taken in this interpretation, however, because conditions of temperature and elevation, especially in the upper reaches of many streams, may preclude achieving the evaluation criterion of 11.0 mg/L.

Table 10-8. Sites in the Upper Sprague River subbasin with more than 10 measurements for various water quality constituents. (Data Source: ODEQ 2006)

Site Name	Number of Samples
Sprague River at Power Plant	150
Sprague River at Godowa Road	146
SF Sprague @ picnic area	137
NF Sprague @ 3411 Rd	135
Sprague River at Lone Pine	134
USGS Gage	30
SF Sprague @ Ivory Pine Road	14
NF Sprague @Ivory Pine Road	14

pH

Measurements for pH were taken at the same time as those for dissolved oxygen. Values measured for pH are presented in Figure 10-3. Of all pH measurements at all sites, fewer than 1 percent were below 6.5 and 16 percent were above 8.5. With 16 percent of values outside the acceptable evaluation range, the Upper Sprague River subbasin would be considered moderately impaired with respect to pH. The high pH values are not, however, evenly distributed across the subbasin. Of the 113 measured pH values that exceeded 8.5, 93 percent were measured at sites in the mainstem Sprague River, suggesting that pH impairment may be localized to the mainstem. The Sprague River has been listed as water quality limited for pH, and was included in the Upper Klamath Basin TMDL.

Nutrients

Algal nutrients, especially nitrogen and phosphorus, can exert an adverse influence on water quality indirectly through their effect on the growth of aquatic plants, both attached (periphyton) and suspended (phytoplankton). Excessive plant growth can result in excursions of both pH and dissolved oxygen outside the relevant criteria.

Phosphorus

Data for total phosphorus are presented in Figure 10-4. All of the measured values for total phosphorus exceed the US Environmental Protection Agency (EPA) criterion value of 0.022 mg/L, and 65 percent of measured values exceed the Oregon Watershed Assessment Board (OWEB) evaluation criterion of 0.05 mg/L. The Upper Sprague River subbasin would be considered impaired with respect to phosphorus concentration. There are no point sources discharges in the subbasin that might contribute phosphorus to subbasin streams, so the elevated concentrations are the result of nonpoint or natural sources. High phosphorus values are not localized to a particular subbasin within the assessment area.

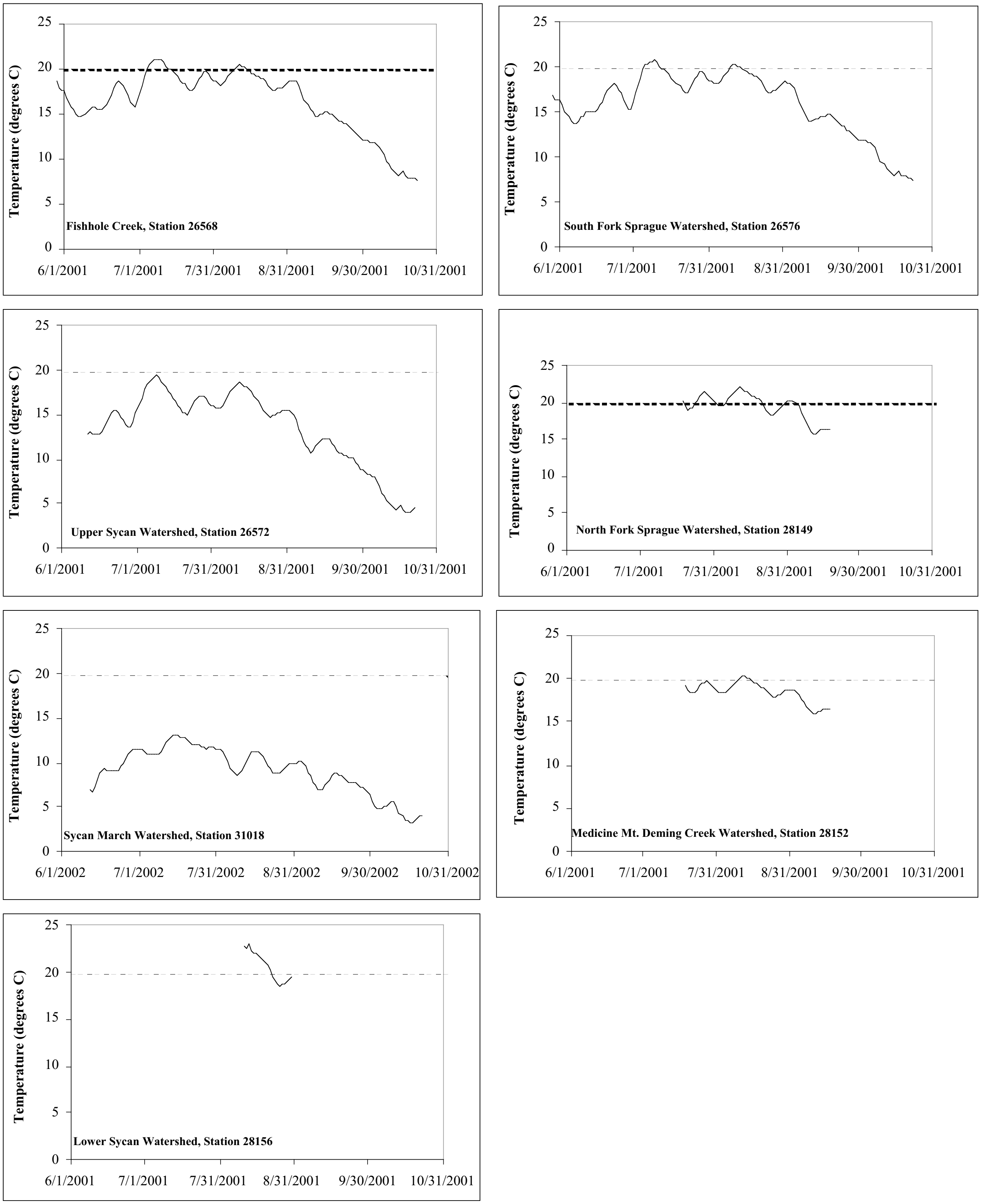


Figure 10-1. Seven-day-average maximum daily temperature at several sites in the Upper Sprague River subbasin. The dashed line represents the evaluation criterion for support of redband trout. Based on hourly data collected by the US Forest Service in 2001-2002. (Data Source: USFS 2006)

High total phosphorus concentration in subbasin streams is partially the result of high concentration in the groundwater due to volcanic soils. The average total phosphorus concentration of 14 springs in the Upper Sprague and Upper Williamson subbasins was 0.077 mg/L (ODEQ 2002). Phosphorus also tends to bind to soil particles and enters streams as a result of soil erosion. Sediment core studies in Upper Klamath Lake have shown that erosion in the Klamath Basin has increased substantially in the past 100 years as changes in land use have occurred (Eilers et al. 2001). A high correlation in the Sprague River between flow and phosphorus load indicates that increased erosion due to high runoff is contributing to high phosphorus concentration in Upper Sprague River subbasin streams (ODEQ 2002). However, there is not data that clearly determines what proportion of loading is due to natural sources, and what proportion is due to degraded riparian conditions.

Nitrogen

Nitrate-nitrogen data collected in the Upper Sprague River subbasin are presented in Figure 10-5. No measured value exceeds the evaluation criterion of 0.38 mg/L. The Upper Sprague River subbasin is not impaired with respect to nitrogen concentration in the water.

Bacteria

Bacterial contamination of water from many sources, including mammalian or avian sources, including livestock feeding operations or improperly functioning sewage treatment systems, etc., can cause the spread of disease through contact recreation or ingestion of the water itself. Bacteria of the coliform group (either *E. coli* or fecal coliform bacteria) are used as an indicator of possible fecal bacterial contamination. A limited number of samples for *E. coli* were collected during the summer in 1999 and 2000. The available data are summarized in Table 10-9.

Five samples (11 percent) exceeded the single sample maximum evaluation criterion of 406 colonies/100 mL. Those samples were generally from sites in the lower reaches of the Sprague, North Fork Sprague, and South Fork Sprague watersheds (Table 10-10). The samples were not collected in a manner that would permit proper calculation of the geometric mean for any one site; however, the geometric mean for all samples was well below the evaluation criterion of 126 colonies/100 mL.

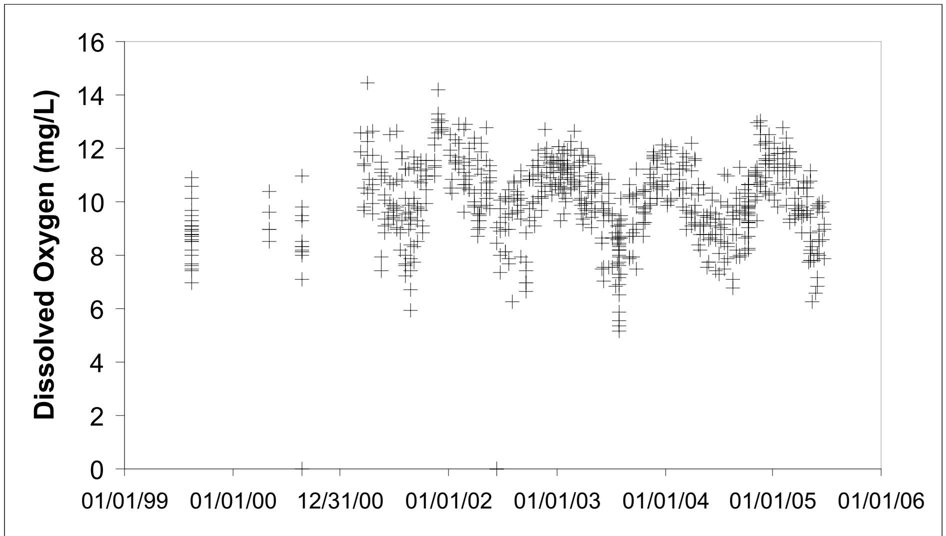


Figure 10-2. Dissolved oxygen concentration measured at several sites in the Upper Sprague River subbasin in 1999 through 2005. (Data Source: ODEQ 2006)

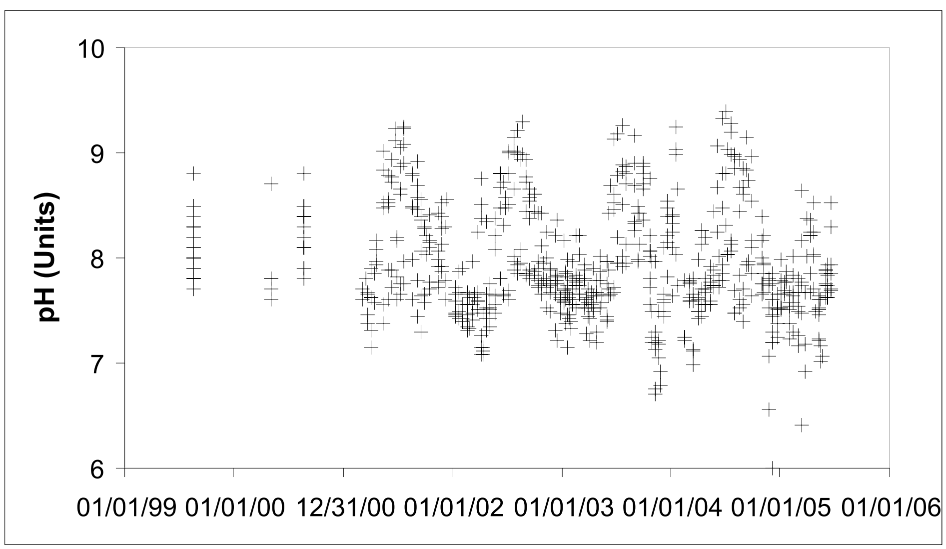


Figure 10-3. pH values measured at several sites in the Upper Sprague River subbasin in 1999 through 2005. (Data Source: ODEQ 2006)

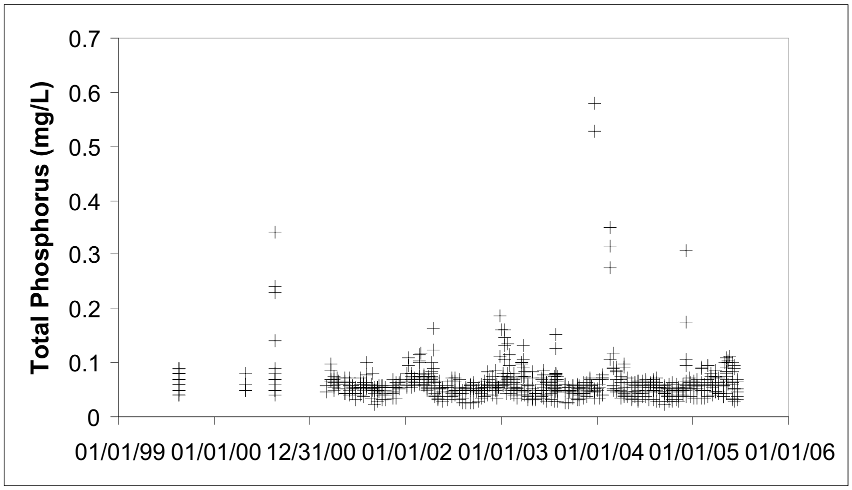


Figure 10-4. Total phosphorus values measured at several sites in the Upper Sprague River subbasin in 1999 through 2005. (Data Source: ODEQ 2006)

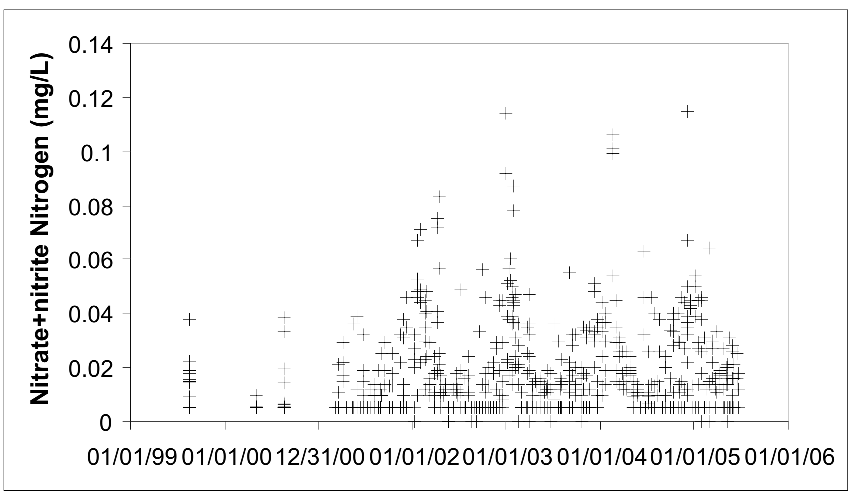


Figure 10-5. Nitrate-nitrogen values measured at several sites in the Upper Sprague River subbasin in 1999 through 2005. (Data Source: ODEQ 2006)

Table 10-9. Statistical summary of *E. coli* values collected in the Upper Sprague River subbasin in 1999 and 2000. (Data Source: ODEQ 2006)

No. of values used	47
Minimum	2
1st quartile	28
Median	88
3rd quartile	150
Maximum	500
Mean	129
Geometric mean	56
CV (standard deviation/ mean)	1

Table 10-10. Locations with *E. coli* samples that exceeded the single sample maximum evaluation criterion (406 colonies/100 mL). (Data Source: ODEQ 2006)

Date	Site Name	*E. Coli* Concentration (colonies/100 ml)
08/22/00	Sprague River at Hwy 140 Public Access Gage Station	500
08/19/99	SF Sprague River at Dairy Creek Road	490
08/22/00	SF Sprague River @ Ivory Pine Road	480
08/23/00	SF Sprague River @ Ivory Pine Road	470
08/19/99	SF Sprague River @Ivory Pine Road	410

Turbidity

Turbidity is a measure of the clarity of the water. High turbidity is associated with high suspended solids, and can be an indicator of erosion in the watershed. At high levels, turbidity can have negative effects, such as impairing the ability of salmonid fish to see their prey is impaired. A limited number of turbidity measurements were made in the Upper Sprague River subbasin in 1999 and 2000. They are summarized in Table 10-11. No value exceeded the evaluation criterion of 50 NTU; however, most of the measurements were made during the summer when turbidity values might be expected to be low. Few, if any, measurements were made during high flow periods. The available data are insufficient to determine the status of streams in the Upper Sprague River subbasin with respect to turbidity.

Table 10-11. Summary statistics for turbidity measurements (NTU) in the Upper Sprague River subbasin. (Data Source: ODEQ 2006)

Mean	5.4
Median	3.9
Mode	2.0
Standard Deviation	4.5
Minimum	1.0
Maximum	18.0
Count	46

Contaminants

Synthetic organic compounds, pesticides, and metals can be toxic to aquatic organisms, and can pose potential threats to public health. The presence of such contaminants in the water may suggest the presence of sources of pollution that could have an adverse effect on the stream ecosystem.

There were no data available to assess water quality conditions in the Upper Sprague River subbasin with respect to contaminants. However, local knowledge recognizes illegal dumping from methamphetamine laboratories and other activities (B. Hyde, pers. comm., September, 2006).

SUMMARY OF WATER QUALITY CONCERNS

At the screening level of this assessment, water quality in the major streams of the Upper Sprague River subbasin would be considered impaired because of the frequency of exceedence of the evaluation criteria for temperature, pH, phosphorus, bacteria, and possibly dissolved oxygen. Insufficient data are available to determine the status of streams with respect to inorganic or organic contaminants. These water quality impairments (e.g. temperature, pH, and dissolved oxygen) have been addressed in the Upper Klamath Lake Basin TMDL and WQMP (ODEQ 2002). Concerns have been raised, however, that the proposals of the WQMP will not be adequate to address the water quality impairment issues (NAS 2003). There are many sources of water quality impairment related to human activities in the subbasin. These include current activities associated with agriculture, forestry, recreation, illegal dumping, and urban development. In particular, however, water quality is affected by a long-term legacy of land use and water use that have developed over more than a century. The relative importance of the various water quality stresses is not completely clear, and our understanding of issues such as phosphorous loading is imcomplete. It is likely that additional data, obtained through a carefully designed water quality monitoring program, will be required in order to adequately address the causes of water quality impairment throughout the subbasin.

In many western watersheds water quality problems are linked to limited water quantity, inadequate riparian vegetation along some reaches, associated soil erosion, and loss or degradation of wetland habitats. Each of these issues can affect water quality, especially temperature, in a variety of ways depending on site-specific conditions. It would be important for any future research to confirm whether or not this is the case within the assessment area.

Water quality-limited streams are found in every watershed throughout the assessment area (Map 10-1). Water quality limitations are particularly prevalent along the lower mainstream river reaches, especially in the southern half of the subbasin. In virtually all cases, water quality limitation is associated with water temperature. Summer water temperatures are too high in many streams to support healthy fish populations.

Stream temperature is of vital importance to the health and well-being of cold-water fish species. It influences the metabolism, growth rates, availability of food, predator-prey interactions, disease-host relationships, and timing of life history events of fish and other aquatic organisms (Spence et al. 1996). Temperature requirements vary by species, season, and life stage, and conditions most frequently approach harmful levels in the late summer when air temperatures are high and streamflows are low. High water temperature also contributes to reduced dissolved oxygen levels, which in turn can affect the ability of fish to breathe.

Many studies have concluded that stream temperatures increase in response to timber harvesting, especially when vegetation is removed up to the edge of the stream (Levno and Rothacher 1967, Meehan 1970, Feller 1981, Hewlett and Fortson 1982, Holtby 1988, ODF and ODFW 2002). While the direct applicability of these studies to the assessment area is variable, allowing riparian vegetation to remain near the stream has been shown to reduce the effects of harvesting on stream temperature (Brazier and Brown 1973, Kappel and DeWalle 1975, Lynch et al. 1985, Amaranthus et al. 1989, ODF and ODFW 2002). Consequently, forest management policies now require the maintenance of a riparian vegetation buffer along streams on private, state, and federal lands.

Riparian corridors in forested areas develop a microclimate characterized by cooler air temperatures and higher relative humidity as compared with unvegetated streamside areas. Near-stream ground temperatures can be an even greater source of heat to the stream because the heat conductivity of soil is typically 500 to 3,500 times greater than that of air (Halliday and Resnick 1988).

In addition to stream shading, other factors, some of which are related to stream shading, might also be at least partially responsible for the observed high temperature of some streams within the subbasin. They include:

- prevailing watershed aspect (south- and west-facing are often warmer than north- and east-facing),
- prevalence and temperature of seeps, springs, groundwater and tailwater inflow,
- amount of exposed rock in the stream channel (which can effectively absorb solar heat),
- reduced summer flows,
- prevalence of deep pools, and

In addition to the effects of shade, a properly functioning riparian-wetland area with a well-developed floodplain and deeply-rooted riparian plants captures and stores water during the wet season, slowly releasing cool water during the dry late summer months. Many lowland valley areas and wet meadows in the Upper Sprague probably have never been heavily shaded, but are characterized by well developed floodplains and a variety of marshy and swampy areas which functioned to maintain water quality conditions, including temperature. This is a central issue in the assessment area, as many regulatory indicators of riparian health and water quality standards focus on the presence/absence of woody riparian vegetation. This topic should be a focus of future research and monitoring.

A relatively unique issue pertinent to the assessment area is the influence of groundwater pumping on water temperatures. Groundwater pumped at 59 degrees enters surface flows as tailwater, and may lower temperatures locally. Future monitoring and research should be aimed at confirming the extent to which this is the case.

Water temperature and water quantity are closely linked. A reduction in flow during low-flow periods contributes to higher water temperature. Nevertheless, even if some reaches have elevated solar radiation and stream temperature levels, an adequate supply of deep pools can provide cold-water refugia that allow fish to avoid adverse temperature conditions. Temperature differences between the stream surface and stream bottom can be substantial in deep pools (Matthews et al. 1994, Nielson et al. 1994). Deep pools are less prevalent today than in the past, mainly because of changes in the flow dynamics within stream channels. The supply of gravel in the streambed can also serve to moderate stream temperature. A large amount of water flows through gravel deposits, sheltered from the warming rays of the sun. Where gravel deposits are diminished or filled with fine sediments, such deep inter-gravel stream flow is reduced.

There are a number of large springs in the subbasin that discharge cool water to the streams and provide thermal refugia for fish. Alterations of the stream channel through ditching or diking can separate the springs from the stream, thereby removing vital habitat.

There are also a number of geothermally heated springs both near and within stream channels. These springs have measurable effect one water temperatures within the assessment area.

It is not clear whether or not summer and early fall stream temperatures in many streams within the Upper Sprague River subbasin were ever as low as the 12° C (53.6° F) spawning and rearing evaluation criterion for bull trout, or even the core cold-water habitat criterion for salmonid fish of 16° C (60.8° F). Nevertheless, efforts to reduce stream temperatures subbasin-wide would be expected to have positive effects on fish habitat quality.

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CHAPTER 11. AQUATIC SPECIES AND HABITAT

CHARACTERIZATION

The major focus of habitat quality issues within the Upper Sprague River subbasin concerns native fish species, in particular the influence of habitat quality on bull trout (Federally Threatened), Klamath largescale sucker (Federal Species of Concern), Lost River Sucker (Federally Endangered), shortnose sucker (Federally Endangered), redband trout and two species of extirpated anadromous salmonids, chinook salmon and steelhead trout. In addition to their intrinsic value and importance as a sport fishing resource, the native fishes in the Upper Sprague River subbasin function as keystone species and are indicators of watershed condition (Mills et al. 1993). Watershed protection, enhancement, and restoration actions are often focused on possible benefits to fish because managing for fish habitat would be expected to benefit aquatic ecosystems generally.

This chapter provides an overview regarding the current status of fisheries and aquatic habitat within the study area. It also provides known information about historical fisheries conditions.

Historical evidence suggests that fish populations in the Upper Sprague River subbasin were dramatically different from those which exist today (Buettner and Scoppettone 1990). A variety of factors contributed to changes in the fisheries and aquatic habitats in the assessment area. Prior to the construction of Copco Dam on the Klamath River in 1917, anadromous chinook salmon and steelhead trout utilized the Upper Sprague River and its tributaries as spawning and rearing habitat (Fortune et al. 1966). Helen Crume Smith, born in 1934, remembers "people gathering there at the river, and here were these people and here were these fish, about twice as tall as me. Those salmon, those were the last run of the salmon, of the ones that were left after the dams. This had to be 1937 or 1938, and I've got people that say that couldn't be. But I say, I remember 'em. And my granddad called them salmon, and who am I to dispute his word. But they were HUGE. . . and that was so, so, so fabulous." (quoted from Frank 2006 p. 162). Lost River, shortnose, and Klamath largescale suckers had previously used the waters of the Upper Sprague River subbasin as well (Buettner and Scoppettone 1990). Construction of Chiloquin Dam on the mainstem Sprague River was completed in 1918. Although no formal research has investigated fish passage over Chiloquin Dam, there are indications that the dam interrupts normal fish passage (US House of Representatives 2001, Battelle 2005).

The introduction of non-native fish species has also altered the fishery in the subbasin. Stocking programs, intentional introductions by sportfishers, and accidental introductions are all possible sources of introductions. Competition and hybridization between native and introduced fish species can limit the reproductive potential of native fish and create inter-species competition for resources (Tyus and Saunders 2000). Efforts to reduce the interaction between native and non-native fish species are underway by the Oregon Department of Fish and Wildlife (ODFW) with the intent of sustaining native fish populations.

Fish habitat conditions have also changed over the years. Aerial photographs show dramatic changes over the years in the riparian corridor. The loss of stream side riparian zones has led to changes in fish habitat due to stream bank destabilization and loss of vegetation cover (Armour et al. 1994, Sheffield et al. 1997, Platts 1991). In general, salmonids species such as bull trout and rainbow trout require slow-moving backwaters for rearing fry, in-stream cover, and very cold water (USFWS 2005, Behnke 2002, ODFW 2001). Loss or alteration of stream side vegetation can lead to increased stream width (Platts 1991). Wider stream channels allow for increased solar radiation gain, which increases water temperatures (Quin et al 1997, Platts 1991).

Further changes in fish habitat conditions will be discussed later in the chapter. However, changes in fish habitat characteristics are not well documented for the entire study area. Most available information regarding fish habitat characteristics is for tributaries in the Fremont-Winema National Forest and known information gaps (i.e. mainstem Sprague River channel) will be supplemented from appropriate research.

FISH SPECIES

This section will present a short summary of what is known about native species in the Upper Sprague River Basin. Due to the listing of bull trout under the Endangered Species Act in 1999, a large portion of the available data pertains to headwater tributaries where current bull trout populations are found. To supplement data gaps for other known native species, both present and past, information will be drawn from research conducted on geographically and environmentally similar populations. Because this assessment will provide a foundation for future enhancement and restoration projects, a brief summary of native anadromous species will be presented in light of potential reintroduction of salmon and steelhead.

Bull Trout (*Salvelinus confluentus*)

Klamath Basin bull trout exist in the southern portion of the species' range, which extends northward to the Canadian Northwest Territories and southeastern Alaska. Bull trout are members of the char subgroup of the salmon family, and can be easily distinguished from other salmonid species by the absence of teeth on the roof of the mouth (Goetz 1989). Bull trout are similar in appearance to Dolly Varden (*Salvelinus malma*), though genetic studies have confirmed the distinction between these two species (Phillips et al. 1989). Bull trout are most closely related to Japanese char (*S. leucomaenis*; USFWS 2002a). Bull trout in the Klamath Basin, including the Upper

Sprague River subbasin, are genetically distinct from Columbia River Basin bull trout (Leary et al. 1991).

Bull trout are especially important because of their status as a Federally Threatened Species and the designation by the US Fish and Wildlife Service (USFWS) of 37.6 miles of critical bull trout stream habitat in the Upper Sprague River subbasin.

Life History and Habitat Requirements

Bull trout can exhibit diverse life strategies, incuding anadromous, fluvial, adfluvial, and lacustrine forms. They therefore require a wide range of habitat types (Quinn 2005, Behnke 2002). In general, bull trout populations have experienced large distribution declines, primarily due to elevated water temperatures (Behnke 2002). The populations of bull trout found in the Upper Sprague River Basin are residual and limited to streams with appropriate water temperatures (USFWS 2002a, Selong et al. 2001). For these remnant headwater populations, spawning occurs from August through November and is initiated by a drop in temperature below 48° F (8.8°C). Spawning bull trout require loose clean gravel with well oxygenated flows (USFWS 2002a). Spawning areas are often found in high-elevation streams and/or streams fed by groundwater or springs (Reiman et al. 1997). Eggs incubate for 100 to 145 days, making them susceptible to sedimentation deposition during this relatively long period. (Pratt 1992). Optimum temperatures for incubation are between 36 and 39° F (2.2-3.8°C) (Goetz 1989). Hatched fry remain in the substrate for up to three weeks and emerge from early April though May (USFWS 2002a). Optimum rearing temperatures range from 45 to 46° F (7.5°C ,Goetz 1989).

Juveniles remain near where they hatched for at least one year. Many will stay close to this area for their entire life. Due to habitat degradation, this resident form of bull trout is the predominate form found in the Upper Sprague River subbasin (USFWS 2002a). Rearing juvenile and adult bull trout require colder stream water temperatures than other salmonids. Dunham et al. (2003) observed that the probability of bull trout occurrence is low when mean daily temperatures exceed 57 to 61° F (13-16°C). Bull trout are opportunistic feeders, preying on terrestrial and aquatic insects, macro-zooplankton, and small fish (Goetz 1989). Maximum growth occurs at 56° F (13°C), and lethal water temperatures occur around 70° F (20.9°C) (Selong et al 2001). Resident bull trout range from 6 to 12 inches in length and have relatively lower fecundity than migratory forms, which can grow larger than 2 feet (Quinn 2005, Pratt 1992, Goetz 1989).

Abundance and Distribution

The Upper Sprague River Basin bull trout populations were federally listed as Threatened in 1999 (USFWS 2002a). The Klamath River Basin bull trout populations are estimated to be at about one-fifth of their historic numbers

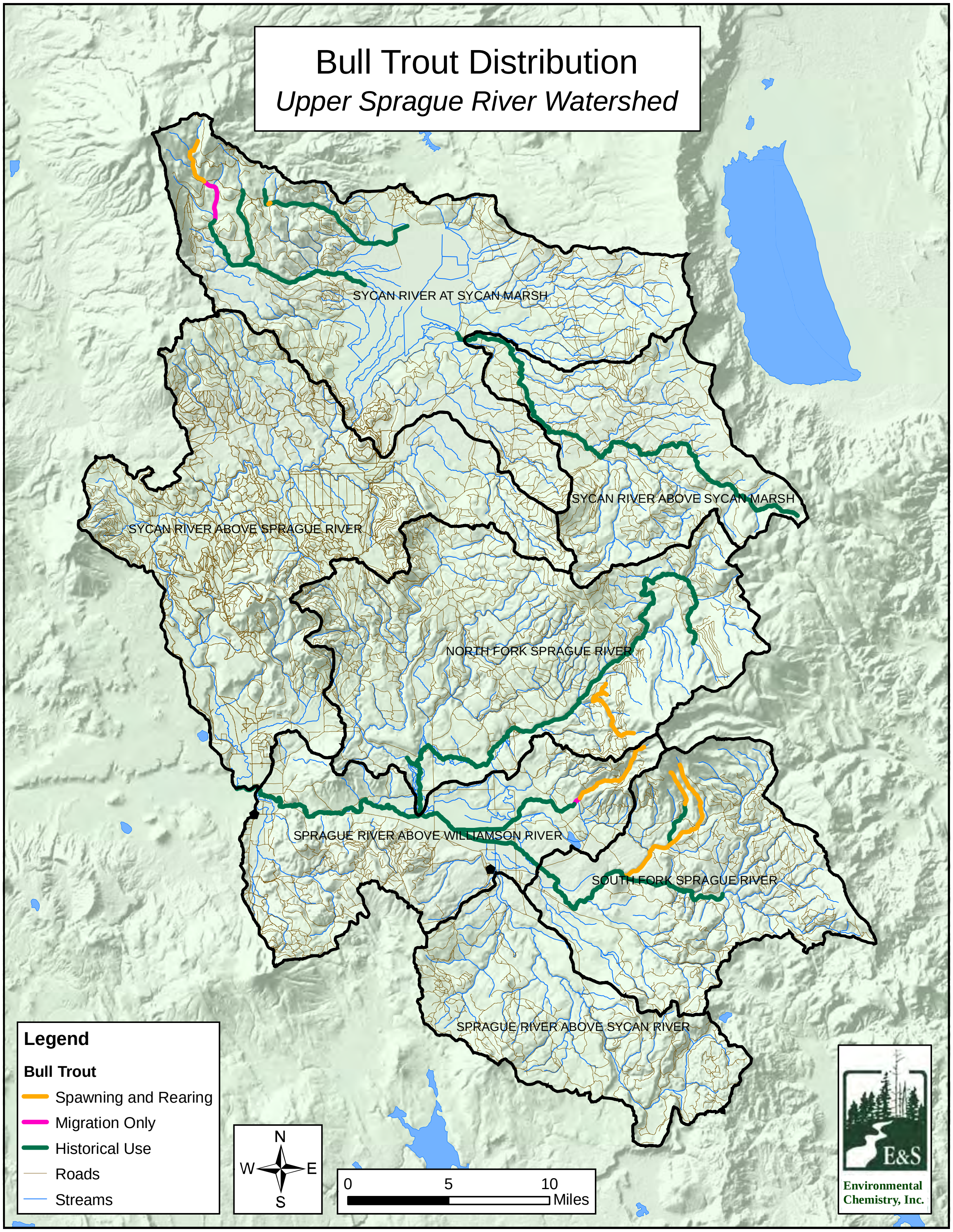
(Quigley and Arbelbide 1997). The once widely distributed Klamath subpopulations once exhibited several life history strategies, including fluvial and adfluvial forms (Ziller 1992). These native fish are now found primarily as nonmigratory populations in isolated headwater reaches in three watersheds within the Upper Sprague River subbasin (Map 11-1), as summarized below.

Sycan Marsh Watershed. Long Creek sustains the only substantial population of bull trout within the Sycan Marsh Watershed. Two bull trout and two hybrid bull trout/brook trout were observed in Coyote Creek in 1998 (USFWS 2002a). In view of the proximity of Coyote Creek to Long Creek, these fish most likely originated from the Long Creek population. Bull trout were also once present in Calahan Creek, Upper Sycan River, and South Fork Sycan River, but have not been observed in any of these streams since 1994 (Buchanan et al. 1997, Ziller 1992, Light et al. 1996).

The resident bull trout population in Long Creek was estimated in 1991 at 842 total fish, including 362 adults. In 1995, the estimated population was roughly 50 percent lower (Buchanan et al. 1997). During this same time period, increasing populations of brook trout were observed (Light et al. 1996). Competition and hybridization with brook trout has been determined to be one cause for the decline in bull trout populations (USFWS 2003). Brook trout were stocked in portions of the upper Klamath River basin from the 1920s through the early 1970s (Light et al. 1996).

The Long Creek population failed to meet Oregon's Native Fish Conservation Policy (NFCP) criteria for productivity as a result of hybridization with brook trout. Population surveys in 2000 estimated 491 bull trout in the upper 2.1 miles of Long Creek, though presence/absence surveys indicated that bull trout are found throughout the 13.9 miles of the creek (ODFW 2000). The uppermost 1.7 miles of Long Creek are within the Fremont-Winema National Forest, while the lower 12.2 miles of river are located on privately owned timber land. It was once thought that only resident forms of bull trout occur in Long Creek, though observations of fish up to 16.7 inches were made during presence/absence surveys in 1998, indicating that fluvial or adfluvial forms may persist. Bull trout may also utilize the Sycan Marsh and its tributary streams, though a more detailed survey is necessary for this to be established (USFWS 2002a).

South Fork Sprague Watershed. Bull trout are known to exist in the upper portions of both Deming and Brownsworth Creeks within the South Fork Sprague Watershed. Deming Creek sustains the largest population of bull trout in the Upper Sprague River subbasin. Ziller (1992) estimated 1,293 fish present in 1989. The ODFW resampled this stream in 1997 and estimated that there were 1,470 bull trout present (Dambacher 1995). Bull trout distribution in Deming Creek extends along 3.8 miles of stream above the diversion dam located at river mile 9.4 (USFWS 2002a).



Map 11-1. Bull trout distribution in the Upper Sprague River subbasin. (Data Source: ODFW 2004)

Buchanan et al. (1997) estimated that bull trout abundance in Brownsworth Creek was 964 fish. They reported that bull trout were found only in the upper 1.9 miles of the stream. Subsequent presence/absence surveys in 1999 extended the known range of bull trout within Brownsworth Creek to the 5.2 miles upstream from its confluence with Leonard Creek (USFWS 2002a). A total of 1,290 bull trout were found distributed throughout the entire 9.3 miles of Brownsworth Creek during population surveys in 2000 (ODFW 2000). Leonard Creek, a tributary to Brownsworth Creek, sustains approximately 834 bull trout in its uppermost 1.7 miles of stream length (Buchanan et al. 1997). The bull trout population found in Brownsworth Creek is the only population within the Upper Sprague River subbasin that meets all of the established NFCP criteria for managing Oregon fisheries (ODFW 2005a).

North Fork Sprague Watershed. Bull trout in the North Fork Sprague Watershed are primarily found in Boulder and Dixon creeks. Several observations and reports indicate that fluvial bull trout are present in the North Fork Sprague River near the confluence with Boulder and Dixon creeks (Light et al. 1996, USFWS 2002a). These two tributary streams contain resident forms of bull trout and are likely to serve as spawning grounds for fluvial fish. Due to their close proximity, bull trout in Boulder and Dixon creeks are considered a single population (USFWS 2002a). They are distributed along a combined 6.8 miles in the upper reaches of these streams during the summer. Population estimates by Ziller (1992) indicated that 219 fish were present in the combined system. This population failed to meet NFCP criteria for distribution, abundance, and productivity (ODFW 2005a). It is likely that these fish primarily utilize Dixon Creek because 1998 presence/absence surveys did not indicate any bull trout to be present in Boulder Creek (USFWS 2002a). Three bull trout were found in Sheepy Creek during presence/absence surveys in 1998, a location where bull trout were once thought to be extirpated (Weyerhaeuser 1995a).

Productivity

According to the USFWS Bull Trout Draft Recovery Plan (USFWS 2002a), bull trout are present within the Upper Sprague River subbasin in 35 miles of Long, Deming, Leonard, Boulder, Dixon, Brownsworth, and Sheepy creeks. Productivity data are limited for these creeks, but generally suggest low productivity in some areas and stable populations in other areas. Bull trout populations in the North Fork Sprague Watershed and Long Creek failed to meet NFCP productivity criteria due to competition and hybridization with brown and brook trout, low densities, decreasing populations, and decreasing distributions. Deming and Brownsworth creeks met the NFCP productivity criteria since their habitat quality is good and improving, abundance trends are stable, and efforts are underway to remove brown trout from these streams (ODFW 2005a). Bull trout are considered extirpated from Calahan Creek, Coyote Creek, and the Upper Sycan River (USFWS 2002a, ODFW 2005a).

Policy

The USFWS recovery plan delineates actions that are believed by USFWS to be necessary to recover and/or protect the species. Because bull trout populations in the Klamath River basin are small, isolated, and threatened with extinction, it was recommended that any land or resource actions leading to changes in, or disruptions to, watershed processes in occupied, historical, and potential habitat should be minimized. Significant threats to long-term persistence of bull trout in the Klamath River basin include sedimentation, low in-channel complexity, elevated water temperature, competition and hydridization with non-native fish, barriers to movement, habitat isolation and fragmentation, and agricultural water diversions (USFWS 2002a).

Major bull trout recovery goals include objectives related to maintaining and restoring:

- distribution,
- trends in abundance,
- habitat conditions, and
- genetic diversity.

Recovery criteria were established by USFWS to reflect adequate improvement in each area.

Critical Habitat

The USFWS has designated critical habitat for the conservation of bull trout in portions of Oregon, Washington, Idaho, Montana, and Nevada, including the Upper Sprague River population (USFWS 2005). These determinations were largely based on the USFWS Bull Trout Draft Recovery Plan (USFWS 2002a). Proposed critical habitat designations were made by USFWS (2002b) and were left open for public comment. An economic impact analysis was performed (Bioeconomics 2004) and after considering and responding to input from various stakeholders and interested parties, the final critical habitat designations were made (USFWS 2005). Map 11-2 shows these designations for the Upper Sprague River subbasin.

The final critical habitat rule designated 37.6 miles as critical habitat in nine streams (Table 11-1), along with 24,610 acres of the Sycan Marsh. Long Creek was the longest designated stream reach, at 10 miles. All of the locations where bull trout occur presently are included in the critical habitat designation. Locations were selected for inclusion in order to protect sufficient amounts of spawning and rearing habitat in upper watershed areas, provide suitable habitat in downstream rivers and lakes as foraging and overwintering habitat for fluvial and adfluvial fish, and sustain and reestablish migratory corridors and gene flow for and between local populations by maintaining adequate fish passage (USFWS 2002b).

Table 11-1. Breakdown of bull trout critical habitat by stream. (Source: USFWS 2002b)

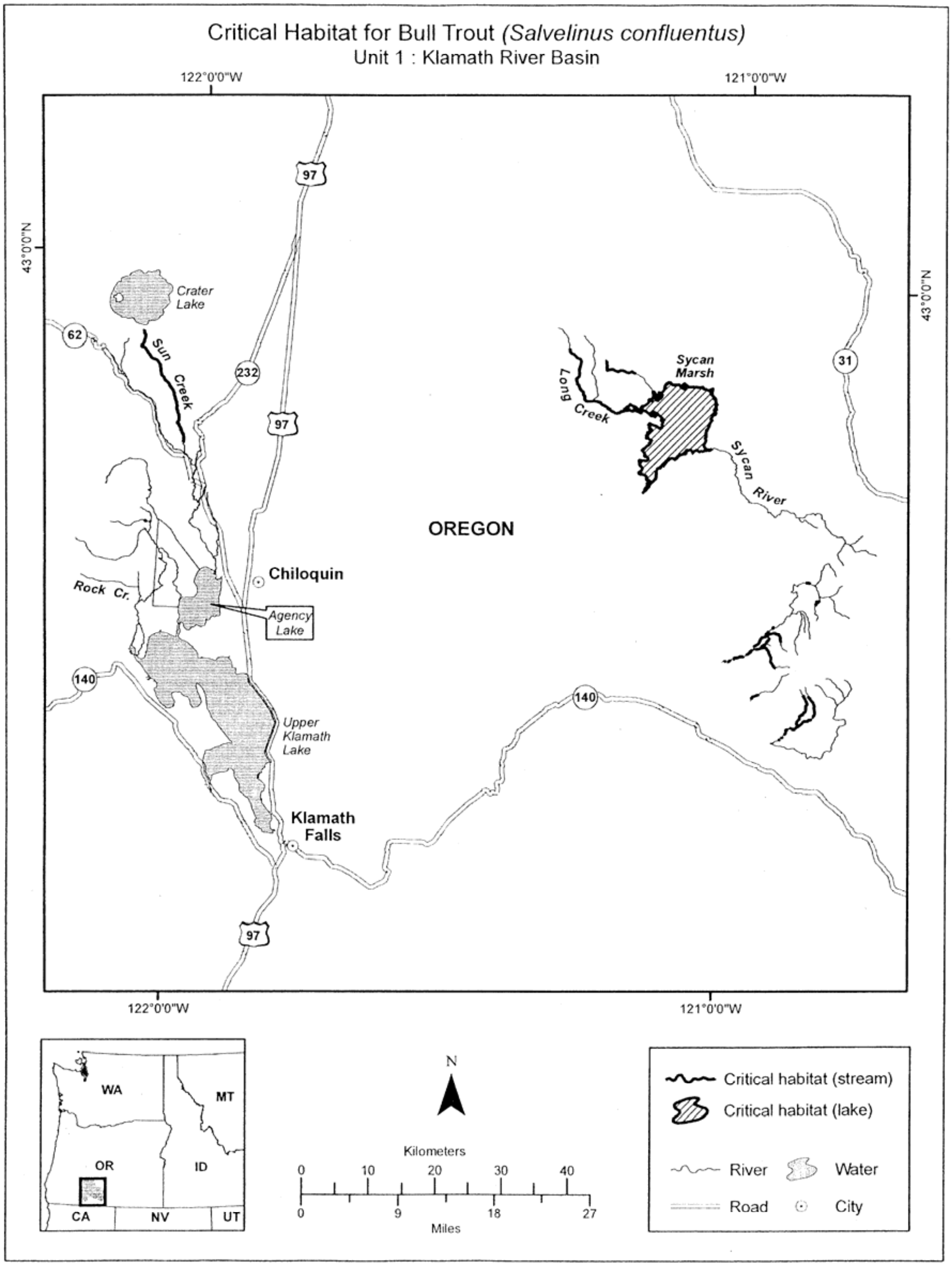
Stream	Miles of Designated Bull Trout Critical Habitat
Boulder Creek	3.3
Brownsworth Creek	5.9
Coyote Creek	4.0
Deming Creek	0.9
Dixon Creek	1.4
Leonard Creek	3.5
Long Creek	10.0
North Fork Sprague River	6.4
Sheepy Creek	2.1
Total	37.6

Redband Trout (*Oncorhynchus mykiss newberrii*)

Habitat Requirements and Life History

Redband trout are the only other native salmonid species other than bull trout currently found in the Upper Sprague River subbasin (Weyerhaeuser 1995a). These fish are generally considered the same species as coastal rainbow trout (Currens 1997), though Behnke (1992) has distinguished several substantial redband groups as separate subspecies (*newberrii*). Redband trout populations in the Upper Klamath basin are believed to important to the diversity of the overall population of redband trout and represent a key-stone species (Behnke 1992).

Redband trout found in the Upper Klamath Basin exhibit two life strategies. One strategy is an adfluvial form were they live in larger lakes, attaining larger body sizes and higher fecundity, and migrate upstream to spawn. The second form is fluvial form that spends its entire life in smaller tributaries and rivers (Behnke 2002). Both forms of redband trout spawn in headwater streams were they can find appropriate cool water temperature for egg incubation and juvenile rearing (Behnke 2002). They typically spawn in the head of a riffle or just downstream from a pool (Orcutt et al. 1968) in loose gravel substrate (Behnke 2002). Spawning in the spring is initiated by an increase in stream temperature. Eggs hatch within 30 to 40 days, and fish remain in shallow waters with good cover through the winter (Weyerhaeuser 1996). Juveniles will move to deeper and faster moving waters, seeking larger pools prior to reaching maturity after about two years. Adult redband trout thrive when water temperatures are between 55 and 65° F (12-18°C) (Cherry et al. 1977). Growth rates have been observed to slow in water above 68° F (20°C) (Hokanson et al. 1977). Rodnick et al. (2004) showed that large (0.8 – 3.0 pound) redband trout in southeastern Oregon were more susceptible to



Map 11-2. Map of critical habitat for bull trout within the Klamath River Basin. (Source: USFWS 2002b)

the negative effects of elevated stream temperatures than smaller redband trout. Redband trout, like other salmonids, are typically found closely associated with riparian cover such as overhanging vegetation, undercut banks, and large woody debris (Fausch and Northcote 1992, Theurer et al. 1985).

Distribution, Abundance and Productivity

Resident and migratory redband trout exist in the Upper Sycan River, the North and South Fork Sprague rivers, and their tributaries (ODFW 2005a). A quantitative evaluation to determine the upper and lower limits of this species has not been made, although populations in the Upper Sycan River have been reported upstream from the mouth of the river at Sycan Marsh. Redband trout have been documented in Brownsworth and Whitworth creeks, and their tributaries, located on the south face of Gearhart Mountain in the South Fork Sprague Watershed (Weyerhaeuser 1995a,b).

Density estimates in Long and Deming creeks received a “low” rating, whereas densities in Brownsworth and Boulder Creeks were considered “moderate”. Most recent redband trout density estimates were between 0.025 and 0.05 age 1+ fish per square mile for Long and Deming creeks, with somewhat higher densities in Deming Creek. Estimated densities in Brownsworth and Boulder creeks were 0.091 and 0.15 age 1+ fish per square mile, respectively (ODFW 2005a).

Potential productivity for redband trout failed to meet NFCP target criteria for the Upper Sycan and Upper Sprague rivers populations. Habitat disturbance, inadequate fish passage, limited abundance, and competition with brook and brown trout all contributed to this failed rating. Efforts to restore habitat conditions for native fish in streams that flow into the Sycan Marsh are currently underway (ODFW 2005a).

Anadromous Salmonids

Chinook salmon and steelhead (anadromous rainbow trout) utilized the Upper Sprague River and its tributaries as spawning and rearing habitat prior to Copco Dam’s construction on the Klamath River in 1917 (Fortune et al. 1966). Chinook salmon and steelhead trout can exhibit a wide diversity of life histories.and their exact historical distributions within the Sprague River drainage is unkown, so onlybrief description of their spawning and rearing habitats requirements will be presented here.

Chinook salmon (*Oncorhynchus tshawytscha*)

Chinook salmon are the largest of the Pacific salmon species reaching average body weights of ten to twenty-five pounds , with individuals recorded as large as ninety-plus pounds (Behnke 2002). Chinook salmon typically spawn in middle-sized to large rivers (Quinn 2005) and require cool water temperatures for higher spawning success (generally around 41-55°F (5-13°C) (Richter and Kolmes 2005). They require a large gravel substrate with well oxygenated water (Quinn 2005). McCullough et al (2001) recommend that temperatures stay below 54°F (12°C) for proper egg incubation and fry development. A temperature range of 54-68°F (12-20°C) has been recorded for rearing and growth of chinook juveniles (Richter and Kolmes 2005). Juvenile chinooks express two life strategies, ocean-type or stream-type. Ocean-type individuals migrate downstream immediately or shortly after emerging from an egg. Stream-type individuals typically spend one full year in the river before migrating downstream (Quinn 2005).

Steelhead (rainbow) trout (*Oncorhynchus mykiss*)

Steelhead are defined as a coast rainbow trout that spend a portion of their life in freshwater and saltwater. Steelhead usually weigh between two and twelve pounds, but individuals have been recorded at over thirty pounds. Like most trout, they spawn in headwater streams requiring small- to medium-sized gravel and well oxygenated waters (Quinn 2005). Bell (1991) reported daily temperature range of 50-54°F (10-12°C) for spawning steelhead. McCullough et al (2001) recommend a constant incubation and fry development temperature between 52-54°F (11-12°C) for steelhead. A temperature range of 57-60°F (14-15°C) has been described as optimal range for growth of juvenile steelhead (Hicks 2000). Steelhead generally spend one to three years in freshwater streams and then migrate to the ocean where they can spend one to three years before returning to their natal stream to spawn (Quinn 2005).

Sucker Species

Three native species of suckers exist in the Upper Klamath Basin: the shortnose sucker (*Chasmistes brevirostris*), the Lost River sucker (*Deltistes laxatus*), and the Klamath largescale sucker (*Catostomus snyderi).* Both shortnose suckers and Lost River suckers are federally listed as endangered. Klamath largescale suckers are recognized as a species of concern, and are listed by the State of Oregon as not rare or apparently endangered, but with cause for long-term concern. (ONHIC 2004). All three species are long-lived, iteroparous, obligatory lake dwellers that often migrate up large streams to spawn (Cooperman and Markle 2003). Little information is available about spawning distribution in the Upper Sprague River, but all three species have had larvae collected from the Sprague River as far upstream as Beatty Gap (M. Buettner, pers. comm., August 2006). Because sucker larvae will drift downstream to suitable foraging habitat after emergence (Cooperman and Markle 2003), the presence of larvae in this reach suggests that suckers are spawning above Betty Gap. However, most of the information available on spawning suckers is provided by Klamath largescale suckers. During spawning they have been observed on five occasions within the Fishhole Creek, Sprague River above Beatty, and Lower Sycan watersheds (USFS 2005). USGS has monitored larval sucker emigration in the Sprague River from 2004 through 2006 and has collected larval suckers from as early as March in the Sprague River near Beatty. Peak larval emigration occurred during April and May (M. Buettner, pers. comm., September 2006).

Other Fish Species

Brook trout (*Salvelinus fontinalis*) are widely distributed, but not native to the Upper Sprague River subbasin. During one survey, brook trout were identified at 178 locations within five of the seven watersheds in the subbasin (USFS 2005). Brook tout occur mainly in cool, well-oxygenated water in small- to medium-sized rivers, and in lakes. They feed primarily on benthic invertebrates, insects, and small fish. Life span for brook trout typically extends for 7 years, although 15-year-old introduced brook trout have been reported in California (Froese and Pauly 2006).

Brown trout (*Salmo trutta*) prefer cold spring-fed streams, similar to bull trout. These non-native fish were found at 54 locations in five of the seven watersheds within the Upper Sprague River subbasin (USFS 2005). Brown trout feed on small fish and insects. Sexual maturity is reached after three years, and spawning occurs in the fall (October through November). Fry typically emerge in March (USFS 2006).

Kokanee (*Oncorhynchus nerka*) is the landlocked form of the anadromous sockeye salmon. Sixteen kokanee were found in the Fishhole Creek Watershed and two observations were made in the North Fork Sprague Watershed (USFS 2005). Kokanee feed mainly on plankton, but also consume small fish and bottom dwelling insects. Their lifespan ranges between two and seven years (Froese and Pauly 2006).

Pacific lamprey (*Lampetra tridentata*) life forms are typically anadromous, though land-locked populations do exist, as is the case for those found in the Upper Sprague River subbasin. Pacific lamprey were observed twice in the South Fork Sprague Watershed (USFS 2005). As an adult, this species is parasitic to other fish. Lamprey spawn and bury their eggs in streambed sediment. Hatched larvae develop into ammocoetes and will spend between three and eight years in gravelly to fine sediments located in shallow backwaters (Froese and Pauly 2006).

Miller Lake lamprey (*Lampetra minima*) are the world's smallest predatory lamprey, reaching 3 to 6 inches in length. Like Pacific Lamprey, adults are parasitic, while the larval form (ammocoetes) are filter feeders. They are endemic to the Upper Klamath River system, and were believed to be extinct until re-discovered in 1992 in the upper Williamson River, and then subsequently in Long Creek and other streams of the upper Sycan River drainage basin (ODFW 2005b). They are federally listed as a species of concern because of their limited geographic distribution and evolutionary uniqueness, although the population is currently considered stable and not immediately threatened (ODFW 2005b, ONHIC 2005).

Pit-Klamath brook lamprey (*Lampetra lethophaga*) are non-migratory fish that are native to the Upper Sprague River subbasin. They inhabit riffles and runs in streams that are low in suspended sediment. Ammocoetes occur in close proximity to weed beds and sand bars. Unlike the Pacific lamprey, these fish are non-parasitic (Froese and Pauly 2006). One observation was made in each of the Sprague River Above Beatty Watershed, Lower Sycan Watershed, and Sycan Marsh Watershed (USFS 2005).

Craig Bienz, The Nature Conservancy manager of the Sycan Marsh preserve shares, "We have measured the channels and found that they have increased in habitat quality, which has produced native salmonids of greater physiological condition in the Sycan. The populations are dependent on the quality of habitat. We have monitored redband trout moving from Long Creek into the Sycan River, then into the Sprague River and eventually into Upper Klamath Lake.
As we continue to make improvements in habitat and water quality, we'll see more fish moving back and forth in this system from Sycan to Upper Klamath Lake.
Those populations increase in abundance and health with habitat improvements.
We've also increased waterfowl populations and wetland habitat types. We have more species using Sycan Marsh now than we did ten years ago" (pers. comm. January 22, 2007).

Tui chub (*Gila bicolor*) are native fish that inhabit lakes and vegetated mud- or sand-bottom pools of small creeks to large rivers. This species was observed on one occasion in the Sycan Marsh Watershed (USFS 2005). There are many subspecies of tui chub that occur throughout its range in Washington, Oregon, Idaho, Nevada, and California. *Gila bicolor bicolor* is the subspecies found in the Klamath Basin (Froese and Pauly 2006).

Brown bullhead (*Ameiurus nebulosus*) are not commonly found in the Upper Sprague River subbasin, but were observed once in the Fishhole Creek Watershed (USFS 2005). These bottom-dwelling fish were introduced to the subbasin. They utilize a wide variety of food sources including benthic invertebrates, insects, algae, small fish, and fish eggs. Brown bullhead are able to withstand low dissolved oxygen concentrations and temperatures up to 89º F. As defense against adverse environmental conditions, brown bullhead have been observed to bury themselves in the mud (Froese and Pauly 2006).

Speckled dace (*Rhinichthys osculus*) were found at 64 locations in all of the watersheds within the subbasin, except for the North Fork Sprague Watershed (USFS 2005). These native fish can be found in a wide variety of stream habitats, including riffles, runs, and pools of headwater creeks to medium-sized rivers. Speckled dace can be an important forage species for co-existing larger fish (Froese and Pauly 2006).

Other fish that have been found in the Upper Sprague River subbasin include bluegill, channel catfish, largemouth bass, marbled sculpin, and slender sculpin. Information is not available on the status of these species in the subbasin at this time.

AQUATIC HABITAT

Introduction

The characteristics that define habitat suitability differ from species to species and from habitat to habitat. In general, parameters of habitat suitability reflect the needs of a species for food, water, cover, reproduction, and social interactions (Young and Sanzone 2002). Such needs are fulfilled through aspects of the physical, chemical, and biological environment, including water temperature, dissolved oxygen, flow velocity, substrate type, and the presence of predator, prey, and competitor species.

Appropriate habitat conditions in upland streams (headwaters reaches) would include adequate shading of the stream channel, an abundance of large woody debris (LWD) and deep pools, intact riparian vegetation that includes large-diameter trees, adequate in-stream gravel conditions, an absence of passage barriers, and the availability of off-channel refugia. In lowland locations (mainstem reaches), additional important habitat conditions would include stream sinuosity, connection to freshwater wetlands, floodplain functionality, deep channels and serviceable riparian vegetation (WPN 1999). The importance of springs and inflow from coldwater tributaries is not completely known for the Upper Sprague River but research indicates that they provide important seasonal thermal refugias during summer peaks in temperature (Ebersole et al. 2001, Torgersen et al. 1999, Matthews and Berg 1997)).

There is a large void in the information available for aquatic habitats in the Sprague River Basin and what information that is available is primarily focused on headwater streams on forest service land. Therefore, this section primarily characterizes aquatic habitat conditions of stream reaches within the headwater reaches of the Upper Sprague River subbasin. Data for the headwater streams is available from ODFW for Boulder Creek, Brownsworth Creek, Calahan Creek, Deming Creek, Long Creek, and Dixon Creek. In-stream and riparian features such as riparian shading, pool and riffle characteristics, presence of LWD, and fish passage barriers are considered in this assessment of aquatic habitat conditions from the perspective of resident trout species.

Distribution and abundance of fish varies with habitat conditions. Many fish utilize different locations of a stream network for different parts of their life cycle. For example, bull trout will seek gravel substrates for spawning, but will move to other locations in the stream where feeding and rearing is better accommodated by other in-stream and riparian habitat features (Behnke 2002). Fluvial populations migrate between native tributary streams and the mainstem river or marsh for feeding and rearing (Behnke 2002).

Habitat requirements differ somewhat from species to species. Nevertheless, healthy populations of native trout species are generally associated with the following habitat characteristics:

- cool, clean, well-oxygenated water;
- unobstructed access to spawning grounds;
- clean, stable spawning gravel;
- winter off-channel refuge habitat for juveniles;
- complex stream channel structure with an appropriate mixture of riffles, pools, and glides;
- deep pools;

- stream channels with an abundant supply of large woody debris;
- abundant food supply;
- adequate summer stream flows;
- diverse, well-established riparian plant communities (Quinn 2005, Biosystems 2003, Behnke 2002, WPN 1999).

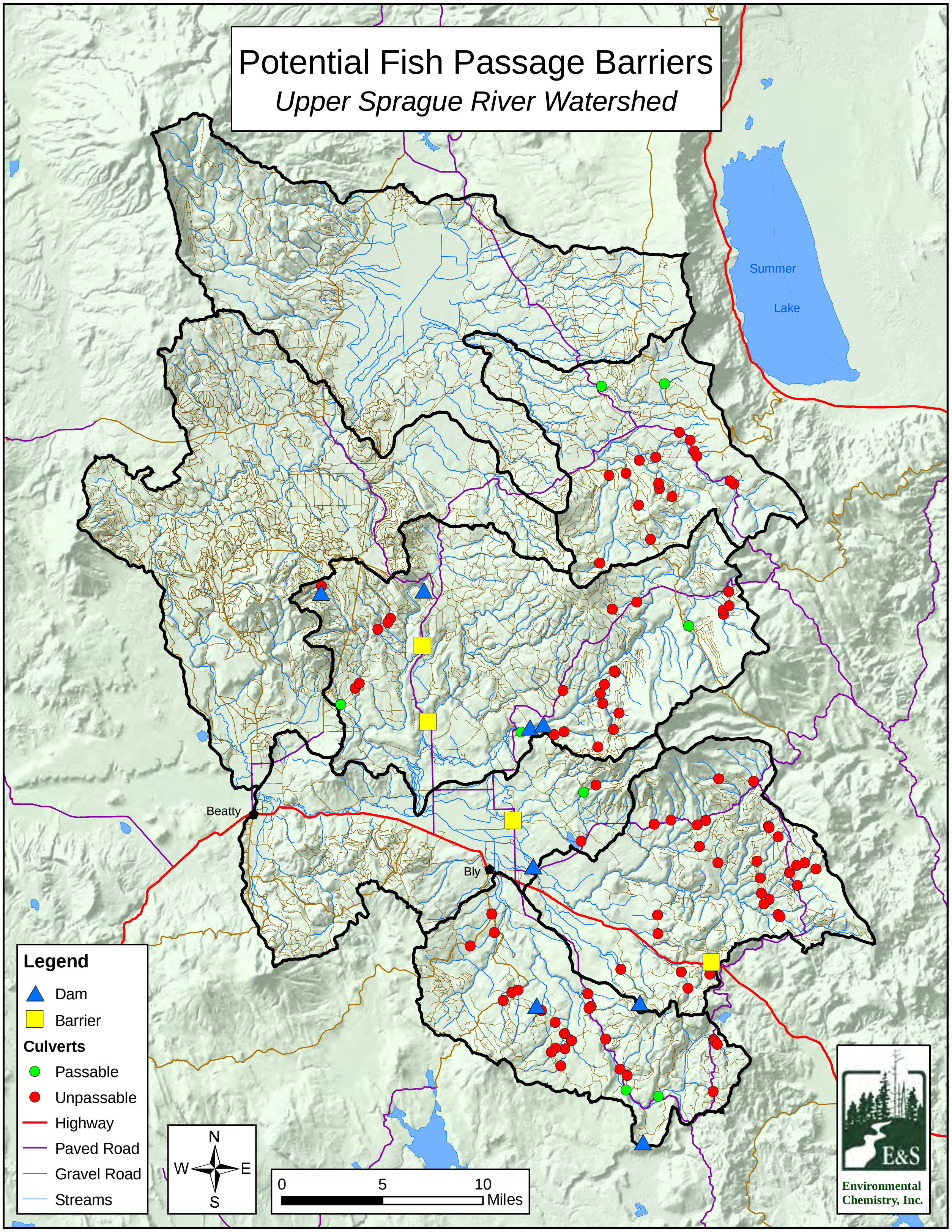
The data for the surveyed reaches in the Upper Sprague River subbasin were collected under ODFW protocols (Moore et al. 1997) between 1991 and 1993 and constitute the best of the limited source of information for assessing the present status of aquatic habitat within the subbasin. However, streams are dynamic and channel features may change dramatically from year to year, depending on climatic conditions. Thus, conditions today may vary considerably from those that prevailed in the early 1990s. Also, the effects of restoration work performed after 1993, particularly road repair, streambank stabilization, and riparian revegetation, are not reflected in the survey data presented here.

Potential Barriers to Fish Passage

Of the information that is available it suggests that there are major concerns with fish passage. Many fish species migrate seasonally within the stream network. However, the ability of fish to move up and down the stream system has been impeded by roads and culverts in some locations. The degree of impedance is not known. Migration may also be inhibited by low-flow conditions and elevated water temperatures (Behnke 2002). Unscreened diversions may pose an additional hazard to migrating and rearing fish.

For the upper headwater tributaries of the Sprague River there are potential barriers to fish passage in the form of culverts (Map 11-3). These potential barriers are largely in the form of road/stream crossings, which are especially numerous in the Fishhole Creek and South Fork Sprague watersheds and in the upper reaches of the Upper Sycan Watershed. There are no known potential barriers in either the Sycan Marsh or Lower Sycan watersheds, and only two in the Sprague River above Beatty Watershed.

At most crossings, the stream is routed through a culvert. Culverts may block passage of juvenile, and in some cases also adult, migratory fish. The extent of blockage is a complex function of several factors, including fish species, life stage, velocity of water in the culvert, the height that a fish must jump to reach the lower end of the culvert from the stream immediately below the culvert, and the depth and length of the pool below the culvert from which the fish must jump (Biosystems 2003). Some of these conditions vary with season and with weather and flow conditions. Some species can jump higher than others. Adult fish can often make a jump that would prevent juvenile fish passage. For such reasons, a culvert may be passable under some conditions, but be impassable under other conditions.



Map 11-3. Known potential fish passage barriers in the Upper Sprague River subbasin. (Data Source: USFS 2005)

In order to determine which of the culverts shown in Map 11-3 actually constitute barriers to fish passage, it would be necessary to survey the culverts in the field and make a series of measurements at each. OWEB provides specific guidelines for such survey activities. Some culvert survey work has been conducted by Fremont-Winema National Forest, as described below.

There are over 1,700 road crossings in the Upper Sprague River subbasin on public and private land. The Fremont-Winema National Forest recently conducted an inventory of the current status of the road crossings on fish-bearing streams within the national forest. Road crossings were determined manually from district maps (USFS 2006). The culverts were inventoried following Forest Service Region 6 protocols. A matrix was used in the field to rate whether or not the culvert met the criteria to allow fish passage. Of the 114 culverts surveyed within the Upper Sprague River subbasin, 102 did not meet the criteria set for fish passage and were determined inadequate for fish passage (Table 11-2). Within all of Fremont-Winema National Forest, including the portion of the forest within the Upper Sprague River subbasin, an estimated 1,549 miles of stream length are blocked for trout passage. Of that stream length, 97 percent was deemed otherwise suitable for redband trout, and the remainder for bull trout.

Table 11-2. Culvert survey data from Fremont-Winema National Forest. (Source: USFS 2006)

Watershed	Culvert Condition	No. of Culverts Surveyed
Upper Sycan	Inadequate	16
	Undetermined	2
Sycan Marsh	Adequate	1
	Inadequate	1
	Undetermined	1
North Fork Sprague	Inadequate	27
	Undetermined	3
South Fork Sprague	Adequate	1
	Inadequate	29
	Undetermined	1
Fishhole Creek	Adequate	2
	Inadequate	27
Sprague River Above Beatty	Adequate	1
	Inadequate	2
Total		114

The surveyed culverts are now being prioritized by the Forest Service for possible upgrading based on a point system. Points are assigned to culvert locations based on fish species present or expected, stream length upstream from the passage barriers, key watersheds, stream type, passage status, and ownership. The number of points reflects the importance placed on a particular characteristic. The more points a culvert receives, the higher that culvert is placed on the priority list for replacement (USFS 2006).

In-Stream and Riparian Habitat

Analysis of ODFW Survey Data

To access current in-stream habitat conditions within the Upper Sprague River subbasin, fish habitat survey data collected according to the ODFW protocols has been compiled. To interpret the habitat survey data, ODFW has established statewide benchmark values as guidelines for an initial evaluation of habitat quality (Table 11-3). The benchmarks rate habitat characteristics as "good," "fair," or "poor." The use of the numerical standards in these benchmarks need to take into consideration the potential of the riparian-wetland areas and associated stream types. Different stream types located in different positions in the watershed produce varied habitat characteristics. In stream reaches that have the potential to produce the desired benchmarks, the numbers can be used directly. If not, an interdisciplinary team uses knowledge and experience to understand the physical function as well as appropriate desired habitat characteristics. The benchmarks and fish habitat assessment are designed to look at combinations of habitat characteristics rather than to single out an individual numerical standard. This approach is meant to help identify patterns within these characteristics that can then be interpreted in a broader watershed context.

Aquatic habitat is created and maintained when the physical processes are functioning. Streams and their associated riparian areas are shaped by watershed processes through adjustments to handle the water and sediment load delivered by the watershed. Proper functioning condition (PFC) is a state of resiliency that will allow a riparian-wetland area to hold together during frequent events such as the 5-, 10-, and 20- year events with a high degree of reliability. This resiliency allows an area to then produce, over time, desired values such as fish habitat or neotropical bird habitat. This happens through the interaction of soil/landform, vegetation, and water. Healthy riparian-wetland areas are typically characterized by vigorous and diverse riparian plant communities which have the root structure and mass necessary to resist the erosive forces of water and sediments, or in forested reaches provide for the recruitment of large woody material to the stream channel to accomplish the same thing. If a riparian-wetland area is lacking in these critical attributes it will not be resilient to normal variations in water and sediment loads, and aquatic habitat will likely be negatively impacted.

Recovery of aquatic habitat starts with recovery of physical function – acquiring the right element(s) to dissipate energy (adequate landform, vegetation, or large woody material), which puts the physical process into working order and provides the foundation to create and maintain the necessary combination of habitat characteristics. Once we know that a stream reach has "fair" or "poor" habitat quality characteristics and has the potential for recovery, understanding physical functions and trend over time can help develop adaptive management and monitoring scenarios that takes advantage of droughts and floods. Trend over time is the tie between current conditions and desired habitat.

To obtain a complete picture of riparian-wetland health, including both physical and biological sides, one must have information on both physical status, provided through PFC assessment, and biological habitat quality, provided through habitat assessments or inventories. Neither will provide a complete picture when analyzed in isolation. As stated earlier, the interdisciplinary team must make interpretations on both types of assessments based on the potential of each site, which helps determine linkages between desired conditions and reach/watershed processes that produce desired conditions.

ODFW has surveyed 35 creeks and rivers in the Upper Sprague River subbasin, totaling approximately 36.4 miles of the stream network. The location of surveyed reaches is shown in Map 11-4. It is important to note that only a very small percentage (2.8 percent) of the overall stream habitat in the watershed has been surveyed by ODFW for habitat conditions. Furthermore, the streams that were surveyed are clustered in two locations within the subbasin (Map 11-4). In addition, no streams were surveyed for habitat conditions within the Sycan River above Sprague River, Sycan River above Sycan Marsh, or Sprague River above Sycan River subwatersheds. Thus, stream habitat conditions summarized here represent less than three percent of the overall habitat and may or may not be similar to conditions in reaches that were not surveyed. High-velocity peak flows and flood conditions have likely further altered LWD and sediment distribution conditions somewhat, compared to conditions that existed at the time of surveying. The condition of in-stream habitat is dynamic, and although watershed-scale assessments can provide information useful for prioritizing restoration activities, all sites should be field-verified before specific restoration actions are planned.

Tables 11-4 through 11-6 summarize important measures of stream habitat for pools, riffles, and LWD, following OWEB guidelines and ODFW benchmarks. For the stream reaches surveyed within each subwatershed, reach ratings are shown for each of the summarized stream habitat characteristics.

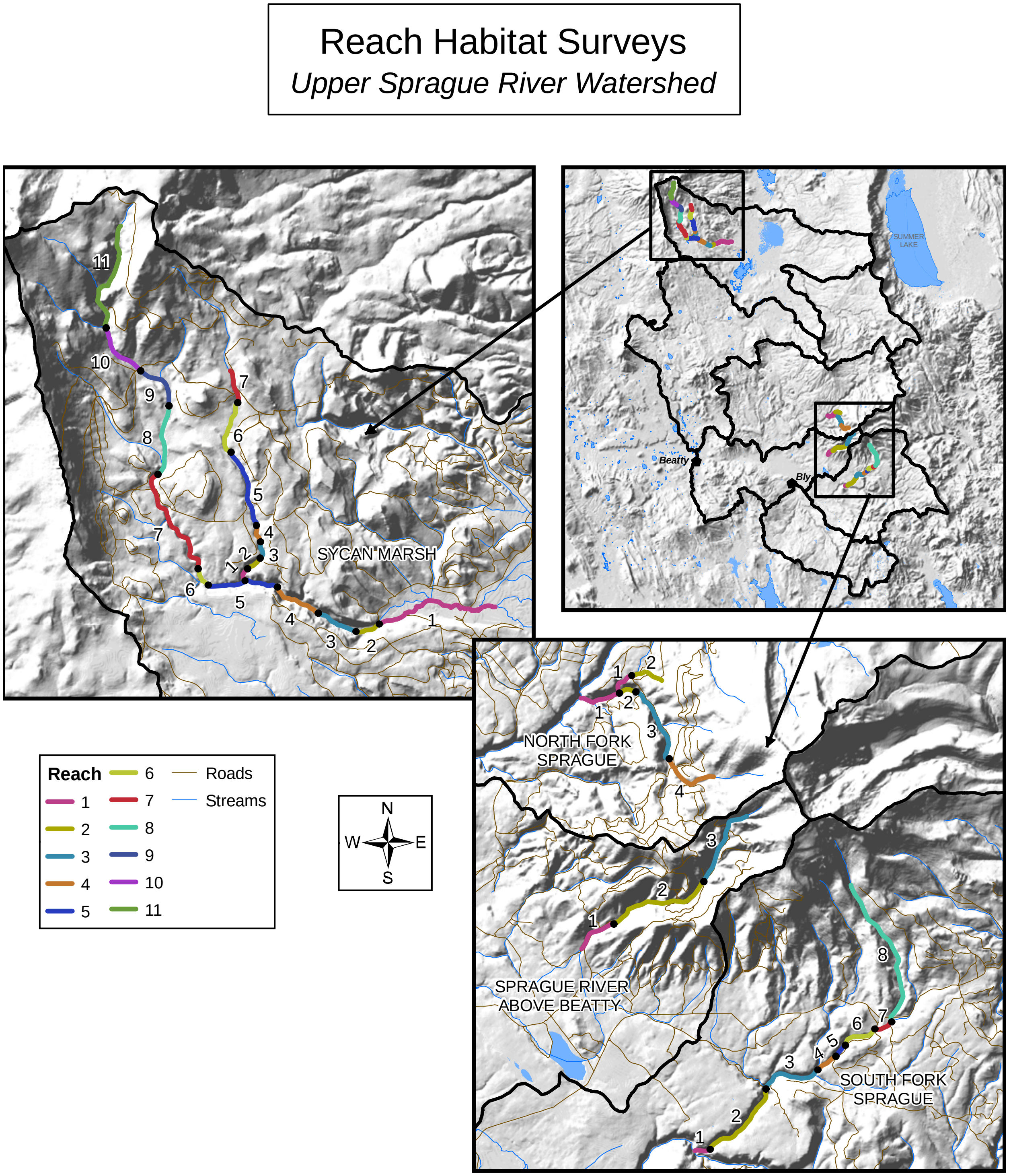
Overall, pool conditions were moderate to poor in most surveyed stream reaches (Table 11-4). Conditions were worst in Brownsworth Creek and best in Long Creek. Residual pool depth was almost uniformly rated as moderate throughout all surveyed reaches. Percent pools and pool frequency conditions were more variable, with many reaches rated as poor and some rated as good.

In general, gravel conditions were somewhat better than pool conditions, especially for the variable that expresses the percent of the riffle area covered by gravel. This item was rated as good in 63 percent of the surveyed reaches, most noticeably in Brownsworth, Boulder, and Deming creeks. The riffle width-to-depth ratio and the percent of riffles covered by silt, sand, and organic materials were both good in Calahan Creek and generally moderate elsewhere.

Table 11-3. Stream habitat survey benchmarks (Source: WPN 1999).

Habitat Characteristic	Measurements Used for Rating Habitat Quality	Benchmark Values		
		Good	**Fair**	**Poor**
Pools	**Percent area in pools:** percentage of the creek area that has pools	> 35	10 - 35	< 10
	Residual pool depth: depth of the pool (m), from the bottom of the pool to the bottom of the streambed below the pool	> 0.5	0.5 - 0.2	< 0.2
	Pool frequency: channel widths between pools	5 - 8	other	> 20
Riffles	**Width to depth ratio:** width of the active stream channel divided by the depth at that width	< 10	10 - 30	> 30
	Percent gravel in the riffles: percentage of creek substrate in the riffle sections of the stream that are gravel	> 35	15 - 35	< 15
	Percent sediments (silt, sand, and organics) **in the riffles:** percentage of creek substrate in the riffle sections of the stream that are sediments	< 8	8 - 15	> 15
Riparian	**Dominant riparian species:** hardwoods or conifers	large diameter conifers	medium diameter conifers & hardwoods	small diameter hardwoods
	Percent of the creek that is shaded	> 50	40 – 50	< 40
Large Woody Material in the Creek	**Number of wood pieces**[1] per 100m (328 ft) of stream length	> 20	10 - 20	< 10
	Volume of wood (cubic meters) per 100m of stream length	> 30	20 - 30	< 20

[1] Minimum size is 6-inch diameter by 10-foot length or a root wad that has a diameter of 6 inches or more.



Map 11-4. Stream reaches surveyed by ODFW within the Upper Sprague River subbasin. All surveyed reach locations are shown in the upper right panel. They were clustered in two regions within the subbasin, each of which is depicted on a higher resolution map panel. (Data Source: ODFW 2001)

Table 11-4. Pool habitat conditions, by subwatershed, based on ODFW survey data. (Data Source: ODFW 2001)

Watershed	Stream	Reach	Percent Pools	Rating[1]	Residual Pool Depth (m)	Rating	Pool Frequency (pools/100m)	Rating
Sprague River Above Beatty	Deming Creek	1	13.7	••	0.2	••	13.2	••
		2	8.5	•	0.3	••	14.4	••
		3	4.4	•	0.2	••	21.8	•
North Fork Sprague	Boulder Creek	1	2.6	•	0.4	••	35.9	•
		2	2.5	•	0.4	••	29.5	•
		3	10.1	••	0.3	••	7.8	•••
		4	4.8	•	0.2	••	17.2	••
	Dixon Creek	1	0.8	•	0.3	••	192.2	•
		2	31.7	••	0.2	••	6.5	•••
South Fork Sprague	Brownsworth Creek	1	3.8	•	0.5	••	30.7	•
		2	7.3	•	0.3	••	23.4	•
		3	5.6	•	0.3	••	31.2	•
		4	1.0	•	0.3	••	105.9	•
		5	11.9	••	0.3	••	26.8	•
		6	0.9	•	0.4	••	92.3	•
		7	4.2	•	0.3	••	37.4	•
		8	2.3	•	0.3	••	68.8	•
Sycan Marsh	Calahan Creek	1	5.8	•	0.3	••	9.9	••
		2	22.9	••	0.2	••	12.3	••
		3	8.6	•	0.2	••	19.7	••
		4	27.8	••	0.2	••	16.4	••
		5	13.0	••	0.4	••	27.9	•
		6	0.0	•	0.0	•	0.0	•
		7	0.4	•	0.3	••	390.4	•
	Long Creek	1	44.1	•••	0.4	••	7.2	•••
		2	31.8	••	0.4	••	7.0	•••
		3	3.9	•	0.5	••	33.4	•
		4	11.9	••	0.4	••	18.7	••
		5	4.4	•	0.4	••	45.4	•
		6	17.8	••	0.4	••	8.9	••
		7	15.4	••	0.5	••	14.3	•
		8	30.6	••	0.4	••	9.1	••
		9	47.6	•••	0.4	••	4.5	•
		10	4.7	•	0.4	••	25.4	•
		11	6.3	•	0.3	••	12.7	••

[1] Condition rating: • Poor; •• Fair; ••• Good

Table 11-5. Riffle habitat conditions, by subwatershed, based on ODFW survey data. (Data Source: ODFW 2001)

Watershed	Stream	Reach	Gravel in Riffles (% area)	Rating[1]	Width/Depth Ratio	Rating	Silt-Sand-Organics (% area)	Rating
Sprague River Above Beatty	Deming Creek	1	51	•••	18.2	••	17	•
		2	40	•••	20.4	••	11	••
		3	50	•••	16.9	••	15	••
North Fork Sprague	Boulder Creek	1	58	•••	14.4	••	17	•
		2	48	•••	13.2	••	33	•
		3	53	•••	22.5	••	9	••
		4	57	•••	21.0	••	12	••
	Dixon Creek	1	0	•	11.5	••	0	•••
		2	27	••	14.9	••	37	•
South Fork Sprague	Brownsworth Creek	1	35	•••	14.0	••	15	••
		2	37	•••	15.5	••	15	••
		3	38	•••	16.1	••	21	•
		4	48	•••	9.2	•••	25	•
		5	56	•••	14.3	••	21	•
		6	55	•••	17.8	••	20	•
		7	60	•••	17.7	••	27	•
		8	60	•••	21.1	••	23	•
Sycan Marsh	Calahan Creek	1	0	•	7.8	•••	0	•••
		2	0	•	6.8	•••	0	•••
		3	0	•	7.4	•••	0	•••
		4	50	•••	8.0	•••	40	••
		5	39	•••	8.7	•••	45	••
		6	0	•	0.0	•••	0	•••
		7	0	•	0.0	•••	0	•••
	Long Creek	1	42	•••	12.5	••	40	•
		2	36	•••	15.1	••	28	•
		3	29	••	18.6	••	25	•
		4	32	••	16.4	••	31	•
		5	25	••	17.3	••	27	•
		6	33	••	24.4	••	28	•
		7	31	••	23.5	••	25	••
		8	38	•••	13.6	••	37	•
		9	41	•••	15.9	••	43	•
		10	33	••	18.9	••	24	•
		11	52	•••	18.5	••	11	••

[1] Condition rating: • Poor; •• Fair; ••• Good

Table 11-6. Large woody debris habitat conditions, by subwatershed, based on ODFW survey data. (Data Source: ODFW 2001)

Watershed	Stream	Reach	# Pieces/100m	Rating[1]	Volume (m^3/100m)	Volume Rating
Sprague River Above Beatty	Deming Creek	1	1.8	•	1.4	•
		2	3.2	•	2.6	•
		3	8.8	•	12.2	•
North Fork Sprague	Boulder Creek	1	10.3	••	8.3	•
		2	9.6	•	8.7	•
		3	12.9	••	9.1	•
		4	9.2	•	7.0	•
	Dixon Creek	1	10.8	••	9.0	•
		2	21.7	•••	12.4	•
South Fork Sprague	Brownsworth Creek	1	4.5	•	1.5	•
		2	4.1	•	2.0	•
		3	4.5	•	4.7	•
		4	3.7	•	3.2	•
		5	5.7	•	10.6	•
		6	7.1	•	18.1	•
		7	6.8	•	7.2	•
		8	8.9	•	22.1	••
Sycan Marsh	Calahan Creek	1	15.7	••	15.3	•
		2	15.5	••	19.6	•
		3	17.9	••	20.4	••
		4	13.2	••	7.6	•
		5	15.7	••	17.8	•
		6	0.4	•	0.3	•
		7	18.5	••	21.5	••
	Long Creek	1	15.3	••	16.0	•
		2	26.0	•••	33.5	•••
		3	24.6	•••	18.9	•
		4	29.0	•••	27.2	••
		5	15.6	••	19.4	•
		6	12.8	••	15.3	•
		7	17.4	••	19.8	•
		8	3.8	•	6.8	•
		9	45.0	•••	34.5	•••
		10	17.6	••	28.4	••
		11	6.4	•	7.1	•

[1] Condition rating: • Poor; •• Fair; ••• Good

LWD conditions were generally poor to moderate throughout the Upper Sprague River subbasin, although there was a higher proportion of good LWD volume and density conditions in the Long Creek subwatershed (Table 11-6). The surveys reported an absence of key LWD pieces (large LWD that are relatively stable in the stream channel and help to provide functional habitat) throughout the study area.

Stream shade conditions throughout the Upper Sprague River subbasin were good in 60 percent of the surveyed reaches (Table 11-7). However, several of the stream reaches in the Long Creek and Calahan Creek subwatersheds were rated as having poor stream shade conditions, with 35 percent or less stream shading. Riparian vegetation condition was rated as good in Boulder and Dixon creeks, but generally fair elsewhere (Table 11-6).

Table 11-8 provides an overall rating summary for stream and riparian condition. To construct the overall rating scores for each stream reach, an average score was computed for each parameter that reflected an aspect of conditions within a designated habitat type. Thus, the overall rating for pool conditions was computed as the average of measured conditions for percent pools, residual pool depth, and pool frequency. This overall condition summary indicates that stream habitat conditions are generally fair within the survey area, whereas riparian conditions tend to be somewhat better. Based on the surveyed reaches, stream habitat conditions tend to be worst in Brownsworth Creek and best in Long Creek. Riparian conditions tend to be worst in Long Creek and best in Boulder and Dixon creeks.

Results of Forest Service and Weyerhaeuser Surveys

Analyses of in-stream habitat condition were conducted in the Upper Sycan and South Fork Sprague watersheds by Fremont-Winema National Forest and Weyerhaeuser in the 1990s. These results are summarized below.

Upper Sycan Watershed

The USFS conducted a watershed analysis in the mid-1990s in which aquatic habitat conditions were identified in 41 stream reaches within the Upper Sycan Watershed (USFS 1999). Habitat features were evaluated within five major categories: large woody debris, pools, spawning gravel fines, stream temperature, and fish passage. Five streams (a total of 55 miles) were surveyed: Paradise Creek (9 miles), Crazy Creek (7 miles), Watson Creek (6 miles), Sycan River (27 miles), and Skull Creek (6 miles). Results are summarized in Table 11-9. The entire 27 miles of the Sycan River, from its headwaters in the Hanan Trail Roadless Area to its entrance into the Sycan Marsh was surveyed and divided into 13 reaches (USFS 1999).

Table 11-7. Stream shade and riparian vegetation condition, by subwatershed, based of ODFW survey data. (Data Source: ODFW 2001)

Watershed	Stream	Reach	Shade (average %)	Rating[1]	Riparian Veg[2]	Rating
Sprague River Above Beatty	Deming Creek	1	83	●●●	D3	●
		2	94	●●●	D3	●
		3	74	●●●	C50	●●●
North Fork Sprague	Boulder Creek	1	58	●●●	M50	●●●
		2	53	●●●	M50	●●●
		3	65	●●●	M50	●●●
		4	70	●●●	M50	●●●
	Dixon Creek	1	54	●●●	M50	●●●
		2	53	●●●	M50	●●●
South Fork Sprague	Brownsworth Creek	1	44	●●	D3	●
		2	46	●●	D3	●
		3	56	●●●	M15	●●
		4	46	●●	M15	●●
		5	66	●●●	M15	●●
		6	71	●●●	M15	●●
		7	55	●●●	M15	●●
		8	66	●●●	M30	●●
Sycan Marsh	Calahan Creek	1	63	●●●	C15	●●
		2	44	●●	P	●
		3	59	●●●	C15	●●
		4	56	●●●	C3	●
		5	54	●●●	C15	●●
		6	25	●	P	●
		7	62	●●●	C30	●●
	Long Creek	1	18	●	P	●
		2	35	●	S	●
		3	48	●●	C30	●●
		4	41	●●	S	●
		5	54	●●●	C15	●●
		6	40	●●	S	●
		7	50	●●	C15	●●
		8	24	●	P	●
		9	49	●●	C3	●
		10	55	●●●	C15	●●
		11	44	●●	C30	●●

[1] Condition rating: ● Poor; ●● Fair; ●●● Good

[2] M - Mixed conifer/deciduous (approx. 50/50)
D - Deciduous dominated (canopy more than 70% alder, cottonwood, big leaf maple, or other deciduous spp.)
C - Coniferous dominated (canopy more than 70% conifer)
P - Perennial grasses, sedges, and rushes
S - Shrubs (willow, salmonberry, some alder

3 - Seedlings and new plantings
15 - Young established trees or saplings
30 - Large trees in established stands
50 - Mature timber; developing understory of trees and shrubs

Table 11-8. Summary of stream survey ratings. (Data Source: ODFW 2001)

Watershed	Stream	Reach	Stream Miles	Gradient (%)	Average Condition Rating[1]			
					Pools	Riffles	LWD	Riparian
Sprague River Above Beatty	Deming Creek	1	0.8	3.9	••	••	•	••
		2	2.1	5.6	••	••	•	••
		3	1.6	12.0	•	••	•	•••
North Fork Sprague	Boulder Creek	1	0.8	6.2	•	••	••	•••
		2	0.4	6.3	•	••	•	•••
		3	1.6	7.0	••	••	••	•••
		4	1.1	7.0	••	••	•	•••
	Dixon Creek	1	0.5	17.3	•	••	••	•••
		2	0.6	4.6	••	••	••	•••
South Fork Sprague	Brownsworth Creek	1	0.3	4.3	•	••	•	••
		2	1.7	3.5	•	••	•	••
		3	1.2	4.0	•	••	•	•••
		4	0.4	3.7	•	••	•	••
		5	0.3	3.4	••	••	•	•••
		6	0.7	3.9	•	••	•	•••
		7	0.4	3.5	•	••	•	•••
		8	3.0	5.2	•	••	••	•••
Sycan Marsh	Calahan Creek	1	0.3	4.9	••	••	••	•••
		2	0.3	2.1	••	•••	••	••
		3	0.3	2.4	••	•••	••	•••
		4	0.4	1.8	••	••	••	••
		5	1.5	1.7	••	••	••	•••
		6	1.1	1.4	•	••	•	•
		7	0.6	3.1	•	••	••	•••
	Long Creek	1	2.6	0.6	•••	••	••	•
		2	0.5	1.0	••	••	•••	•
		3	0.8	1.9	•	••	••	••
		4	0.9	1.6	••	••	•••	••
		5	1.4	1.8	•	••	••	•••
		6	0.4	1.2	••	••	••	••
		7	2.3	1.4	••	••	••	••
		8	1.4	0.9	••	••	•	•
		9	1.0	1.6	••	••	•••	••
		10	1.1	3.4	•	••	••	•••
		11	2.2	6.5	••	••	•	••

[1] Condition rating: • Poor; •• Fair; ••• Good

Large Woody Debris

Of the surveyed reaches, the majority were considered to contain an appropriate level of LWD. All of the reaches that pass through mixed forest/meadow were considered to be adequate for LWD. Just over half of the forested reaches were considered adequate, with the remaining segments rated as at-risk (USFS 1999).

Pools

All but one of the 41 reaches surveyed were considered adequate for pool numbers. The single at-risk reach was found in Paradise Creek. However, only 41 percent of surveyed reaches were considered adequate for large pool frequency. Crazy Creek and Skull Creek did not have any reaches classified as desirable large pool habitat. Overall, pool habitat quantity and quality were considered high, and the Sycan River was rated as the watershed having the highest quality pool habitat (USFS 1999).

Spawning Gravel Fines

Eleven sites were surveyed for spawning gravel fines in 1999. Six were determined to be adequate, four were considered to be at-risk, and one was found to be inadequate. Overall, the amount of fine sediment in streams in this watershed was low to moderate due to high bank stability, abundance of late-seral vegetation, and stream type conforming to the surrounding landscape appropriately. Fine sediments that make their way into the streams in this watershed generally do not clog gravel beds since the stream types present have a good ability to transport fine sediment downstream. A flood occurred in 1997 which was likely responsible for flushing fine sediment from the system prior to the survey (USFS 1999).

Stream Temperature

Of the 37 surveyed stream reaches rated for stream temperature, 20 (54 percent) were determined to be adequate, with the remaining 17 rated as at-risk. All portions of Crazy and Skull creeks were rated as adequate for temperature, but only the upper reaches of these streams were rated as having favorable stream temperatures for bull trout. Segments of several other streams were determined to have suitable temperatures for bull trout, including upper reaches of Paradise Creek and Sycan River, Rock Creek, Boulder Creek, South Fork Sycan River, and Rifle Creek. It was determined that Watson Creek did not have much favorable bull trout habitat in terms of stream temperature conditions. The reaches that did not meet the desired stream temperature criteria were generally located in open meadows, lacking streambank shade-producing vegetation (USFS 1999).

Fish Passage

The Sycan River was found to be functioning appropriately for fish passage, with no culverts identified as blocking fish movement in the river. Each of the other surveyed streams had at least one culvert found to block fish passage (USFS 1999).

Table 11-9. Results of in-stream habitat surveys conducted by Fremont National Forest and presented in the Upper Sycan Watershed Analysis. (Source: USFS 1999)

Reach	Reach Length (miles)	Wetted Width (feet)	Gradient (%)	LWD/ Mile	Pools/ Mile	Large Pools/ Mile	Spawning Gravel Fines (%)	Stream Temperature		Potential Fish Passage (Culvert) Concern
Paradise Creek										
1	0.7	10	1	6	46	9	19	19.7	67.5	No
2	2.1	14	2-4	5	96	6	15	NA	NA	Yes
3	2.0	13	1	3	80	3	NA	NA	NA	No
4	0.6	13	1	8	71	2	NA	NA	NA	No
5	0.8	6	1	**	61	5	NA	NA	NA	No
6	0.4	4	<1	**	108	3	NA	NA	NA	No
7	0.7	3	<2	**	106	0	NA	NA	NA	No
8	1.2	4	4	21	128	1	NA	NA	NA	No
9	0.5	4	8	22	131	0	25	14.3	57.7	Yes
Crazy Creek										
1	1.7	6	3	41	139	0	13	17.1	63.0	Yes
2	1.4	5	1	20	153	1	NA	NA	NA	No
3	0.8	5	1	17	228	1	NA	NA	NA	No
4	0.6	4	1	**	131	0	NA	NA	NA	No
5	0.9	4	1	23	152	8	67	NA	NA	Yes
6	0.9	3	1	**	156	0	NA	15.8	60.0	No
7	0.3	3	2	9	226	0	NA	NA	NA	No
Watson Creek										
1	1.4	9	2	2	76	28	NA	22.9	73.2	No
2	1.5	8	2	8	81	4	NA	22.2	72.0	No
3	0.9	7	2	1	132	1	20	NA	NA	Yes
4	1.1	6	2	5	115	1	NA	NA	NA	No
5	0.8	5	1	1	131	0	NA	NA	NA	No
6	0.5	5	1	**	133	4	NA	NA	NA	No
Sycan River										
1	2.3	43	2	3	21	23	24	19.8	67.6	No
2	1.6	42	2	8	26	18	NA	NA	NA	No
3	1.3	33	3	6	45	13	NA	NA	NA	No
4	4.3	38	3	12	28	22	NA	19.6	67.3	No
5	1.9	30	3	22	32	19	NA	NA	NA	No
6	0.8	30	2	16	22	5	14	NA	NA	No
7	1.9	24	1	11	32	8	NA	NA	NA	No
8	1.5	22	3	24	29	3	NA	NA	NA	No
9	2.4	22	2	22	55	14	NA	NA	NA	No
10	1.6	20	1	17	53	9	NA	NA	NA	No
11	0.6	19	2	3	52	7	NA	NA	NA	No
12	3.2	12	1	**	48	19	20	15.9	60.6	No
13	4.0	4	2	8	75	1	8	15.2	59.4	Yes
Skull Creek										
1	4	1	22	209	0	NA	17.5	63.5	No	98
2	4	<1	11	195	0	NA	NA	NA	Yes	99
3	3	<1	4	183	3	NA	17.5	63.5	Yes	96
4	3	<1	6	168	0	NA	NA	NA	No	97
5	3	2-4	19	174	0	NA	NA	NA	No	98
6	1-2	2-4	6	138	0	NA	NA	NA	No	99

NA – Information Not Available; ** - Habitat element not applicable for this reach
Habitat Abbreviations and Explanations: LWD – Large Woody Debris; Large Pools – Pools > 2.6 feet deep; % Spawning Gravel Fines - <6.4mm

South Fork Sprague Watershed

Fremont National Forest Analyses

Results of habitat surveys conducted by Fremont National Forest in the South Fork Sprague River Watershed are summarized in Table 11-10. Only two of the streams surveyed, Upper Brownsworth and Upper Leonard creeks, were observed to have average stream shading of more than 70 percent. Stream temperatures in these segments are likely to be cooler, and more hospitable to trout, than many of the other segments. Buckboard Creek, Lower Corral Creek, and the Lower Sprague River all exhibited very low (25 percent or less) average stream shading values (USFS 1999).

Pool frequency was highest in Pothole, Lower Corral, and Upper Camp Creek. Portions of Leonard and Paradise creeks exhibited seven percent or less of their surface area as pool habitat. Average residual pool depth was highest in the South Fork Sprague River (1.8 feet). It was 1.1 feet or less in all of the other surveyed reaches.

Average stream bank stability was 75 to 98 percent in most reaches. It was 60 percent or less, however, in the Upper South Fork Sprague River and Pothole Creek.

Upper Leonard and Hammond Creeks both had relatively high amounts of LWD per mile. The lowest value of LWD per mile was found in Lower Brownsworth Creek. About half of the stream beds surveyed for percent fine sediments showed values greater than 35 percent while the other half had less than 35 percent fines.

Weyerhaeuser Analyses

Brownsworth Creek

A watershed analysis for Brownsworth Creek was carried out in 1995 to assess how inputs of wood, water, and sediment are routed through the stream channel (Weyerhaeuser 1995a). Of the 22 segments of stream, 11 were surveyed using the Standard Methodology outlined by the Washington Forest Practices Board, including a survey of riparian vegetation, bank stability, large woody debris, and pool habitat.

Fish species found in the Brownsworth Creek Watershed include bull trout, redband trout, brook trout, and brown trout. Bull trout are found in Leonard and Brownsworth creeks (Ziller 1992). Redband trout are broadly distributed in the watershed. Non-native redband trout were stocked in the South Fork Sprague between 1928 and 1975. Stocking history in Brownsworth Creek is unknown. Brook and brown trout are both introduced species that are contributing to the changing composition of trout species in the watershed. The following observations were made:

- Other than the occasional beaver dam, there are no natural barriers to fish passage. However, there are six culverts that present passage difficulties for at least part of the year, and one which is totally impassable.

- Suitable spawning-sized gravel was observed throughout the stream reaches of the watershed in well sorted patches. However, high ratios of fine sediment to gravel were documented in many stream segments.
- Infrequent and shallow pools were observed, many of which had been filled with fine sediment.
- Boulders and cobbles present in the streams were noted to have interstices filled with fines as well.
- Large woody debris was moderately low in the watershed, except in the upper portions of Brownsworth and Leonard creeks.
- Water temperatures were moderately high for trout, with temperatures exceeding 64^{o} F for the 7-day average, except in the upper portions of Brownsworth and Leonard creeks.

Overall, aquatic habitat quality was judged to be highest in the headwater reaches of Brownsworth and Leonard creeks, but less desirable in the lower perennial reaches. An excessive amount of fine sediment was rated as the largest contributor to compromised aquatic habitat in Brownsworth Creek.

Whitworth Creek

An analysis was carried out in 1995 for Whitworth Creek to assess how inputs of wood, water, and sediment are routed through the stream channel, and to estimate how these inputs affect fish habitat (Weyerhaeuser 1995b). A reconnaissance-level field survey was used to examine and determine the channel conditions at the time of the survey. Of the 36 segments of river, 11 were surveyed.

Historically, fluvial suckers most likely used streams in the Whitworth Creek Watershed for spawning. Bull trout may have also have used these streams for spawning. The only trout species found in the watershed during the time of this assessment was redband trout, found in Whitworth and Pothole creeks (Weyerhaeuser 1995b).

There are currently 13 miles of fish-bearing waters in the Whitworth Creek Watershed. Intermittent streams may also be used during periods of high flow in the spring. Three culverts on Pothole and Whitworth creeks affect fish passage. Low water flow may also be a hindrance to fish passage during the summer months. The main locations of concern for habitat quality were the lower reaches of Whitworth Creek due to fine sediment filling gravel areas and high potential for dewatering. Low pool habitat was also a concern.

Table 11-10. Results of in-stream habitat surveys conducted by Fremont National Forest and presented in the South Fork Sprague River Watershed Analysis. (Source: USFS 1999)

Stream Reach	Stream Conditions					
	Average Stream Shading (%)	Pool Frequency (% of surface area)	Average Residual Pool Depth (feet)	Average Stream Bank Stability (%)	Pieces of LWD/ mile	Fine Sediment (%)
South Fork Sprague River						
Lower	6	41	1.8	68	14	> 35
Upper	40	35	1.1	> 50	55	> 35
Brownsworth Creek						
Lower	60	17	1.1	75	2	35
Upper	75	17	0.7	75	NA[1]	NA
Leonard Creek						
Upper	80	7	0.7	98	396	< 35
Hammond Creek	60	18	1	75	138	> 35
Camp Creek						
Lower	55	16	1.1	90	41	< 35
Upper	35	44	0.7	90	60	> 35
Corral Creek						
Lower	25	44	NA	90	35	< 35
Upper	30	22	NA	80	43	< 35
Pothole Creek						
Lower	60	47	0.8	60	24	> 35
Upper	30	44	0.5	60	15	> 35
Paradise Creek						
Upper	35	5	0.7	80		< 35
Lower	NA	NA	NA	NA	NA	NA
Badger Creek	35	NA	NA	80	NA	NA

[1] NA – not analyzed or data otherwise not available

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CHAPTER 12 TERRESTRIAL WILDLIFE SPECIES AND HABITAT

INTRODUCTION

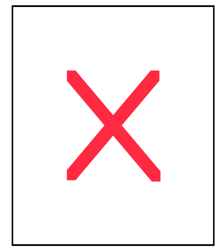
The Upper Sprague River subbasin is noteworthy from a wildlife perspective because it contains a high diversity of species and because it is home to many species that have been classified as rare or deserving of special conservation status. Both of these factors are due, at least in part, to the location of this subbasin at the intersection of five different ecological regions.

In particular, riparian areas and wetlands provide for diversity of wildlife species. Conservation and restoration of these areas will have disproportionately large benefits to wildlife. Key issues that limit wildlife diversity include a reduction in vegetation complexity (multiple vegetation layers, including large trees), scarcity of snags and down logs, and increasing abundance of noxious invasive plants.

Overall biotic condition is reflected in the condition, health, and viability of populations of all native species within the watershed. Characterizing and monitoring all species is not possible from a practical standpoint, however. Resource managers therefore focus attention on species whose presence or absence reflects the health of the ecosystem, on Aspecial status@ species, such as Threatened and Endangered species, and on game species.

Because the Upper Sprague River subbasin lies near the intersection of five different ecoregions, it is not surprising that the area supports a wealth of animal diversity. It is estimated that 314 species of vertebrates occur in, or have been extirpated from, the assessment area ORNHIC 2005). Table 12-1 summarizes the number of species "closely" or "generally" associated with major habitat types in the assessment area.

Many landowners manage their property for wildlife.



Bob and Roberta Valladao shared that "the land has been managed in a way that improves the riparian area and increases wildlife habitat. As we irrigate pasture, it brings in birds. The calving pasture promotes eagles, and deer are attracted to the alfalfa. We fenced our riparian area, which promoted perennials and increased bird populations. Coyote management has promoted diversity in other species. We recently saw our first river otter."

Roberta shares that she likes watching wildlife. That is one of the reasons they came to the Sprague River Valley (pers. comm. December 22, 2007).

FORESTS AND WOODLANDS

Wildlife Diversity and Function

The composition and structure of forests and woodlands in the Upper Sprague River subbasin are highly variable as a result of variations in topography, climate, elevation, and patterns of natural disturbance. Some "generalist" species of wildlife can be found throughout many forest types in the assessment area, whereas other "indicator species" have a narrow ecological tolerance for certain types or successional stages. For example, Townsend's warbler is only associated with subalpine parklands, whereas red crossbill is found in virtually every forest type of the assessment area. However, the distribution and abundance of most species is more influenced by vegetation structure than generalized vegetation type.

Table 12-1. Comparison of vertebrate species richness among ten habitat types in the Upper Sprague River subbasin. Note: many species are associated with more than one habitat type. Data are based on species-habitat relationships reported in O'Neil et al. 2001

	Vertebrate Class				
Habitat Type	**Amphibians**	**Reptiles**	**Birds**	**Mammals**	**Total**
Subalpine Parkland	3	1	48	27	79
Eastside Mixed Conifer Forest	5	6	80	42	133
Ponderosa Pine Forest/Woodland	5	9	101	34	149
Lodgepole Pine Forest & Woodlands	4	9	49	31	93
Western Juniper Woodlands	5	11	60	25	101
Shrub-Steppe	5	12	53	36	106
Eastside Riparian-Wetlands	5	6	114	41	166
Herbaceous Wetlands	5	3	103	34	145
Open Water	5	0	84	18	107
Agriculture/Mixed Environs	3	6	109	28	146

In a review of wildlife-habitat associations in eastside forests of Oregon and Washington, Sallabanks et al. (2001) reported that snags are an important element for 33% of vertebrate species inhabiting eastside forests, and downed logs are used by 29% of forest wildlife species. Eastside late successional forests ("old-growth") have fewer closely associated wildlife species (4) than Westside old-growth forests (75; Sallabanks et al. 2001). In contrast, many species dwelling in eastside forests are closely associated with early-successional stages (Sallabanks et al. 2001).

Management Issues

The increasing severity of forest health problems in eastern Oregon results from a number of interacting causes. These include drought, insect reproduction cycles, and the effects of past forest management practices and fire suppression. Changes to vegetation structure and composition caused by these stressors will affect wildlife communities in a variety of ways, but the response of wildlife assemblages to forest health problems has not been well researched. It is known that some species are well adapted to forests with high volumes of dead wood (e.g., black-backed woodpecker) and are likely to thrive in stands dying from insect outbreaks or disease. In addition, much of the wildlife diversity in the assessment area is associated with early-seral conditions and semi-open canopy forests (Sallabanks et al. 2001), which are less common now than under the natural fire regime. In recent years, forest management by both the US Forest Service and private timber companies has been modified to focus more heavily on improving wildlife habitat.

SHRUBLANDS AND WESTERN JUNIPER WOODLANDS

Shrub-steppe and western juniper woodlands provide habitat for a variety of wildlife species. These arid habitats share many commonalities, but there are some important structural differences. A lack of trees is a defining characteristic of the shrub-steppe vegetation type. This results in fewer vegetation layers and associated habitat strata, which combine with lower water availability to produce a corresponding decrease in wildlife diversity, as compared with ponderosa pine or mixed conifer forest. The presence of scattered trees in an open-canopy juniper woodland provides an additional structural element that functions as thermal cover for land animals and roosting habitat for birds.

Wildlife Diversity and Function

There are 106 vertebrate species present in the assessment area that are considered to be associated with shrub-steppe habitats and 101 species associated with western juniper woodlands (Table 12-1). There is considerable overlap in the species composition of these two arid habitat types. Some species that are unique to arid shrublands and juniper woodlands include:

- Striped whipsnake (*Masticophis taeniatus)*
- Merriam's shrew (*Sorex merriami)*
- Great Basin pocket mouse (*Perognathus parvus)*
- Sagebrush vole (*Lagurus curtatus)*
- Kit fox (*Vulpes macrotis)*

Two taxonomic groups are particularly noteworthy for their ecological importance in arid shrublands and juniper woodlands: 1) reptiles and 2) ground squirrels of the genus *Spermophilus*. Of the 28 native reptile species in Oregon, 21 occur in shrub-steppe habitats (Vander Haegen et al. 2001). This habitat type provides for a greater diversity of reptiles than any other habitat type in the state. Because of their successful adaptation to the environmental extremes that are characteristic of shrub-steppe communities, reptiles can occur in high densities and contribute significantly to the overall biomass available to other trophic levels (Vander Haegen et al. 2001).

Although considered a pest by many ranchers, ground squirrels (i.e., *Spermophilus beldingi, S. lateralis, S. townsendii*), serve several important ecological roles. Ground squirrels provide an important prey base for many snakes, raptors, and mammalian carnivores. Furthermore, burrows that are excavated by ground squirrels provide a crucial refuge for a large number of other wildlife species. Finally, soil mixing that results from the burrowing activity of ground squirrels (as well as the badgers pursuing them) improves aeration and water infiltration (Vander Haegen et al. 2001). In Idaho, ground squirrel activity was found to increase the productivity of native bunchgrasses by 20% (Laundré 1998). However, sheet runoff during spring melt can result in sediment deposition to streams from ground squirrel deposits (C. Sokol, pers. comm., November 2005).

Management Issues

In some cases irrigated pastures result in benefits to certain species by providing additional vegetation for a longer period during the year. In other cases, grazing can diminish habitat quality for wildlife that depend upon the vegetation structure of shrubs or feed upon the associated plant species. Research conducted in eastern Oregon by Irwin et al. (1994) has demonstrated that plots exposed to grazing by livestock and elk have, on average, 75% less shrub cover than was estimated on plots excluded from grazing. Also, soil disturbance can foster the establishment of cheatgrass and other noxious weeds, decreasing the availability of native plants that wildlife use for cover and forage (Vander Haegen et al. 2001). The wildlife species richness in annual grasslands (such as stands of cheatgrass) is estimated to be only 55% of that in native shrub-steppe habitats (Vander Haegen et al. 2001).

It should be noted, however, that some shrub-steppe species do benefit from at least three components of agricultural operations. First, buildings and farm structures are used as shelter by many species of wildlife. Second, edges, fencerows, and odd areas are used as feeding sites, nesting habitat, and movement corridors by many species. Finally, irrigated fields and reservoirs developed for farms increase water availability, an important life requisite for all wildlife and a limiting factor for many species in arid habitat types. Most non-native animal species that inhabit the assessment area (e.g., Bullfrog [*Rana catesbeiana*], European starling [*Sturnus vulgaris*], English sparrow [*Passer domesticus*], Virginia opossum [*Didelphis virginiana*]) are strongly associated with disturbed habitats.

Open woodland of western juniper has been an important habitat for wildlife through at least the Holocene epoch (Present to 10,000 years ago). Indeed, the Townsend's solitare, American robin, and other frugivores are the primary agents of seed dispersal for western juniper (Bedell et al. 1993). However, the expansion of dense stands of juniper into shrub and grassland communities (particularly those habitats formerly dominated by *Artemesia tridentata* var. *vaseyana*) represents an important threat to wildlife associated with shrub-steppe vegetation. The Prineville District of the Bureau of Land

Management (BLM) estimates that open juniper woodlands support 146 species of wildlife, but species richness declines to 71 species when canopy closure excludes shrubs and grasses (Bedell et al. 1993).

RIPARIAN AREAS AND WETLANDS

Wildlife Diversity and Function

Riparian areas and wetlands are characterized by numerous physical and ecological attributes that foster a high degree of animal diversity. The proximity to water, nutrient deposition via stream or slope, and vegetation heterogeneity all combine to create a variety of ecological niches that wildlife communities are able to exploit. Of the 314 vertebrate species estimated to occur in the assessment area, 166 species are strongly associated with riparian areas and 145 are associated with herbaceous-type wetlands (Table 12-1). Riparian areas and wetlands provide the following primary habitat functions:

- Food and water—Riparian areas and wetlands offer an abundance and variety of food for wildlife. The well-developed vertical stratification that is typical of riparian areas in forests offers feeding habitat for understory and canopy foragers. Only a small number of wildlife species can satisfy their entire requirement for water from what is available in their food. Therefore, a large number of upland species regularly visit streams and wetlands to drink.
- Resting/thermal/hiding cover—Vegetation density and complexity of landforms offer many species of wildlife cover from predators and climatic extremes, allowing them to conserve energy. The abundance of downed logs in forested riparian areas provides an important refuge for many amphibians, reptiles, and small mammals.
- Breeding and rearing areas—Habitat elements essential to reproduction are often among the most limiting factors to population abundance and long-term persistence. Aquatic habitats, tree cavities, large trees, and shrubs are some examples of habitat elements essential for a number of species, including waterfowl and wading birds, to breed. These features tend to be aggregated in riparian areas and wetlands to a greater extent than in surrounding forests and rangelands.

Management Issues

Human land uses tend to be concentrated near streams, wetlands and on floodplains because of the resources found in these habitats, including water supply, productive sites for crops, and transportation routes, to mention a few. Riparian areas and wetlands are vulnerable to natural and man-made disturbances because of their susceptibility to upslope and upstream events.

Forestry practices can have a number of impacts on streamside and wetland environments. Clearcut harvesting in riparian areas can lead to increased air and stream temperatures (Fowler et al. 1988, Brown and Krygier 1970) and promote overland transport of sediment into streams under some conditions (Beschta 1978). Research has indicated a number of serious effects on fish, amphibian, and small mammal populations as a consequence of these actions (Bunnell et al. 1997). The most serious impacts to forested riparian areas and wetlands are now limited by state forest protection rules for private lands and by BLM and Fremont-Winema National Forest resource management plans for federal lands. Forestry practices can also be used for positive effect such as improving riparian buffers, retaining corridors for habitat connectivity, and reforestation following fires.

While proper grazing can provide habitat benefits, uncontrolled grazing in riparian areas and wetlands can eliminate desirable native plants and alter the habitat structure to which wildlife are adapted (Oakley et al. 1985). Heavy grazing in riparian areas and wetlands can also lead to changes in channel morphology and lowered water tables (Oakley et al. 1985). Increasingly however, managed grazing programs and riparian or wetland exclusion fences are serving to minimize and eliminate these problems.

BIG GAME

Four species classified by the Oregon Department of Fish and Wildlife (ODFW) as big game mammals regularly occur in the Upper Sprague River subbasin: Rocky Mountain mule deer (*Odocoileus hemionus hemionus),* Rocky Mountain elk *(Cervus elaphus nelsoni*), black bear (*Ursus americanus),* and cougar *(Puma concolor).* Pronghorn (*Antilocapra americana*) may occasionally use the watershed, but there is not a significant population documented as breeding in the assessment area. ODFW establishes hunting seasons, harvest quotas, and other game regulations for each of 70 wildlife units across the state. Portions of four wildlife units (i.e., Interstate, Silver Lake, Sprague, and Klamath Falls) encompass the assessment area.

Goods and services purchased by recreational hunters can have a significant, positive impact on regional and local communities. For example, studies conducted in eastern Oregon and elsewhere indicate a net economic value of $40-$60 per hunter per day for elk hunting (ODFW 2003). In ODFW wildlife units that encompass the assessment area, there were approximately 4,439 hunter days during the 2003 archery and rifle seasons for elk (ODFW 2003).

Mule Deer

Rocky Mountain mule deer occupy a variety of habitat types, including sagebrush steppe, juniper woodland, and semi-open conifer forest. Population densities have fluctuated greatly since Euro-American settlement.

Pioneers arriving in eastern Oregon during the early 19th century reported a paucity of deer (Verts and Carraway 1998). However, 50 to 75 years later, miners found deer to be abundant (Verts and Carraway 1998). During the 1960s the total statewide population ranged between 510,000 and 570,000 deer (Verts and Carraway 1998). In 2004, the state mule deer population was estimated to be 247,350 (ODFW 2005). In the assessment area, the causes of recent mule deer population declines are believed to be increased closed forest cover and a corresponding decrease in foraging habitat, greater mortality due to predators, encroachment by developments, stress-related diseases, and increased roadkill (T. Collom pers. comm., 2006). Population estimates specific to the assessment area are not available, but the population in the Interstate Wildlife Unit was believed to be about 7,400 mule deer during spring 2005, much lower than the ODFW management objective for the unit of 14,000 deer (T. Collom pers. comm., 2006).

Elk

Elk require landscapes composed of forested cover and forage-producing openings such as prairies, clearcuts, or hayfields. Local forestry and agricultural practices can lead to improved or diminished habitat conditions for elk, depending upon the resulting changes to vegetation patterns (ODFW 2003). Elk strongly avoid humans (except in certain areas where they have become habituated to human presence), so hunters, snowmobiles, and other forest recreation can greatly increase elk movement, decrease foraging time and lower survival rates (ODFW 2003). Chronic wasting disease (CWD) is a serious threat to wild elk populations in certain Rocky Mountain and Midwestern States, but the disease has never been detected in Oregon herds since ODFW began surveillance testing in 1996 (ODFW 2003).

ODFW has established general rifle and archery hunts for elk that allow one animal to be harvested per tag (bulls only may be taken by rifle during the general season). There is also a controlled hunt for either sex in a portion of the Interstate Wildlife Unit. ODFW does not conduct systematic surveys for elk, but records observations of the species during annual mule deer surveys (T. Collom pers. comm., 2006). Population estimates specific to the assessment area are not available, but the Interstate Wildlife Unit is believed to contain approximately 300 elk (T. Collom pers. comm., 2006).

Black Bear

Black bears (*Ursus americanus*) are habitat generalists, using many types of forested habitats. Bears tend to shift their activities according to seasonal food availability. Brushy clearcuts are often preferred because of the berry and fruit-producing shrubs that are common in these areas (Verts and Carraway 1998). In eastern Oregon, many black bears are coated in shades of brown, causing a number of mistaken reports of grizzly bears (*Ursus arctos*) each year (ODFW 2005). The last grizzly bear documented in Oregon was killed in Wallowa County on September 14, 1931 (Verts and Carraway 1998).

Open general hunting season in eastern Oregon for black bears is from August through November. Hunters are limited to one bear per tag. There is also a controlled spring hunt for black bears in some ODFW management units, but in 2005 no spring hunts were allowed in the assessment area. ODFW does not conduct regular surveys because of the difficulty of detecting bears (ODFW 2005). Instead, the department relies on voluntary cooperation by hunters to submit samples of teeth and reproductive tracts from harvested animals for purposes of population analysis (ODFW 2005). Black bear populations are believed to be increasing across the state (ODFW 2005). A total of 308 black bears were harvested from ODFW management units east of the Cascade crest in 2003 (most recent data available), although none were taken in the assessment area (ODFW 2005).

Cougar

Optimum cougar habitat east of the Cascades is characterized by a mosaic of mixed conifer forest, juniper woodland, and riparian areas (Verts and Carraway 1998). Steep terrain is usually preferred over more gentle topography. The density of cougar populations is largely determined by the abundance of major prey species, especially deer and elk.

Since 1994, ODFW has allowed unlimited tags for a year-round, statewide cougar hunting season (ODFW 2005). ODFW has established a system of cougar hunting zones with quotas, and hunting is closed in a zone for the remainder of the year when the harvest quota is attained (ODFW 2005). ODFW does not conduct annual surveys for cougars, but does require hunters to have animals they have taken be inspected by ODFW staff so they may record sex and age data. Based on this information, increased animal damage reports, and road-related cougar mortalities, ODFW believes cougar populations have significantly expanded since 1980 (ODFW 2005). Harvests during 2001-2003 in the Southeastern Cascades cougar hunt zone (which encompasses all of the Upper Sprague River subbasin) has averaged 16.3 cougars taken per year (minimum = 12 cougars, maximum = 21 cougars).

THREATENED, ENDANGERED, AND SENSITIVE ANIMAL SPECIES

Table 12-2 lists species with special conservation status that may be likely to occur in the assessment area. A short description of each species is provided below.

Invertebrates

No listed or candidate species are known to occur in the assessment area.

Table 12-2. Animal species that have special conservation status and are likely to occur in the Upper Sprague River subbasin.

Class	Scientific Name	Common Name	Federal Status[1]	State Status[2]
Amphibians	*Bufo boreas*	Western toad		SV
	Rana pretiosa	Oregon spotted frog	C	C
Reptiles	*Phrynosoma platyrhinos*	Desert horned lizard		SV
	Sceloporus graciosus graciosus	Northern sagebrush lizard	SOC	SV
Birds	*Plegadis chihi*	White-faced ibis	SOC	
	Accipiter gentilis	Northern goshawk	SOC	SC
	Buteo swainsoni	Swainson's hawk		SV
	Haliaeetus leucocephalus	Bald eagle	LT	LT
	Coturnicops noveboracensis	Yellow rail	SOC	SC
	Grus canadensis tabida	Greater sandhill crane		SV
	Bartramia longicauda	Upland sandpiper	SOC	SC
	Chlidonias niger	Black tern	SOC	
	Melanerpes lewis	Lewis' woodpecker	SOC	SC
	Picoides albolarvatus	White-headed woodpecker	SOC	SC
	Contopus cooperi	Olive-sided flycatcher		SV
	Empidonax traillii adastus	Willow flycatcher		SU
	Progne subis	Purple martin	SOC	SC
Mammals	*Antrozous pallidus*	Pallid bat	SOC	SV
	Lasionycteris noctivagans	Silver-haired bat	SOC	SU
	Martes americana	American marten		SV
	Myotis ciliolabrum	Western small-footed myotis	SOC	SU
	Myotis evotis	Long-eared myotis	SOC	SU
	Myotis thysanodes	Fringed myotis	SOC	SV
	Myotis volans	Long-legged myotis	SOC	SU
	Myotis yumanensis	Yuma myotis	SOC	
	Sorex preblei	Preble's shrew	SOC	
	Vulpes macrotis	Kit fox		LT

[1] Federal Status: LT=Listed ESA Threatened; C=Candidate for Listing; SOC=Species of Concern
[2] State Status: LT=Listed State Threatened; SC= Sensitive-critical; SV=Sensitive-vulnerable; SU=Sensitive-undetermined.

Amphibians

Western Toad (*Bufo boreas*)—Adult toads are primarily terrestrial, spending most of their time in underground burrows or buried under forest litter. Breeding occurs in marshes, stock ponds, and high-elevation lakes. The reasons for declining western toad populations are unclear, but increased atmospheric UV-B radiation and a fungus normally found in fish have been implicated (Marshall et al. 1996). Western toads are present in the assessment area (Nussbaum et al. 1983).

Oregon Spotted Frog (*Rana pretiosa*)—The Oregon spotted frog is a highly aquatic species associated with emergent vegetation and floating algae in lakes, marshes, and river side channels. The species has completely disappeared from large areas of its previous geographic range. Predation by non-native bullfrogs and fish are believed to be the primary causes of population decline (Marshall et al. 1996). Spotted frogs have been previously documented in the Upper Sprague River (Nussbaum et al. 1983), but it is unknown whether the species is still present.

Reptiles

Desert Horned Lizard (*Phrynosoma platyrhinos*)—This species is easily confused with the more common short-horned lizard (*P. dougassi*) and both species occur in the vicinity of the assessment area (Nussbaum et al. 1983). The desert horned lizard is associated with areas having sandy, loose soil and sparse shrub cover. It is very rarely found near forests or woodlands. Desert horned lizards are easily captured and illegal collection is believed to threaten the persistence of the species.

Northern Sagebrush Lizard (*Sceloporus graciosus graciosus*)—As the name suggests, the northern sagebrush lizard can be quite common in sagebrush-steppe habitats, but also uses pine and western juniper woodlands. No specific threats to northern sagebrush lizard populations have been identified, but the species may be at risk in certain localities because of habitat degradation on rangelands (NatureServe Explorer 2005).

Birds

White-Faced Ibis (*Plegadis chihi*)—White-faced ibis is a colonial species that uses wetlands and flooded agricultural fields. The species was negatively impacted by over-hunting during the 19th century, but has recovered and is expanding its geographic range. White-faced ibis may still be at risk from cattle grazing on nesting sites and pesticide use on agricultural lands, particularly on wintering grounds in Mexico (Marshall et al. 2003). A flock of white-faced ibis was observed at Sycan Marsh in 1994 (ORNHIC 2005).

Northern Goshawk (*Accipiter gentilis*)—The northern goshawk is a large, aggressive hawk that usually nests and rears young in late-successional forests with relatively open understories. However, goshawks also nest in aspen stands in shrub-steppe environments. The species is believed to be sensitive to the loss of mature and old-growth forests (Marshall et al. 2003). Goshawks have been known to nest in the assessment area (USFS 1995).

Swainson's Hawk (*Buteo swainsoni*)—A hawk of the bunchgrass prairies, Swainson's hawk is most common in the Blue and Wallowa mountains, but occasionally range into Lake and Klamath Counties (Marshall et al. 2003). Once the most common hawk in eastern Oregon, Swainson's hawk populations have undergone precipitous declines during the 20th century. Reported threats to the continued persistence of the species include pesticide-related mortality on wintering grounds in Argentina and loss of bunchgrass prairie habitat in the western U.S. (Marshall et al. 2003).

Bald Eagle (*Haliaeetus leucocephalus*)—Usually associated with large bodies of water such as estuaries, lakes, and large rivers, bald eagles nest in large trees or snags, usually within one mile of water (Anthony and Isaacs 1989). Eagle surveys have been conducted every year in Oregon since 1978 (Marshall et al. 2003). Surveys indicate that nesting pairs have increased from a low of 56 to a recent estimate of 393 pairs (Isaacs and Anthony 2001). Bald eagles are known to have recently nested at six different sites along the Sprague and Sycan rivers (ORNHIC 2005).

Yellow Rail (*Coturnicops noveboracensis*)—The yellow rail is a rare, secretive bird that nests in flooded wetlands dominated by sedges. There were no reported sightings of yellow rails in Oregon from 1926 until 1983 (Marshall et al. 2003). Since then, the species has been observed only rarely in Oregon. Most sightings are from Klamath and Lake counties. Yellow rails have been recently observed at Sycan Marsh and several sites in the Sprague River Valley (Marshall et al. 2003). Threats to the species include agricultural practices that lead to wetland loss (e.g. ditching, diking) and intensive grazing that reduces vegetation cover (Marshall et al. 2003).

Greater Sandhill Crane (*Grus canadensis tabida*)—Sandhill cranes forage in wet meadows and agricultural fields. Floating nests are constructed in marshes. Sandhill cranes that breed in Sycan Marsh migrate in winter to the Butte Sinks Basin in northern California. Surveys conducted in Sycan Marsh indicate that the population has been relatively stable (113-135 pairs) between 1983 and 2000 (Marshall et al. 2003). Predation by coyotes occasionally causes significant loss of nests and juveniles (Marshall et al. 2003).

Upland Sandpiper (*Bartramia longicauda*)—Upland sandpiper nesting sites are usually located in montane meadows surrounded by ponderosa or lodgepole pine forests (Marshall et al. 2003). The upland sandpiper is one of the rarest breeding birds in the western U.S. However, the species has been seen several times at Sycan Marsh since 1981 (ORNHIC 2005). Threats to the species include trampling of nests by cattle and changes to vegetation composition in meadows (Marshall et al. 2003).

Black Tern (*Chlidonias niger*)—The black tern is a colonial species that is associated with marshes having abundant emergent vegetation. Sycan Marsh supports a major population of black terns; 778 individuals were banded there between 1982 and 1984 (Stern 1987). Black tern populations declined throughout the period 1966 to 1996 because of habitat loss and degradation, but now may be increasing (Marshall et al. 2003).

Lewis's Woodpecker (*Melanerpes lewis*)—Associated with open canopy woodlands, especially ponderosa pine-Oregon white oak communities, Lewis's woodpeckers nest in tree cavities excavated by other woodpecker species. Once common on the east side of the Cascades and portions of western Oregon, Lewis' woodpecker populations have declined dramatically since the 1940s. Factors causing population declines are thought to be the loss of oak woodland and savanna habitat, as well as nest site competition from European starlings (Marshall et al. 2003).

White-headed Woodpecker (*Picoides albolarvatus*)—The white-headed woodpecker is strongly associated with open-canopy ponderosa pine woodlands, but is occasionally found in mixed-conifer forests. White-headed woodpeckers prefer stands composed of large-diameter trees. Nests are excavated in large snags, usually >25-in diameter breast height (Marshall et al. 2003). Logging of old-growth ponderosa pine forests and fire suppression are reported to have reduced habitat availability for the species.

Olive-sided Flycatcher (*Contopus cooperi*)—The olive-sided flycatcher occurs mostly in open canopy conifer forest or near forest edges. Prominent trees and snags are an important habitat element. It has been estimated that Oregon populations decreased 5.1% from 1966 to 1996 (Marshall et al. 2003). The principal threat to olive-side flycatcher populations is believed to be habitat loss in South American wintering areas, although fire suppression and loss of late-successional forests in the western U.S. may contribute to declines (Marshall et al. 2003).

Willow Flycatcher (*Empidonax traillii adastus*)—In eastern Oregon, willow flycatchers occur almost exclusively in shrubby riparian areas. The principal threat to the species is believed to be degradation of riparian habitat due to over grazing and altered hydrological regimes (Marshall et al. 2003). Nest parasitism by brown-headed cowbirds may contribute to lower population recruitment (Marshall et al. 2003).

Purple Martin (*Progne subis*)—The purple martin is a colonial nester that uses snags and man-made nest boxes. The species is most frequently found near large rivers, lakes, and estuaries. Purple martins are extremely rare east of the Cascades in Oregon, but have been observed along Alder Creek near the Sprague River (ORNHIC 2005). Reasons given for population declines are the reduction of large snags on managed forestlands and nest site competition from European starlings (Marshall et al. 2003).

Mammals

Preble's Shrew (*Sorex preblei*)—Very little is known about the biology of Preble's shrew. It has usually been captured in sagebrush-bunchgrass habitats or marshes. There are no observations of Preble's shrew documented from the Upper Sprague River subbasin, but the geographic range of the species does overlap the assessment area (Verts and Carraway 1998).

Myotis Bat Species (*Myotis evotis, M. thysanodes, M. volans, M. yumanensis, M. ciliolabrum*)—Although all five of these *Myotis* species exhibit differences in behavior, diet, and reproduction, all of these bats are primarily associated with conifer forests and are often captured at the same sites. *Myotis* bats use a variety of natural (caves, rock crevices, tree cavities) and man-made (mines, abandoned barns, bridges) structures for roosting and maternity colonies. They are thought to be at risk because of the loss of old-growth forests, human disturbance at roosts and hibernacula, and pesticide use (Marshall et al. 1996). All five of these *Myotis* species have been captured within the assessment area (ORNHIC 2005).

Silver-Haired Bat (*Lasionycteris noctivagans*)—Associated with conifer forests, including western juniper woodlands, silver-haired bats usually roost in tree cavities and under peeling bark, but will use caves and mines if available. The species strongly prefers late-successional forests to younger stands (Perkins and Cross 1988), and therefore is thought to be vulnerable to the loss of old growth forest. Silver-haired bats have been captured at several springs and stock ponds in the assessment area (ORNHIC 2005).

Pallid Bat (*Antrozous pallidus*)—In central and southeastern Oregon, the pallid bat inhabits shrublands and western juniper woodlands. Day roosts used by the species include caves, mine shafts, rock crevices, and tree cavities. Pallid bat populations have declined, mainly because of human disturbance at roosts and limited habitat (Marshall et al. 1996). Pallid bats have been observed in the assessment area (ORNHIC 2005).

American Marten (*Martes americana*)—American martens are extremely rare throughout Oregon. Most observations have been at high elevations in the Cascades and Blue mountains; however it was estimated that the Fremont National Forest supported between 240 and 330 martens during the period 1929 to 1945 (USFS 1999). One specimen was collected from within the assessment area (Verts and Carraway 1998). Martens use a variety of forest habitats including lodgepole pine forests, mixed conifer forests, and western juniper woodlands. The species prefers late-successional forests that have an abundance of large trees, snags, and downed logs (Marshall et al. 1996). The loss of old-growth forest is thought to be the primary cause for the decline in American marten populations (Marshall et al. 1996).

Kit Fox (*Vulpes macrotis*)—The kit fox is associated with shrub-steppe and desert habitats. The diet of kit foxes includes jackrabbits, cottontails, and kangaroo rats. Motor vehicle mortality is thought to be a significant limiting factor to kit fox populations (Verts and Carraway 1998). It is unclear whether predator control programs harm or benefit the species (Verts and Carraway 1995). The Upper Sprague River subbasin lies near the western boundary of the geographic range of the kit fox (Verts and Carraway 1998).

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CHAPTER 13. WATERSHED FUNCTION SUMMARY

Throughout this document certain principles have been emphasized, principles that have emerged from the watershed assessment process itself. These include:

- The conviction that scientific understanding must be joined with social and economic understanding to produce lasting solutions that have solid community support.
- The insight that overall watershed condition and function -- in both riparian areas and in the uplands -- are the result of dynamic interactions between soil, water, and vegetation.
- The importance of basing restoration, management planning, and even regulatory actions on site-specific analysis, rather than just on generalized judgments about conditions at the watershed scale.
- The importance of focusing on "trend over time," which allows resource managers to determine whether fundamental processes are in place that will produce a stable -- but dynamic -- landscape over the long term.

Although changes from pre-settlement condition have clearly occurred, the challenge for us is to try to determine whether, and to what extent, watershed function has been compromised. Return to pre-settlement condition is not necessarily possible, or even desirable. Ultimately, the goals of future natural resource management actions and watershed restoration should focus on improving and restoring stable but dynamic function to the extent that is practical.

GENERAL GEOGRAPHIC CHARACTERISTICS

The Upper Sprague and Sycan River subbasins cover 1,126 square miles, and drain a varied landscape, from steep-sloped, highly-dissected headwaters to low-gradient floodplains. Within the assessment area lies a variety of aquatic features including perennial, intermittent, and ephemeral streams, constructed ditches, lakes, and marshes. Only 27 percent of the streams in the subbasin are perennial. Most streams are intermittent or ephemeral. The major streams within the watershed flow generally from east to west, from headwaters along Winter Ridge and Gearhart Mountain to the broad valley of the Sprague River near Bly and Beatty. Elevations within the watershed range from 4,304 feet at the confluence of the Sprague and Sycan rivers west of Beatty to approximately 6,700 feet along Winter Ridge.

Average annual precipitation ranges from 10 to 15 inches in the valleys, 16 to 25 inches in nearby hills, and 30 to 40 inches at higher elevation. About 44 percent of the precipitation in the survey area occurs in winter. Snowfall accounts for 30 percent of the annual precipitation in the valleys and as much as 50 percent in the mountains.

Prior to the settlement of European Americans in the late 19th century, human activity in the Upper Sprague and Sycan watersheds consisted primarily of seasonal subsistence hunting and gathering by Native Americans. Native Americans may have used fire intentionally to encourage certain types of flora and fauna that they considered desirable. Suppression of fire in the late 19th and early 20th centuries had a significant effect on flora, fauna, and the hydrology of the assessment area.

In the late 19th century, the nature of human dependence upon the area's natural resources began to change. The Bureau of Indian Affairs promoted intensive livestock grazing – including horses, mules, sheep and cattle – as early as the 1870s. About the same time, European settlers began to arrive in greater numbers, establishing livestock and hay operations in and around the town of Bly, and grazing the uplands, which were then public domain. Many of the negative effects on riparian vegetation and stream channel function can be traced to this relatively brief period of uncontrolled use.

GEOLOGIC PROCESSES

Although erosion is a natural process, an increase in the amount of erosion due to human activities can compromise stream function because an abundance of fine sediment can fill the spaces in streambed gravel and reduce the habitat quality for fish. Soils within the assessment area are typically high in phosphorous. Stream bank erosion is an important concern in some areas within the Upper Sprague River subbasin, due in part to concerns about phosphorous loading in downstream habitats. There appears to be little active bank erosion within the Sprague River Above Beatty and North Fork Sprague watersheds, but available data are limited. Bank erosion appears to be extensive in the South Fork Sprague and Sycan Marsh watersheds. Many reaches were experiencing bank erosion along half or more of the surveyed reach.

Roads are another potential source of excessive sedimentation. There are 3,500 miles of roads in the Upper Sprague River subbasin, at an average road density of three miles of road per square mile. Approximately 22 percent of the stream miles in the Upper Sprague River subbasin are within 200 feet of a road.

HYDROLOGY AND WATER USE

The available data indicate that changes in vegetation and soil conditions in the Upper Sprague and Sycan watersheds– including forest structure, the prevalence of fire, riparian vegetation conditions, and juniper ecology – have reduced the capacity for the watershed to retain and safely release available precipitation.

Water is currently withdrawn from both the Upper Sprague and the Sycan rivers for a variety of beneficial uses. Water is used for crops or forage for livestock and for domestic use. Most diversions are for irrigation. It is difficult to establish the precise effect of diversions on stream flow because of the return and reuse of tail-water, and the complicated interaction of groundwater and surface water.

In the Sycan Marsh, channeling and diking may have altered fundamental aspects of the hydrology in the upper reaches of the subbasin to such a degree that completely halting consumptive water use might not result in a return to natural flow conditions.

Where favorable permeable zones for fracture are intersected by streams, groundwater is discharged by large springs. Discharge is widespread in the prominent marshes such as Sycan Marsh and the marsh reaches of the Sprague River valley. There are some data suggesting that development of irrigation wells to substandard specifications may be negatively affecting flow from springs (Bruce Topham, pers. comm.). In some cases, groundwater pumped for irrigation may supplement surface flows.

TERRESTRIAL VEGETATION

Historically, the forested areas were characterized by open stands of large ponderosa pine. At the time of European settlement, the Upper Sprague River subbasin landscape contained only minor components of lodgepole pine, mixed conifer, and true fir forests. Western junipers were most common on pumice sands and areas of rock outcrops.

With the arrival of the railroad in the late 1920s, large-scale logging became feasible in the assessment area, and continued through the 1970s, resulting in substantial changes in the forested uplands. Early tree harvesting greatly reduced the volume of ponderosa pine saw timber in the assessment area. In some cases, logged areas were left unmanaged, resulting in shrub-dominated plant communities, or dense stands of smaller diameter trees. In later years, private-sector foresters paid particular attention to the restoration and protection of riparian areas, resulting in improved high-elevation riparian landscapes in some areas.

As a result of tree harvesting and a dramatically altered fire regime, climax species such as white fir and grand fir were able to grow to much greater densities as compared with pre-settlement conditions. Stream function has been affected because of the reduction in the availability of large wood. Fire suppression also led to increased fuel loadings and more widespread mixed-species (ponderosa pine dominant) stands. Although data from other regions indicate that changes in stand composition and structure increase susceptibility to insect outbreak, historical records have shown that severe insect outbreaks occurred before significant timber harvest began. Throughout the 20th century, the range and density of juniper increased dramatically, due to fire suppression and reduction in fine fuels.

Site-specific assessments of the uplands by the Working Landscapes Alliance indicated opportunities for land managers who may not have streams or wetlands to contribute to the overall functionality of the watershed. Juniper dominated sites that were assessed were found to be functioning-at-risk or non-functioning hydrologically. As part of the loss of hydrologic function have come losses in plant vigor and productivity and in plant community diversity.

RIPARIAN AREAS

The straightening and diking of significant reaches of the Sprague River and some of its tributaries constituted substantial modifications to riparian and wetland areas. Removal of native riparian vegetation increased bank erosion. These actions reduced or eliminated the ability of certain key stream segments to dissipate the high energies of peak flows by spreading these flows out over a floodplain, or by accessing secondary high flow channels. These actions also reduced the viability of in-stream fish habitat by simplifying streambed topography and flow dynamics.

The data gathered for the watershed as a whole has indicated some general changes in riparian condition, including erosion of channels both outward and downward, local lowering of the water table, disconnection of stream channels from their floodplains, shifts in vegetation communities, and changes in certain key fish habitat features.

As a result of the involvement of the National Riparian Service Team (NRST) and the Working Landscapes Alliance (WLA), considerable attention was devoted to riparian areas during this assessment. The involvement of the NRST and the WLA has allowed us to supplement the large-scale data in this this assessment with information gathered during specific site visits on public and private lands.

Some key findings emerged from specific site assessments conducted during the 2005 field season. First, there was wide variability with regard to conditions and function across the watershed, and even within a particular site. Second, there was evidence at most sites that major changes had taken place in the early part of the last century, and that the sites have been on a gradual upward trend since that early disturbance. Third, there was clear evidence at each site of the potential for substantial and rapid recovery of vegetation conditions with relatively minor shifts in management. And finally, it gradually became clear over the course of the field season that in riparian areas where vegetation conditions and hydrologic function had declined, forage production for livestock had also declined. This was considered to be of critical importance, because strategies could be developed that would simultaneously contribute to the functionality of the riparian area, as well as to the economic viability of the agricultural operation.

WETLANDS

According to available data, wetlands cover about 60,485 acres (9.5 percent) of the Upper Sprague River subbasin. The largest amount of wetland area is located in the Sycan Marsh Watershed, which contains 27,349 acres of wetland, and in the Sprague River Above Beatty Watershed, with 11,000 acres.

Wetland conditions have changed since pre-settlement times as a result of draining, diking, grazing, forestry, and irrigation. Former willow and woody vegetation has been replaced in many lowland areas by wetland/sedge/wet pasture and meadow/grass/pasture vegetation types. In the higher elevation areas, landscape changes have lowered the water table and enabled encroachment of forests into meadow areas.

The engineered flood control projects implemented by the US Army Corps of Engineers during the 1950s caused significant changes in wetlands in the assessment area. In particular, the South Fork of the Sprague River was diked, straightened, and isolated from its floodplain. These manipulations occurred for most of the reach from Fish Hole Creek to the confluence with the North Fork. As part of this same effort, wetland and riparian vegetation – including native willows, sedges and rushes – were removed.

CHANNEL CHARACTERISTICS

Channel conditions include the cross-sectional profile, the longitudinal profile, the ratio of width to depth, the connection of channel to its floodplain, the sinuosity (or meandering pattern), and vegetation conditions. Each of these components is directly related to how the channel is functioning in terms of its ability to dissipate the energy of high flows. Each is also related to the quality of habitat for fish, because proper function with regard to these conditions results in the development of key habitat features for native species.Modifications of channel characteristics can result either from intentional reconfiguration of channel form to serve other purposes (dikes, reservoirs, dams, etc), or from gradual erosive process stemming from management of riparian areas.

The most intensive channel modifications in the assessment area, resulting from federal flood control projects, have already been discussesd. Several reservoirs exist in the headwater reaches of the Upper Sprague River and are present in the Fishhole Creek, North Fork Sprague, South Fork Sprague, and Sprague River above Beatty Watersheds. Splash dams have been used on both public and private lands in the Upper Sprague River subbasin.

There are stream channels throughout the Upper Sprague River subbasin that have experienced substantial channel modification associated with excessive erosion. Such changes to the channel morphology are associated with a variety of activities, including over-grazing, beaver trapping, removal of riparian vegetation, land clearing, wildfires, and loss of wetlands.

WATER QUALITY

Water quality is directly associated with the viability of habitat for aquatice organisms, as well as other beneficial uses. At the screening level of this assessment, water quality in the major streams of the Upper Sprague River subbasin would be considered impaired with respect to Oregon Department of Environmental Quality (ODEQ) statewide water quality standards for temperature, pH, phosphorus, bacteria, and possibly dissolved oxygen.

Most streams listed by the state as water-quality limited are listed for temperature. Reduced streamside vegetation, reduced wetlands, channel widening, and geothermal springs may contribute to elevated stream temperatures. Groundwater pumping and flood-irrigated pastures may contribute to late-season lowering of water temperatures.

The streams and groundwater of the Upper Sprague River subbasin are relatively high in dissolved phosphorus, due in part to erosion of soils and volcanic bedrock that are naturally high in phosporous.

AQUATIC SPECIES AND HABITAT

The major focus of habitat quality issues within the Upper Sprague River subbasin concerns native fish species, in particular the influence of habitat quality on bull trout (Federally Threatened), Klamath largescale sucker (Federal Species of Concern), Lost River Sucker, shortnose sucker (the later two are Federally listed Endangered Species), redband trout and two currently extinct species of anadromous salmonids, chinook salmon and steelhead trout. Historical evidence suggests that fish populations in the Upper Sprague River subbasin were different from those which exist today.

A variety of factors have contributed to the changes that have occurred. The construction of Chiloquin Dam interrupted normal passage, and the introduction of non-native fish species resulted in competition and hybridization. The loss in stream side riparian zones has lead to changes in fish habitat due to changes in channel form and flow dynamics, reduction in vegetation cover, and increases in stream temperature.

TERRESTRIAL WILDLIFE AND HABITAT

The Upper Sprague River subbasin is noteworthy from a wildlife perspective because it contains a high diversity of species and because it is home to many species that have been classified as rare or deserving of special conservation status. Both of these factors are due, at least in part, to the location of this subbasin at the intersection of five different ecological regions.

Because the Upper Sprague River subbasin lies near the intersection of five different ecoregions, it is not surprising that the area supports a wealth of animal diversity. It is estimated that 314 species of vertebrates occur in, or have been extirpated from, the assessment area ORNHIC 2005). Table 11-1 summarizes the number of species "closely" or "generally" associated with major habitat types in the assessment area.

Key issues that limit wildlife diversity include a reduction in vegetation complexity (multiple vegetation layers, including large trees), scarcity of snags and down logs, and increasing abundance of noxious invasive plants.

There are 106 vertebrate species present in the assessment area that are considered to be associated with shrub-steppe habitats and 101 species associated with western juniper woodlands (Table 11-1). There is considerable overlap in the species composition of these two arid habitat types.

In some cases irrigated pastures result in benefits to certain species by providing additional vegetation for a longer period during the year. In other cases, grazing can diminish habitat quality for wildlife that depend upon the vegetation structure of shrubs or feed upon the associated plant species.

CONCLUSION

There is no doubt that the Upper Sprague and Sycan watersheds have experienced significant changes over the last century. Some of these changes have been positive, and some have been negative. And in some cases we've changed our minds about whether a given change is a positive or a negative, based on a better understanding of how the natural systems in the area function.

Healthy rivers, streams, riparian zones, wetlands, forests and uplands are critical to maintaining the economic, social, and ecological benefits that residents receive from the watersheds within the subbasin. Although there is growing agreement concerning the benefits provided by watershed functions, there is considerable disagreement about the current condition of the natural resources, appropriate use of these resources, treatments and tools that can be used to restore and maintain healthy ecosystems, and prioritization of ecological and economic concerns.

Disagreement over the management and use of natural resources has recently led to litigation and regulatory actions, which sometimes exclude those most affected by management decisions. Increasingly, collaborative approaches are attempting to build capacity in local communities to confront complex natural resource problems in an integrated fashion.

The most useful lesson we have learned about the assessment area is that local landscapes can be highly responsive to relatively modest shifts in management. Riparian areas and stream channels, in particular, have proven to respond in ways that result in short and long term benefits for both the human and non-human inhabitants of the watersheds. In some cases, more intensive or costly projects may be needed to reach the goals we set for ourselves. But our initial investigation has shown us that there is more potential for rapid improvements than was previously thought to be possible.

CHAPTER 14. RESTORATION ACCOMPLISHMENTS

Sometimes it is assumed that watersheds assessments are necessary because there are ecological problems that no one is doing anything about. This is certainly not the case in the Upper Sprague watershed, although it is true that there is much work yet to do. This chapter summarizes just some of the enormous amount of restoration and management work that has been done in the Upper Sprague in recent years. This is work that has, in most cases, been done collaboratively, with partnerships involving private landowners, government agencies, advocacy organizations, community groups, and everyday citizens. It is especially important to acknowledge the significant amount of work done by private landowners which is difficult to document or quantify, due to the fact that they have done this work without government assistance.

PRIVATE LANDOWNERS

After conducting personal interviews with landowners of the Upper Sprague and Sycan Watersheds for this assessment, there is no doubt that support for restoration efforts has increased amongst Sprague and Sycan Watershed landowners over the last ten years. With the help of local restoration and watershed education groups such as the Klamath Basin Ecosystem Foundation (KBEF), Klamath Watershed Council (KWC), and Oregon State University Klamath Basin Research and Extension Center, landowners are able to find answers, advice, and direction quickly on how they can proceed with habitat restoration projects on their properties.

Measuring the exact amount of projects is difficult as the sources of funding and monitoring are so diverse. This is a data gap in which further research is needed to summarize projects by private landowners both independently and with financial assistance for local, state, and federal agencies and organizations.

It is known that many landowners are doing projects without any local, state, or federal assistance. For example, Rodney Todd a landowner on Lower Fishhole Creek, has been working on his property, primarily without assistance, since 1980. Sample projects include rebuilding and securing exterior fences to keep the outside cattle out, rehabilitating the hundred year old irrigation system, installing electric fences along the creek and planting willows in riparian areas, and designing fences to divide the property into smaller grazing units or paddocks that can be used rotationally (Todd, personal communication, January 23, 2007). Alan Withers, a long time landowner on the Sycan shared how he has two ranch staff that work solely on weed control all summer in an effort to improve the watershed (Withers, personal communication, January 17, 2007).

The National Resource Conservation Service estimates that 86 projects on private lands in the assessment area have been reported to NRCS, OWEB, USFWS ERO, USFS RAC Committee, or the Klamath Watershed Council since 1999 in the Upper Sprague and Sycan Watersheds alone. This number does not include those projects that are not reported to one of the above agencies, or those that are reported but permission has not been granted by landowner for inclusion in these statistics. Projects include but are not limited to riparian fencing, upland juniper removal, wetland restoration, wetland fencing, riparian stabilization, willow planting, in stream fish passage improvements, improved road crossings, improved irrigation water management, sprinkler installation, fish screens, new head gates, noxious weed treatments and more.

KLAMATH WATERSHED COUNCIL: SPRAGUE RIVER WORKING GROUP

The Klamath Watershed Council (KWC) serves the entire Upper Klamath Basin from the Headwaters of the Klamath River to the California border. The board of directors represents eight working groups that serve sub-watersheds within the Upper Basin. Of these eight working groups, comprised mostly of landowners and community members, the Sprague River Working Group is the most active with nearly 30-40 participants at each of the monthly meetings. These meetings are designed to encourage sharing amongst landowners concerning progress on agricultural lands and management strategies, inform landowners of opportunities from local, state, and federal agencies and organizations, and educate landowners on current issues such as endangered species and policy changes.

The Sprague River Working Group of the Klamath Watershed Council has helped members to better understand the process of obtaining restoration support on their property, and therefore, the amount of projects happening in the basin has increased dramatically. The KWC is currently awaiting funding for seven miles of riparian fencing, offstream watering projects, and spring reconnection on private property of the Upper Sprague Watershed.

SYCAN WATERSHED COUNCIL

The Upper Sycan Watershed Council is made up of a diverse group of people ranging from local ranchers, to agency representatives, to The Nature Conservancy. Just as diverse as the people, are the management practices and priorities of the area. The watershed is managed for timber, range, recreation, research, wildlife, and a number of other things.

The majority of the Sycan marsh is owned by the Nature Conservancy, who manages the property for grazing, timber, and ecological values. Most of the forested land is owned by the USFS and Timber Resource Services as described above. The USFS land is managed for multiple uses including: timber, grazing, wildlife, and recreation. Several private landowners own Forest Service permits in the Sycan Watershed, where they run their cattle at specific times through the year. Management of those permits is a joint effort between the USFS and the permitees. Timber thinning and harvesting is also conducted in this watershed. Timber Resource Services manages primarily for timber production.

In 2005 the Upper Sycan Watershed Council, TNC and the US Forest Service initiated an investigation into fish passage barriers for the entire Upper Sycan Watershed. Through this assessment over thirty barriers were identified and prioritized as sites that would offer the greatest benefits to aquatic fauna. This cooperative effort, funded by RAC money will be implemented before 2010. These restoration actions have also been supported and enhanced by the Upper Sycan Watershed Council. The Council has participated in funding for technical assistance and project design.

The watershed council's primary concern is managing for Bull Trout habitat and passage. Many projects have been done on both public and private property to enhance Bull Trout habitat. The Nature Conservancy and USFWS are working cooperatively to research Bull Trout habitat and their needs. Future watershed council direction and objectives will be geared toward an action plan that will promote and restore connectivity of the Sycan River.

Other watershed council activities include riparian fencing on private land, juniper thinning, education, and various restoration activities.

The council uses their watershed analysis and landowner needs and desires to prioritize projects. The council tries to help private landowners meet their individual goals for their property.

Active Programs and Projects

Weir II Design

This project involves survey and design work for Weir II on the Sycan River. This is one layer of a multiphase project. Providing for the ecological requirements of salmonids in riverine environments requires the council to address multiple limiting factors, across much ownership, both public and private. Technical expertise is essential to design a system that sustains natural stream process, provides habitat for and movements of fish, and also provides for agriculture water withdrawals. In the Upper Sycan Watershed of the Klamath Basin restoring connectivity (fish movement) has been an ongoing effort with extensive collaboration. Past investments to provide connectivity in this watershed have exceeded $407,000 with some projects funded by OWEB.

<u>The Upper Sycan Grazing Allotment Project</u>

The Upper Sycan Grazing Allotment Project is a cooperative project between the Fremont-Winema National Forest, two privately owned ranches, and the Sycan Watershed Council. The project involves fence construction on the Sycan and Riverbeds Allotments. This project will reduce grazing pressure on the Sycan River by changing rangeland management practices (switch grazing from season long to early on early off). This project also allows for more efficient management for both ranches.

<u>Paradise – Watson Project</u>

Watershed Council Coordinators, USFS biologists and private landowners were concerned over an on-going headcut problem that was occurring where Paradise and Watson Creek merge. This on-going problem was a difficult one to assess, so in 2006 the National Riparian Team visited the site along with approximately 20 additional landowners and agency employees that wanted to learn more about watersheds in Lake County. The final recommendation from the team was to treat the headcut by placing rock in areas of high erosion and alter grazing management to elevate grazing pressure on the riparian areas. The USFS, private landowners and the Upper Sycan WSC are currently working together to accomplish the recommendation. Funding has been obtained and project implementation is expected to take place spring/summer of 2007.

KLAMATH BASIN ECOSYSTEM FOUNDATION

The Klamath Basin Ecosystem Foundation (KBEF) aims to protect, conserve, and restore the natural resources of the Klamath Basin and to promote long term sustainability of the region's economy. KBEF is made up of members representing the diversity of culture and lifestyle in the Upper Klamath Basin.

KBEF supports watershed restoration and long-term sustainability through two types of activities. First, KBEF works with private landowners to complete on-the-ground restoration and water quality improvement projects. Second, KBEF partners with local communities to complete watershed assessments, engaging local stakeholders in the decision-making process. Watershed assessments help communities identify watershed issues and set restoration priorities.

KBEF recently finished work with private landowner, Greg Bulkley, on a restoration project on Five Mile Creek in the Upper Sprague Watershed. Five Mile Creek is a snowmelt and springfed stream that is relatively low-gradient, meandering through wet meadows and irrigated pastures. About halfway through the project area, Five Mile joins the North Fork of the Sprague River, which serves as the property boundary between two neighboring ranches.

As part of the Upper Sprague and Sycan Watershed Assessment Field Season in 2006, KBEF worked with the landowners, the National Riparian Service Team (NRST) and the Working Landscapes Alliance (WLA) to perform a site-specific assessment of riparian and upland conditions. The recommendations from this assessment focused on enhancing streamside forage and vegetation conditions by managing livestock access to riparian areas. Over the course of the 2006 season, KBEF partnered with US Fish & Wildlife Service and the Oregon Department of Fish & Wildlife to complete riparian fencing along both sides of Five Mile Creek, plus the remainder of the North Fork Sprague.

Post project monitoring has already revealed dramatic responses from the streamside vegetation that was planted. KBEF hopes to continue restoration projects in the Upper Sprague and Sycan Watersheds with new projects identified in this assessment.

PRIVATE INDUSTRIAL FORESTLAND PROJECTS

North Fork Sprague Watershed

Weyerhaeuser Company improved fish passage in Boulder Creek during 1994 and 1995 by replacing a blocked culvert, allowing for fish migration though this area. They also increased streambank stabilization and protection along Boulder Creek, while decreasing livestock access to the stream in 1994 and 1995 (PSMFC 2006). This land was subsequently purchased from Weyerhaeuser Company by Timber Resource Services.

A major road improvement project was implemented by Weyerhaeuser Company in 1994 along sections of road near Boulder Creek. Due to the success of this project, this road system did not require much further improvement when it was reassessed in 1997. Work performed during this time included grading the primary roads, pulling all of the ditches, and installing water bars on two roads. Post implementation monitoring showed successful results (Timber Resource Services 1999).

Road Improvement projects were also performed along Boulder and Coyote Creeks by Weyerhaeuser Company in 1994 and 1995 (PSMFC 2006).

South Fork Sprague Watershed

Weyerhaeuser Company increased streambank stabilization and protection along Brownsworth and Whitworth Creeks while decreasing livestock access to the stream in 1994 and 1995 (PSMFC 2006).

Ponderosa pine seedlings were planted by Timber Resource Services along both streambanks of Lower Brownsworth Creek in the Spring of 1998. The objective of this project was to increase large woody debris recruitment potential and conifer stream shading. This work was investigated the following fall and had remained undamaged from animal activity (Timber Resource Services 1999).

Timber Resource Services performed extensive improvement to the road system in the area of Brownsworth and Leonard Creeks in 1997 (Timber Resource Services 1999). The objectives of this work were to reduce sedimentation to the streams caused by eroding road surfaces. Remediation efforts included blading, shaping, ditching, and installing water bars and road closure barriers. Two gates were also installed to permit seasonal road closure. The sites were revisited for inspection during the summer of 1998. The majority of the structures were functioning appropriately, while modifications were made to structures that had failed.

Road Improvement projects were also performed along Brownsworth and Whitworth Creeks by Weyerhaeuser in 1994 and 1995 (PSMFC 2006).

Sycan Marsh Watershed

Timber Resource Services made treatments to road surfaces along Long Creek at two different road crossings in 1998 (Timber Resource Services 1999). The improvements included covering the existing red cinder surface with clean crushed rock and constructing rolling dips and sediment catch basins in the ditches leading to the creek.

NRCS, FSA, AND KSWCD RESTORATION PROJECTS

The Natural Resource Conservation Service (NRCS) has performed environmental restoration work in the Upper Sprague River subbasin. A variety of Federal programs are available to assist farmers and ranchers with conservation efforts. Such programs provide cost-share and land rental funds to accomplish certain tasks. The major programs are described briefly below.

Active Programs and Projects

The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and Tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation (CCC). CRP is administered by the Farm Service Agency (FSA) and the Klamath Soil and Water Conservation District (KSWCD), with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.

Goals of the CRP are to reduce soil erosion, protect the Nation's ability to produce food and fiber, reduce sedimentation in streams and lakes, improve water quality, establish wildlife habitat, and enhance forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally-sensitive acreage to vegetative cover, such as native grasses, wildlife plantings, trees, filterstrips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices (NRCS 2006).

An offspring of the CRP, the Conservation Reserve Enhancement Program (CREP) is a voluntary program for agricultural landowners. Unique state and federal partnerships allow landowners to receive incentive payments for implementing specific conservation practices. Through the CREP, farmers can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible land (NRCS 2006).

The Environmental Quality Incentives Program (EQIP) is a voluntary conservation program administered through the USDA Natural Resources Conservation Service (NRCS), re-authorized in the 2002 Farm Bill. The program supports production agriculture and environmental quality as compatible goals.

Through EQIP, farmers and ranchers may receive financial and technical help, in the form of cost share, with structural and management conservation practices on agricultural land. NRCS administers EQIP based on locally identified natural resource needs consistent with national EQIP priorities. Local Work Groups (LWG) convened by the Soil and Water Conservation Districts provide advice to NRCS about local priorities within their local area. With this advice, NRCS evaluates applications for funding EQIP contracts consistent with these local and national priorities.

EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement selected conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are typically carried out according to a conservation plan developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address landowner and agency identified resource concerns. The practices are subject to NRCS technical standards adapted for local conditions (NRCS 2006).

The Wetlands Reserve Program (WRP) is a voluntary program that provides technical and financial assistance to eligible landowners to restore, enhance, and protect wetlands. Landowners have the option of enrolling eligible lands through permanent easements, 30-year easements, and restoration cost-share agreements.

The Oregon WRP is focused to address the following issues on private and public lands: restoration of the functional role of wetlands in agricultural ecosystems; development of habitat for migratory birds; restoration and preservation of ancient crop areas for traditional, cultural practices and subsistence; and restoration and connectivity of aquatic and riparian habitat for endangered species.

Projects have been funded from the coastal estuaries to mountain meadows. Through WRP, significant investment has been made in the Klamath Basin. The goal of this investment is to restore wetland hydrology and help aid this water short area (NRCS 2006). CCRP and EQIP projects are shown in Figure 14-1. There are a total of nine CCRP and EQIP projects currently active. The Lower Sycan and Sprague River Above Beatty Watersheds each have four active projects, and the North Fork Sprague Watershed has one active project. All of these projects were initiated between 2003-2005. There is no record of any completed CCRP or EQIP projects in the subbasin.

NRCS also administers the Wetlands Reserve Program (WRP) for the area. In many instances, the USFWS will partner on a WRP project or it will be done in association with a CREP project. There are seven WRP projects in the Upper Sprague River subbasin. Five of which occur in the Sycan Marsh Watershed, while the other two are located in the Sprague River Above Beatty Watershed.

THE NATURE CONSERVANCY

The Nature Conservancy (TNC) is working to enhance and restore populations of native species in the Sycan Marsh and surrounding area which includes improving natural hydrologic conditions and ecological functions while maintaining a healthy economic system.

TNC, in partnership with the ZX Ranch, is exploring methods of integrating livestock management with wetland restoration. Construction of several dikes, weirs, and artificial deltas at the mouths of tributary streams has resulted in restoration of more than 6,000 acres of wetlands in the marsh. Fish population research and habitat restoration projects focusing on bull trout and redband trout are striving to enhance native fish populations through implementation of innovative grazing and fire management techniques.

The Nature Conservancy has developed a Management Intensive Grazing Program at Sycan Marsh. This program incorporates an annual grazing plan that considers the time of year, plant phonology, size of pasture, number of animals and composition of the herd. Fences are a critical part of this cattle-grazing program at the Sycan Marsh Preserve. Fences are perhaps the biggest change in pasture management, as pasture design is not dependent on the size of the area, but on the capability of the sites within the pasture to provide specified forage productivity. Plant communities and successional state provide information that is useful to establish the pasture size. TNC believes that areas with less available forage and lower quality forage will tend to require more acreage. Conversely, as management actions increase the productivity of an area, field size can be reduced in size, to optimize the use of forage and animal condition (Beinz, personal communication, January 22, 2007). In general, the objective was to increase the use of meadow foxtail (*Alopecurus pratensis*).

In general, the approach used by TNC since 1999, was initially intended to restore the historic hydrologic regime at Sycan Marsh. In 2001 TNC began to restore the natural flow patterns of both surface water and ground water. The objective was to fill irrigation diversion ditches that had altered the natural hydrologic patterns and returning the natural surface contours. With the assistance of the Oregon Watershed Enhancement Board (project # 99-559 Chocktoot Drain) a 2 _ mile drainage ditch in the NE quadrant of the Sycan Marsh was filled in 2002. The ditch was about 20 feet wide and 4 to 5 feet deep and moved water from the east side of the marsh toward the middle of the marsh and ultimately into the main drain that flows south then off the marsh.

To test the benefits of the restoration monitoring was initiated to document the effects of climate and water management on hydroperiods. Specifically, TNC aimed to restore historic water amounts, timing, and flow variability through the Marsh. TNC has been monitoring the vegetation using exclosures to measure the relationships between grazed and ungrazed areas. The exclosures were built in 1981, when The Nature Conservancy purchased the property. During this same period we have seen an increase in the health of the cattle (Beinz, personal communication, January 22, 2007).

TNC is also restoring forest structure of ponderosa pine forests and returning historic fire frequency and intensity to restore plant communities to their historic composition. The health and vigor of aspen is being increased through use of prescribed fire and hydrologic restoration. Prescribed burns will restore a healthier forest, in turn benefiting the entire marsh watershed. To examine fire effects on wildlife and habitats in ponderosa pine forests, TNC initiated has worked with the US Forest Service an ambitious eight state, large scale, multi-year project know as the Birds and burn Research Project.

Craig Beinz, Sycan Marsh Preserve Director for TNC, believes primary issues in the Upper Klamath Basin appear to be with water quality and water quantity. The Nature Conservancy uses an approach that quantifies the extent of various threats and develops strategies to abate those threats, which we call *Conservation by Design*. Sycan Marsh provides an opportunity to conduct applied research to address the threats and measure the benefits. TNC continually monitors their management, which then allows for changes to better meet the conservation objectives. This is what some call adaptive management. At a much bigger scale we have been working with the US Forest Service, Oregon Department of Forestry (ODF), the Klamath Tribes and other private landowners to expedite the restoration of fire-adapted ecosystems within the Sprague Watershed. We have called this approach the Sprague Watershed Fire Learning Network (FLN). The goal of the group is to by increasing communication and working knowledge of fire-adapted ecosystems. To achieve this goal, the Sprague Watershed FLN group will work simultaneously with on-the-ground projects and broad-scale modeling efforts. Additionally, the following objectives have been identified: (1) develop a spatially explicit map that identifies forest structure, (2) developing models to quantify forest successional disturbance, (3) implement small-scale projects to validate large-scale activities, (4) increase collaboration to enhance stewardship opportunities, and (5) develop and implement monitoring to preserve and protect threatened, endangered, and imperiled plant and animal species and threatened ecosystems (Beinz, personal communication, January 22, 2007).

Restoration actions by TNC at Sycan Marsh have also been pursuant to the priorities of the US Fish and Wildlife Service Bull Trout Recovery Plan. In 1999 TNC initiated a radio-telemetry study to monitor fish movement, which documented that bull trout in Long Creek express a fluvial life history pattern. TNC initiated changes in the grazing program in 1999 to enhance riparian habitat and stream channel recovery. In cooperation with the US Forest Service TNC has developed a channel form metric that allows quantification of the health of the environment to sustain all aquatic fauna (Bienz et al. 2004). TNC has been removing non-native brook trout with traps since 2000 and assisting the Klamath Basin Bull Trout Working Group with snorkel spearing since 1999. OWEB project 203-184 removed brook trout and fenced off 2 miles of potential bull trout habitat. OWEB Project 205-194 removed two barriers to fish movement and addressed sections 1.23 fish passage; 1.24 eliminates entrainment; and 5.3 restore connectivity of the Klamath Basin Bull Trout Recovery Plan.

USFWS (ERO) PROJECTS

The US Fish and Wildlife Service (USFWS) Ecosystem Restoration Office (ERO) is involved in a variety of restoration projects in the Upper Sprague subbasin, including fence construction for livestock management, stream bank stabilization to reduce sedimentation and erosion, restoration of wetlands, habitat restoration for native species, and planting of vegetation for stream shading and to control erosion. Funding for restoration is available through programs including Partners for Wildlife, the Hatfield Restoration Program, Jobs-in-the-Woods, and the Bureau of Reclamation Restoration Program. Since 1994, 160 projects involving nearly 14,000 individuals have been undertaken in the Sprague River Watershed by ERO. Many of these involve projects on private lands with the help and support of the farmers and ranchers of the community. Active USFWS projects in the Upper Sprague and Sycan Watersheds are presented in Table 14-1 and Figure 14-1.

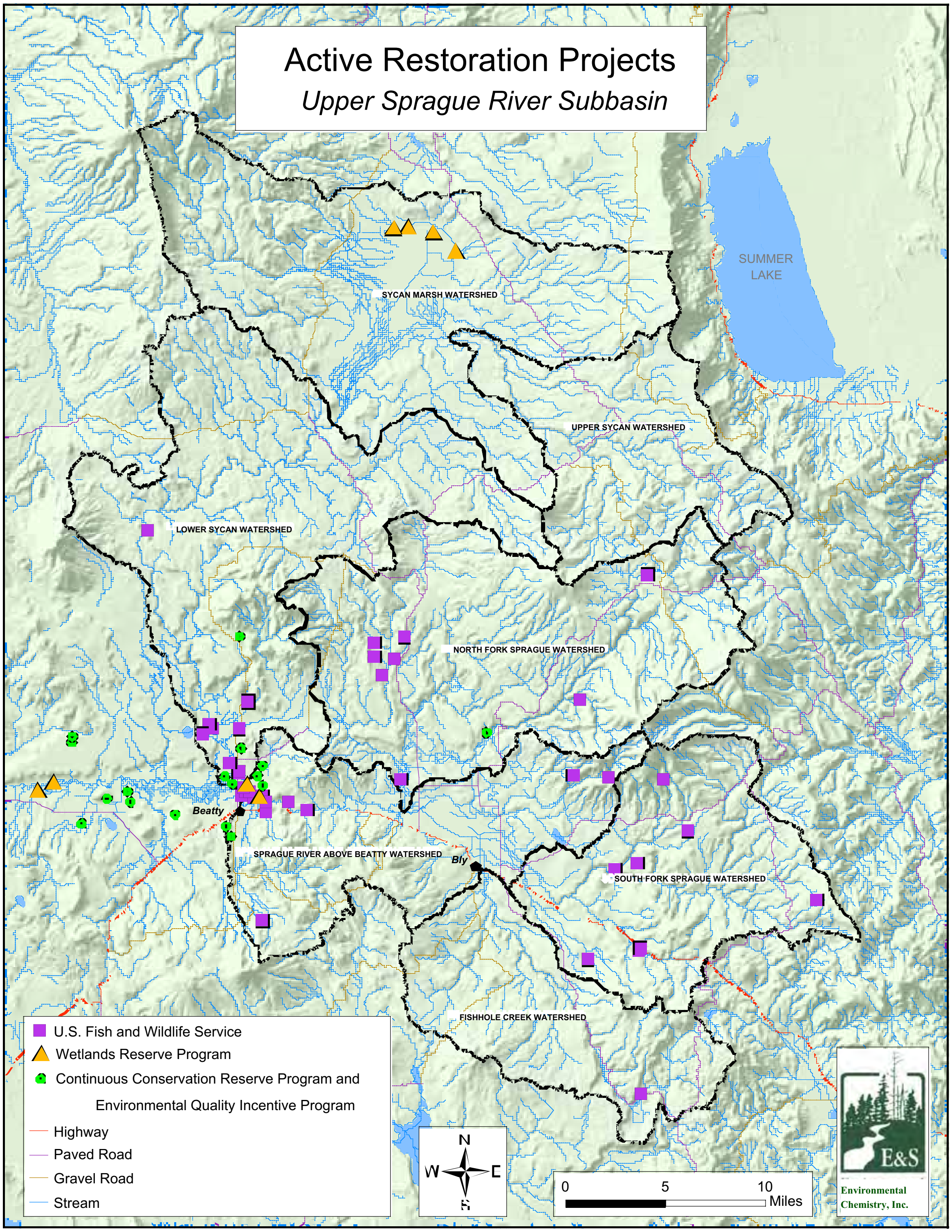

Figure 14-1. Active restoration projects. (Data Source: Timber Resource Services, 1999, Sue Mattenberger, pers. comm., June, 2006], NRCS 2006, PSMFS 2006)

Table 14-1. Active habitat enhancement projects through USFWS. (Source: S. Mattenberger, USFWS, Pers. Comm., June 2006)

Watershed Name	Project Description	Funding Year	# of Projects
Sprague River Above Beatty	Channel, Streambank Restoration	FY2005	1
	Channel, Wetland Restoration	FY2005	1
	Fencing	FY1998	1
	Fencing	FY2001	1
	Fencing, Willow Planting	FY1994	1
	Fish Screens	FY1999	1
	Flood Damage	FY1997	1
	Gate	FY2001	1
	Instream	FY2003	1
	Road Removal, Revegetation	FY1997	1
	Spring, Stream, Upland Restoration	FY2001	1
	Stream Enhancement	FY1999	1
	Wetland Restoration	FY2001	1
	Wetland Restoration	FY2004	1
North Fork Sprague River	Fencing	FY1998	4
	Fencing, Snag	FY1997	1
	Fish Screens, Fencing	FY2002	1
	Road Crossing	FY1997	1
	Stream Restoration	FY1996	1
South Fork Sprague River	Fencing	FY1994	1
	Fencing	FY1999	1
	Fish Screens	FY1999	1
	Meadow Restoration	FY1999	1
	Riparian Stabilization	FY1994	1
	Road Crossing	FY1997	1
	Road Removal, Revegetation	FY1996	2
	Streambank Stabilization	FY2000	1
Fishhole Creek	Fencing, Revegetation	FY1996	1
Lower Sycan River	Creek Channel Restoration	FY2005	1
	Fencing	FY1996	1
	Fencing	FY2001	1
	Rv & Flood Plain Restor	FY2004	1
	Stream Restoration	FY2004	2
	Wetland Restoration	FY1999	1
	Wetland Restoration	FY2000	1
	Wetland Restoration	FY2001	2
	Wetland Restoration	FY2003	1
Total			43

REFERENCES CITED

NRCS (Natural Resource Conservation Service). 2006. Website. http://www.or. nrcs.usda.gov/programs (accessed June 2006).

PSMFC (Pacific States Marine Fisheries Commission). Streamnet Database. Online database. http://www.streamnet.org (accessed June 2006).

Timber Resource Services. 1999. Progress Report: Bull Trout Watershed Restoration Project. FWS Agreement #1448-11450-97-J161.

CHAPTER 15. RECOMMENDATIONS AND DATA GAPS

BACKGROUND

As has been emphasized throughout this document, specific restoration actions must be based on site-specific analysis of relevant parameters. The following generalized recommendations are intended to assist the prioritization process, but they are not meant to imply that a given recommended action is appropriate for all, or even most, sites.

Prime locations for restoration should be selected based on the importance of various limiting factors, probability of success, proximity to core habitat areas, landowner willingness and ability to participate, and cost/benefit tradeoffs. Restoration activity should be focused in areas that are the most likely to respond to management actions. To the extent possible, restoration should be coordinated among the landowners and other stakeholders in the subbasin to take advantage of possibilities to leverage multiple efforts for greater benefit. It is particularly important to develop an effective and affordable long-term monitoring program, so that the effectiveness of various restoration actions can be evaluated and documented.

GEOLOGIC PROCESSES

Erosion problems in the watershed can be addressed in some areas by riparian planting efforts and especially by efforts to control sediment inputs from roads and stream banks. Emphasis should be placed on road repair and decommissioning in roaded areas that are in close proximity to the stream channel and on steep slopes, and also on riparian enhancement subbasin-wide. Erosion control efforts in upland portions of the watershed should be especially focused on areas subject to recent or ongoing land-disturbing activities.

Roads should be considered for closure and stabilization if they are presently causing, or are likely to cause, serious future erosion; are near fish-bearing streams; have excessively high maintenance costs; or are determined to be unneeded. Stabilization of closed roads can include measures such as waterbar installation, removal of fill material, culvert removal, and planting of native grasses and other plants.

Riparian areas that may be experiencing bank erosion, including sections of Brownsworth, Calahan, and Long creeks (Table 4-6), should also be considered good candidates for erosion control actions where it is determined that the bank erosion is attributable to human activities. These could include such actions as management changes, riparian planting, LWD emplacement (where appropriate), and culvert replacement.

Action recommendations include the following:

- Identify in greater detail areas of excessive stream bank and gully erosion.
- Implement management changes or native vegetation plantings in riparian zones that are experiencing excessive erosion.
- Decommission roads that are no longer needed, especially those near streams, on steep slopes, and where road maintenance has been difficult.

HYDROLOGY AND WATER USE

In the uplands, the ability of the watershed to capture, store and safely release available precipitation has been reduced as a result of changes in vegetation composition. Optimizing the capture of available precipitation will result in significant benefits with respect to all beneficial uses, including irrigation, fish habitat, and water quality. Measures that can be taken to improve the capture of available precipitation are discussed in the following section (Terrestrial Vegetation).

Regarding diversions and water uses, there is much uncertainty about the impact of these on habitat and hydrologic function. Some of this uncertainty is due to the ongoing adjudication process. But there are also unanswered question regarding the impact of groundwater pumping, the role of irrigated pastures in groundwater storage, and the effect of irrigation development on total annual flows. While it is assumed that reducing unnecessary applications of diverted water would provide benefits to all users, it is critical that the above questions be resolved, so it will be clearer what potential there is for improvement.

TERRESTRIAL VEGETATION

The uplands of the Upper Sprague Basin, which consist primarily of ancient volcanic landforms (strato volcanoes, cinder and lava cones, basalt flows and deposits of welded tuff), wind-deposited volcanic ash and pumice, and ancient lake (lacustrine) sediments, make up more than 90 percent of the basin. These landforms, now expressed as mountains and hills and their associated sideslopes and alluvial fans; the tablelands, tilted lava lands, lake terraces and ancient beaches have given rise, over time, to a wide array of soils with a vastly different capabilities. These soils vary in the kinds and amounts of vegetation they produce, in the way they process precipitation and in the way they respond to treatment (management). Much of this information is available to landowners, land managers planners in the NRCS and Forest Service Soil Survey publications developed under the National Cooperative Soil Survey Program. It is strongly recommended that these locally prepared reports be referred to in the early stages of planning and applying any land treatment.

Because these lands constitute such a large portion of the watershed, their conditions govern, in large extent, the quality, quantity, timing and duration of flow of the Sprague River and its tributaries. Significant changes in plant community composition and plant density have occurred since the arrival of European man. These changes have greatly influenced the fate of water in the Klamath Basin. Future decisions regarding land use and treatment need to promote the capture of precipitation where it falls, the storage of that moisture in the soil for plant use and other forms of biological activity, and the eventual safe release of that moisture to deep percolation for groundwater recharge and/or lateral flow that maintains springs, seeps and streams.

Historic timber management has resulted in a loss of late and early seral stage forests and over stocking of current mid-seral stage woodlands. Suppression of fire has led to an overabundance of understory growth. Management to protect and develop late-successional forest habitat will promote the health and diversity of terrestrial ecosystems. Such habitat should be fostered, where possible, in large blocks rather than small patches. This should be accompanied by thinning to reduce overstocking. Increased prevalence of late-successional forest habitat will benefit a large number of species that utilize such habitat for their prosperity or survival.

Every effort should be made to curtail the spread of noxious and exotic plants and eradicate isolated patches of noxious weeds before they spread. Management actions could include cleaning large silvicultural and agricultural machinery of weed seeds and propagules to prevent unintentional dispersal of the plants. Such preventative actions would likely be more successful than attempted treatments subsequent to an invasion by a particular invasive species.

It will be important to reintroduce frequent low-intensity fire as an important component of forest management in the ponderosa pine lands. Fire is also important to the control and reduction of encroachment of juniper into shrub and grassland habitat.

Action recommendations include the following:

- Manage upland vegetation to maximize capture and safe release of available precipitation
- Restore fire ecology.
- Eradicate invasive, non-native plants.
- Reduce juniper encroachment into grasslands and riparian shrublands.

RIPARIAN AREA

Among the most effective measures to enhance the overall health of the Upper Sprague River sub-basin would be improvement of riparian health and associated in-stream habitat conditions. Efforts should be directed toward restoration of native riparian vegetation, especially native sedges, rushes, woody shrubs, and trees.

Proper Functioning Condition (PFC) site assessment are an excellent way to initiate the restoration process, and to determine what type of restoration, if any, is necessary. Private landowners should be provided with the assistance to develop riparian restoration plans that can be effectively implemented within the constraints of their operating resources.

Some benefits of these riparian enhancement efforts will be seen almost immediately, while some may not be seen for several years. Still others will be manifested over a period of decades or longer. The vegetation type and overall conditions present in a specific area should be verified on the ground prior to planning any restoration activity.

High priority should be placed on preserving areas that currently are functioning well and provide acceptable habitat for riparian-dependent species. Such areas should be managed to further promote the development of desirable features, including densely-rooted riparian plants, sediment capture, water storage capacity, large conifers and cottonwoods where appropriate, down logs, snags, and high species diversity.

Action recommendations include the following:

- Work with landowners, the community, and other entities to develop a local PFC or site assessment team.
- Work with landowners, the community, and other entities to secure funds to coordinate data collection, prioritization of projects, identification of priority surveys areas etc
- Continue to work cooperatively with landowners, the community, and other entities to conduct Proper Functioning Condition site assessments of important riparian areas.
- Assist in implementation of land use practices that enhance or protect riparian areas.
- Work with NRCS and other agencies to help identify sites within prioritized reaches where Protect riparian areas by providing stock water systems and shade trees outside of the stream channel and riparian zones would aid in management. Fence riparian areas as appropriate.
- Work with the Army Corp of Engineers to identify dikes where removal would increase floodplain access and improve stream function. Investigate the need to remove dikes along the streams.

- Identify sites where planting native riparian trees, shrubs, and understory vegetation in areas with poor or fair riparian area conditions would be beneficial in accelerating recovery, where site potential will support them. Work with landowners who know areas where these species were removed in the 1950's and 60's.
- Manage forested riparian zones for uneven-aged stands with large diameter trees and younger understory trees to allow establishment of shade intolerant riparian species to establish.
- Maintain areas with good native riparian vegetation, noting that non-native species such as Canary reedgrass may currently play a critical role for maintaining function.
- Where appropriate, establish buffers of native trees and/or shrubs, depending upon local conditions. If sites do not have potential for woody vegetation manage for establishment of sedge/rush communities to aid in bank narrowing and reduction of width/depth ratios.
- Identify riparian zones dominated by xeric species and non-native plants and work to re-establish a higher water table that will support riparian/wetland species

WETLANDS

There are many opportunities for wetland enhancement and restoration within the assessment area. It is especially important to reconnect streamside wetlands and springs that have been hydrologically isolated from the stream system. These areas, once reconnected, can provide rearing habitat and off-channel refugia for fish and other aquatic organisms during high flow periods. They also can provide important moderating controls on hydrology by helping to decrease peak flows and increase low flows. Wetland restoration will be most feasible in the Sycan Marsh and Sprague River Above Beatty watersheds, which were historically heavily wetland-dominated.

Wetland restoration often involves engineering efforts to restore previously-altered hydrological conditions. Such projects are often large, complex, and expensive. However, there is also a great need for many smaller wetland restoration projects to restore hydrological connections to small off-channel low-lying areas. The cumulative benefits in terms of water retention and habitat enhancement can be substantial if many such projects are undertaken.

Action recommendations include the following:

- Encourage practices that limit adverse effects on existing wetlands, such as off-channel watering, hardened crossings, livestock exclusion (part or all of the year), and provide stream shade.
- Increase awareness of wetland functions and benefits.

- Reconnect to the stream system, where practical, streamside wetlands, floodplains, and other areas having hydric soils.
- Reestablish beaver populations where appropriate, giving consideration to agricultural needs.

CHANNEL CHARACTERISTICS

Substantial changes to channel conditions occurred as a result of federal flood control efforts in the 1950s. Some of the effects of these actions, such as eradication of riparian vegetation, are easily reversible, and have been reversed in places. Other effects, such as channelization and diking, are more problematic because certain land uses now depend upon those modifications. Also, because flood control efforts involved substantial engineering and earth-moving, reversing the effects of these actions can be very costly. Nevertheless, opportunities to mitigate the negative hydrologic and biological effects of these modifications should be investigated.

While the watershed assessment can help to guide general restoration planning, site-specific field condition evaluations are needed for individual project scoping It is recommended that a field-based analysis of channel conditions be conducted in advance of any detailed restoration project planning. One such analysis is currently being conducted by the Klamath Tribes Natural Resource Department. Members of the Working Lands Alliance can assist with site-specific plans.

In the uplands, one of the most important needs regarding stream channel condition is to restore channel structural elements. One restoration measure that may provide structural benefits for aquatic species is the introduction, or reintroduction, of large woody debris (LWD) and boulders into the stream channel. An additional measure could be to manage upland forest vegetation to provide for a continuing source of large wood to the streams in the future. Structural improvements will help to retain gravel (important for fish spawning), promote pool development, and maintain cooler water temperature.

Action recommendations include the following:

- Increase overall understanding of channel morphology conditions through more detailed field-based analyses.
- Inventory major channel modifications resulting from federal flood control efforts; investigate feasibility of restoring channel function.
- Where appropriate, improve pools and riffles while increasing in-stream large woody material by placing large wood and/or boulders in streams with channel types that are responsive to restoration activities and have an active channel less than 30 feet wide.
- Continue PFC-based landowner visits, as well as programs to increase understanding of the importance of appropriate channel

function, including the role of vegetation management on channel function.

- Establish and manage riparian pastures for both optimum channel stability and forage production; investigate options for timing and stocking of pastured livestock; where appropriate, manage access to sensitive riparian areas with off-site watering and/or riparian fencing.

WATER QUALITY

In 1998 the Oregon Department of Water Quality (ODEQ) listed the Sprague River as water quality limited for temperature, pH, and DO. Therefore activities to improve and restore riparian conditions will have beneficial effects on water quality by increasing the amount of stream shading and increase bank stability decreasing erosion and preventing stream widening (Platts 1991). Properly functioning riparian conditions will increase the potential for large woody debris deposition, increase sediment bedloading along stream banks thereby decreasing in channel substrate embedment and increasing pool and stream channel depth.

Furthermore, it is suggested that the decrease in properly function riparian corridors has lead to an increase in phosphorus loading. Increased erosion of naturally high-phosphorus soils and irrigation returns may be contributing to elevated phosphorus concentrations in subbasin streams and Upper Klamath Lake (Bradbury et al. 2004, USGS 2003). Such an effect contributes to eutrophication. Therefore, efforts to restore properly functioning riparian corridors and control erosion will have beneficial effects on several aspect of water quality.

Action recommendations include the following:

- Continue monitoring and incorporation of existing projects within the subbasin will help to increase our understanding and management practices. In addition, expanding monitoring efforts to include more tributaries and mainstem sites will add to our ability to understand and manage the subbasin.
- Investigate the feasibility of constructing tailwater re-use systems or designed tailwater treatment wetland ponds for irrigation returns.
- Support projects that restore proper stream function by developing and/or reestablishing floodplains and wetlands.
- Increase shade and stream depth by managing to restore properly function riparian corridors.
- Develop livestock grazing practices (i.e. rotation grazing and seasonal grazing) that limit stream access during critical growing seasons for riparian vegetations. In addition, provide stock water systems and shade trees outside of the stream channel and riparian zones to limit cattle congregation along stream edges. Fence riparian

areas to limit or exclude cattle from foraging along critic riparian corridor areas.

- Manage for robust riparian communities. Develop management strategies that maintain and create properly functioning riparian corridors.

AQUATIC SPECIES AND HABITATS

Restoration activities for aquatic species should be concentrated in areas with the best potential for success of coldwater species. Coldwater species such as bull trout and redband trout exhibit high levels of sensitivity to habitat depredation and are great indicator species. Therefore, efforts should be focused on projects that help to establish or maintain their populations as well as recreate connectivity between populations.

The USFWS Bull Trout Recovery Plan (USFWS 2002) contains a number of specific recommendations intended to protect and restore bull trout in current, historical, and potential habitats within the Upper Sprague River subbasin. It is recommended that distribution recovery criteria will necessitate establishment and protection of at least 10 to 12 local populations in the Upper Sprague core area from among 25 potential local populations. This will entail establishment of three to five new local populations. Abundance criteria will require an increase in the number of adult bull trout in the Klamath River Basin core areas to at least 8,250 individuals. Trend criteria will be met when adult bull trout exhibit stable or increasing trends in abundance in each core area. Connectivity criteria will require removal of specific migration barriers at culverts, installation of fish passage structures at water diversions on bull trout streams, and installation of fish screens on diversion pipes and canals. In addition, restoring water temperature to suitable levels for fish migration will help eliminate thermal barriers.

Although comparable issues affect redband trout populations in headwater reaches of the Upper Sprague River, management issues should also address fluvial and adfluvial populations of redband trout. Redband trout populations exhibit diverse life histories and are excellent indicators of a wide assortment of issues that effect fish populations throughout the Sprague River Basin. For example, seasonal increases in water temperatures observed in the lower reaches of the Upper Sprague River can exceed the thermal tolerance level for redband trout, causing fish stress and/or death. Managing and restoring thermal refugias could provide essential habitat for redband trout and provide migratory fish with a thermal relief during periods of intolerable temperature limits. Increase management and research practices that address such issues can have beneficial effects on additional species such as suckers, which also could benefit from cold water refugias.

Management actions to improve fish habitat should focus on preserving and recreating riparian corridors. Properly function riparian corridors will help bank stabilization, prevent erosion, substrate embedment, improving LWD

recruitment potential, and reducing stream temperatures. Other important activities should include identifying and removing fish passage barriers, restore properly functioning wetlands and floodplains. Actions such as these will benefit all native species of fish in the Upper Sprague River.
It will be important to work with landowners to improve key stream segments for the federally threatened bull trout, particularly in the Sycan Marsh and North Fork Sprague watersheds. It will also be important to work with landowners to improve key stream segments for fluvial and adfluvial redband trout. Furthermore, increase habitats conditions for both bull and redband trout will have dramatic beneficial results for sucker populations. In general what is good for keystone species is good for other species. It is also important to recognize thermal refugias that can provide suitable habitat for both residential and migratory fish during seasonal peaks in stream temperatures.

Action recommendations include the following:

- Encourage restoration of stream connectivity by eliminating barriers and obstacles to fish passage. Restoration and enhancement projects should focus on physical barriers that, when removed or repaired, create access to the greatest amount of high quality fish habitat.
- Identify stream reaches that may serve as "oases" or refugia for fish during the summer months, such as at the mouth of small or medium-sized tributaries and coldwater springs. Protect or enhance these streams and spring riparian buffers and develop proper functionality.
- Encourage community participation in fish monitoring activities. Raise awareness about potential problems associated with introducing non-native fish species into rivers and streams.
- Work cooperatively with landowners to improve fish habitat conditions. Develop BMP for agriculture and cattle grazing. Establishing cheap passive restoration and enhancement projects to restore properly functioning conditions in riparian corridors.
- Provide landowners and appropriate entities with additional resources to assist in restoration and enhancement projects (i.e. find grant funding, project planning, and etc).

TERRESTRIAL WILDLIFE

Much of the wildlife diversity in the assessment area is associated with early seral conditions and semi-open canopy forests, which are less common now than under the natural fire regime. Efforts to return the upland forests to a state of greater biological diversity will benefit terrestrial wildlife.

Open woodland of western juniper has been an important habitat for wildlife in the Upper Sprague River subbasin. However, the expansion of dense stands of juniper into shrub and grassland communities represents an important threat to wildlife associated with shrub-steppe vegetation. A return to a more normal (historically speaking) fire regime will contribute to restoration of shrub and grassland communities.

Local forestry and agricultural practices can lead to improved or diminished habitat conditions for elk, depending upon the resulting changes to vegetation patterns. Forest management that promotes late seral stage woodland with open areas can lead to improved elk habitat.

Action recommendations include the following:

- Promote the development of late-seral ponderosa pine forest.
- Manage woodlands for creation of snags and large down wood, especially near streams.
- Reduce fuels loadings by implementing forest thinning operations.
- Create periodic openings in dense mid-seral stage forests.
- Manage for increased plant species diversity, especially in wetlands and riparian areas.
- Control invasive non-native plants.

DATA GAPS

A number of data gaps were identified in the process of conducting this assessment. In the following section, we describe each major data gap, explain its significance, and list steps that could be taken to fill the data gap.

Stream Channels

There are stream channels throughout the Upper Sprague River subbasin that have experienced substantial channel modification due to federal flood control measures and other activities, as well as gullying, stream incisement, and channel widening. Unfortunately, few data exist regarding the specific locations of channel modifications and historical channel disturbances. A geomorphological study is currently being conducted for parts of the assessment area, but that information was not available for inclusion in this assessment.

Aquatic Species and Habitats

Locations of fish passage barriers (in particular, culverts). Identification and removal of fish passage barriers would provide fish access to upstream areas, potentially increasing the amount of available habitat. Fish passage barrier removal is one of the most effective means of improving conditions for fish populations. Field inventories of potential barriers, such as culverts, would be required. The Forest Service has inventoried some culverts on their lands, but not all potential barriers have been assessed for fish passage.

Riparian Vegetation

Refinement of Riparian Vegetation Information. More information on riparian plant community species composition would be helpful to identify areas of high quality riparian vegetation. Additional field verification and refinement of the air photo and LIDAR-based analyses of riparian vegetation could greatly improve the understanding of riparian vegetation in the Upper Sprague subbasin. Half-meter aerial photos from the summer of 2005 are expected to become publicly available from the State of Oregon in 2007, and may provide a high enough level of resolution to further classify riparian plant communities.

Weeds

Information regarding distribution and trends of establishment for noxious and exotic weed species. The development of a noxious weed database that allows analysis and characterization of the status of noxious and exotic weeds would be useful. Information regarding the location of weeds could be gathered in the field during routine weed eradication efforts or obtained directly from landowners, and the information could be analyzed on a periodic basis to determine trends and spatial patterns of noxious weed populations in the subbasin.

Roads

Detailed road and culvert condition information, including mapped locations of problem culverts and road segments. Detailed road and culvert information would help to prioritize actions to reduce erosion and sediment contribution to the stream system. Although the US Forest Service maintains information on road conditions, data are incomplete in many parts of the subbasin. Data on roads outside of federally-managed public lands are very limited.

Wetlands

Historical wetland distribution. Information regarding the historical location of wetlands would be useful for planning riparian and wetland restoration activities. Historical wetlands could be mapped by identifying hydric soils from SSURGO and US Forest Service soils maps.

REFERENCES CITED

Church, C. 2000. Williams Creek Watershed Action Plan. Prepared for the Williams Creek Watershed Council. Resource Assistance for Rural Environments. Eugene, OR.

USFWS (US Fish and Wildlife Service). 2002. Chapter 2. Klamath River Recovery Unit, Oregon. In: Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. US Fish and Wildlife Service. Portland, OR.

WPN (Watershed Professionals Network). 1999. Oregon Watershed Assessment Manual. Prepared for the Governor's Watershed Enhancement Board. Salem, OR.

APPENDIX A. GLOSSARY

Adfluvial – migrating between lakes and rivers or streams.

Aerobic – with oxygen.

Aggradation – the process of building up a stream channel as sediment is deposited.

Ammocoetes – a prolonged larval stage of lampreys.

Anadromous – fish that spawn in fresh water, migrate to sea as juveniles, grow to maturity, and return to their freshwater stream to reproduce.

Anaerobic – without oxygen. This condition occurs in soil when water fills all of the pore spaces, leaving no room for oxygen.

Aquatic – consisting of, relating to, or being in water; also, living in, on, or near water.

Bankfull – the flow stage of a river or stream in which the flow completely fills the channel and the elevation of the water surface coincides with the bank margins.

Bedload – the sediment along a streambed.

Benthic – of, pertaining to, or living on the bottom or at the greatest depths of a body of water.

Biochemical oxygen demand – the amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water. It is used as a measure of the degree of water pollution

Biodiversity – a measure of the variety of living things in an area.

Caldera – a large crater formed by volcanic explosion or by collapse of a volcanic cone.

Capability – the highest ecological status an area can obtain given political, social, or economical constraints.

Channel confinement – the degree to which the shape of a stream channel is constrained by resistant bedrock or boulders.

Channel habitat types (CHT) – stream segments that have similar characteristics with regard to slope, sinuosity, confinement, substrate, and other parameters.

Channel morphology – the study of the channel pattern and the channel geometry at several points along a river channel, including the network of tributaries within the drainage basin. Also known as river morphology; fluviomorphology; stream morphology.

Channelization – the process of reconstructing the natural course of a stream in order to make it flow into a restricted path.

Colluvium (*adj.* colluvial) – loose deposit of rock debris accumulated through the action of gravity at the base of a cliff or slope.

APPENDIX B. RESOURCE DIRECTORY

Bureau of Land Management - Lakeview District - Klamath Falls Office
Entity Type: Federal Agency
2795 Anderson Avenue, Bldg. #25
Klamath Falls, OR 97603
Phone: (541)883-6916
Website: http://www.blm.gov/or/districts/lakeview/index.php
Description: Manages forest and rangelands in the Upper Sprague and Sycan areas.

Bureau of Land Management - Lakeview District - Lakeview Office
Entity Type: Federal Agency
1301 South G Street
Lakeview, OR 97630
Phone: (541)947-2177
Website: http://www.blm.gov/or/districts/lakeview/index.php
Description: Manages forest and rangelands in the Upper Sprague and Sycan areas.

Concerned Friends of the Winema
Entity Type: Organization
PO Box 204
Chiloquin, OR 97624
Phone: (541)783-3462
Website:
Description: Promotes environmentally responsible, ecosystem-based management on public lands in the Upper Klamath Basin.

Family Farm Alliance
Entity Type: Organization
PO Box 216
Klamath Falls, OR 97601
Phone: (541)850-9007
Website: http://www.familyfarmalliance.org/
Description: Non-profit organization whose mission is to ensure the availability of reliable, affordable irrigation water supplies to Western farmers and ranchers

Farm Service Agency
Entity Type: Federal Agency
2316 S 6th Street, Suite C
Klamath Falls, OR 97601
Phone: (541)883-6924
Website:
http://www.fsa.usda.gov/FSA/webapp?area=home&subject=landing&topic=landing
Description: Administers and manages farm commodity, credit, conservation, disaster and loan programs through a network of federal, state and county offices to improve the

APPENDIX C. AERIAL PHOTO-BASED RIPARIAN AREA ANALYSIS

The following riparian area assessment was conducted according to protocols which are appropriate from a regulatory stand point. The methods are used by US Forest Service and Oregon Department of forestry. The methods use the average tree height to define the riparian area width. These methods provide a rough estimate and assessment of the riparian areas. While this has value and merit to serve as a preliminary look, it does not address the more specific needs of the land manager or riparian restoration specialist. Other limitations of this analysis are as follows:

- Artificially establishes width of riparian zone, which naturally fluctuates a high degree from the assumed 75 feet width.
- Over- or underestimates the actual acreage of the natural riparian area. This inaccuracy makes it impossible to compare acreage of riparian areas in different reaches and present a meaningful result.
- Misclassifies the vegetation classes for the riparian area. The vegetation classes of the natural riparian area should be wetland plant communities. Instead by setting an artificial boundary, many upland plant communities have been erroneously included in the vegetation classes for the riparian area. For example, conifers such as ponderosa pine are upland species, not wetland species.

  A land manager or restoration specialist will want to look at the riparian areas in more detail on a site specific basis prior to making management or restoration decisions. More appropriate methods for conducting site specific analysis are addressed in Chapter 7 Riparian Areas.

The riparian zone refers to the area adjacent to the streambank where vegetation transitions from water-dependent species to plants that can thrive in drier upslope conditions. Riparian zones link uplands to the stream. They provide an array of watershed functions and influence virtually all aspects of water quality and in-stream habitat condition. Thus, the importance of the riparian zone far exceeds its spatial extent. This narrow zone of vegetation that occurs along the stream contributes much of the large woody debris that provides stream channel structure, controls bank erosion, shades the stream to maintain cool water temperatures, and generally provides for higher species diversity than any other habitat type. (Gregory et al. 1991)

Riparian vegetation was classified by E&S Environmental (E&S) from 1-meter digital aerial color photographs taken during the summer of 2005 (ODSL 2005). E&S analyzed perennial streams from the USFS 1:100,000 streams layer using the geographic information system (GIS). Vegetation type