Malheur River Subbasin Assessment and Management Plan For Fish and Wildlife Mitigation

Management Plan

Malheur Watershed Council

And

Burns Paiute Tribe

May, 2004

Prepared with assistance of:

Watershed Professionals Network, LLC

Boise, Idaho.

Malheur River Subbasin Assessment and Management Plan For Fish and Wildlife Mitigation

Management Plan

Submitted to the Northwest Power and Conservation Council, Portland, Oregon

Prepared Jointly by:

Malheur Watershed Council
Ontario, Oregon

And

Burns Paiute Tribe
Burns, Oregon

May, 2004

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1 INTRODUCTION

1.1 Purpose and Scope

Historically, salmon and steelhead migrated into the Malheur River through the Columbia and Snake Rivers from the Pacific Ocean providing a sustainable resource to the Native Americans of the Subbasin. The Wadatika, descendents of the Northern Paiute Indian Tribe, depended upon the Spring Salmon run in the upper Malheur River as a critical part of their food and spiritual resource base. Beginning in the late 1800s and increasing from the 1930s on, salmon and steelhead in the Columbia River system declined due to loss of habitat, increased harvest, variable ocean conditions and the construction and operation of hydroelectric dams in the Columbia River Basin. In addition, dams constructed in the Malheur River Subbasin in the early 1900's blocked migration into the headwaters historically used by anadromous fish for spawning and rearing. Construction of Brownlee Dam on the Snake River in 1958 completed the full blockage of anadromous fish into the Malheur River Subbasin. As a consequence, the Burns Paiute Tribe (descendents of the Wadatika) and the local communities of Eastern Oregon have lost access to this significant natural resource.

In addition, development of the Federal Columbia River Power System resulted in direct effects on resident fish and wildlife populations and their habitats through construction of facilities and reservoir inundation. Wildlife continues to be affected via operational and indirect effects of the federal power system. The 1980 Pacific Northwest Power Act directed the Northwest Power Planning Council to prepare a program to protect, mitigate and enhance fish and wildlife of the Columbia River Basin that have been affected by the construction and operation of hydroelectric dams. In 2000, the Northwest Power Planning Council revised the Fish and Wildlife Program around a comprehensive framework of scientific and policy principles. More detailed strategies were to be developed by local fish and wildlife professionals and stakeholders for each subbasin.

This plan is submitted to the Northwest Power Planning Council to provide specific objectives and measures for the Malheur River Subbasin. This plan was developed to be consistent with the Council's Year 2000 comprehensive framework. The Malheur Subbasin Plan is submitted to the Council for consideration as subbasin specific amendments to the Council program. Once adopted into the Columbia River Fish and Wildlife Program, this plan will provide the foundation for specific projects recommended by the Council to Bonneville Power Administration for funding and implementation.

1.2 Organization of Document

The Malheur River Subbasin Assessment and Management Plan for Fish and Wildlife Mitigation is comprised of several documents. Because of the size of the documents the primary documents are further divided into sections for the purpose of saving as electronic files. This document, the Management Plan, provides a summary of the assessment and inventory and describes the strategies needed to protect and restore fish and wildlife habitats within the subbasin. It is supported by two Appendices, the Assessment Document (Appendix A) and the Inventory Document (Appendix B). The Assessment Document is divided into three major sections; the Basin Overview, the Aquatic Assessment and the Terrestrial (Wildlife) Assessment. The

Inventory Document (Appendix B) provides a summary of and an assessment of existing programs implemented in the subbasin to protect and restore fish and wildlife habitats. All references are included in a separate document.

Note to Reviewers: To facilitate the electronic review of this document we have used hyperlinks to all figures, tables, and other sections of the document. To easily see where the hyperlinks have been inserted please choose **Tools** > **Options** > and on the "**View**" tab choose "always" under "Field Shading". All of the live fields will then be highlighted like this. Clicking on these hyperlinks will take you to that item in the document. Use the Back Arrow on the toolbar (⇦) to return to your original location. The Back Arrow is on the Web toolbar. To open the Web toolbar, place your cursor anywhere over the toolbar in Word, and right-click the mouse. When the menu pops up, make sure that the Web toolbar is enabled.

1.3 Description of Planning Entity

The planning entity for the Malheur River Subbasin Assessment and Management Plan is the Malheur Watershed Coalition (the Coalition). The Coalition is comprised of the Malheur Watershed Council, located in Ontario, Oregon, and the Burns Paiute Indian Tribe, located in Burns, Oregon. The Malheur Soil and Water Conservation District served as fiscal agent for the planning project.

The Malheur Watershed Council evolved from the Malheur County Water Resources Committee established by the Malheur County Court in 1991. In 1995, the Water Resources Committee was expanded to form the Malheur-Owyhee Watershed Council, and later this joint council was divided and the current Malheur Watershed Council was established in 2000. The Malheur Watershed Council represents a cross section of people representing agricultural producers, industries and organizations, urban residents and small business owners, environmental groups, irrigation districts and local governments. The Council is supported by a technical advisory committee from various county, state and federal agencies as indicated in the list of participants.

The Burns Paiute Reservation is located north of Burns, Oregon in Harney County. The current tribal members are primarily the descendants of the "Wadatika" band of Paiute Indians that roamed in central and southern Oregon. The Constitution and Bylaws for the tribe were approved in 1968, and the Burns Paiute were formally recognized as an independent Indian Tribe in 1972. The business of the tribe is conducted by the seven-member Tribal Council, which includes a chairperson and a vice-chairperson. The tribal government includes nine departments and various committees. The Burns Paiute Fish and Wildlife Department led tribal participation in this plan.

The Malheur Watershed Coalition hired Watershed Professionals Network, LLC of Boise, Idaho to provide project management, technical support, and technical writing support.

1.4 Participants in the Malheur Subbasin Plan

Many people in the Subbasin participated in development of the assessment and management plan (See Table below). The Malheur Watershed Council members and the Malheur County Soil and Water Conservation District staff provided invaluable insight into stakeholder issues and concerns, and ongoing conservation actions. State, federal and tribal biologists and other natural resource staff provided the professional knowledge base to accomplish the assessment and provide ideas on solutions.

First	Last	Representing	Project Role/Interest
Al	Bammann	BLM	Wildlife Tech Team
Steve	Bauer	WPN	Project Manager
Jim	Bentz	MW Council	Harney Co Rancher
Larry	Bright	Malheur N.F.	Wildlife Tech Team
Tom	Dabbs	BLM	Area Manager
Ken	Diebel	ODA	Advisory Group
Duane	Pearson	Malheur Co SWCD	Inventory
Amos	First Raised III	Burns Paiute Tribe	Coalition Project Manager
Tom	Friedrichsen	Malheur N.F.	Aquatic Tech Team
Herb	Futter	MW Council	Stakeholder
Ed	Gheen	Malheur Co SWCD	Wildlife Tech Team
Brent	Grasty	BLM	GIS
Ron	Jacobs	OWRD	Irrigation
Bob	Kindschy	MW Council	Wildlife Tech Team
Glenn	Kline	MW Council	Stakeholder
Chris	Moore	MW Council	News Correspondent
Bob	Moore	MW Council	Environmental
Jim	Nakano	MW Council	Council Chairman
Nancy	Napp	WPN	Wildlife Tech Team
Keith	Paul	USFWS	Tech Teams
Ray	Perkins	ODFW	Aquatic Tech Team
Lance	Phillips	Malheur Co SWCD	Project Fiscal Agent
Kathy	Pratt	MW Council	Council Coordinator
Kirk	Prindle	WPN (EDAW)	Wildlife Tech Team
Frank	Robinson	MW Council	Stakeholder
Ed	Salminen	WPN	Aquatic Tech Team
Lawrence	Schwabe	Burns Paiute Tribe	Aquatic Tech Team
Clinton	Shock	OSU Extension	UI Extension Specialist
Jim	Soupir	Malheur N.F.	Biologist
Joan	Suther	BLM	Area Manager
Cynthia	Tait	BLM	Aquatic Tech Team
Fred	Taylor	BLM	Wildlife
Walt	Van Dyke	ODFW	Wildlife Tech Team
Cindy	Weston	BLM	Aquatic Tech Team

Although we depended heavily on information from the stakeholders in the subbasin, the WPN technical staff recognize that the fast pace of the project did not allow for the thorough review that we would desire. Any errors in fact or interpretation are the sole responsibility of WPN.

1.5 Stakeholder Involvement Process

Structure. The organizational structure (Figure 1) of the Coalition assured coordination with all the groups actively working on watershed restoration in the Malheur subbasin. The Malheur Watershed Council, Malheur Soil and Water Conservation District, and the Burns Paiute Tribe form the Core Partnership and represent major stakeholder groups in the Subbasin. The Coalition helped organize Technical Working Groups and Stakeholder and Advisory Groups as indicated in the organizational structure.

Public Participation. The Malheur Watershed Coalition served as the focal organization in assuring opportunities for public participation. The Council provided regular updates to the Council members and the public through the regularly scheduled monthly meetings. In addition, the Council formed ad-hoc groups to participate in development of plan components such as the vision statement, goals and objectives, and strategies. Specific public participation processes are listed in the table below. Public invitations were made via an internet e-mail list and announcements on the local radio station.

Public Participation		
Date	**Meeting/Process**	**Objective**
January 15, 2004	Watershed Council, Ontario, OR	Mid-process review; focal species, stream reaches, and habitat units.
April 06, 2004	Planning Coalition Members, Boise, ID	Review Preliminary Draft
Ongoing	Interim products e-mailed to ad-hoc committees	Involve Coalition members in plan development
Ongoing	Subbasin Plan Website	Provide access to working documents, draft and final plan.
May 03, 2004	Preliminary Plan Distributed for Review	Stakeholder Review & Comment
May 17, 2004	Final Review of Comments	BPT and Malheur Watershed Council

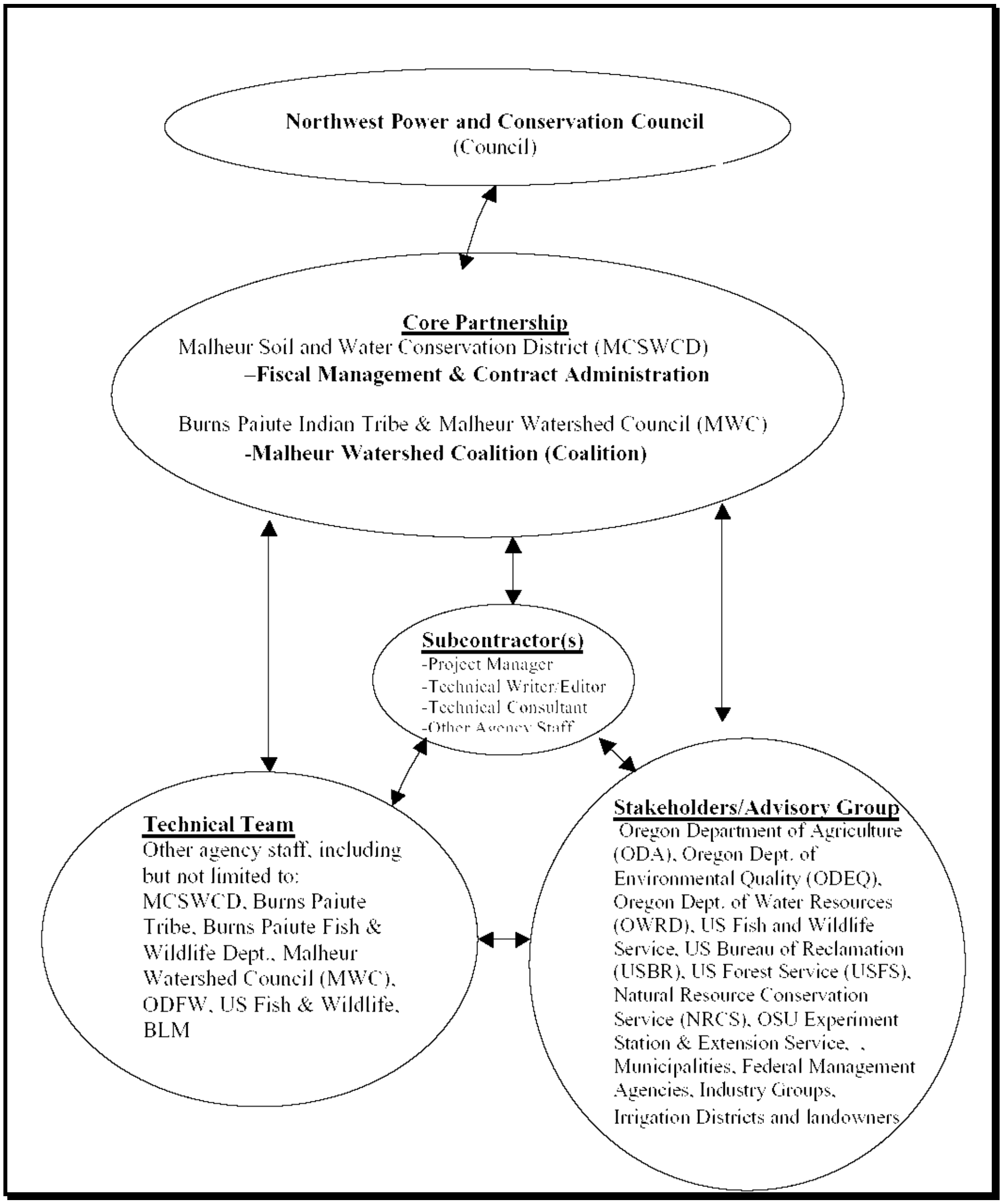

Figure 1: Malheur Subbasin Coalition Organizational Structure.

Technical Assistance. The Coalition formed two technical teams to assist in development of the plan (see list of participants). The Aquatic Technical Team participated in scoring the attributes for the Qualitative Habitat Assessment, and evaluating the prioritization for protection and restoration strategies. The Wildlife Technical Team participated in review and correction of the habitat units and selection of focal species. Both technical teams provided invaluable assistance in review and suggestions on technical issues.

1.6 Overall Approach

The subbasin plan followed the guidance provided in the Oregon Specific Guidance (Oregon Subbasin Planning Coordination Group 2002) and the Technical Guide for Subbasin Planners (NWPCC Document 2001-20). The steps are illustrated diagrammatically in Figure 2.

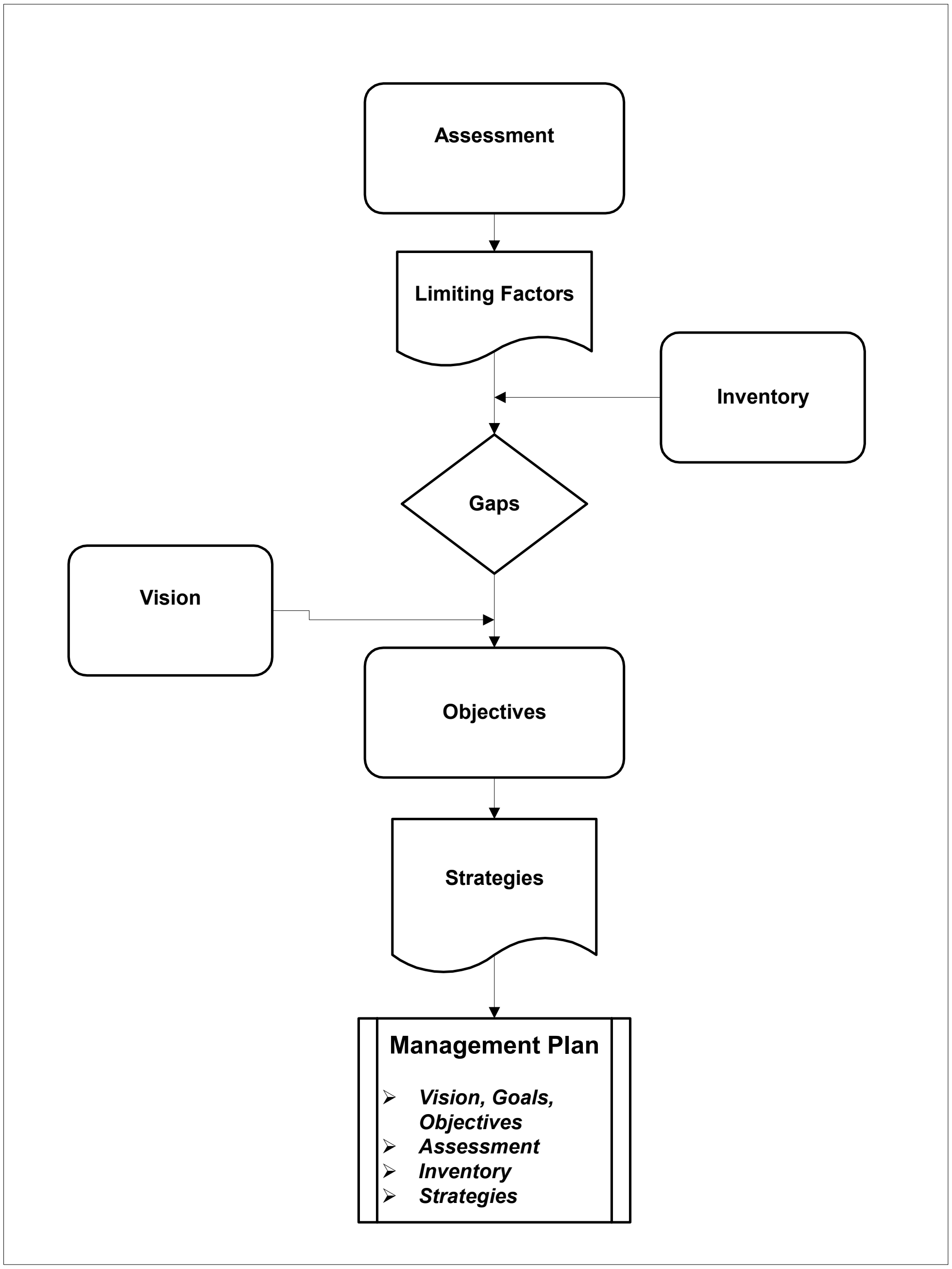

Figure 2: Malheur Subbasin Plan Approach.

The Aquatic Assessment used the Qualitative Habitat Assessment (QHA) procedure described by Mobrand (Mobrand 2003). The methods and decision-making used in completing the QHA are described in the Aquatic Assessment document (Appendix A, Part 2). The Wildlife Assessment followed the general procedure described in the "*Oregon technical guide for developing wildlife elements of a subbasin plan*" (Marcot 2003). Historic and current habitat type distributions and candidate focal species were developed from existing data sources. The Wildlife Technical Team made revisions of the existing and expected historic distribution and selected wildlife focal species from the list of candidate species. Details of these methods are described in the appropriate section.

The Aquatic and Wildlife assessments led to descriptions of existing conditions. In addition, these assessments provided the basis for identification of limiting factors, gaps in protection or restoration, and objectives. The inventory of existing projects and programs was completed through a review of existing programs and a questionnaire distributed to land managers and cooperating agencies.

Strategies for protection, restoration, and enhancement were developed to address the limiting factors and objectives identified during the assessment in close coordination with stakeholders and advisory agencies participating in the Malheur Watershed Council and the Burns Paiute Tribal Fish and Wildlife Program.

Equally important to using the Oregon Specific Guidance approach outlined above was the direction from the Coalition to build on existing planning documents already developed by Coalition members or affiliated agencies in the basin. The following documents were used as core references for developing the management plan.

1. **Malheur Basin Action Plan**. Malheur-Owyhee Watershed Council (MOWC). 1999. MOWC, Ontario, Oregon.
2. **Draft Malheur Subbasin Summary**. Burns Paiute Tribe (BPT). 2002. May 17, 2002.
3. **Malheur River Basin Fish Management Plan**. Hanson, M.L., R.C. Buckman, and W.E. Hosford. 1990. Oregon Department of Fish and Wildlife, Portland, Oregon.
4. **Southeast Oregon Resource Management Plan, Final Environmental Impact Statement, and Record Of Decision.** Bureau of Land Management (BLM). 2003. Vale District, BLM, Vale, Oregon.

1.7 Process and Schedule for Revising/Updating the Plan

The Burns Paiute Tribe formed a Coalition with the Malheur Watershed Council expressly to develop a plan that would be acceptable to both the tribal interests and to the local stakeholders in the subbasin. As such this same Coalition is the best entity to revise and update the plan in the future to assure that the plan is doable and will be accepted by the communities that it affects.

The schedule for revising and updating the Malheur Subbasin Plan depends in part on the schedule of the Northwest Power and Planning Conservation Council for updating the Fish and Wildlife Program Plan to which this subbasin plan will be appended. This plan is developed at a general strategy level of resolution, and therefore does not need to be revised on a frequent basis.

We suggest that a five-year review with a planned ten-year update should be sufficient to keep the plan current.

Since the plan is developed at a fairly coarse spatial scale and a broad scale of resolution it will be important to step-down the plan to finer scales – the watershed, subwatershed, stream system etc. to assure that solutions envisioned at the subbasin scale are meaningful at the project scale. We describe some ideas for stepping down this plan in the discussion of strategies.

2 VISION FOR THE SUBBASIN

The vision provides the overall expectation for the Malheur River Subbasin Plan. The vision guides the development of objectives and strategies for protecting, restoring, or enhancing fish and wildlife resources. Implementation projects recommended at the watershed and stream reach level need to be consistent with and designed to fulfill this vision. The vision statement consists of the vision summary and restoration principles described below.

Vision Statement

> *The vision for the Malheur River Subbasin is an ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife while sustaining the economic and social vitality of the communities in the region. The vision will be accomplished by protecting and enhancing the natural ecological functions, habitats, and biological diversity of the Malheur River Subbasin.*

Restoration Principles

This vision statement sets the overall long-term direction for natural resource managers and community stakeholders in further developing strategies and management actions. How the vision is accomplished, however, is as important as the outcome described in the vision statement. Stakeholders share this vision, but have legitimate concerns about the economic impacts of some restoration approaches. Farm and ranch communities depend on the natural resources provided on both the public and private lands, and require the continued use of these resources while addressing wildlife habitats. The concentration of private lands in valley bottoms near streams and rivers also requires the "buy in" from landowners to make significant headway on restoring fish and wildlife habitat especially in reconnecting fragmented habitats.

A way to move toward the watershed vision is to utilize the concepts of community-based conservation as described in "*Ecosystem Management – Adaptive, Community Based Conservation*" by Meffe et al. 2002. In this approach, Ecosystem Restoration[1] is defined as ***"an approach to maintaining or restoring the composition, structure, and function of natural and modified ecosystems for the goal of long-term sustainability"***. Long-term sustainability applies to the social and economic well being of the community as well as the long-term recovery of habitats for fish and wildlife.

To a large extent, the existing stakeholder groups and agency institutions in the Malheur River Subbasin have already embraced this conceptual framework. The Watershed Council and Soil and Water Conservation Districts are working with farm and ranch operators to implement management practices that often integrate habitat improvement with soil and water conservation

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[1] (Note: The word "restoration" is used in a broad sense. More specifically, **restoration** means reproducing the ecosystem structure and function that existed prior to disturbance ((See Allen 1995). This landscape has the highest wildlife values, but may be difficult to achieve. **Reclamation** refers to an ecosystem that provides ecosystem functions, but may rely on exotic species versus native species. **Rehabilitation** implies restoring productivity, but with a different community such as monocultures used in rangelands.

objectives. Resource Management Plans for private lands are developed to address multiple goals such as water quality, water conservation, riparian area management, and restoration of upland vegetation. The Oregon Watershed Enhancement Board funds projects that are tiered to watershed assessments to assure that restoration funding is targeting fundamental watershed processes and functions, and EPA 319 funds are targeted primarily to resolve issues identified in Watershed Management Plans developed to address Total Maximum Daily Loads (TMDL).

In summary, the restoration principles to implement the vision in the Malheur River Subbasin are to:

1. Emphasize the balance between ecological integrity and production of commodities inherent in the Community Based Conservation approach to ecosystem restoration.
2. Use methods that result in self-sustaining restoration compared to methods that require continued maintenance or periodic reestablishment.
3. Emphasize holistic changes to management systems across areas (e.g., integrating riparian and upland treatments) compared to single objective treatments.
4. Emphasize strategies aimed at restoring watershed processes and functions (i.e. address causes versus symptoms). However, we recognize the need to be flexible in balancing short term and long-term approaches. Human intervention is oftentimes necessary because of the long time needed for natural recovery to occur (for example, use of large woody debris placement in the short term while protecting riparian buffers for future wood recruitment).
5. Use passive restoration as a first step where feasible. Passive restoration, in comparison to active restoration (Kauffman et al. 1997), refers to stopping or modifying those management practices that cause degradation or prevent ecosystem recovery. Land management agencies, farmers and ranchers in the subbasin are already implementing this principle by incorporating riparian buffer protection and changing upland grazing practices, allowing soils to form at natural rates and vegetation to reestablish.
6. Use active restoration where past human activities prevent natural processes from working. For example, reestablishing the natural meander pattern in streams that have been channelized or constrained by levies. These types of management activities require further detailed analysis and design before they can be implemented and are generally more costly than passive restoration.
7. Use management methods that mimic natural processes to restore upland ecosystems. Prescribed fire followed by seeding can be used effectively to help restore native plant communities and hydrologic processes.
8. Encourage collaborative means to develop projects within small watershed areas (micro-watershed projects) and partnerships between private landowners and public agencies on mixed ownerships. Valley bottoms are often comprised of private property with public lands in the adjacent uplands.

9. Adjust management activities and strategies (adaptive management) based on monitoring and evaluation (M&E) results rather than continue implementing actions that do not support fish and wildlife habitat restoration objectives.

2.1 Existing Stakeholder Plan Goals and Objectives

This plan builds on previous programs and planning efforts designed to protect and enhance fish and wildlife habitats and promote natural resource conservation. Subbasin stakeholders have participated in many previous planning exercises with local, State and Federal entities and have ownership in these plans and programs. Malheur Watershed Council stakeholders seriously questioned the need to develop ‘another plan” when existing plans were still on the shelf.

Although there are many planning documents pertaining to the subbasin (See Appendix B Inventory), the four documents listed below provide examples of objectives and related actions, previously developed by stakeholders and fish and wildlife agencies that were used in development of this subbasin management plan.

1. **Malheur Basin Action Plan**. This plan was developed by the Malheur-Owyhee Watershed Council (MOWC 1999) to focus on soil and water conservation issues aimed primarily at improving water quality. Because of its focus on water quality, it did not address fish and wildlife habitat issues.
2. **Draft Malheur Subbasin Summary**. The Malheur Subbasin Summary (Burns Paiute Tribe 2002) provided the basic background for the Subbasin Management Plan and was used extensively in developing this plan. This document also summarized the goals and objectives from many of the major management programs for fish and wildlife in the subbasin.
3. **Malheur River Basin Fish Management Plan**. The subbasin fish management plan (Hanson et al., Oregon Department of Fish and Wildlife 1990) provides the status of fishery resources, policies, and objectives for fisheries management.
4. **Bull Trout Draft Recovery Plan, Malheur Recovery Unit**. The draft recovery plan (U.S. Fish and Wildlife Service 2002) identifies goals, objectives and actions that are specific to recovery of bull trout in the Malheur Subbasin. We have integrated the recovery plan into the Malheur Subbasin Plan where possible.

Selected goal statements from these existing planning documents address broader watershed issues such as soil and water conservation in addition to targeting goals for species conservation; together these programs reflect the broader goals of ecological restoration.

2.1.1 Soil and Water Conservation Goals

1. Reduce soil loss and associated pollutants from irrigated croplands and improve irrigation efficiency (MOWC 1999).
2. Improve or maintain rangeland condition for watershed health and wildlife habitat (MOWC 1999).
3. Reduce the proliferation of noxious weeds (MOWC 1999).

4. Reduce pollutants from urban runoff (MOWC 1999).
5. Reduce nonpoint source pollution and meet federal and state water quality standards (MOWC 1999, BPT 2002, ODFW 1990).

2.1.2 Aquatic Species Goals

1. Restore native resident fish species to near historic abundance throughout their historic ranges where habitats exist and where habitats can feasibly be restored (BPT, 2002).
2. Substitute lost anadromous fish populations with resident populations to mitigate the loss of salmon and steelhead in areas currently blocked to anadromous fish due to construction and maintenance of hydroelectric dams (BPT, 2002).
3. Return salmon and steelhead to the Malheur River by restoring fish passage and reintroduction of salmon and steelhead to the subbasin (BPT 2002).
4. Ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout distributed throughout the species' native range so that the species can be delisted (USFWS 2002), and may be sustained at levels to provide harvest opportunities (BPT 2002).
5. Provide substitution resources to the Malheur River Subbasin in the place of lost anadromous fish resources that have been blocked by federal and federally licensed dams.

2.1.3 Bull Trout Recovery Goals

1. Maintain the current distribution of bull trout within the core area and reestablish bull trout in previously occupied habitats in the Upper Malheur River and tributaries and the North Fork Malheur River and tributaries (from the U.S. Fish and Wildlife Service 2002).
2. Maintain stable or increasing trends in abundance of bull trout in the Malheur Recovery Unit.
3. Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies.
4. Conserve genetically diverse populations of bull trout within the Malheur Recovery Unit. This can be best be achieved by ensuring connectivity between the North Fork Malheur and the Upper Malheur River.

2.1.4 Wildlife and Wildlife Habitat Goals

1. Restore and maintain native plant communities and habitat diversity for wildlife (BPT 2002).
2. Maintain and enhance plant species important to tribal culture (BPT 2002).
3. Maintain the historical distribution of dry and wet meadow types (BPT 2002).
4. Enhance and restore upland communities for wildlife winter range (big game winter range on upland shrub-steppe and forest habitat types) (BPT 2002).

5. Maintain Oregon's wildlife diversity by protecting and enhancing populations and habitats of native non-game wildlife at self-sustaining levels throughout natural geographic ranges (ODFW 1993).

The following additional goal statements were added by the Wildlife Technical Team during review of a draft of this document.

6. Permanently protect, enhance, maintain, and/or restore native plant communities within riparian, wetland, shrub-steppe, and forest habitats to increase habitat function/diversity and promote wildlife diversity for current and future generations (Burns Paiute Tribe).
7. Increase mule deer, elk, upland game bird, and waterfowl populations and harvest potential for tribal members and non-tribal hunters alike (Burns Paiute Tribe).
8. Enhance and restore summer range for big game and sage grouse (ODFW).

3 SUBBASIN PHYSICAL SETTING

This section provides a brief introduction to the physical and biological setting of the Malheur River Subbasin. The reader is referred to the Subbasin Overview (Appendix A, Part 1) for a more detailed description of the physical setting and the macro-scale processes that affect hydrologic response in the subbasin. The overview in Appendix A describes the ecoregions, geology, soils, climate, land use patterns, hydrologic regimes, and water use in more detail.

3.1 General Characteristics

The Malheur River Subbasin is situated in southeastern Oregon. The Malheur River is tributary to the Snake River, entering at approximately river mile (RM) 370. The majority of the Subbasin is located in northern Malheur County, with the remainder located in Harney, Grant, and Baker counties (Figure 3). The Malheur Subbasin is approximately 4,700 square miles in size. For the purposes of this assessment the subbasin has been subdivided into six watersheds. Subwatershed characteristics are given in Table 1. Elevations range from approximately 2,100 feet at the confluence with the Snake River to approximately 8,600 feet in the Strawberry Mountains, in the headwaters of the Upper Malheur watershed.

Table 1: General characteristics of the Malheur Subbasin and watersheds (USGS, (2004a).

Watershed	Area (sq.mi.)	Elevation (feet)			Slope (proportion of area by slope class)		
		Mean	Min	Max	<10%	10-50%	>50%
Main Malheur	1,012	3,593	2,133	5,968	46%	49%	5%
Upper Malheur	1,080	4,735	3,261	8,570	43%	54%	3%
Willow Creek	787	3,736	2,198	7,815	45%	52%	4%
Bully Creek	601	3,986	2,241	6,447	37%	60%	3%
North Fork Malheur	550	4,932	2,920	7,904	26%	68%	5%
South Fork Malheur	705	4,523	3,268	6,355	55%	44%	2%
Entire Malheur Subbasin	4,735	4,221	2,133	8,570	43%	54%	4%

Land management for the entire subbasin is 48.2 % BLM, 34.9% Private, 12.3 % US Forest Service, 4.1 % State Agencies, 0.5 % Bureau of Reclamation, and 0.04% Federal Energy Regulatory Commission.

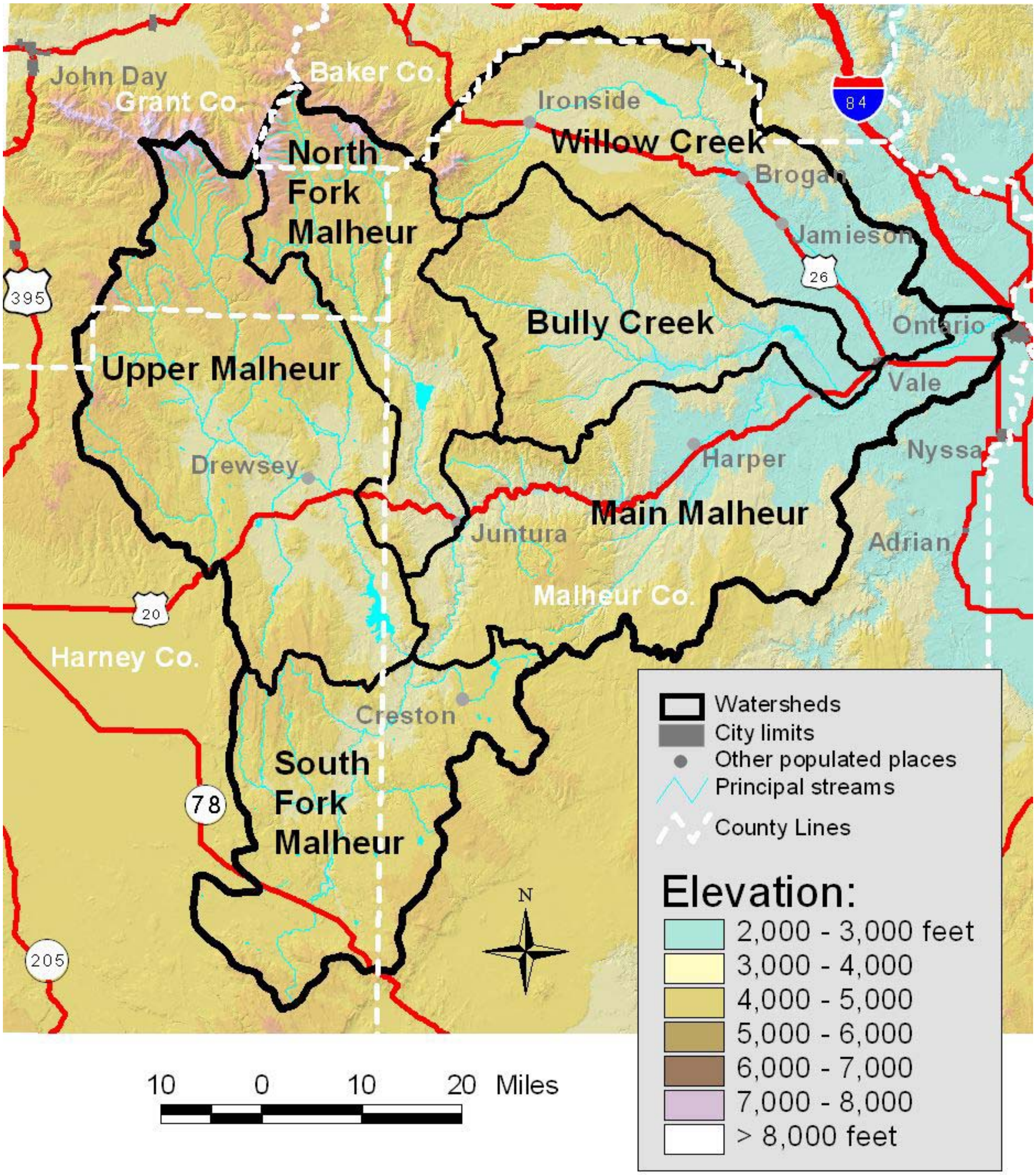

Figure 3: Malheur subbasin shaded-relief map. Data sources: USGS (2004a).

3.2 Geology

Most of the Malheur Subbasin consists of gently sloping to rolling lava plateau uplands dissected by river canyons or valleys (Figure 3). Topography in the Malheur Subbasin is the result of volcanic mountain building processes, limited alpine glaciation, erosion, deposition and faulting (USFS 2000). The Malheur River flows mostly through igneous rock terrain that is composed principally of volcanic rocks. Sedimentary rocks, mostly tuffaceaous stream and lake deposits, also occur throughout the Subbasin (Laird 1964 *in* Fuste and McKenzie 1987). The watershed is bounded to the north by the Strawberry Mountain range, dominated by Tertiary Strawberry volcanics. An episode of glacial activity that ended about 11,000 years ago left glacial u-shaped valleys and limited areas of unsorted glacial deposits and moraines in this area (USFS 2000). Most the Malheur Subbasin consists of rolling, grass-shrub hills underlain by old lacustrine sedimentary formations of Tertiary age, as well as lava flows of Tertiary to Recent age (MOWC 1999). River canyons and valleys that dissect these hills result from block faulting and weathering of volcanic ash, basalts, and sediments. In the lower Subbasin, extensive low elevation floodplains and terraces parallel the Snake River and extend up the valleys of the Malheur River and Willow Creek (MOWC 1999).

3.3 Soils

Soils in this semi-arid Subbasin are generally young, thin, and poorly developed. Soils in the mountainous areas in the northwest part of the Subbasin are extremely diverse, depending on interactions with vegetation, topographic aspect, glacial history, and fluvial processes. Forested north slopes tend to have productive volcanic ash mantles (from the Mount Mazama eruption 6,500 years ago (USFS 2000). Less protected south slopes have eroded over time to soils of underlying silt loams. Ridges tend to be comprised of shallow residual soils. Logan Valley soils are shallow with cemented hardpan (USFS 2000). Many soils in the forested northwest portion of the Subbasin are of the Klicker series, underlain by basalt and andesite. These are stony, moderately deep, slightly acidic, and fine loamy soils (MOWC 1999). Within the rolling hills that comprise most of the Subbasin, a thin surface mantle of wind-born loess is present in places on top of the lacustrine sedimentary formation. Narrow alluvial floodplains may also occur along streams. These soils are light colored, low in organic matter, and generally calcareous (MOWC 1999). Floodplain soils in the lower watershed are diverse alluvial soils, generally easily eroded and alkali (MOWC 1999). In general, chemical and biological soil-building processes proceed slowly in this semi-arid Subbasin and disruption of soils can lead to long-term changes in ecological condition and productivity (MOWC 1999, USFS 2000).

3.4 Climate

The climate in the Malheur Subbasin is semiarid, characterized by hot dry summers and cold winters. Summer temperatures may exceed 100 Fahrenheit (F), and winter temperature may drop below –20 F. Summer nights are cool, however, due to the generally clear skies and dry air: even in the warmest months. Mean annual precipitation within the Malheur Subbasin varies with elevation, ranging from 49 inches in the upper mountains to seven inches in the lower reaches, and is 14 inches overall (Table 2). Precipitation results from short, intensive convection thunderstorms in the summer and from frontal storms in the winter and spring (Fuste and McKenzie 1987). Unlike most of Oregon, annual precipitation in the Malheur Subbasin is distributed rather evenly throughout the year, although winter months tend to have the highest total precipitation (OCS, 2004a). The driest month throughout the region is July.

Table 2. Mean annual precipitation (inches) in the Malheur Subbasin (OCS, 1998).

Watershed	Area-weighted mean	Minimum	Maximum
Bully Creek	12.2	9	23
Main Malheur	11.3	7	17
Upper Malheur	16.5	9	49
North Fork Malheur	19.8	9	49
South Fork Malheur	11.4	9	25
Willow Creek	12.6	9	23
Entire Subbasin	13.8	7	49

3.5 Waterbodies and Water Use

There are approximately 6,500 miles of stream within the Subbasin, 1,400 miles of which is classified as perennial, and 5,100 of which is classified intermittent. An additional 370 miles of irrigation-related canal and ditches are identified, located primarily in the lower portions of the Main Malheur and Willow Creek watersheds.

Approximately 1,110 miles of the total length of stream in the Malheur Subbasin were identified as being significant with respect to the aquatic focal species (i.e., redband trout, bull trout, and Spring Chinook) and was included in the aquatic assessment. These streams were grouped into 63 reaches[2] for the purpose of this assessment. Streams included in this assessment are shown in Figure 3 above. More detailed reach maps, and a summary of reach characteristics, can be found in attachments to the Aquatic Assessment (Appendix A).

Over 1,100 lakes and ponds have been identified within the subbasin. Impoundments include reservoirs, dugouts, catchments, etc. The largest impoundments include Warm Springs Reservoir on the mainstem Malheur River (~4,000 acres), Beulah Reservoir on the North Fork Malheur (~1,800 acres), Bully Creek Reservoir on Bully Creek (~900 acres), and Malheur Reservoir on Willow Creek (~500 acres). Wetlands are probably underrepresented in the BLM data. National Wetland Inventory (NWI) data would better-represent current conditions in the Subbasin, however, this data has not yet been digitized for the Malheur area.

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[2] A reach is defined as a linear segment of stream that is reasonably homogonous with respect to hydrologic and ecologic characteristics and functions. Further discussion on reach selection and characteristics can be found in the aquatic assessment.

Table 3. Summary of water bodies within the Malheur Subbasin (BLM, 2003b).

	Area (acres)			Frequency		
Watershed	Lakes and Ponds	Impound-ments	Wetlands	Lakes and Ponds	Impound-ments	Wetlands
Bully Creek	63	1,063	1	103	87	1
Main Malheur	70	318	2	101	320	2
Upper Malheur	329	4,725	0	398	58	0
North Fork Malheur	3	1,885	72	8	166	26
South Fork Malheur	182	1,067	79	343	159	5
Willow Creek	70	685	12	201	313	5
Entire Subbasin	718	9,742	165	1154	1103	39

Much of the river flow in the Malheur River Subbasin is controlled by reservoirs and by a complex system of diversions, canals, and siphons originating near Namorf (at ~RM 65) and extending downstream to the mouth of the Malheur River near Ontario. Warm Springs, Beulah, and Bully Creek reservoirs are major components of the Bureau of Reclamation’s Vale Project, which is operated and maintained by the Vale-Oregon Irrigation District. A total of about 132,000 acres are irrigated in the Malheur Subbasin, representing about 4.4 percent of the total Subbasin acreage (Table 4). The primary method of irrigation is flood irrigation through ditch systems that divert water from the streams and rivers. Three irrigation districts in the Subbasin water about one-half of the total irrigated acreage.

Table 4. Irrigated acreage in the Malheur Subbasin (M. Grainey, OWRD, pers. comm. 2001).

Holder of water right	Acres irrigated	Percent of irrigated acreage	Percent of Subbasin
Vale-Oregon Irrigation District	38,000	28.8%	1.3%
Warm Springs Irrigation. District	20,000	15.2%	0.7%
Orchards Water Company	6,000	4.5%	0.2%
Individual water rights	68,000	51.5%	2.3%
Total	132,000	100.0%	4.4%

4 AQUATIC ASSESSMENT SUMMARY

4.1 Aquatic Focal Species

Sixteen species of fish historically occurred, or have been suspected to have occurred, within the Malheur Subbasin (Table 5). A mix of salmonids and native nongame fish inhabited the Subbasin with each species dominating in its favored habitat niche. The North Fork and Upper Malheur River were probably the most important spawning and rearing tributaries in the Subbasin for most anadromous salmonids. Anadromous salmonids were blocked from the watershed by dams early in the 20th century, leaving redband trout and bull trout as the major focus of fisheries management. Therefore, the Malheur Subbasin Coalition have selected spring Chinook salmon, redband trout, and bull trout as aquatic focal species for the Malheur River Subbasin based on their cultural, biological, and esthetic value.

Table 5: Historical fish species of the Malheur Subbasin

Common Name	Scientific Name	ODFW Management	Status	Location
Pacific Lamprey	Lampetra tridentate		Extinct	
Chinook Salmon	Oncorhynchus tshawytscha	Gamefish	Extinct	
Coho Salmon	Oncorhynchus kisutch	Gamefish	Extinct	
Steelhead	Oncorhynchus mykiss	Gamefish	Extinct	
Columbia River Redband Trout	Oncorhynchus mykiss	Gamefish	State Sensitive	Higher elevation areas of most major subbasins
Bull Trout	Salvelinus confluentus	Gamefish	Federal Threatened	Headwaters of North Fork and Logan Valley streams
Whitefish	Prosopium williamsoni	Gamefish		Lower sections of North Fork, Upper Malheur, and lower Malheur River
Northern Pike-minnow	Ptychocheilus oregonensis	Nongame		Lower sections of major subbasins
Chiselmouth	Acrocheilus alutaceus	Nongame		Lower Malheur river
Redside Shiner	Richardsonius balteatus balteatus	Nongame		Lower sections of major subbasins
Speckled Dace	Rhinichthys osculus	Nongame		Lower sections of major subbasins
Long-nosed Dace	Rhinichthys cataractae	Nongame		Lower sections of major subbasins
Largescale Sucker	Catostomus macrocheilus	Nongame		Larger river and reservoirs
Bridgelip Sucker	Catostomus columbianus	Nongame		Lower sections of major subbasins
Shorthead Sculpin	Cottus confusus	Nongame		Headwater areas of perennial streams

Common Name	Scientific Name	ODFW Management	Status	Location
Mottled Sculpin	Cottus bairdi	Nongame		Headwater areas of perennial streams

Source: ODFW, Ontario District Office 2001

4.1.1 Bull Trout

Bull Trout Status

The U.S. Fish and Wildlife Service listed bull trout in the Columbia River Basin, including the Malheur Subbasin, as threatened in June 1998. Information on bull trout population status, distribution and trends in the Malheur River system is fairly good because of the studies completed by ODFW and Burns Paiute Tribe in relation to the listing and development of the draft recovery plan (See Appendix A, Part 2, the Aquatic Assessment for details and sources of information.)

Under the listing, the Malheur Subbasin bull trout are considered members of the Columbia River Bull Trout Distinct Population Segment (DPS). Two distinct local populations of bull trout have been identified in the Malheur River Subbasin; the Upper Malheur River bull trout population and the North Fork Malheur River population. The Malheur Bull Trout Recovery Team refers to these populations of bull trout as two local populations of one core population (Malheur River Subbasin). The core population, or the core area, represents the closest approximation of a biologically functioning unit.

The upper Malheur River population was isolated from all other populations of bull trout with the construction of Warm Springs Dam in 1919. Conversely, the population of bull trout in the North Fork Malheur River was isolated from other populations of bull trout in 1926 with the construction of Agency Valley Dam. Both Warm Springs and Agency Valley Dams are upstream migratory barriers to fish as they have no fish passage facilities.

The categorical status of bull trout in the North Fork Malheur River is “of special concern” The recovery potential for the North Fork Malheur River bull trout population is considered to be “very good” (Buchannan et al. 1997). The Oregon Department of Fish and Wildlife estimated the population in the North Fork Malheur River and tributaries in 1991 and 1992 to be 4,132 bull trout of at least age one. Habitat degradation, diversion losses, and past chemical treatment projects are listed as the main suppressing factors for the North Fork Malheur River bull trout population (Ratliff et al. 1992).

The upper Malheur River bull trout population status is at a “high risk of extinction”. Buchannan et al. (1997) concludes that the recovery potential level for the upper Malheur River bull trout population at the given status will require major effort to restore. Habitat degradation, diversion losses, and the presence of sympatric brook trout populations are listed as the main suppressing factors for the upper Malheur River bull trout population (Ratliff et al. 1992). The Oregon Department of Fish and Wildlife estimated the population in tributaries of the Upper Malheur River in 1993 and 1994 to be 3,554 bull trout of at least age one.

Metapopulation theory also suggests bull trout in the Malheur system are in trouble. Bull trout core areas with fewer than five local populations are considered to be at increased risk, core areas that have five to ten local populations are at intermediate risk, and core areas with more than ten interconnected local populations are at diminished risk. Since only two local populations have been identified in the subbasin and these are comprised of less than 1000 spawning adults, the Malheur River bull trout core population is considered to be at increased risk from stochastic events and the deleterious effects of genetic drift.

Bull Trout Current Distribution

The current distribution of bull trout is summarized in Table 6. Bull trout primarily occur in the headwaters of the Malheur River Subbasin.

Table 6: Current distribution of bull trout in the Malheur River Subbasin.

Streams	Habitat Use
North Fork Malheur River from mouth to Agency Dam	Migration/overwintering/foraging
Beulah Reservoir	Migration/overwintering/foraging
North Fork Malheur River from Beulah Reservoir to confluence with Crane Creek	Migration/overwintering/foraging
Malheur River from Drewsey to Logan Valley	Migration/overwintering/foraging
Crane Creek	Migration/foraging
Cow Creek	Rearing
North Fork Malheur River from confluence with Crane Creek to the headwaters	Spawning/rearing
Little Crane Creek	Spawning/rearing
Horseshoe Creek	Spawning/rearing
Flat Creek	Spawning/rearing
Swamp Creek	Spawning/rearing
Sheep Creek	Spawning/rearing
Elk Creek (including both north and south forks)	Spawning/rearing
Lake Creek	Spawning/rearing
Big Creek	Spawning/rearing
Meadow Fork Big Creek	Spawning/rearing
Snowshoe Creek	Spawning/rearing

Bull Trout: North Fork Malheur River Local Population

Current distribution of bull trout includes the North Fork Malheur River and upper Malheur River (upstream of Drewsey). Spawning and juvenile rearing takes place in selected headwater tributaries of both systems, as well as in the upper mainstem North Fork Malheur.

Bull trout in the North Fork Malheur River migrate to and overwinter in Beulah Reservoir. Entrainment in Agency Valley Dam has also been observed. Radio telemetry of entrained bull trout tend to stay within two river kilometers of the tailrace (Schwabe et al. 2000), though local residents have reported bull trout in the Malheur River around the vicinity of Juntura, Oregon. Although bull trout have been observed in the North Fork Malheur River below Agency Valley

Dam, it is suspected that the entrained bull trout will not successfully spawn or rear due to the lack of spawning and rearing habitat and a highly altered seasonal hydrograph.

Migratory bull trout have also been observed in the lower one mile of the Little Malheur River. Adult bull trout mainly migrate into the upper reaches of South Fork Elk Creek, North Fork Elk Creek, Swamp Creek, Sheep Creek, Horseshoe Creek, Little Crane Creek, and Upper North Fork Malheur River. Reports of bull trout have been observed in Cow Creek and Upper Crane Creek.

Bull Trout: Upper Malheur River Local Population

Bull trout occur in several headwater tributaries of the Upper Malheur River and occur as far downstream as Wolf Creek. Bull trout use of the Malheur River below Wolf Creek to Warm Springs Reservoir is currently restricted seasonally probably due to elevated stream temperatures, lack of water, and lack of fish passage facilities at irrigation diversions. The Burns Paiute Tribe and ODFW have observed bull trout in Lake Creek, Big Creek, Meadow Fork of Big Creek, Snowshoe Creek and Summit Creek. The Tribe also collected a bull trout from Crooked Creek on September 10,1998 and recent observations of bull trout were noted from Summit Creek. Brook trout outnumber bull trout in all headwater streams of the upper Malheur River except for Meadow Fork Big Creek where bull trout outnumber brook trout 15 to 1. Brook trout appear to be present in the lower two river kilometers of Meadow Fork Big Creek, with the upper two river kilometers dominated exclusively by bull trout.

Bull Trout: Historic Distribution

Information on the historic distribution of bull trout in the Malheur Subbasin is limited. However, bull trout would have had access to the Snake River prior to dam construction. Stream temperatures in the lower Malheur River would have limited bull trout spawning and juvenile rearing, but the area would have been used for migration corridors and overwintering habitat. Furthermore, the genetic similarities between the Malheur local populations of bull trout to the populations of bull trout in the Boise and Jarbidge drainage imply that the mainstem North Fork Malheur River and Upper Malheur River were historically utilized as migratory habitat.

Data collected within the last 50 years document bull trout in areas outside their current distribution. This data leads local resource land and fisheries managers to suspect historical or potential habitat for bull trout in several streams in the Malheur River Subbasin, including Little Malheur River on the Malheur National Forest, Crooked Creek, and Bosonberg Creek.

Many of the headwater streams were chemically treated to eradicate bull trout in the Upper Malheur River in 1955. Streams include Lake Creek, McCoy Creek, Crooked Creek, Big creek, Bosonberg Creek and Summit Creek. Considerable numbers of bull trout were reported killed from this project (Bowers et al. 1993).

4.1.2 Redband Trout

Redband Trout Status

Rainbow trout that are found primarily east of the Cascade Mountains in the U.S. are often called redband. The redband trout was considered a candidate species for listing under the federal

Endangered Species Act (ESA) until March 20, 2000 when a final decision was made to not list redband (USFWS 2000). Redband trout are listed as a Sensitive Species under Oregon's Endangered Species Act. The health of the redband population in the Malheur River watershed is currently unknown and an interagency team has initially begun research on life history characteristics (Schwabe et al. 2000).

Redband Trout Current Distribution

Redband trout are the most prevalent indigenous salmonid in the Subbasin, having been identified by ODFW in seventy-six streams in the Malheur River Subbasin (Hanson et al. 1990). They are found in tributaries of the South Fork Malheur and the Malheur River below Warm Springs Reservoir, the mainstem and North Fork and their tributaries and above Bully Creek reservoir and its tributaries. The strongholds for redband trout are similar to that of bull trout – the North Fork and Upper Malheur River upstream of the reservoirs. Downstream of the reservoirs and in smaller tributaries, habitat is considered marginal for spawning and rearing due to low flows, poor water quality, and blockages due to irrigation structures (Hanson et al. 1990, Wayne Bowers, ODFW, pers. comm. 2001). Tributaries redband trout inhabit in the Malheur River Subbasin are shown in Table 7. Fish present in these tributaries can either be migratory, rearing, and/or spawning or a combination thereof.

Table 7: List of tributaries where redband trout are currently found.

Main Water Body	Associated Tributaries with Redband Trout Present
North Fork Malheur River	Horseshoe Creek; Deadhorse Creek; Swamp Creek; Cow Creek; Little Cow Creek; Sheep Creek; Short Creek; North and South Fork Elk Creeks; Little Crane Creek; Crane Creek; Buttermilk Creek; Fopian Creek; Kate Creek; Bear Creek.
Little Malheur River	Rock Creek; South Bullrun Creek; Lunch Creek; Larch Creek; Canteen Creek; Camp Creek; Hunter Creek.
Upper Fork Malheur River	Meadow Fork Creek; Big Creek; Snowshoe Creek; Lake Creek; McCoy Creek; Corral Basin Creek; Bosonberg Creek; Little Logan Creek; Summit Creek; Larch Creek; Crooked Creek; Dollar Basin Creek; Bluebucket Creek; Pine Creek; Griffin Creek; Otis Creek; Cottonwood Creek; Stinkingwater Creek; Pine Creek; Little Pine Creek; Wolf Creek; Little Wolf Creek; Magpie Creek; Calamity Creek; Gunbarrel Creek.
South Fork Malheur River	Coleman Creek; Crane Creek; Little Crane Creek; Alder Creek; Camp Creek, Swamp Creek; East Swamp Creek; Granite Creek; Big Granite Creek.
Mainstem Malheur River	Calf Creek; Canyon Creek; Hunter Creek; Pole Creek; Black Canyon; Gold Creek; Hog Creek; North Fork Squaw Creek; Cottonwood Creek.
Bully Creek	Rall Canyon Creek; Clover Creek; South Fork Indian Creek; West Fork Cottonwood Creek; Cottonwood Creek; Reds Creek.
Willow Creek	Bridge Creek; South Willow Creek; Basin Creek.

Redband trout currently do not occupy habitats in the Malheur River from RM 0 to 69, Willow Creek from RM 0 to RM 30, and Bully Creek from RM 0 to 14 (Hanson et al. 1990). Historically this habitat was primarily utilized for migration and provided marginal habitat for rearing.

Redband Trout Historic Distribution

Although management and land use activities have affected the seasonal use of habitat within some reaches of the Malheur Subbasin, redband trout continue to utilize a good percentage of habitats historically available to the species. Information on the historic distribution of redband trout in the Malheur River Subbasin however is fairly limited. Redband trout would have had access to the Snake River prior to dam construction. Due to the historic runs of anadromous life history forms of redband trout, known as steelhead, the lower habitats of the subbasin would have at least been considered migratory corridors for the species. It is presumed by local fish and land managers that fluvial redband trout currently utilize habitats in the lower Malheur River Subbasin for winter rearing and migration, but this has not been officially documented. Redband trout historically were found in the tributaries of the North Fork, Upper Malheur and the South Fork of the Malheur; in the tributaries of Willow Creek; and in the tributaries of Bully Creek (Hanson et al. 1990).

4.1.3 Spring Chinook Salmon

Spring Chinook Salmon Status

Chinook salmon, as well as all other runs of anadromous fish species native to the Malheur River Subbasin, are extinct due to a combination of factors, but primarily associated with migration blockage. Dams built on the Malheur River, on the Snake River, and on the Columbia River have all contributed to the ultimate extinction of the Spring Chinook Salmon in the subbasin.

Construction of Warm Springs Dam on the Malheur River in 1919 and Agency Valley Dam on the North Fork Malheur River in 1935 for irrigation and flood control likely had a significant impact on salmon runs and the associated fishery by blocking the more productive spawning habitat in the Malheur River Subbasin. The upper reaches of both these streams have miles of excellent spawning gravels and rearing area for anadromous species, but generally lack pool area (Pribyl and Hosford 1985).

Each subsequent dam associated with the Federal Columbia River Power System built on the Columbia and Snake River contributed to the irreversible impacts on the Chinook salmon and other anadromous fish species. Construction of Brownlee Dam by Idaho Power on the Snake River in 1958 completed the blockage to anadromous fish from reaching the Malheur River (NWPPC 2000).

Spring Chinook Salmon Historic Distribution

The native population of chinook salmon have been extirpated from the Malheur River subbasin. The Aquatic Technical Team for this subbasin plan estimated that there are 280 miles of lost aquatic habitat in the entire subbasin, including tributaries (See Appendix A and Appendix A2). The miles of lost habitat in the Malheur Subbasin was previously estimated at 205 linear miles (NWPPC 1986).

Most of the Malheur River was used by anadromous species (Fulton 1970). Before construction of Warm Springs Reservoir in 1919 and Beulah Reservoir in 1935, the Malheur River supported runs of spring chinook salmon, steelhead (Haas 1965, Fulton 1970), and probably coho salmon (Thompson and Haas 1960, Pribyl and Hosford 1985, Thompson and Fortune 1967). According to Pribyl and Hosford (1985) "long-time residents of the area can remember spearing salmon in the Logan Valley area of the Upper Malheur and also in the mainstem Malheur near Ontario. Hand forged spears and gaff hooks, used to catch salmon, can still be found at the ranches below Beulah Reservoir on the North Fork Malheur". Logan Valley was ethnographically documented as an important locality for fishing, hunting and gathering by Native American Tribes as well as a trade center (Couture 1978). Tribal Elders have oral histories of fishing for salmon from the upper Malheur River to where it feeds into the Snake River (Amos First-Raised III, personal communication). In July of 1926, the Oregon Fish Commission's Master Fish Warden toured the Malheur Subbasin and noted:

> *"About thirty-five miles out of Crane, we crossed Camp Creek, a tributary of the south fork of the Malheur River. Upon investigation there, we found that the stream seemed to be alive with young Chinook salmon and a few steelheads" (Ballagh 1926).*

Potential spawning streams for anadromous fish include but are not limited to the upper Malheur River, North Fork Malheur River, South Fork Malheur River, Willow Creek, Cottonwood Creek, and Bully Creek. Historical information on the distribution of chinook salmon in the Malheur River is limited. Information on the historical distribution of anadromous fish runs in the Malheur River is referenced in a few journals written by early explorers and military personnel (Williams 1865, Ogden 1950). These early journals are subject to interpretation as stream names have changed since the early expeditions in the early 1800's. A difficulty in the determination of historical distribution of chinook salmon in particular streams is debated among professional managers and local residents. Many can concur that the upper Malheur River and North Fork Malheur drainages most likely sustained anadromous fish. The Upper Malheur River, North Fork Malheur River and associated headwaters are presumed to have produced significant numbers of anadromous fish and currently has adequate habitat for anadromous fish and have been recommended for reintroduction (Buckman 1990, Thompson and Haas 1960).

4.2 Performance Measures

4.2.1 Introduction to Performance Measures

Biological objectives are described in terms of "tributary performance measures" by the Independent Science Advisory Board ("A Review of Strategies for Recovering Tributary Habitat", ISAB, Bilby et al. 2003):

> *"Biological objectives are important because they provide measurable targets for habitat recovery. Tributary performance standards are referenced in the All-H Report and are taken to mean the habitat conditions that would achieve biological recovery in an area of interest. These standard become the de facto biological objectives for tributary habitat…Habitat standards based on the distribution of conditions observed in unmanaged watersheds are more ecologically relevant, especially if they are expressed at appropriately large scales of space and time."*

The Independent Science Advisory Board clearly rejects the concept of fixed habitat standards, because these fixed standards do not easily account for natural environmental variation, differences in habitat requirements among species, or changes in habitat needs over a species life cycle.

In the Malheur Subbasin habitat performance measures were developed using the expert system procedure in the Qualitative Habitat Assessment (QHA) in combination with reference condition information on stream geomorphology and riparian condition. The QHA procedure asks experienced fisheries biologists in the subbasin to compare the existing habitat condition with a hypothesized reference condition when evaluating the habitat attributes. A hypothesized reference condition is necessary because of the diversity of natural stream conditions in the subbasin and the lack of a rigorous reference condition database for the subbasin.

For the aquatic assessment, QHA provides an organized forum for an expert panel to make judgments about existing and reference condition. The assumed "accuracy" of such a system depends primarily on the years of experience individual members have within the subbasin. We were fortunate that our expert panel did indeed have many years of experience in the Malheur Subbasin and we believe there is a high degree of confidence in identifying the limiting factors at the subbasin and watershed scale. The degree of confidence varies by watershed and reach depending on the studies and a biologist's localized experience in a specific area. This variation in confidence is reflected in the reach-by-reach documentation confidence rating columns recorded in the QHA form.

4.2.2 Channel Stability or Channel Geomorphology

The limiting factors, as evaluated within QHA, are interrelated (not independent) and vary to the degree of confidence that can be assessed using professional judgment. The attributes can be sorted into major limiting factors, for which we can develop a reasonable general objective based on hypothesized reference condition, and secondary factors, which are generally dependent on the major limiting factors. Reference conditions are described in the paragraphs that follow for the major limiting factors; this includes Riparian Condition, Channel Stability (Channel Form), Low Flows, and Obstructions.

<u>Reference condition</u>: For the purposes of QHA channel stability is defined as the condition of the channel in regard to bed scour and artificial confinement. Channel stability in this context is a measure of how the channel can move laterally and vertically and form a "normal" sequence of stream unit types. As for all habitat attributes there are no specific reference condition information available for the Malheur subbasin. Reference conditions can best be estimated by first classifying channels into a common framework. Channels with similar gradient and confinement would be expected to respond similarly to inputs of water, sediment and large woody debris. A simple stream classification was performed based on channel gradient and confinement (See Assessment Section for methodology).

An example of the resulting distribution of reference gradient and confinement classes for the Main Malheur is shown in **Figure 4**. Low-gradient unconfined channels made up the largest single grouping within the Main Malheur watershed. In their reference condition these channels would most likely have been classified as Rosgen type C, or type E channels (Rosgen, 1996).

The next largest grouping is the low-gradient confined channels. In their reference condition these channels would most likely have been classified as Rosgen type F channels. The remaining channels are all in confined category, and in their reference condition would most likely have been classified as Rosgen type Aa+, A or B channels, depending on gradient.

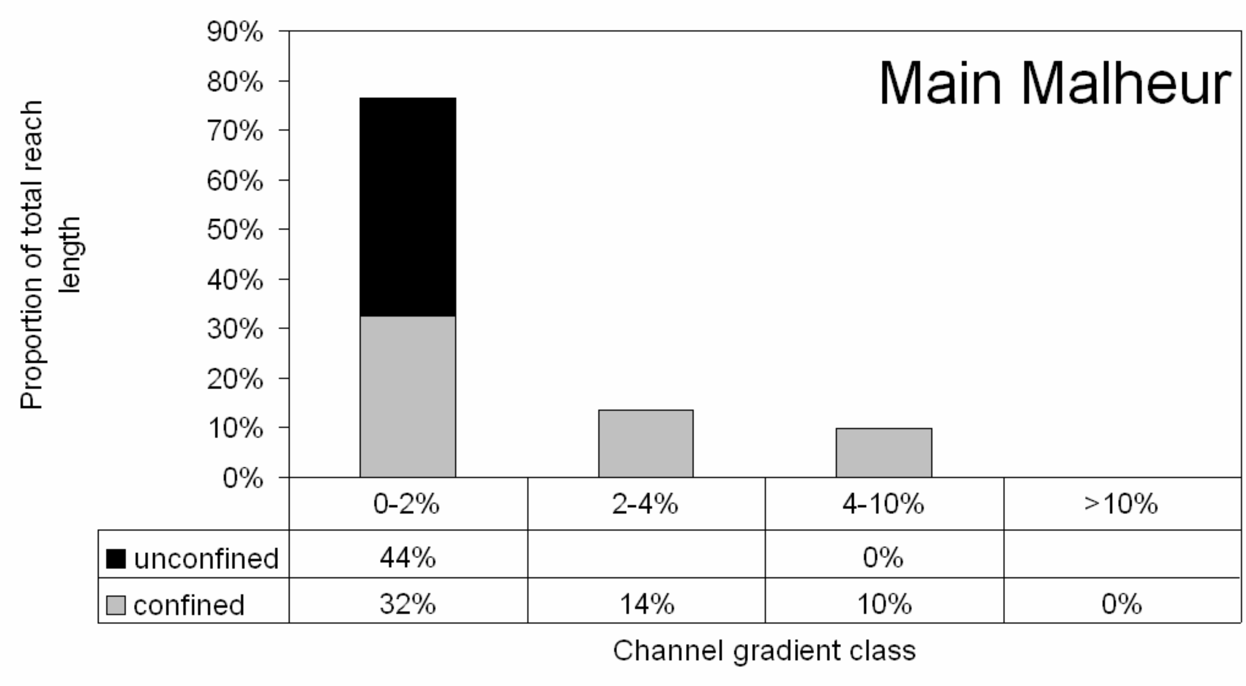

Figure 4. Estimated distribution of reference channel type in the Main Malheur watershed.

4.2.3 Riparian Condition

Reference conditions: For the purposes of QHA, Riparian Condition is defined as the condition of the stream-side vegetation, landform and subsurface water flow. Reference riparian conditions were estimated for the entire Malheur subbasin using Oregon Natural Heritage Program historical vegetation descriptions and riparian descriptions prepared for EPA Ecoregions. (Refer to the Assessment for methods and rationale.) The underlying geomorphic variability among streams also influences riparian conditions. For example, wide areas of phreatophytic vegetation would have been expected to develop along low-gradient unconfined reaches in response to fluvial deposition of fine sediments, and a high near-stream water table.

Almost the entire riparian length in the Main Malheur watershed is located within either the Snake River Plain or Northern Basin and Range level III ecoregions. Reference conditions in the immediate streamside area would have consisted primarily of hardwood species (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage). Moving laterally away from the streams the riparian and adjacent upland vegetation consisted primarily of Wyoming big sagebrush (58% of total length), Riparian hardwoods (15%), and other sagebrush species (Basin big sagebrush, low sagebrush-Wyoming big sagebrush, Low sagebrush, Wyoming big sagebrush-squawapple – 10%). (Note: The Oregon

Natural Heritage Program vegetation types are useful primarily as a qualitative description of expected vegetation, not for the mapped historical extent of vegetation types, which local experts believe contain substantial errors.)

4.2.4 Flow Conditions

High Flow Reference Condition: is defined within QHA as the frequency and amount of high flow events. Volumes of runoff within the entire Malheur subbasin are greatest during the spring months, occurring primarily from runoff associated with snowmelt. Peak flows occur typically in the winter months and can be generated by either rainstorms or rain-on-snow events, particularly in the northern area bordering the Blue Mountains. Frozen ground contributes to the winter flooding events. Spring peak flows associated with both rain and snowmelt also occur in portions of the Subbasin. Summer rainstorms also generate peak flows in this area although, infrequently.

Low Flow Reference conditions: Low Flow is defined within QHA as the frequency and amount of low flow events. An example of estimating the low flow reference condition is shown for the Main Malheur Watershed for the Malheur River and Cottonwood Creek. Natural volumes of runoff are lowest in both tributary (Figure 5) and mainstem reaches (Figure 6) during the late summer and early fall. Within low-elevation tributaries (i.e., those lacking significant snow pack) the ratio of low flow to high flows is quite large (Figure 5) as compared to mainstem reaches (Figure 6) which are buffered by late season snowmelt. The negative flow rates (Figure 6) refer to the deficit in flows if all the appropriated water rights were fully utilized.

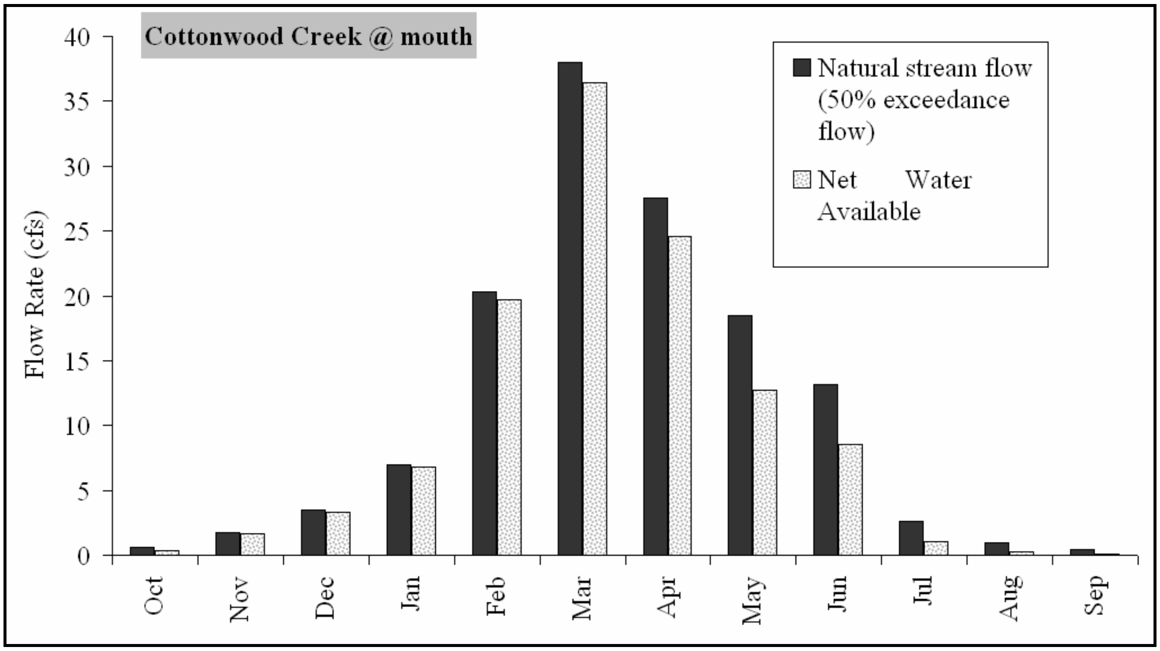

Figure 5: Estimated natural streamflow, and net available flow, at the mouth of Cottonwood Creek (Main Malheur watershed) (OWRD, 2004)

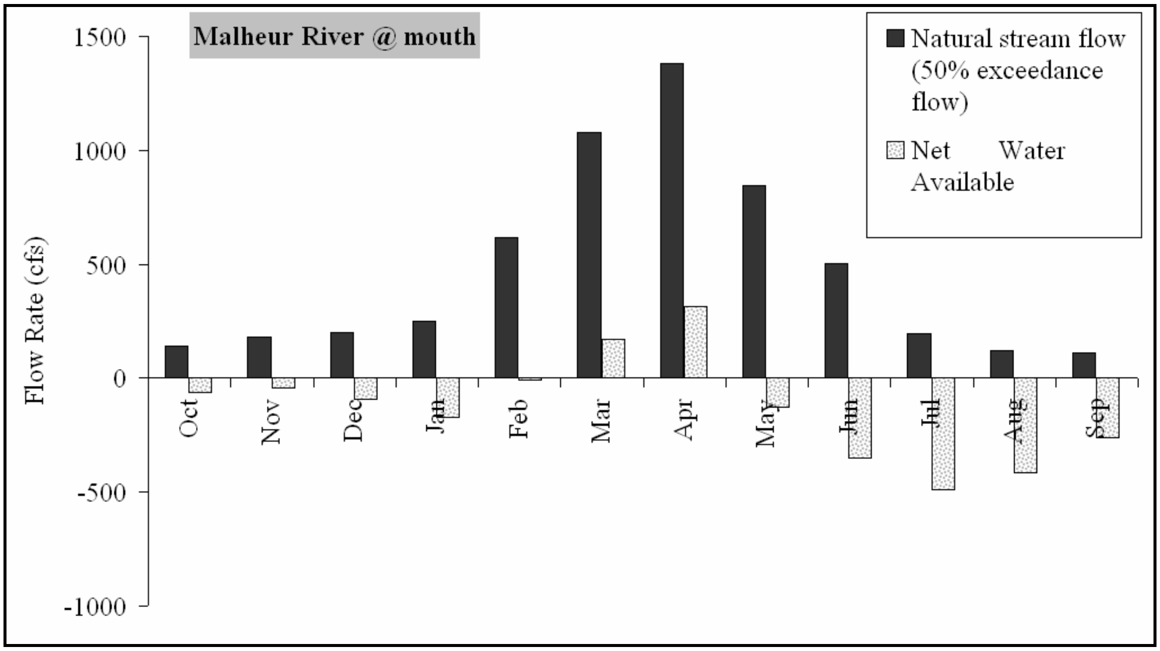

Figure 6: Estimated natural streamflow, and net available flow, at the mouth of the Malheur River (OWRD, 2004)

4.2.5 Reference Condition for Other Habitat Attributes

The other habitat factors; habitat diversity, fine sediment, dissolved oxygen, low temperature, high temperature, pollutants, and obstructions; are in some manner dependent on or directly related to the major limiting factors discussed above. *Habitat Diversity* (Channel Complexity) is closely related to channel stability and riparian condition. Sequences of habitat units would be expected to follow a distribution that was driven by the channel type. Given this inherent variability it is not possible to use a static metric (e.g., frequency of pools, frequency of LWD pieces) to describe habitat diversity in the reference condition, and it is beyond the scope of this document to develop reference conditions for habitat diversity. *Fine Sediment* deposition is driven by the overriding valley geomorphology that would result in higher deposition within the low gradient, unconfined reaches, and higher rates of deposition in steeper more confined channels. Reference sediment levels would also be driven by natural rates of bank erosion (driven in part by the reference riparian vegetation conditions), upland vegetation and disturbance, and flow regime.

Natural low *Dissolved Oxygen* levels are not known within streams of the Malheur Subbasin, however, they would be expected to be inversely proportional to water temperatures, which would vary with elevation and stream shading. Consequently, reference dissolved oxygen levels would be expected to be higher in the forested headwater reaches than in the lower elevation, non-forested streams. *Low Temperature* is defined as the duration and amount of low winter temperatures that can be limiting to fish survival. Low wintertime temperatures can negatively impact fish when anchor ice forms. Natural low water temperatures are a result of a lack of thermal retention along streams (due in part to a lack of riparian canopy), shallow streams, low wintertime water levels, and elevation. *High Temperature* is defined as the duration and amount of high summer water temperatures that can be limiting to fish survival. Reference conditions for high summertime water temperatures would be expected to be inversely proportional to elevation and riparian cover, and would be influenced by streamside microclimate. *Pollutants* are defined as toxic (acute and chronic) substances introduced into the stream. In the reference condition it is unlikely that any significant sources of pollutants existed within the subbasin. *Obstructions* are defined as physical barriers to the movement of fish throughout the reach. In the reference condition it is unlikely that any significant sources of obstructions existed within the reaches defined for this assessment.

Summary

Key Habitat Attributes can be used as surrogates for other related habitat characteristics. Identifying hypothesized reference condition for the key habitat attributes provides a logical framework for discussing a subbasin wide hypothesis, and organizing strategies to address the limiting factors. The key habitat attributes are channel conditions (channel stability or channel geomorphology), riparian conditions, flow conditions, and connectivity. Connectivity is evaluated in QHA by assessing the impact of obstructions in a stream reach, essentially the inverse of connectivity.

4.3 Summary of Aquatic Limiting Factors at the Basin Scale.

4.3.1 Methods

We used the Qualitative Habitat Assessment (Oregon TOAST version 1.01 dated 10-24-2003) to identify current condition of the habitat and limiting factors. The methods for this analysis are described in detail in the Aquatic Assessment document (Appendix A, Section 3, Part 2). The critical elements of the QHA procedure are:

- The "Expert System", using professional judgment of the Subbasin Aquatic Technical Team,
- Reach Selection and Focal Species Range,
- Aquatic Species Hypothesis, and
- The Identification of Reference Condition, Current Condition and Limiting Factors.

The limiting factors are identified at the stream reach scale, and then summarized at the watershed scale, the most appropriate spatial scale for reporting habitat conditions using the QHA methodology. The limiting factors are summarized in the Aquatic Assessment document (Section 3, Appendix A, Part 2) for the six watersheds within the Malheur Subbasin (i.e., Main Malheur, Upper Malheur, Willow Creek, Bully Creek, North Fork Malheur, and South Fork Malheur). These summaries demonstrate that the primary limiting habitat attributes are:

1. Channel Conditions,
2. Riparian Conditions,
3. Flow Conditions (emphasis on low flows), and
4. Obstructions (habitat connectivity).

For the purposes of summarizing the aquatic habitat condition and communicating results in the Management Plan, the results are discussed below at the Subbasin Scale.

4.3.2 Channel Conditions

Current channel conditions throughout the Malheur subbasin are shown in Figure 7, and summarized in Figure 8. The best current channel conditions (i.e., reaches having current channel conditions that are 75-100% of optimum) are located primarily in headwater areas of the Upper Malheur, North Fork Malheur and Bully Creek watersheds (Figure 7), and make up approximately 20% of the total reach length in the subbasin (Figure 8). Another 40% of the total reach length currently has channel conditions that are in moderately good shape (50-75% of optimum (Figure 8). These streams are located throughout all watersheds, primarily in headwater and middle positions. Streams that currently are rated as having only 25-50% of optimum channel function are located both along mainstem rivers and in tributary headwaters, and comprise about 25% of the total reach length. Finally, those channels that have the most severe impacts to channel function (currently rated as 0-25% of optimum) are located along the mainstem Malheur River, mouth to Namorf, Bully Creek below the reservoir, and the lower reach of Willow Creek, and comprise about 10% of the total reach length. The management that have resulted in these current channel ratings include:

- Roads (highways and forest roads) and railroads (abandoned) encroaching on floodplains and stream channels and limiting lateral channel migration and the development of natural channel habitat sequences.
- Relocation and channelization of formerly unconfined stream reaches for the purpose of maximizing pasture and tillable lands.
- Loss of beaver and beaver dam complexes from most streams and meadows.
- Mechanical damage to streambeds and streambank from livestock and wildlife grazing.
- Dikes and other flood control structures.
- Incision due to upland practices that have changed flow regime and sediment dynamics.
- Legacy impacts from hydraulic and placer mining (Willow Creek watershed).
- Utilization of channels as irrigation conveyance (lower Malheur River, Bully Creek and Willow Creek.

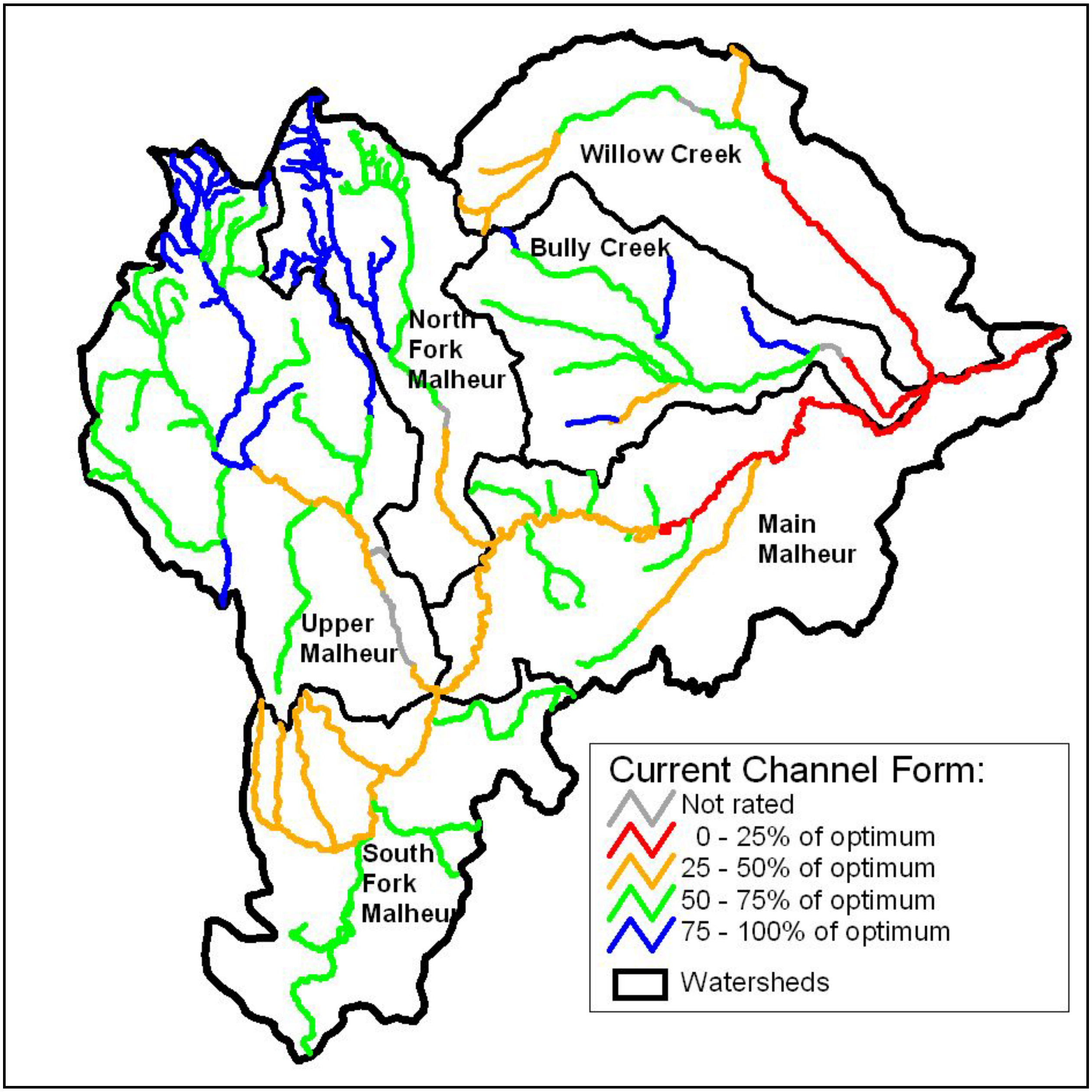

Figure 7: Summary map of current channel conditions within the Malheur Subbasin.

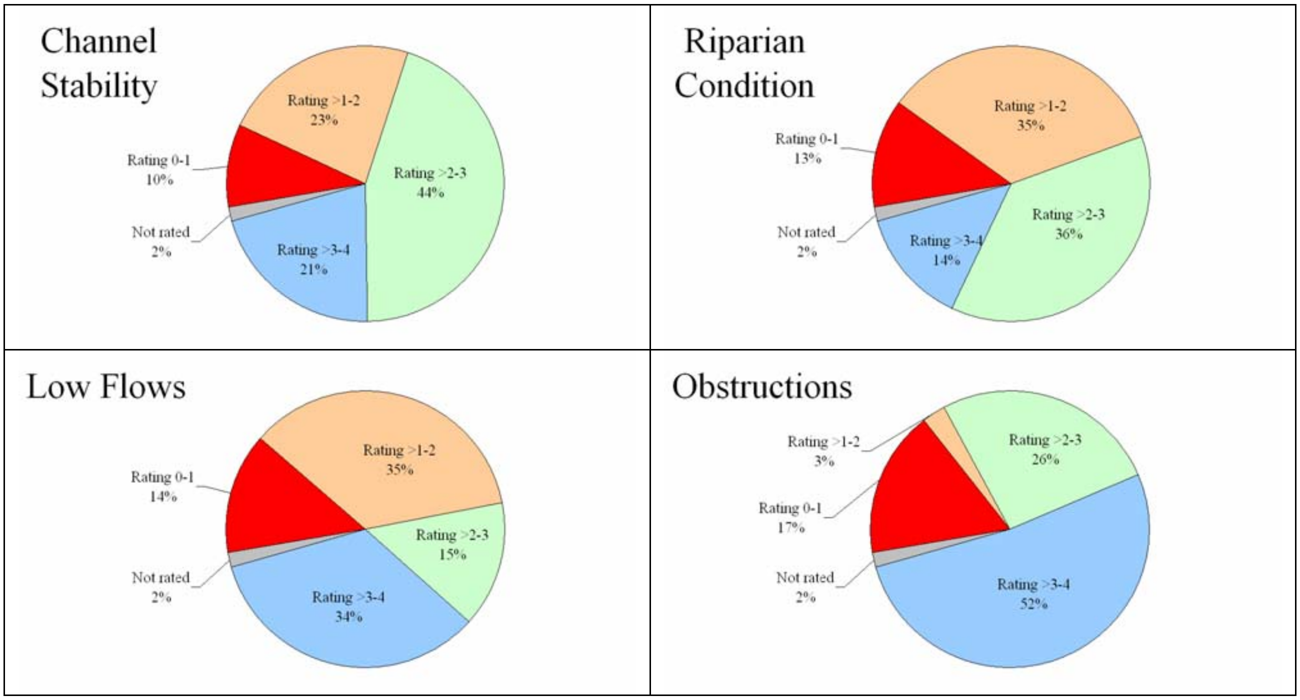

Figure 8. Summary of total reach length within the Malheur Subbasin

4.3.3 Riparian Conditions

Current riparian conditions throughout the Malheur subbasin are shown in Figure 9, and summarized in Figure 8. The best current riparian conditions (i.e., reaches having current conditions that are 75-100% of optimum) are located primarily in headwater areas of the Upper Malheur and North Fork Malheur watersheds (Figure 9), and make up approximately 14% of the total reach length in the subbasin (Figure 8). One third of the total reach length currently has riparian conditions that are in moderately good shape (50-75% of optimum). These streams are located throughout the subbasin, in headwater, middle, and mainstem positions. Interestingly, the lower Malheur River, which was rated as having severe channel impacts is rated as having only moderate riparian impacts. Streams that currently are rated as having only 25-50% of optimum riparian function make up another 30% of total reach length, are located throughout the subbasin, but make up the greatest proportion of reach length in the South Fork and Bully Creek watersheds. Those channels that have the most severe impacts to riparian function (currently rated as 0-25% of optimum) are located along lower Willow Creek, the lower portion of Cottonwood Creek in the Main Malheur watershed, lower Stinkingwater Creek, several stream segments in the Logan Valley area, and in the recently-burned headwaters of the North Fork Malheur. These streams comprise about 14% of the total reach length. The actions that have resulted in these current riparian ratings include:

- Roads (forest and highway) and (abandoned) railroads have eliminated riparian vegetation along some sections of stream. Of particular concern is the probable loss of cottonwood along the larger mainstem rivers.

- Farming practices have limited the functional riparian zone to a narrow band along many streams, and changed the composition and density of riparian species.

- Grazing by livestock and wildlife have changed riparian species composition and density, resulting in fewer large wood recruitment opportunities, and reduced riparian shade. It should be noted that changes in grazing management along some streams have resulted in reestablishment of sedge meadows and woody vegetation in places. (*Note: The relative effect of livestock versus wildlife grazing has not been determined, and therefore both sources are considered together here.)*

- Exotic vegetation has replaced or reduced native plant communities in some locations.

- Loss of beaver and beaver dam complexes from most streams and meadows has eliminated productive riparian and floodplain habitat important to salmonids. In some cases, push-up dams and flood irrigation may mimic beaver dams with respect to locally raising water tables, thereby encouraging development of riparian and wetland vegetation.

- Recent large flood events (e.g., in the lower Cottonwood Creek reach in the Main Malheur watershed) have eliminated woody riparian vegetation in areas.

- Past timber harvest operations has removed riparian vegetation, or limited it to a narrow band along some streams, and changed the composition and density of riparian species. It is expected that current forest practices rules and agency policies will prevent this impact from occurring in the future.

- Channelization and straightening of streams has lowered water tables and eliminated wet meadow systems.

- Wildfire, particularly in the headwaters of the North Fork Malheur, has set riparian vegetation back to an earlier successional phase.

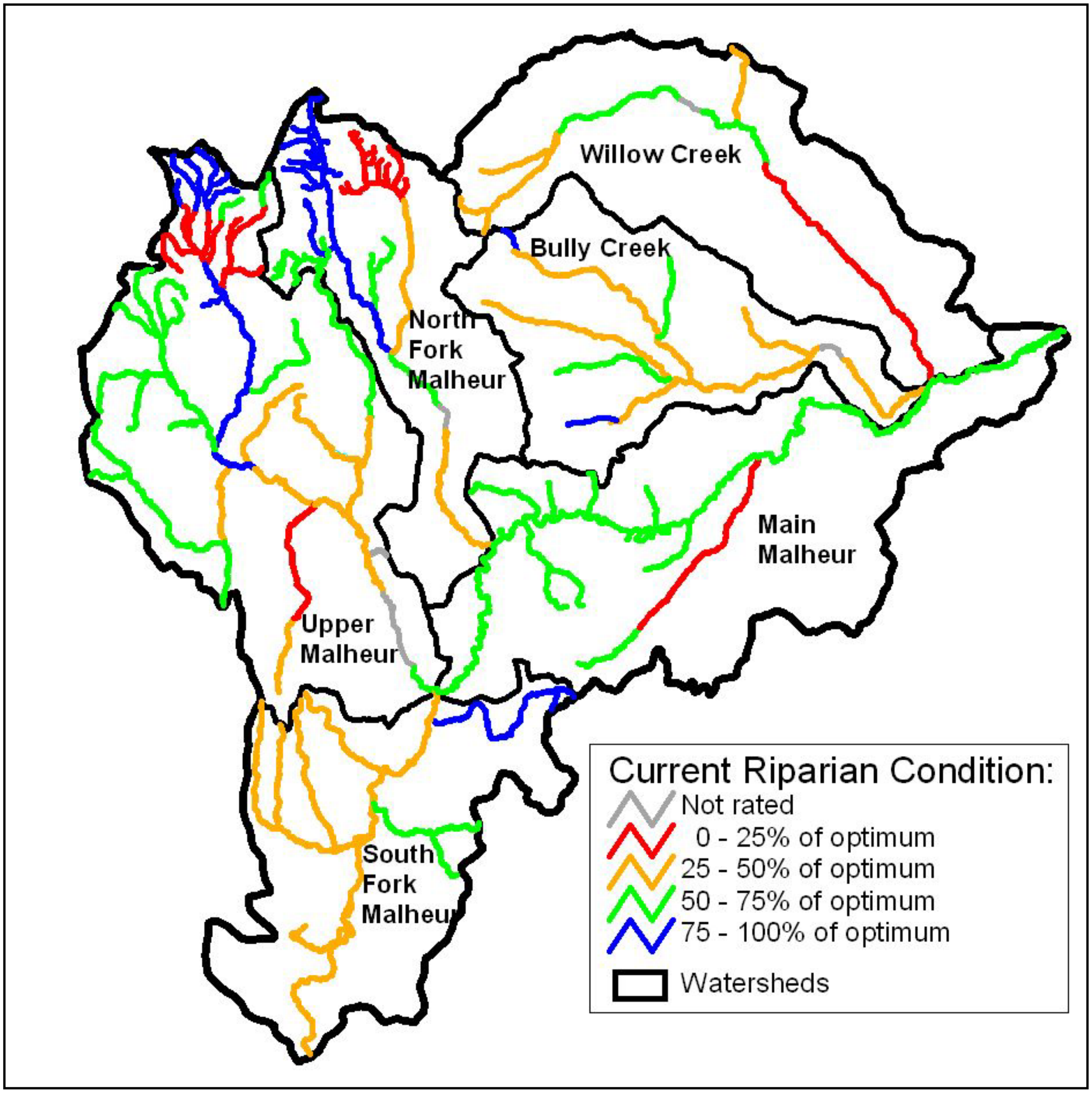

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Figure 9. Summary map of current riparian conditions within the Malheur Subbasin.

4.3.4 Low Flow Conditions

Low flow impacts within the Malheur subbasin are shown in Figure 10, and summarized in Figure 8. The best current conditions with respect to low flows (i.e., reaches having current channel conditions that are 75-100% of optimum <u>for that reach</u>) are located primarily in headwater areas of the Upper Malheur and North Fork Malheur watersheds, and in some headwater tributaries in the Bully Creek and Main Malheur watersheds. These reaches make up a total of approximately 30% of the total reach length in the subbasin. An additional 15% of the total reach length currently has low flow conditions that are in moderately good shape (50-75%

of optimum). These streams are located throughout all watersheds, with the exception of the North Fork Malheur. Streams that currently are rated as having only 25-50% of optimum low flow conditions make up an additional 30% of the total reach length, and are located along mainstem rivers, middle portions of streams, and in tributary headwaters. Finally, those channels that have the most severe impacts to low flows (currently rated as 0-25% of optimum) are located along the mainstem Malheur River and lower North Fork Malheur; and along lower Willow, Bully, and Stinkingwater Creeks. This grouping comprises about 14% of the total reach length in the subbasin. The actions that have resulted in these current low flow ratings include:

- Irrigation withdrawals directly reduce instream flows.
- Channels that have been negatively impacted (as described above) often times have lower effective summertime flows due to flow going sub-surface.
- Dam operations have changed instream low flows. In many cases the utilization of channels as irrigation conveyance downstream of dams has resulted in higher low flows than optimum (e.g., North Fork Malheur below Beulah). Conversely, in some areas (e.g., lower Willow Creek) reservoir releases travel through off-channel canals, with little water released directly to the stream channel, and return flow reenters channel far downstream.
- Loss of beaver and beaver dam complexes from most streams and meadows has eliminated water storage, resulting in lower summertime base flows. In some cases, push-up dams and flood irrigation may mimic beaver dams with respect to locally raising water tables, thereby helping to support base streamflows.
- Channelization and straightening of streams has lowered water tables and eliminated wet meadow systems, resulting in decreased water storage and lower summertime base flows.
- Juniper encroachment is widely considered to adversely affect base flows through increased canopy interception and removal of soil moisture. However, it is not clear if this is a significant problem throughout the range of juniper encroachment. The most probable impacts to base flows are in the immediate streamside area and in the vicinity of seeps and springs.
- Inter-basin (or inter watershed) transfers have reduced low-flows in some portions of the subbasin (e.g., Malheur River below Namorf).

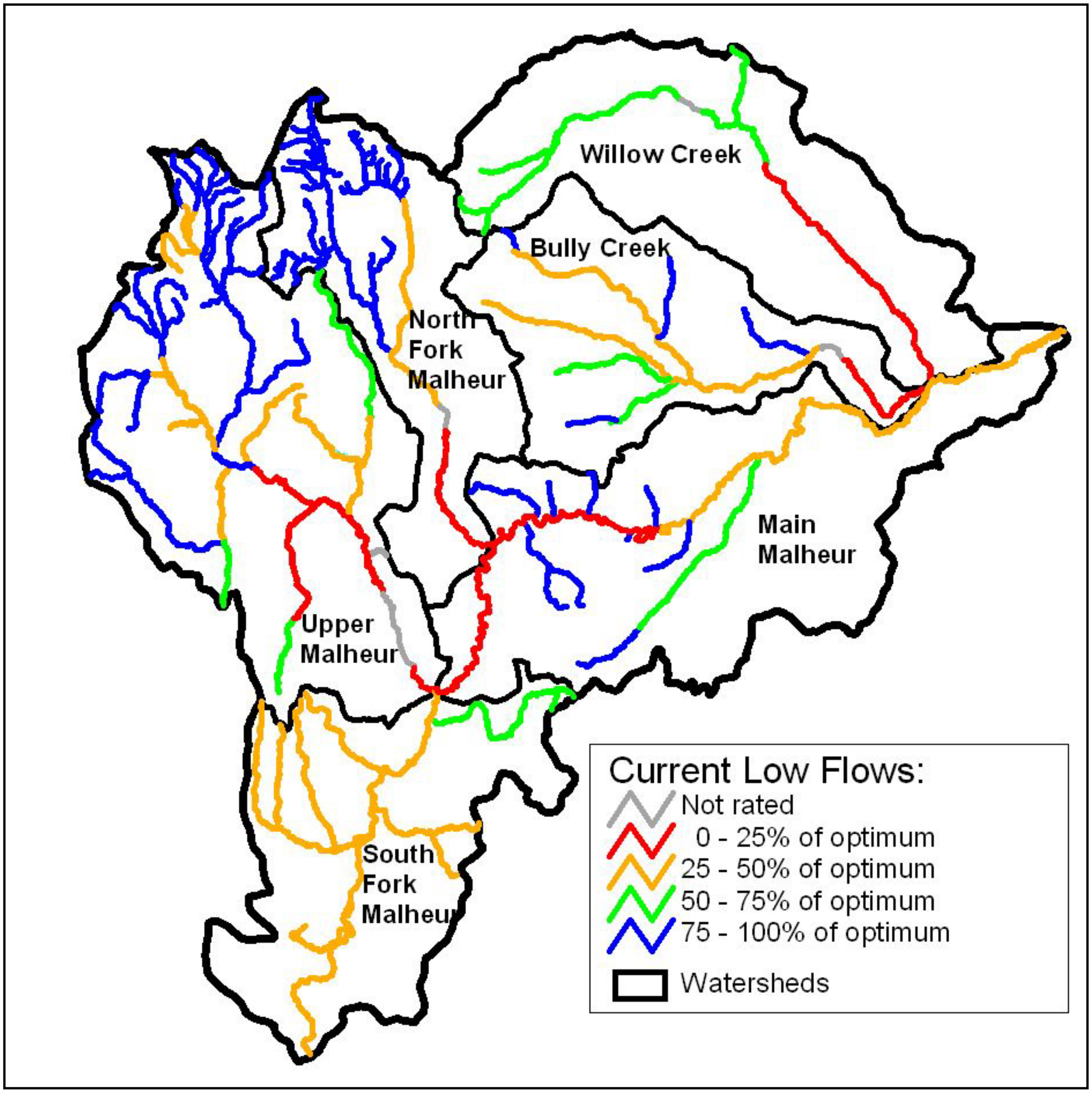

Figure 10. Summary map of current low flow conditions within the Malheur Subbasin.

4.3.5 Obstructions

Reach-level impacts due to obstructions within the Malheur subbasin are shown in Figure 11, and summarized in Figure 8. Obstructions have little impact (i.e., reaches having obstruction ratings that are 75-100% of optimum) over the majority (52%) of the total reach length in the subbasin. These little-impacted reaches are located throughout all watersheds. An additional 25% of the total reach length has only moderate impacts (50-75% of optimum) with respect to obstructions; these reaches also being located throughout all watersheds. Streams where obstructions result in a current rating of 25-50% of optimum occur only in the Logan Valley area and in Griffin Creek; both located in the Upper Malheur watershed, and comprising only 3% of total reach length. The reaches having the most severe impacts (0-25% of optimum) with respect to obstructions are make up 17% of the total reach length, and are located along the mainstem Malheur River from the mouth to Griffin Creek, Stinkingwater Creek, upper Cottonwood Creek (Upper Malheur watershed), and upper Bosonberg Creek. The actions that have resulted in these current obstruction ratings include:

- Dams directly blocking fish passage.
- Direct passage blockage from infrastructure associated with irrigation withdrawals (diversion structures, push up dams).
- Channels that have been negatively impacted (as described above) having sub-surface (or extremely low) flows that prevent fish passage.
- Road and (abandoned) railroad culverts that directly block upstream passage.
- Low water levels associated with dam operations.
- Extremely low flows that result from irrigation diversions.

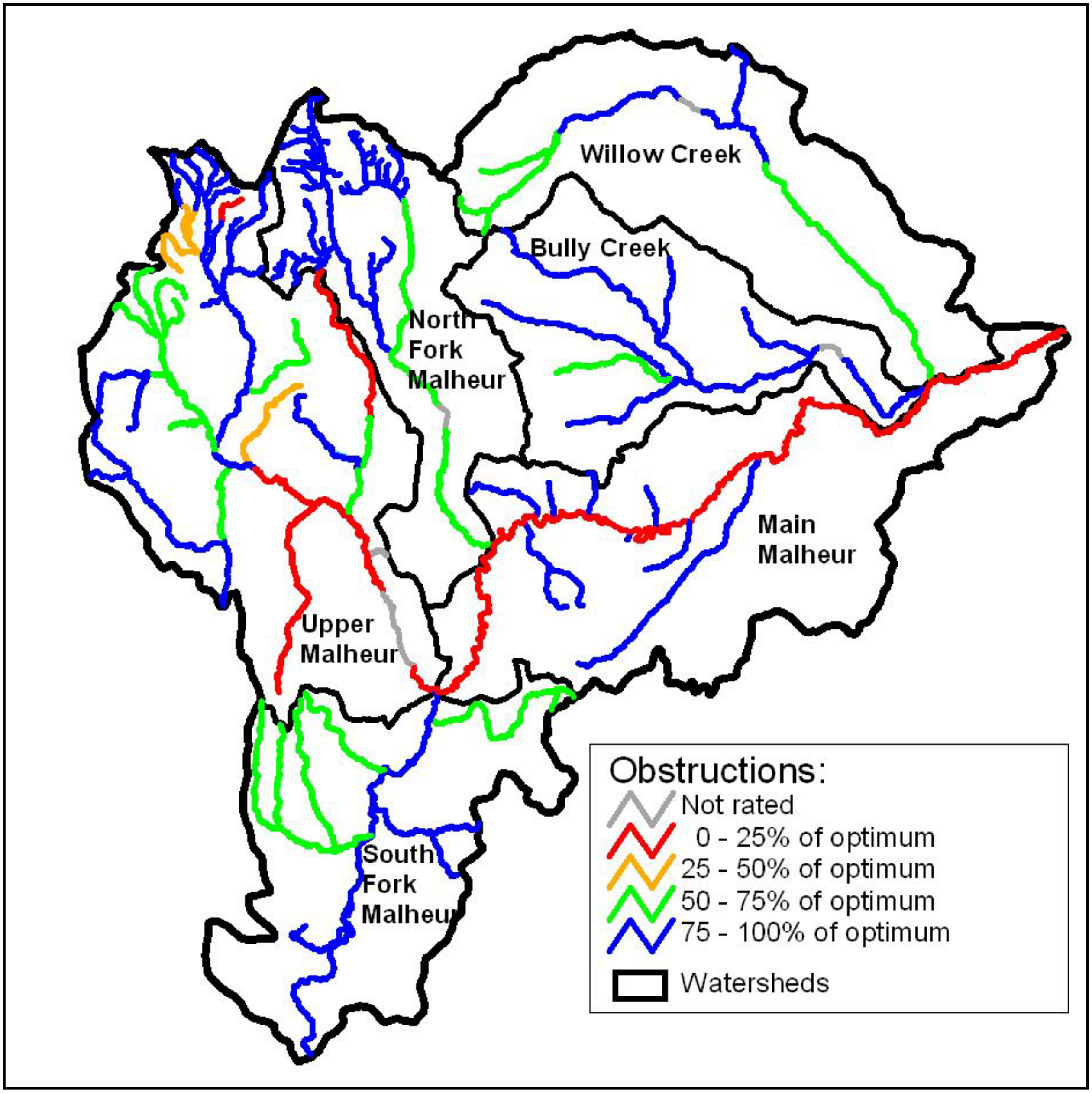

Figure 11. Summary map of current limitations due to obstructions within the Malheur Subbasin.

4.4 Aquatic Biological Objectives

The aquatic assessment sets the stage for development of the aquatic biological objectives. The summary of limiting factors (Section 4.3) identifies four primary habitat attributes (channel conditions, riparian conditions, low flow conditions, and obstructions) that limit the abundance of the three focal species in the subbasin, and also identifies the primary management related activities that result in these limitations. This section summarizes the overall biological objectives for the limiting factors. In assembling these objectives we have been mindful of the need to steer clear of the pitfall of developing static habitat target values, or "one size fits all" solutions. The Independent Science Advisory Board (ISAB, Bilby et al. 2003) recognizes the need to take a spatially variable and temporally dynamic approach to setting biological objective by noting that:

> *"In many cases the application of environmental standards and performance thresholds will divert attention from the real issue – managing watersheds in such a way that ecological processes supporting aquatic productivity and diversity are restored and conserved. Habitat standards have often failed….because they are taken as fixed and do not focus on dynamic processes that create and maintain ecologically complex and resilient watersheds…"*

The ISAB goes on to note that:

> *"This approach* [of setting fixed standards] *is inappropriate because the general trend is to homogenize habitat rather than maintain the complexity of conditions that support biological diversity at multiple scales"*

In outlining the biological objectives for the Malheur subbasin we have tried to incorporate these guidelines. The result is a road map of how to arrive at the "dynamically stable" future condition that will support the full spectrum of aquatic species. The detailed and spatially explicit information needed to implement these objectives (e.g., the current and potential distribution of Rosgen channel types, and the appropriate range of channel conditions that should be represented within those channel types) constitute and important data gap that should be a high priority for evaluation.

The following discussion is organized around the primary limiting factors identified in the QHA analysis.

4.4.1 Channel Conditions

Simply stated, the biological objective for future channel condition is:

Objective 1: To have both a 1) distribution of channel types (e.g., Rosgen (1996) channel types[3]), as well as 2) a distribution of habitat conditions within those channel types, that are as close as possible to the historic distribution of these two variables within the subbasin.

By "as close as possible" we are recognizing that there are human institutions, and infrastructure that supports those institutions, that may result in a difference between the historic and potential future condition.

In the Aquatic Assessment (Summarized above in Section 4.2.2) we presented a simple approach to describing the current and historic distribution of channel types based on a simple channel gradient and valley confinement approach. This channel classification is too coarse to provide the resolution that we would require at the reach or finer scales to implement these objectives. Consequently, a more detailed analysis (e.g., OWRD, 1999) will be needed to identify the current, historic, and potential future distribution of channel types. This approach must also incorporate the concepts of the evolutionary stages of channel adjustment outlined by Rosgen (1996) that channels will proceed through as they adjust to natural disturbances (e.g., wildfire and flooding).

Once the distribution of channel types is known we can then evaluate the appropriate habitat characteristics (e.g., width/depth ratios, entrenchment, pool frequency, etc.) within these channel types. Again, it is important not to think of these as static values within a given channel type, but also to consider the range of values and how that would be distributed across the landscape. Generic reference values (and ranges of values) could be used (e.g., those found in Rosgen 1996), however, it would be more appropriate to use information from the local management agencies (BLM, USFS, etc.) in developing a set of conditions appropriate to the local area.

4.4.2 Riparian Conditions

The biological objective for future riparian conditions follows a similar line of reasoning as for channel conditions:

Objective 2: To achieve a distribution of riparian communities having 1) a species composition, 2) size, and 3) structure that is appropriate for the channel type and ecoregion, recognizing that the distribution will also vary in time in response to natural disturbance factors.

In the Aquatic Assessment (and summarized above in Section 4.2.3) we presented an assessment of historic riparian communities that varied around the subbasin by EPA level III and IV

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[3] The Rosgen classification system is used in this discussion, given it's ubiquity and usefulness in the interior west, however, other classification systems may be equally appropriate

ecoregion and channel type. The values described are for only a portion of the subbasin (the Blue Mountains level III ecoregion), however, similar descriptions could be developed for streams in other ecoregions within the subbasin. The recognition that the potential riparian communities will vary with varying channel conditions ties this biological objective to the previous. For example, restoration of a stream that presently flows through a channelized former-wet meadow will require not only restoration of the plant community, but also restoration of the channel to restore the hydrology and soil conditions under which the potential plant community can develop.

The recognition that natural disturbance factors (e.g., wildfire, flooding, etc.) will influence the potential community both in space (different portions of the subbasin will be more or less susceptible to these disturbances) and time (disturbance has a probability and distribution associated with it) requires us to think of restoration not in terms of fixed target conditions, but as an improving trend in conditions, a trend that may at times experience set backs, across a broader landscape.

4.4.3 Low Flow Conditions

Unlike the previous two objectives, which can, in our opinion, be achieved while sustaining the economic concerns of the human community, the limiting factors that result from low-flow related impacts are less readily resolved. Human use of water in the arid west comes at the direct cost to aquatic species, and attempts to retain more water instream will come at the expense of existing water-dependent practices (i.e., irrigated farming). However, this reality not withstanding, there are activities that can occur that soften the blow to either the human or the aquatic communities. These include methods such as the more efficient use of water, or the voluntary (and fully compensated) transfer of water rights to instream uses, such as is done under the auspices of the Oregon Water Trust (http://www.owt.org). [For example, in the Pahsimeroi Valley in central Idaho, the US Fish and Wild Service and Trout Unlimited are currently developing partnerships with irrigators to develop sprinkler irrigation systems. The saved water will be used to reconnect spawning habitat for bull trout in a tributary that has been dewatered for over sixty years (Personnel Communication –K. Forster, BLM Challis Field Office)].

Fortunately, from the perspective of restoring the health of the focal species in the Malheur subbasin, low flows are not the primary limiting factor among the assessment reaches. Consequently, moderate improvements in the existing low flow situation (through technological advances as well as voluntary reductions in use), coupled with improvements in channel and riparian conditions, will result in substantial benefits to the aquatic community. In light of this we propose the following biological objective with respect to low flows in the Malheur subbasin:

Objective 3: To enhance low flow conditions such that they mimic the natural hydrograph to the extent possible, given the limitations posed by agriculturally dependent water use in the region.

The practical implication of this objective is that we will seek to reduce irrigation impacts to the extent possible, through both technological innovation and voluntary reductions in water use, however our focus will be on the non-consumptive factors that also affect low flows such as 1) lower effective summertime flows due to poor channel conditions that result in flow going subsurface, 2) dam operations and irrigation infrastructure changes that can keep more water in the stream at the times and in the places that it is needed, and 3) restoration of natural storage pathways within the subbasin such as beaver dam/meadow complexes, and channel/floodplain connectivity.

4.4.4 Obstructions

Within-subbasin Obstructions

The limiting factors posed by obstructions are confined to only a small portion of the subbasin; 75% of the total reach length having no or only minor impacts from obstructions. However, the impacts to focal species posed by obstructions are significant. Fortunately, most of the causal agents for these impacts can be remedied by technological means (e.g., irrigation galleries) simple and well-accepted solutions (e.g., culvert removal or replacement), or will be remedied by addressing some of the other concerns discussed above (e.g., improved channel conditions that eliminate sub-surface flow problems). Consequently, the biological objective with respect to obstructions is:

Objective 4: Eliminate, to the extent possible, all human-related obstructions to the movement of the aquatic focal species within the Malheur subbasin.

Again, the term “to the extent possible” is meant to recognize that there are human institutions, and infrastructure that supports those institutions, that may make it impractical to eliminate certain obstructions.

Out-of-Subbasin Effects (Obstructions)

The QHA does not do an adequate job in addressing the limitations presented by out-of-subbasin factors on focal species populations. In particular, the effects of mainstem Columbia and Snake River dams on anadromous species are not addressed. The following objective recognizes that mainstem dams have (at least for the time being) extirpated anadromous fish from the Malheur Subbasin consequently we can only protect and enhance the ecosystem that remains. Therefore, the biological objective with respect to out of subbasin obstructions is:

Objective 5: Mitigate for the loss of anadromous fish species in the Malheur Subbasin through substitution programs that emphasize the long-term sustainability of native resident fish in native habitats wherever possible.

Substitution is appropriate for lost salmon and steelhead in areas that previously had anadromous fish but where anadromous fish access is now blocked by hydropower development and where in-kind mitigation cannot occur. Resident fish substitution for anadromous fish losses should occur in the vicinity of the salmon and steelhead losses being addressed, but substitution and mitigation measures may occur on or off-site.

4.4.5 Other Attributes

The primary limiting factors for the streams in the Malheur subbasin are the four habitat attributes described above. Furthermore, the additional habitat attributes can be considered as being either dependent on these “big four” primary factors, and therefore remedied by the objectives discussed above, or of relatively local and/or minor concern. However, for the sake of completeness, we will explicitly state the biological objectives for these other attributes here:

- Habitat diversity shall be restored as near as possible to historic conditions, as a result of restoring channel conditions and riparian conditions,

- Fine sediment and high flow related impacts are expected to be reduced as ongoing best management practices are implemented that will reduce sediment inputs across the landscape, and as a result of restoring channel conditions that will reduce sediment deposition problems.

- High and low water temperatures and dissolved oxygen conditions shall be restored as near as possible to historic conditions, as a result of restoring channel conditions, riparian conditions, and improving low flow conditions,

- Localized impacts due to Pollutants are expected to be reduced as ongoing best management practices are implemented that will reduce inputs of pollutants across the landscape.

4.5 Basin Scale Limiting Factors Not Addressed in QHA

4.5.1 Major Dams

The QHA category identifies obstructions to fish movement related to irrigation diversions and dewatered sections but does not include the major dams in the subbasin. The major dams are basin-scale limiting factors that are significant barriers to fish movement that block access, isolate fish populations, and prevent access to seasonal use of habitats.

Access to the Malheur from the Snake River was limited after 1881 due to the construction of the Nevada diversion dam located on the Lower Malheur River immediately downstream of Vale at about RM 19. Warm Springs Dam began operation in 1919 on the Upper Malheur River, and the Agency Valley Dam (Beulah Reservoir) was constructed in 1926 on the North Fork. Both Warm Springs and Agency Valley Dams are upstream migratory barriers to fish with no fish passage facilities. Namorf diversion further blocks fish passage on the Main Malheur River below the two main dams. Dams in Bully Creek and Willow Creek prevent seasonal movement of resident species.

Brownlee Dam constructed in 1959 on the Snake River ultimately blocks anadromous fish species from access to the Malheur River. Construction of Ice harbor in 1962, Lower Monumental in 1969, Little Goose in 1970, Lower Granite in 1975, Hells Canyon in 1967, and Oxbow in 1961 have increased the population loss to the Snake River chinook salmon further complicating reintroduction efforts above Brownlee Reservoir. Though reintroduction is possible, significant changes in the operation and design of these facilities will be required.

4.5.2 Exotic Species

Non-native, warm water species generally occur in the lower Subbasin and include largemouth and smallmouth bass, black and white crappie, bluegill, warmouth, pumpkinseed, channel catfish, brown bullhead, yellow perch, and flathead catfish. Warm water, non-native fish displace redband trout in some cases. Non-native, cold water species present include brook trout and hatchery rainbow trout. Brook trout are mainly distributed in the upper Malheur River above Warm Springs Reservoir and associated tributaries.

Introduced brook trout are known to limit bull trout populations in the Upper Malheur River through competition and hybridization. The Draft Bull Trout Recovery Plan (USFWS 2002) describes a number of actions (enforcement, education, eradication) to reduce the effect of exotic species on bull trout. Direct removal of brook trout in the Upper Malheur River is under evaluation by the local bull trout recovery team.

4.6 Subbasin wide Hypothesis

The Aquatic Subbasin wide hypothesis is based on the discussion of limiting factors above as linked to possible and feasible future actions. The primary assumptions and working hypotheses are:

- ***The aquatic technical team has adequately interpreted and synthesized the known data regarding current and reference habitat conditions within the subbasin***. We are confident in this assumption, given the presence on the team of individuals with long experience in the subbasin, and considering the breadth of agency involvement.

- ***The Qualitative Habitat Assessment (QHA) model adequately represents the complex relationships between the focal species and their environments***. The QHA is an expert system, and as such provides a somewhat more structured and better-documented approach to evaluating limiting factors then expert opinion alone. However, unlike the more sophisticated Ecosystem Diagnostics and Treatment (EDT) model, from which QHA is descendent, there is no explicit way to evaluate the validity of the outcome (i.e., no estimates of population size are generated).

- ***The species-specific hypotheses are correct and adequately represent how focal species use the subbasin***. We summarized the aquatic technical teams understanding of how the three focal species use the various reaches within the subbasin, and what habitat attributes are most important to the focal species under both current and reference conditions. Given the aquatic technical teams expertise within the subbasin we feel that these hypotheses are reasonable.

- ***Of the eleven habitat attributes considered in this analysis the following four factors are the most limiting, and adequately illustrate the concerns with respect to the focal species***:

- **Channel conditions**: Channel condition (the condition of the channel in regard to its ability to move laterally and vertically and to form a "normal" sequence of stream unit types) is a primary determinant of the success of all three focal species. Classification of channels allows a mechanism to adequately capture the expected condition of the channel with respect to habitat quality, and can be used to evaluate the potential of a given stream reach. Caveats to this hypothesis are that 1) a systematic subbasin-wide understanding of reference and current channel types does not currently exist, but could be assembled fairly easily using existing methodologies (e.g., Rosgen, 1996; OWEB, 1999); 2) local metrics describing the range of appropriate habitat characteristics by channel type does not currently exist, but could be assembled from existing data and expertise; and 3) in evaluating the current health of the channel system we must consider variability due to stochastic disturbance events. A final hypotheses is that the management-related activities that have contributed to currently degraded channel conditions can be reversed relatively easy with only limited impacts to the social and economic fabric of local communities.

- **Riparian Conditions**: Riparian conditions are also a primary determinant of the success of all three focal species, although the effect varies by species due to the different life stage hypotheses referenced above. Appropriate riparian conditions vary with respect to ecoregion, as well as with channel condition. Consequently, riparian enhancement is tied in many areas to channel restoration. As with channel condition natural disturbance factors influence the potential riparian community both in space and time. Consequently, restoration is best thought of in terms of trend across a broader landscape. An additional hypothesis is that the management-related activities that have contributed to currently degraded riparian conditions can be reversed relatively easy with only limited impacts to the social and economic fabric of local communities.

- **Low flows**: Unlike the previous two biological objectives, which can (in our opinion) be achieved while sustaining the economic concerns of the human community, the limiting factors that result from low-flow related impacts is a much less tractable problem. However, low flows are not the primary limiting factor among the assessment reaches, and moderate improvements in the existing low flow situation, coupled with improvements in channel and riparian conditions, will result in substantial benefits to the aquatic community.

- **Obstructions**: The limiting factors posed by obstructions are confined to only a small portion of the subbasin, however, the impacts to focal species posed by obstructions are significant. Most of the impacts can be remedied by technological means or relatively simple and well-accepted solutions, and many will be remedied by addressing the channel, riparian and low flow concerns discussed above.

- ***In the big picture the other limiting factors (in addition to the four described previously) can be mostly ignored***. Additional habitat attributes are either dependent on the “big four” factors identified above, or are of relatively local and/or minor concern.

- ***Prioritization of restoration and protection can be first approximated using QHA, but must consider additional factors.*** The QHA methodology produces a prioritization approach for reach-scale restoration and protection (see Section 3.7 Aquatic Assessment, Appendix A). However, this first cut must be tempered with additional considerations, such as the additional factors described below.

- ***Additional factors are not adequately addressed in QHA, and must be addressed in a more qualitative fashion.*** As discussed in Section 4.5 at least three additional factors (large dams within the subbasin, exotic species interactions, and out of subbasin effects - primarily dams that block anadromous fish access) are not adequately addressed within QHA. Consequently, these must be highlighted in the management plan as areas of special concern.

- ***Static, "one size fits all" biological objectives are inadequate for outlining a restoration strategy and management plan for the Malheur subbasin***. As noted by the ISAB, and as discussed in Section 4.2.1, biological objectives must be developed with consideration given to inherent variability both in space (among the reaches in various parts of the watershed, and within the reaches themselves), and over time in response to natural disturbance and channel evolutionary response. The biological objectives, particularly for channel and riparian condition, have been outlined with this in mind.

- ***Many, if not most, of the likely strategies derived from these biological objectives are already being implemented within the subbasin***. The products from the aquatic assessment do not implicate a change in direction for the various land management agencies, individuals, or other entities (e.g., watershed council) within the subbasin. Rather, the products here will (hopefully) help direct and prioritize the ongoing activities at the watershed scale.

- ***Population performance is the ultimate arbiter of habitat protection/restoration activities, and must be incorporated into monitoring and evaluation plans***. The underlying assumption of the aquatic assessment is that it is appropriate to focus on habitat, and the focal species response will follow (i.e., "if you build it they will come"). However, this assumption must be borne about by thorough and systematic monitoring programs, many of which are already in place (e.g., ongoing Burns Paiute monitoring in the Logan Valley area).

5 TERRESTRIAL ASSESSMENT SUMMARY

5.1 Terrestrial Focal Species

Fifteen focal species were selected to represent wildlife-habitat types within the Subbasin (Table 8). Focal species characterization and status are described in Appendix A, Part 3- Terrestrial. During the review process, the technical team decided to group a number of wildlife habitat types together because they felt these groups could more accurately reflect wildlife habitat relationships in the Malheur Subbasin.

Table 8: Terrestrial Focal Species as Defined by the Technical Team.

Wildlife-Habitat Type	Focal Species
Mixed Conifer (Montane Mixed Conifer, Interior Mixed Conifer, Lodgepole Pine, Ponderosa Pine, and Alpine Grasslands and Shrublands)	Elk, Pileated Woodpecker, Blue Grouse
Western Juniper and Mt. Mahogany Woodlands (Where Juniper is in its native state, not its encroachment state.)	Mule Deer
Shrub-steppe Habitats (Interior Grasslands, Shrub-steppe, Desert Playa and Salt Scrub Shrublands)	Sage Grouse, California Bighorn Sheep, Pronghorn
Agriculture, Pastures, and Mixed Environs (Includes Urban and Mixed Environs)	California Quail
Open Water, Lakes, Rivers and Streams	Bald Eagle, River Otter
Herbaceous Wetlands	Spotted and Leopard Frog
Interior Riparian Habitat	Yellow Warbler, Yellow-Breasted Chat

The rationale for selection of the focal species is described below:

1. Elk and blue grouse were chosen to represent mixed conifer habitats because there are data available on these species. Both elk and blue grouse require healthy mixed conifer habitats for cover.
2. Clark's nutcracker was discussed as being unsuitable as a focal species for mixed conifer habitats primarily because of their generalist tendencies and their ability to adapt to human disturbance.
3. Pileated woodpeckers were chosen to represent mixed conifer habitats based on the rationale that improved habitat for one cavity nesting species benefits all cavity nesting species.
4. All three species chosen to represent mixed conifer forests and alpine grasslands were chosen to allow for the description of various habitat types within the descriptions of

each species. In this way, the intricacies of each habitat type would be addressed by the chosen focal species.

5. Mule deer was chosen as a focal species for mountain mahogany habitats. There was some debate regarding how to address western juniper, given that it is a problem species in the Subbasin. It was decided that mule deer would adequately represent juniper in its historic state, and the encroachment habits of juniper would be addressed elsewhere.
6. More habitat types were grouped together to accurately reflect wildlife-habitat relationships with respect to shrub-steppe habitats (See Table 8).
7. Sage Grouse was chosen as a focal species for shrub-steppe habitats because it is a shrub-steppe obligate species that is sensitive to degradation of the habitat, so it makes a good indicator species for the habitat.
8. California bighorn sheep were chosen because they are a good indicator for the health of canyon shrub-steppe habitat.
9. Pronghorn antelope are sensitive to habitat loss and degradation, making the species a good indicator of shrub-steppe habitat health.
10. Collard lizards were discussed with respect to shrub-steppe habitats, but rejected because the species is not necessarily associated with a single habitat type.
11. The group discussed salt scrub and playa habitats and found it difficult first to define the habitat type and then to find an indicator species that is obligate to that habitat. The group decided to group the habitat with shrub-steppe, giving it protection under a wider umbrella.
12. Red fox was discussed as a focal species to represent agriculture and mixed environs, but was rejected because of its questionable historic presence this far west.
13. Horned lark was chosen as a representative of grassland health (grasslands are grouped with shrub-steppe habitats).
14. California quail was chosen to represent agriculture and mixed environs because they are a common species in those habitat types.
15. Bald eagle and river otter were chosen to represent open water habitats. They are both good indicators of open water habitat health.
16. Spotted and leopard frogs were chosen as focal species to represent herbaceous wetland habitats because they are good indicators of habitat health.
17. The yellow warbler and the yellow-breasted chat represent interior riparian habitats, both riparian obligate bird species and good indicators of riparian habitat health.

5.2 Terrestrial Habitat Conditions

5.2.1 Characterization of Historic Condition

The ONHP historic or pre-settlement (1850's) mapping and data show that historically, the Malheur Subbasin was dominated by mixed conifer habitats in the upper elevations and shrub-steppe habitats at lower elevations. There were riparian meadows, wetland habitats, lakes, rivers, and streams (See Table 5). Due to limits in available data on historic conditions in the Malheur Subbasin, the accuracy of historic vegetation information is limited and the extent of riparian habitats may be overestimated (J. Kagan, Pers. Comm. 2004). There is a data gap in accurate data regarding historic vegetation information in the Malheur subbasin, particularly in regards to riparian and wetland habitats, therefore change in those habitats cannot be evaluated.

Regular fire cycles influenced both forest and shrub-steppe habitats. The return interval in fire tolerant ponderosa pine and mixed conifer forests is low severity fires with every 1-25 years (Agee, 1981). Fires of moderate severity were common at a 25-100 year interval in dry Douglas fir, mixed evergreen, red fir and Lodgepole pine forests (Agee, 1993). Mountain big sagebrush habitats were maintained with a 20-30 year fire cycle, and Wyoming big sage habitats were maintained by a 50-100 year fire cycle (BLM 2000).

There is a close temporal association between western juniper expansion and the introduction of large numbers of livestock into the Northwest region (both beginning in the late 1800's) lending strong support to the conclusion that livestock grazing and the reduction in fire frequency (due to loss of fine fuels from grazing) are the major causes of juniper expansion (Belsky 1996).

Table 9: Characterization of Wildlife-Habitat Types (Percent of Total).

Wildlife-Habitat Type	Historic Malheur Subbasin	Current Malheur Subbasin	Absolute Change Malheur Subbasin	Relative Change Malheur Subbasin
Montane Mixed Conifer	0.5%	0.2%	-0.3%	-61.3%
Interior Mixed Conifer	1.7%	4.0%	2.3%	139.2%
Lodgepole Pine	0.7%	0.7%	0.0%	-3.4%
Ponderosa Pine	7.9%	5.4%	-2.5%	-32.0%
Alpine Grasslands	0.0%	0.6%	0.6%	Data gap
Western Juniper/Mt Mahogany	2.0%	4.7%	2.7%	134.7%
Interior Grasslands	3.6%	4.8%	1.2%	32.8%
Shrub-steppe	78.9%	68.4%	-10.5%	-13.3%
Desert Playa and Salt Scrub	0.0%	0.0%	0.0%	11.9%
Agriculture, Pasture, Mixed Environs	0.0%	8.2%	8.2%	Not Applicable
Open Water-Lakes, Rivers, Streams	0.1%	0.2%	0.2%	338.7%
Herbaceous Wetlands	Data gap	0.1%	Data gap	Data gap

Wildlife-Habitat Type	Historic Malheur Subbasin	Current Malheur Subbasin	Absolute Change Malheur Subbasin	Relative Change Malheur Subbasin
Interior Riparian-Wetlands	Data gap	0.1%	Data gap	Data gap
Aspen	0.021%	0.023%	0.002%	10.5%
Regenerating young forest	0.0%	0.0%	0.0%	Not Applicable
Barren	2.8%	2.4%	-0.5%	-16.0%
Urban and Mixed Environs	0.0%	0.0%	0.0%	Not Applicable
Note: Total subbasin is 4,730 square miles.				

Source: ONHP Gap Analysis Program Data. The accuracy of this data depends on the accuracy of the original mapping of the historic and current vegetation.

5.2.2 Characterization of Current Habitat

Currently the wildlife-habitat types in the Malheur Subbasin are similar to those historically, with forested habitats in the higher elevations and shrub-steppe habitats in the lower elevations of the Subbasin. However, loss or degradation of terrestrial habitat has occurred throughout the Subbasin due to agricultural development, fire suppression, livestock grazing, logging, western juniper encroachment, noxious weed invasion, roads, and other human disturbance activities.

Loss (legacy conversion in land use) or degradation of habitat has affected shrub-steppe, ponderosa pine, interior grassland, riparian and wetland habitats due to logging, grazing and agricultural use. For a comparison of change from historic to current habitat conditions, refer to Table 5. A map of current wildlife-habitat types is provided in Figure 11.

Overgrazing by livestock (possibly wildlife), fire suppression, introduction of non-native plant species, and roads have caused major changes in native vegetation communities, including riparian areas, wet meadows, and upland habitats over the past century. This has directly impacted many native bird and mammal species. Figure 11 below shows that exotic species establishment and encroachment by western juniper have altered a major portion of the shrub-steppe habitat in the subbasin..

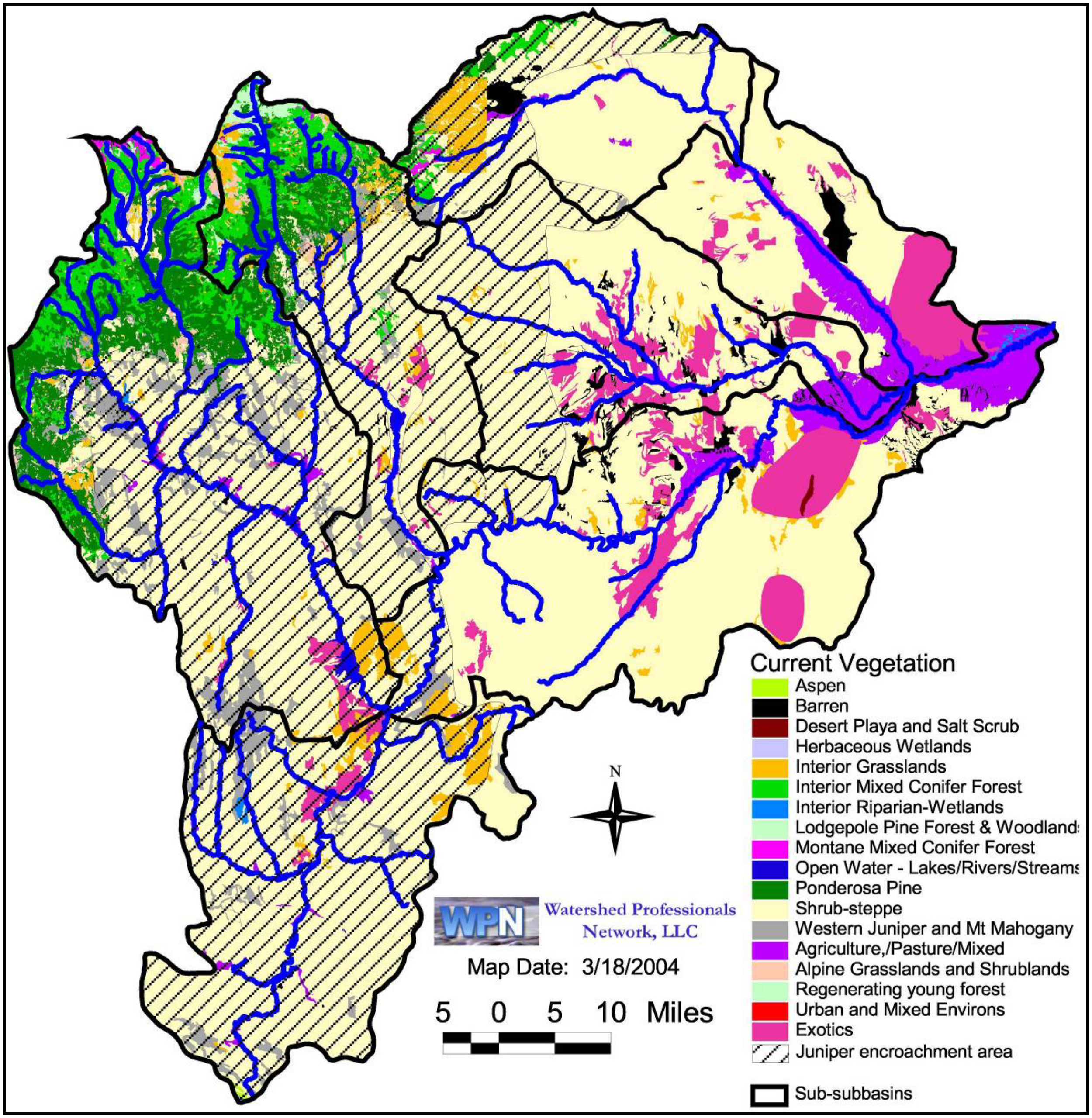


Figure 11: Current Vegetation Grouped by Wildlife-Habitat (Plant Community) Type.

5.3 Biological Objectives and Limiting Factors

Limiting factors describe the current status of species and habitats and the factors that limit their optimal functioning. Biological objectives describe the physical and biological changes needed to achieve the vision for the Subbasin. They have two components: the species-level biological performance, which describes population responses to habitat conditions, and the habitat level environmental characteristics, describing the environmental changes that are needed to achieve the desired population responses (ISAB 2003).

5.3.1 Terrestrial Focal Species Status and Limiting Factors

Specific habitat requirements and limiting factors for individual focal species are provided in Appendix A, Part 3- Terrestrial. Terrestrial focal species were selected primarily because of their sensitivity to habitat loss and degradation.

The majority of focal species population declines within the Malheur subbasin and adjacent areas are generally attributed to a reduction in extent and/or continued degradation of shrub steppe and riparian habitats. Big game species (ungulates) including elk, pronghorn, bighorn sheep, and mule deer have been affected by loss and degradation of habitat. Competition with livestock and encroachment of weedy species has contributed to loss of forage and habitat. Suitable sage grouse habitat is becoming more and more limited in the Subbasin, as the shrub component of shrub-steppe habitat is reduced. In addition, sage grouse habitat has also been lost to post-fire cheatgrass invasions and changes to the grass component of shrub-steppe habitats due to livestock grazing practices. Populations of horned lark and California quail have increased above historic levels.

In terms of riparian focal species, the direct loss of riparian corridors has resulted in a decline in populations of yellow warbler and changes in populations of yellow-breasted chat. Degradation of riparian and wetland habitat has also affected species that are dependent upon aquatic systems for at least a portion of their life cycle e.g. bald eagle, river otter, spotted frog and leopard frog. Degradation of riparian and wetland habitat decreases water quality, which affects both aquatic invertebrate and vertebrate populations, fecundity of amphibians, and food chains. By striving to arrest or reverse the loss and degradation of shrub steppe and riparian/wetland habitat, biological objectives will be met for the majority of Malheur subbasin focal species.

In addition to the direct loss of habitat within the subbasin, degradation of remaining native habitats also negatively affects wildlife populations. Specifically, degradation of shrub steppe habitat has significantly affected sage grouse, horned lark, pronghorn, and California bighorn sheep. Changes in distribution and population trends are the primary results attributed to decreased shrub-steppe habitat quality. This habitat type is so dominant in the subbasin that other species typically associated with alternative habitats have also been affected. Table 6 below lists the status of each focal species as described in Appendix A, Part3-Terrestrial.

Table 10: Malheur Focal Species Population Status.

Species	Decreasing	Stable	Increasing	Unknown	Notes
Rocky Mountain Elk		X			Stable
Blue Grouse		X			Stable to Slightly Increasing
Sage Grouse	X				Petitioned for T & E Listing
Pronghorn	X				Decrease in habitat
CA Bighorn Sheep		X			Stable reintroduction

Mule Deer	X				Predation and habitat degradation
California Quail			X		Increase in Ag habitat
Pileated Woodpecker			X		Forest habitat aging provides additional habitat
Horned Lark			X		Prefer degraded Shrub-steppe
Bald Eagle			X		More open water in the basin
River Otter		X			Present in Subbasin
Columbia Spotted Frog	X				Habitat Loss
Leopard Frog				X	Subbasin at western limit of species range
Yellow warbler	X				Habitat loss
Yellow-breasted Chat	X				Adaptable to variety of shrub habitats

5.3.2 Optimal Habitat Characteristics for Focal Species

Specific habitat requirements and limiting factors for each of the 15 Malheur subbasin focal species are provided in the species accounts in Section 3.2.4 of Appendix A, Part 3-Terrestrial. Environmental factors that affect the constellation of terrestrial focal species selected for the subbasin as a whole emphasizes: habitat loss and habitat degradation. By striving to arrest or reverse the loss and degradation of shrub-steppe and riparian/wetland habitat, biological objectives will be met for the majority of Malheur subbasin focal species. The following table outlines the optimal habitat characteristics for focal species:

Table 11: Optimal Habitat Characteristics of Focal Species.

Species	Subbasin Habitat	Optimal Habitat Characteristics
Pileated Woodpecker	Coniferous Forest Habitat	Forest older than 70 years of age High snag density
Elk	Winter Habitat	60/40 forage cover ratio Limited disturbance within habitat High density of mountain mahogany and bitterbrush in winter range
Blue Grouse	Coniferous Forest	Dense underbrush cover Large contiguous habitat
Sage grouse	Shrub-steppe Habitat	Suitable sagebrush cover Undisturbed lek sites
Horned Lark	Open Areas	Grassland areas for nesting
Pronghorn	Shrub-steppe Habitat	Suitable shrub component Available winter forage Undisturbed rangeland
California Bighorn Sheep	High Elevation Steppe	Undisturbed areas Lack of domestic sheep

Species	Subbasin Habitat	Optimal Habitat Characteristics
Mule Deer	Winter Habitat	Increase mountain mahogany and bitterbrush component Minimize juniper encroachment
California Quail	Shrub-steppe	Open fields nearby Shrub component for cover
Bald Eagle	Open Water Habitat	Healthy water with suitable fish prey Nearby perch sites Large snags/trees for nesting Expansive open water habitat for foraging
River Otter	Open Water/Rivers	Slow-moving pooled areas Large fish prey base
Columbia spotted frog	Aquatic Sites	Minimal bullfrog occurrence Minimal non-native predatory fish Maintained water quality
Leopard Frog	Aquatic Sites	Deeper slow-moving pooled sites Minimal bullfrog occurrence Maintained water quality
Yellow Warbler	Riparian Habitat	Increased willow density Contiguous riparian corridors
Yellow-breasted chat	Riparian Habitat	Dense shrub component Contiguous riparian habitat

5.3.3 Biological Objectives for Focal Species

As discussed in Aquatic Section 4.4, biological objectives for wildlife species and habitats in the Malheur subbasin incorporate ISAB guidelines. The result is a general approach for how to arrive at the ”dynamically stable” future condition that will support a full spectrum of species. The detailed and spatially explicit information needed to implement these objectives (e.g., the current and historic extent of wetland and riparian habitats) constitute an important data gap that should be a high priority for evaluation.

These optimal habitat characteristics, as shown in Table 11, have been translated into the following biological objectives for focal species in the Malheur Subbasin:

- ***Pileated Woodpecker***: Maintain some forests older than 70 years of age. Retain all large-diameter (>53 cm [21 in] d.b.h.) ponderosa pine, cottonwood, Douglas-fir, and western larch snags, preferably in clumps, and provide opportunities for snag recruitment throughout the mixed conifer habitats. As a long-term strategy, conduct mid-scale assessment of species snag use and the dynamics of snags in landscapes and adjust the strategy accordingly (Wisdom 2000).

- ***Elk***: Maintain 60/40 forage to cover ratio or summer range. Increase densities of mountain mahogany and bitterbrush in winter range.

- ***Blue Grouse***: Maintain some forest areas with dense underbrush cover. Maintain some large contiguous areas of habitat.

- ***Sage Grouse***: Optimize sage grouse breeding, nesting, and winter habitat diversity with regards to density, height, structure, and composition. Maintain undisturbed lek sites.

- ***Pronghorn***: Maintain healthy sagebrush-steppe understory composition. Forbs compose the majority of pronghorn diets during spring and summer, and livestock grazing decreases the abundance of forbs (Wisdom 2000). Increase available winter browse forage.

- ***California Bighorn Sheep***: Provide undisturbed areas in canyon shrub-steppe. Reduce human activities near important seasonal foraging areas and around known lambing areas of bighorn sheep (Wisdom 2000). Restore habitat links between summer and winter range and access to escape cover that have been lost due to changes in historical fire regimes. Restore quality and quantity of forage where succession has caused substantial reductions. Implement use of prescribed fire to reestablish inherent fire regime-vegetation patterns (Wisdom 2000).

- ***Mule Deer***: Increase/restore the shrub component in shrub-steppe habitats. Increase densities of mountain mahogany and bitterbrush in winter range.

- ***Bald Eagle***: Maintain healthy water quality with suitable fish prey. Maintain/establish nearby perch sites. Maintain/establish large snags/trees for nesting. Maintain expansive open water habitat for bald eagle foraging.

- ***River Otter***: Maintain slow-moving pooled areas. Maintain large fish prey base.

- ***Frog Species***: Control bullfrog occurrence. Maintain minimal non-native predatory fish. maintain/restore high water quality. Maintain deeper slow-moving pooled sites.

- ***Yellow Warbler***: Increase willow density. Maintain/restore contiguous riparian corridors.

- ***Yellow-breasted Chat***: Increase willow density. Maintain/restore contiguous riparian corridors.

5.3.4 Key Limiting Factors for Habitats

Loss (legacy conversion in land use) of habitat and degradation of habitat quality are the key limiting factors for habitats within the Subbasin. Overgrazing by native ungulates and livestock, fire suppression, introduction of non-native plant species, and roads have caused major changes in native vegetation communities, including riparian areas, wet meadows, and upland habitats over the past century. This has directly impacted many native bird and mammal species.

Cheatgrass and other exotic weeds have invaded most areas throughout the subbasin. Cheatgrass is the most severe weed problem encountered within the Intermountain Region (Monsen 1983). Noxious weeds reduce available wildlife habitat and outcompete desirable plant species. Factors contributing to habitat loss and degradation are described below.

Forest Habitats

- Fire suppression has altered forest structure and function. Many ponderosa pine forests have been invaded with Douglas fir, and western juniper has invaded nearly all forest habitats which reduces available forage for big game. The increase in tree seedling establishment, combined with Douglas fir and western juniper expansion has resulted in dense forest stands that are more susceptible to disease, catastrophic insect infestations, and intense fire. There is an increase in fuel loading in many habitats where fire has been less frequent (BLM 2003).
- Road densities have decreased suitable habitat for big game. Increasing road densities cause habitat fragmentation, increase wildlife mortality, increase noxious weed invasion, increase human use patterns including poaching and other disturbances, and alter riparian function.

Shrub-steppe Habitats

- Livestock grazing, primarily by sheep, has spread disease and is keeping native bighorn sheep from being restored to much of their previous range.
- Livestock and ungulate grazing has impacted shrub-steppe habitats. Frequently more desirable forage plants such as grasses and important broadleaf herbs are lost in shrub-steppe habitats due to selective grazing (Monsen, 1983). Many shrub-steppe wildlife species favor grass or shrub-grass types for nesting, foraging, or hiding, indicating that the grass component of historical shrublands was and is still important (Wisdom 2000). Continued degradation of shrub-steppe habitats caused by overgrazing combined with cheatgrass and other exotic plant invasions can permanently alter habitat potential. Changes in shrub-steppe habitat have resulted in a reduction of habitat effectiveness and quality of elk and mule deer winter range, loss of spring and summer forage for pronghorn, and declines in sage grouse populations.
- Encroachment of western juniper into Shrub-steppe habitats has altered habitat structure and function, and reduced habitat for sage grouse, elk, mule deer and other species. A major portion of the Subbasin has problems with encroachment by western juniper. Western juniper has invaded sagebrush communities on more moist, mesic sites where it has not been limited by fire (BLM 2003). The increase in western juniper has resulted in an alteration of habitat where grassland and shrubland communities have developed into woodlands.
- Grazing and changes in fire patterns have been linked to loss of soil and biological soil crusts, which contribute to degradation of shrub-steppe habitats. In rangelands, biological soil crusts function as living mulch by retaining soil moisture and discouraging annual weed growth. They reduce wind and water erosion, fix atmospheric nitrogen, and contribute to soil organic matter (Belnap et. al. 2001). Biological soil crusts moderate extreme temperatures at soil surfaces, and enhance seeding establishment of native vascular plants (Wisdom et. al. 2000). While there is data available on management and restoration of biological soil crusts, this is a subject that would benefit from additional study in the Subbasin.

- Wildfire in shrub-steppe habitats has encouraged invasion of cheatgrass and other non-native species, destroying habitat for many species of wildlife and plants.

Riparian/Wetland Habitats

- Loss of beaver and beaver dam complexes from most streams and meadows has eliminated productive riparian and floodplain habitat important to many native wildlife species.
- Conversion of low elevation shrublands and valley floors to pasture or cropland has reduced overwintering habitat for ungulates and contributed to loss of riparian and wetland habitats.
- Extirpation of salmon due to dams has eliminated a critical food and nutrient source for many other wildlife species in the subbasin.
- Much of the original acreage of wetland and riparian habitats has been converted to agricultural crops. Grazing has impacted a large portion of the remaining acreage. Grazing of cattle and sheep has altered upland and riparian structure and function. Livestock grazing can affect the riparian environment by changing and reducing vegetation or actually eliminate riparian areas as a result of channel widening, channel aggradation, or lowering of the water table (Armour et al 1991). Loss of dense stands of willow habitat has resulted in the decline in yellow warbler populations.

5.3.5 Biological Objectives for Habitats

The following addresses the limiting factors for habitats that are listed in Section 5.3.4 above. A number of the limiting factors affecting the Malheur Subbasin are also found as limiting factors within the whole Columbia Basin. The Interior Columbia Basin Ecosystem Management Project developed many biological objectives to address limiting factors in the Interior Columbia Basin. Some of the following information is summarized from “Source Habitats for Terrestrial Vertebrates of Focus in the Interior Columbia Basin: Broad-Scale Trends and Management Implications.” (Wisdom et. Al. 2000).

Forest Habitats

- Use prescribed fire, timber harvest, and thinning to change forest composition and structure to reduce risk of stand-replacing wildfires and shift to maintenance with prescribed low-intensity underburn fires.
- Retain stands of ponderosa pine where mature forest conditions are present, and actively manage to promote their sustainability through the use of prescribed burning and understory thinning.
- Look for opportunities to acquire lands in lower elevation forest and forest-rangeland mosaics. Close and restore excess roads to reduce fragmentation of landscapes by roads. Use thinning to restore landscapes to a more natural condition. Where natural process areas occur, prioritize road closures and restoration in adjacent areas to increase the interior core of habitats with natural patterns.

- Close and restore excess roads to reduce fragmentation of landscapes by roads. Where natural process areas occur, prioritize road closures and restoration in adjacent areas to increase the interior functional core of habitats.

Shrub-steppe Habitats

- Proper management of grazing by domestic and wild ungulates.
- Reduce human activities near important seasonal foraging areas and around known lambing areas of bighorn sheep (Wisdom 2000).
- Restore the native grass, forb, and shrub composition within the sagebrush-steppe habitat types.
- Identify and conserve large areas of remaining native upland shrublands and upland herblands where ecological integrity is still relatively high, and actively manage to promote their long-term sustainability.
- Control existing juniper encroachment areas with juniper management techniques.
- Decrease juniper encroachment through maintaining healthy desired vegetation communities.
- Maintain the native grass and forb components of the upland woodland, shrubland, and grassland community in areas where intact understories still occur.
- Control cheatgrass and other exotic plants.
- Research biological soil crusts and their effects on soil stability. Research management opportunities for protection and restoration of biological soil crusts.

Riparian/Wetland Habitats

- Increase quality and amount of riparian areas through restoration of hydrologic flows, vegetation restoration, road management, and control of grazing and recreational activities (Wisdom 2000).

5.3.6 Summary Tables of Biological Objectives

The following biological objectives are derived from the species optimal habitat characteristics and the limiting factors for both focal species and habitats in the Malheur Subbasin. Both habitat and focal species objectives are listed together by habitat group in the summary table below.

Table 12. Summary Table of Biological Objectives for Terrestrial Species/Forested Habitats.

Species/Habitat Benefit	Biological Objective
Mixed Conifer Forest	
Pileated Woodpecker	Maintain some forests older than 70 years of age.
Pileated Woodpecker	Retain all large-diameter (>53 cm [21 in] d.b.h.) ponderosa pine, cottonwood, Douglas-fir, and western larch snags, preferably in clumps, and provide opportunities for snag recruitment throughout the mixed conifer habitats. As a long-term strategy, conduct mid-scale assessment of species snag use and the dynamics of snags in landscapes and adjust the strategy accordingly (Wisdom et. Al. 2000).
Elk	Maintain 60/40 forage/cover ratio on summer range.
Blue Grouse	Maintain some forest areas with dense underbrush cover.
Blue Grouse	Maintain some large contiguous areas of habitat.
Habitat	Limit disturbance within areas of healthy habitat.
Habitat	Retain stands of ponderosa pine where old-forest conditions are present, and actively manage to promote their long-term sustainability through the use of prescribed burning and understory thinning (Wisdom 2000).
Habitat	Look for opportunities to acquire lands in lower elevation forest and forest-rangeland mosaics. Close and restore excess roads to reduce fragmentation of landscapes by roads. Use thinning to restore landscapes to a more natural condition. Where natural process areas occur, prioritize road closures and restoration in adjacent areas to increase the interior functional core of habitats (Wisdom 2000).
Habitat	Use prescribed fire, timber harvest, and thinning to change forest composition and structure to reduce risk of stand-replacing wildfires and shift to maintenance with prescribed low-intensity fires (Wisdom 2000).

Table 13. Summary Table of Biological Objectives for Terrestrial Species/Shrub Habitats.

Species/Habitat Benefit	Biological Objective
Shrub Steppe	
Sage Grouse	Optimize sage grouse breeding, nesting, and winter habitat diversity with regards to density, height, structure, and composition.
Sage Grouse	Maintain undisturbed lek sites.
Pronghorn	Maintain healthy shrub-steppe herbaceous understory populations. Forbs compose the majority of pronghorn diets during spring and summer, and livestock grazing decreases the abundance of forbs (Wisdom 2000).
Pronghorn	Increase available winter browse forage.
California Bighorn Sheep	Provide undisturbed areas in canyon/mountain Shrub-steppe.
California Bighorn Sheep	Reduce human activities near important seasonal foraging areas and around known lambing areas of bighorn sheep (Wisdom 2000).

Species/Habitat Benefit	Biological Objective
California Bighorn Sheep	Restore habitat links between summer and winter range and access to escape cover that have been lost due to changes in historical fire regimes. Restore quality and quantity of forage where succession has caused substantial reductions. Implement use of prescribed fire to reestablish inherent fire regime-vegetation patterns (Wisdom 2000).
Mule Deer and birds	Increase the shrub component.
Habitat	Restore the native grass, forb, and shrub composition within the sagebrush cover types (Wisdom 2000).
Habitat	Control existing juniper encroachment areas with juniper management techniques.
Habitat	Maintain some undisturbed areas.
Habitat	Identify and conserve large areas of remaining native upland shrublands and upland herblands where ecological integrity is still relatively high, and actively manage to promote their long-term sustainability (Wisdom 2000).
Habitat	Control cheatgrass and other exotic plants.
Habitat	Identify and conserve remaining core areas of shrub-steppe habitats where ecological integrity is still high (Wisdom 2000).
Habitat	Proper management of grazing (Wisdom 2000).
Habitat	Restore the native grass and forb components of the upland woodland, shrubland, and grassland community groups to historical levels throughout the basin. Restoration measures include seedings and plantings in combination with effective methods of site preparation, effective management of grazing by domestic livestock, and control of human activities such as off-road vehicle usage and other ground-disturbing factors (Wisdom 2000).
Habitat	Conservation of large core areas to provide long-term habitat stability; these areas will function as anchor points for restoration, corridor connections, and for other key functions of landscape management (Wisdom 2000).
Mountain Mahogany	
Elk, Mule Deer	Increase densities of mountain mahogany and bitterbrush in winter range.
Habitat	Protect areas of habitat from grazing to allow for mountain mahogany and bitterbrush reproduction

Table 10: Summary Table of Biological Objectives for Riparian/Wetland Habitats.

Species/Habitat Benefit	Biological Objective
Open Water	
Bald Eagle	Maintain healthy water quality with suitable fish prey.
Bald Eagle	Maintain/establish nearby perch sites.
Bald Eagle	Maintain/establish large snags/trees for nesting.
Bald Eagle	Maintain expansive open water habitat for bald eagle foraging.
River Otter	Maintain slow-moving pooled areas.
River Otter	Maintain large fish prey base.

Species/Habitat Benefit	Biological Objective
Herbaceous Wetlands	
Frog Species	Control bullfrog occurrence.
Frog Species	Maintain minimal non-native predatory fish.
Frog Species	Maintain/restore high water quality.
Leopard Frog	Maintain deeper slow-moving pooled sites.
Columbia Spotted Frog	Maintain characteristic CSF breeding habitat: shallow waters of ponds, wetlands or backwaters of streams where there is emergent vegetation.
Riparian Areas	
Yellow Warbler, Yellow-breasted Chat	Increase willow density.
Yellow Warbler, Yellow-breasted Chat	Maintain/restore contiguous riparian corridors.
Habitat	Limit disturbance within habitat from grazing, timber practices, vehicle stream crossings, etc.
Habitat	Increase quality and amount of riparian shrublands and woodlands through restoration of hydrologic flows, vegetation restoration, road management, and control of grazing and recreational activities (Wisdom 2000).
Habitat	Restore habitat by fencing and other proper grazing management strategies.

5.3.7 Habitats for High Priority Protection

The following habitats have been identified for high priority protection:

- Functioning wetland and riparian habitats,
- Functional and intact sagebrush steppe habitats,
- Functional and intact quality mountain mahogany habitats,
- Functional mature forests and old growth ponderosa pine habitats.

5.3.8 Habitat to Reestablish Access

Habitats in the Malheur Subbasin that provide corridors for wildlife movements are critical to reestablishing access between habitats. Corridors of vegetation linking wildlife habitats provide valuable areas for movement and are useful habitats themselves. Animals use these areas for dispersal, which limits overcrowding of existing habitats and allows recolonization of areas from which animals have disappeared. Corridors can help promote genetic diversity within species, which makes populations less susceptible to problems associated with inbreeding. They can also provide animals an escape from local disasters or changes in food availability in some areas. The following habitats make good wildlife corridors:

- Riparian habitats; creeks, streams, and rivers,

- Roadless areas in forested habitats at least 30-100m in width that connect large patches of habitat,
- Undisturbed areas that link one type of habitat to another, for example forests to shrub-steppe.

Planning for wildlife corridors requires spatial analysis of current animal migration areas combined with available habitat that could provide wildlife corridors. Once identified, these areas can be established and protected for wildlife use.

5.3.9 Habitat for Restoration

The following habitats have been identified for restoration:

- Degraded riparian and wetland habitats,
- Degraded sagebrush steppe habitats with intact understory,
- Juniper encroachment areas with intact native understory and less disturbed soils,
- Forested areas that would benefit from prescribed fire, timber harvest, and thinning.

5.4 Subbasin wide Hypothesis

- Fire suppression has altered forest structure and function which then reduces available wildlife habitat; prescribed fire, timber harvest, and thinning can be used to change forest composition and structure to reduce risk of stand-replacing wildfires and shift to maintenance with prescribed low-intensity controlled fires.
- Loss (legacy conversion in land use) and degradation of riparian and wetland habitats has limited the habitat of a variety of wildlife species; degraded riparian and wetland habitats can be improved using exclusion from grazing, other grazing management techniques, and restoration or reclamation techniques.
- Degradation of shrub-steppe habitats causes reductions in shrub-steppe dependent wildlife populations including sage grouse, pronghorn, elk and mule deer; Shrub-steppe habitats with intact native understory vegetation can be improved using restoration and proper grazing management techniques.
- Western juniper and other weedy species encroachment results in wildlife habitat loss; juniper encroachment can be controlled using fire or mechanical treatments. This type of control is most effective if control is attempted before the understory vegetation or soil is lost. Research is currently being conducted on restoration of cheatgrass and medusahead infestations.
- Road densities have decreased suitable habitat for deer, elk, and bighorn sheep. Increasing road densities cause habitat fragmentation, increase wildlife mortality, increase noxious weed invasion, increase human use patterns including poaching and other disturbances, and alter riparian functioning; close and restore excess roads to reduce fragmentation of landscapes by roads. Where natural process areas occur, prioritize road

closures and restoration in adjacent areas to increase the interior functional core of habitats.

6 STRATEGIES

6.1 Introduction to Strategies

The Subbasin Plan describes actions needed at the strategy level of organization – in comparison to the smaller spatial scale at which projects will be implemented. The Independent Science Advisory Board (ISAB, Bilby et al. 2003) defined strategies in the following way:

> ***Strategies describe the actions needed to address the limiting factors and therefore achieve the biological objectives****. The strategies identified in the subbasin plans form the basis for Council funding recommendations to the Bonneville Power Administration. Implementation strategies will vary depending on the current condition of the population and habitat, and the biological objectives identified for the species and life stage of interest. Strategies should address the question, "What are the generic or overarching actions needed to address the limiting factors?"*

Strategies should address the limiting factors identified during the assessment without regard to prioritization. Prioritization is a separate and subsequent step that considers other factors, such as the relative threat to species survival and recovery, the practicality of implementing the needed actions, and the ability of agencies and stakeholders to take those actions. Prioritization is not a static process and priorities are expected to change as information gaps are resolved and as new methods develop.

QHA was used to identify current conditions and limiting factors at the stream reach scale; this assessment provides the answer to the question of where in the subbasin aquatic habitats need protection or restoration. To address the types of actions needed we asked the Aquatic Technical Team during the QHA rating process what general actions were needed to improve habitats. These ideas, plus the experience of the management agencies (BLM, NRCS, MCSWCD, MWC, etc.) combined with the experience of the consultant team were used to develop the aquatic strategies. In addition to habitat, we considered the effect of non-native species on native fish, and the effect of major dams on habitat connectivity, which were not assessed in QHA.

The aquatic assessment and terrestrial assessment were developed at different spatial scales. The aquatic assessment used "stream reach" as the smallest spatial scale. Stream reaches were identified as uniform sections with respect to habitat quality and fairly large segments with an average length of 17.6 miles (2.5 to 66 miles). So, even the smallest assessment unit occurs at a fairly coarse spatial scale. Reaches provide the basic information to discuss strategies within a hierarchical spatial organization, from Reach to Watershed to Subbasin. For the Management Plan, we consider the Watershed (six watersheds in the Malheur Subbasin) to be the appropriate spatial scale for discussion of strategies. These watershed scale strategies can be stepped back down to the stream reach scale (strategies to projects) when specific funding requests are developed or scaled up to communicate what needs to occur in the subbasin.

The terrestrial assessment was developed using wildlife-habitat types as assessment units. These wildlife-habitat types were adapted from Interactive Biodiversity Information System (IBIS) and the *Wildlife-Habitat Relationships in Oregon and Washington* (Johnson and O'Neil, OSU Press. 2001). The fourteen Wildlife-habitat types used in the assessment vary in size from over two million acres (Shrub-steppe) down to 500 acres (Desert Playa and Salt Scrub Shrublands). For the purpose of assessing limiting factors it was necessary to evaluate fish and wildlife habitats separately. At finer spatial scales, however, when stepping the strategies down to actions on the ground it is important to consider where the strategies are complementary. For example, individual funding proposals can address the riparian area from both a fish and wildlife perspective, and in fact, project managers generally do address multiple objectives when implementing a project.

6.2 Projects and Restoration Methods

There are many different methods that can be used to accomplish watershed restoration at the project scale. The selection of the appropriate tool depends on a variety of site-specific factors. Examples of these restoration and conservation documents are listed in Table 14. It is important to realize that Strategies were not developed as a generic wish list, but can be implemented on the ground through the types of methods that are listed in Table 14.

Table 14. Example guidelines and methods for watershed restoration.

Restoration Procedures Guidelines
Kauffman, J.B. et al. 1997. An ecological perspective of riparian and stream restoration in the Western United States. Fisheries, 22 (5): 12-24. *Provides a good discussion of passive versus active restoration approaches.*
EPA, 2003. National management measures for the control of nonpoint pollution from agriculture. EPA-841-B-03-004. U.S. Environmental Protection Agency, Office of Water Washington, D.C. 20460. http://www.epa.gov/owow/nps/agmm/
NRCS, 2003. Field Office Technical Guide. http://www.nrcs.usda.gov/technical/efotg/ *The electronic field office technical guide addresses a wide range of management systems and management practices for cropland, pasture and rangeland.*
Malheur Experiment Station. 2004. Website for Agricultural Best Management Practices specific to eastern Oregon. http://www.cropinfo.net/
National Council for Air and Stream Improvement, Inc. (NCASI). 2000. Handbook of control and mitigation measures for silvicultural operations. Unpublished draft Technical Bulletin. Research Triangle Park, N.C.: National Council for Air and Stream Improvement, Inc. *Compendium of management practices for forestry.*
FISRWG, 1998. Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US gov't). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3. http://www.usda.gov/stream_restoration/ *Describes the design principles and examples for active stream channel restoration.*

Restoration Procedures Guidelines
OWEB 1999. Oregon Aquatic Habitat Restoration and Enhancement Guide. Oregon Watershed Enhancement Board. Salem, Oregon. http://www.oweb.state.or.us/publications/ *Describes habitat restoration methods in terms of ecological functions and processes.*
Monson, S.B. and R. Stevens. 2004. (In press). Restoring range and wildlife habitat in the Intermountain Region. RMRS-GTR-000, USDA-FS-RMRS, Fort Collins, Co. *Compilation of papers applicable to Shrub-steppe habitats.*
Campbell, E. and others. 2003. (Draft) Management guidelines for sage grouse and sagebrush-steppe ecosystems. Interagency Committee BLM, ODFW, USFWS, USFS, Or Dept of Lands. Bureau of Land Management, Oregon State Office, Portland, Or.

6.3 Strategy Tables

The strategies are summarized in Table 15 and Table 16. The tables are organized by goal, objective, and the associated strategy to meet the objective. In addition, where feasible, we provide the linkages to maps and figures indicating where the objective applies. For aquatic strategies the extent of the habitat too which the strategy applies is indicated by stream miles and percent of stream miles in the watersheds. This allows the user of this document to link any proposed project in the subbasin to the stream reach location where it applies and the habitat rating.

An effort was made to emphasize actions that can be taken now compared to additional research and studies. However, in many cases, the QHA ratings are not at a sufficient scale or resolution to identify specific locations. Critical step-down analysis, such as channel type classification and riparian condition assessment (e.g., Oregon Watershed Assessment Procedure, OWEB 1999) should be completed at the watershed scale prior to identifying specific needs and locations for many strategies. Few watershed assessments have been completed in the subbasin to connect the strategies more closely to a specific site.

Table 15. Strategy Table for Aquatic Habitats and Fish Species.

Goals and Objectives	Strategies
Goal 1 – Habitat Restoration Restore aquatic habitats to provide optimum carrying capacity for native salmonid species.	
Objective 1.1 : Restore Stream Channel Processes and Conditions To achieve both a 1) distribution of channel types, e.g., Rosgen (1996) channel types, as well as 2) a distribution of habitat conditions within those channel types, that are as close as possible to the historic distribution of these two variables within the subbasin. **Subbasin Scale Map: See Figure 6.**	**1. Channel Classification and Assessment at Finer Scales** Complete fine scale geomorphic analysis at the watershed or subwatershed scale to identify the current, historic, and potential future distribution of channel types. This initial step is needed to more accurately identify current channel conditions and opportunities prior to developing reach specific channel restoration plans. **2. Levies, Berms, Dikes** Evaluate feasibility of removing or modifying existing levies, berms, dikes etc. that impede the natural meander pattern. The abandoned railroad levy may be a candidate along the lower main Malheur River. This evaluation can be incorporated into the channel assessment listed above. **3. Road Encroachment** Evaluate feasibility of closing, rehabilitating, or relocating stream bottom roads that impinge on the stream channels. An evaluation needs to be coordinated closely with road owners and responsible land managers. **4. Confined And Re-Located Channels** Identify channels that have been channelized or re-located and are not functioning properly to form aquatic habitats. Evaluate feasibility of re-establishing a meander pattern by direct channel reconstruction or modifying existing management constraints to allow the stream to reestablish a meander pattern over a longer period of time. **5. Upland Erosion Management** Incorporate upland vegetative management and erosion control into cropland, rangeland, and urban management practices.

Goals and Objectives

Rating: Condition by Watershed and Subbasin (Miles).*

Category	Bully Creek	Main Malheur	Middle Malheur	North Fk Malheur	South Fk Malheur	Willow Creek	Entire Subbasin	Percent
0-1	16	66	11	3	0	32	127	11%
>1-2	9	72	31	18	91	35	256	23%
>2-3	80	55	195	55	85	26	496	45%
>3-4	25	0	116	90	0	0	232	21%
							1112	

*** Habitat Rating Categories: Percent of Optimum**

Rating	Percent of Optimum
0-1	0% - 25% of optimum
>1-2	25% - 50% of optimum
>2-3	50% - 75% of optimum
>3-4	75% - 100% of optimum

Watershed and Reach Scale:

See Appendix A-3, Figure 1

Strategies

6. Off-channel Habitats

Evaluate locations favorable to establishing off-channel habitats to increase quantity of spawning and reading habitats.

7. Hydraulic and Placer Mining

Develop restoration design for legacy impacts from hydraulic and placer mining (Willow Creek watershed).

8. Reduce Mechanical Streambank Damage Associated with Grazing

As part of grazing management strategies and wildlife management programs reduce direct damage to stream banks through herding, location of salt blocks, fencing, riparian pasture management, off-site water and other accepted range management practices.

9. Beaver Management

Historically in similar stream environments ponds and wetlands created by beaver provided natural water storage, salmonid rearing habitats, and habitat for riparian dependent wildlife. Existing riparian conditions may no longer provide beaver with sufficient forage and building materials, therefore beaver reintroductions need to be evaluated carefully. Evaluate the potential for reintroducing or managing existing beaver populations to provide the benefit of beaver created wetlands. As part of this evaluation assess the potential for man-made structures used in wild irrigation to accomplish similar functions as those ascribed to beaver complexes.

Goals and Objectives

Goal 1 – Habitat Restoration

Objective 1.2 : Restore Riparian Condition

Objective: To achieve a distribution of riparian communities having 1) a species composition, 2) size, and 3) structure that is appropriate for the channel type and ecoregion, recognizing that the distribution will also vary in time in response to natural disturbance factors.

Subbasin Scale Map: See Figure 8.

Rating: Condition by Watershed and Subbasin (Miles).*

Category	Bully Creek	Main Malheur	Middle Malheur	North Fork Malheur	South Fork Malheur	Willow Creek	Entire Subbasin	Percent
0-1	3	22	72	32	0	32	161	15%
>1-2	97	1	82	35	133	35	384	35%
>2-3	22	170	141	36	20	26	415	37%
>3-4	8	0	58	63	24	0	152	14%
							1112	

Strategies

1. Riparian Buffer Restoration – Roads and Railroads

Evaluate feasibility of increasing riparian buffer widths between roads and (abandoned) railroads that have eliminated riparian vegetation. Of particular concern is the probable loss of cottonwood along the larger mainstem rivers.

2. Riparian Buffer Restoration – Cropland Areas

Incorporate riparian buffer management in Resource Management Plans in cropland areas that have limited the functional riparian zone to a narrow band or changed the composition and density of riparian species.

3. Riparian Buffer Restoration – Rangeland Areas

Incorporate riparian buffer management as part of Rangeland Management Plans where livestock or wildlife grazing have changed the riparian species composition and density or altered riparian functions for large wood recruitment, bank protection, sediment filtering and temperature modification.

4. Exotic Vegetation and Noxious Weeds in Riparian Areas

Work with Malheur County Weed Control District to eliminate noxious weeds such as purple loose strife in riparian and wetland areas.

5. Riparian Buffer Restoration – Flood Event Related

Recent large flood events (e.g., in the lower Cottonwood Creek reach in the Main Malheur watershed) have eliminated woody riparian vegetation in areas. Further evaluate causative factors and determine feasibility of reestablishing woody riparian species.

6. Riparian Buffer Restoration – Forestland

Past timber harvest operations has reduced riparian vegetation. It is expected that current forest practices rules and agency policies will prevent this impact from occurring in the future. Evaluate riparian condition and determine value of planting seedlings and seeding to riparian

Goals and Objectives	Strategies
Watershed and Reach Scale: See Appendix A-3, Figure 2	function recovery. **7. Riparian Zone Reductions Due to Channelization** Channelization and straightening of streams has lowered water tables and eliminated wet meadow systems. Incorporate riparian planting and protection with channel restoration strategies listed for Objective 1.2. **8. Wetland Protection and Restoration** Wetland resources were not adequately evaluated in this plan. There is a need to assess current, historic, and potential future distribution and status of wetlands as a critical element of the aquatic ecosystem.
Goal 1 – Habitat Restoration	
Objective 1.3 : Enhance Low Flow Conditions To enhance low flow conditions such that they mimic the natural hydrograph to the extent possible, given the limitations posed by agriculturally dependent water use in the region. **Subbasin Scale Map: See Figure 9.**	**1. Irrigation Water Management** Irrigation withdrawals for row crops, pasture, and livestock directly reduce instream flows. Numerous methods to improve irrigation efficiency (straw mulching, PAM, drip, irrigation, surge irrigation, laser leveling, conversion to sprinklers) are being applied within the subbasin. However, water saved through these methods is primarily used for crop production not to enhance instream flows. Institutional mechanisms need to be combined with willing water rights holders to retain water for instream application. See OSU, Malheur Ag Experiment Station, http://www.cropinfo.net/waterq.htm for irrigation management practices developed for the Malheur Subbasin. **2. Market-based Incentives** Oregon Water Trust provides a possible way to increase instream water flows. They provide water right holders with a variety of incentives to convert their consumptive water rights to instream water rights. These include income from marginally productive areas, replacement feed for lost production, funding for irrigation efficiency projects, a possible tax break for permanent donations of water rights, and flexibility in managing water rights. See http://www.owt.org/ for description of the program. **3. Enhancing Natural Storage Pathways** Loss of beaver dam complexes and channel/floodplain connectivity has eliminated water

Goals and Objectives

Rating: Condition by Watershed and Subbasin (Miles).*

Category	Bully Creek	Main Malheur	Middle Malheur	North Fork Malheur	South Fork Malheur	Willow Creek	Entire Subbasin	Percent
0-1	16	51	58	21	0	32	177	16%
>1-2	67	65	85	26	152	1	396	36%
>2-3	22	22	33	0	24	61	162	15%
>3-4	25	55	177	120	0	0	377	34%
							1112	

Watershed and Reach Scale:

See Appendix A-3, Figure 6

Strategies

storage, resulting in lower summertime base flows. Strategies to restore this function are listed under Objective 1.1. – Restoring Channel Conditions.

4. Developing Storage in Headwaters – Created Wetlands

Evaluate the potential to enhance base summer flows by diverting part of the spring runoff into created wetlands. Providing additional storage in the soil and aquifer would benefit both water users and fish/wildlife habitat. This is an experimental concept that would need to be evaluated through research, demonstration projects and monitoring. This concept was investigated in a study on Trout Creek, tributary to the Deschutes River (BOR 1999).

5. Juniper encroachment

Evaluate the effects of juniper encroachment on base flows and the potential benefit in removing juniper as part of a watershed enhancement program (including restoration of wildlife habitats). Juniper encroachment is widely considered to adversely affect base flows through increased canopy interception and removal of soil moisture. However, it is not clear if this is a significant problem throughout the range of juniper encroachment.

6. Rangeland Management for Upslope Hydrologic Function

Intensive livestock grazing alters the hydrologic character of vegetation and soils (capture, storage, and release of water). Grazing Management Strategies are being applied and need to be expanded to enhance hydrologic function in the Shrub-steppe habitat type.

7. Dams Operations

Evaluate feasibility of enhancing flows below irrigation dams during the non-irrigation season. In many cases the utilization of channels as irrigation conveyance downstream of dams has resulted in higher low flows than optimum (e.g., North Fork Malheur below Beulah). Conversely, in some areas (e.g., lower Willow Creek) reservoir releases travel through off-channel canals, with little water released directly to the stream channel, and return flow reenters channel far downstream.

Goals and Objectives

Goal 1 – Habitat Restoration

Objective 1.4 : Restore Fish Passage Connectivity (To the Extent Possible)

Eliminate, to the extent possible, human-related obstructions to the movement of the aquatic focal species within the Malheur subbasin (without exposing isolated native populations to possible hybridization with non-native species).

Subbasin Scale Map: See Figure 10.

Rating: Condition by Watershed and Subbasin (Miles).*

Category	Bully Creek	Main Malheur	Middle Malheur	North Fork Malheur	South Fork Malheur	Willow Creek	Entire Subbasin	Percent
0-1	3	115	88	3	0	3	212	19%
>1-2	0	0	30	0	0	0	30	3%
>2-3	13	0	85	44	93	56	292	26%
>3-4	113	78	150	120	83	35	578	52%
							1112	

Watershed and Reach Scale:

See Appendix A-3, Figure 6

Strategies

1. Culvert Removal, Replacement, Modification

Road crossings (usually culverts) often create a full or partial fish passage barrier due to installation or inadequate size. The first step in correcting these barriers is to complete an inventory of fish passage barriers at a watershed scale. Standard protocols are available for conducting inventories, assessing the barrier (such as the USFS Fish Crossing, http://www.stream.fs.fed.us/fishxing/), and establishing priorities for fixing the barriers.

2. Irrigation Diversion Structures and Push-up Dams

Infrastructure associated with irrigation withdrawals (diversion structures, push up dams) may cause direct fish passage barriers. As with culverts, the first step is to complete an inventory to identify barriers and prioritize remedies. Fish screens, infiltration galleries and other technologic solutions can be used to fix the barrier.

3. Subsurface Flows Associated with Water Withdrawals

Channels that are dewatered (or experience extremely low flows) create fish passage barriers. Each situation needs to be evaluated in regards to critical timing for fish passage and irrigation scheduling to determine if operational changes can be made to provide passage.

4. Evaluate Fish Passage at Dams

Continue to evaluate feasibility of providing fish passage at major dams in the subbasin. See Goal 3 for strategies addressing fish passage at dams.

5. Reconnection via Land Acquisition or Easement

Evaluate critical areas for reconnection of disjunct bull trout and redband populations using acquisition or easements by tribal governments or non-governmental organizations.

6. Reconnection via Riparian and Channel Enhancement

Reconnect disjunct bull trout and redband populations through changes to land management where economically and technically feasible.

Goals and Objectives	Strategies
Goal 1 – Habitat Restoration	
Objective 1.5 : Improve Water Quality Reduce pollutants to the extent feasible from agricultural activities, urban areas and other sources to meet Oregon water quality standards. Note: The QHA methodology did not adequately address all water quality pollutants. Refer to Appendix A – Limiting Factor Rating by Watershed in Stream Miles. *See Appendix A for Limiting Factor Rating by Reach. Figure 4 – Fine Sediment, Figure 7 – Dissolved Oxygen, Figure 9 – Temperature, Figure 10 – Pollutants (likely toxic pollution source locations).*	This objective primarily addresses improving water pollution associated with agricultural sources as identified in the Malheur Watershed Council Basin Action Plan (MOWC 1999), and best management practices (BMPs) developed by or compiled by the OSU Malheur Agricultural Experiment Station. See http://cropinfo.net/waterq.htm. Strategies for improving water quality consist BMPs and Resource Management Systems used by farm operators with technical and financial assistance from NRCS, MCSWCD, Malheur Watershed Council, and the Ag. Experiment Station. The following components are addressed in Table 17. **1. Reduce Irrigation Induced Erosion.** **2. Management Practices to Reduce Nitrate Contamination.** **3. Irrigation System Conservation.** **4. Conservation Practices for Dryland Farming.** **5. Riparian Area Management.** **6. Upland Pasture Management.** **7. Urban Area Management Practices.** **See** Table 17 **for management practices and specific water quality objectives.**

Goals and Objectives	Strategies
Goal 2 – Assist in Recovery of Bull Trout Protect and restore native, locally adapted, naturally reproducing bull trout to a level that will lead to the delisting of the local populations and provide additional harvest opportunities.	
Objective 2.1. Improve Bull Trout Habitat Protect, restore, and maintain suitable habitat conditions for bull trout. **Objective 2.2. Use Strategies Consistent with Bull Trout Recovery Plan (USFWS 2002).** Implement restoration strategies that are consistent with the USFS Bull Trout Recovery Plan developed by the local Bull Trout Recovery Team.	**1. Reduce Loss of Bull Trout at Irrigation Diversions** Reduce bull trout losses associated with irrigation diversions and related irrigation diversion structures in the North Fork and Upper Malheur watersheds. (See Objective 1.4) **2. Reduce Management Impacts to Bull Trout Spawning Areas** Develop reach specific plans to identify and resolve: sediment sources associated with the road network, other sediment sources, channel modifications, and high temperature due to management practices in the North Fork and Upper Malheur watersheds. **3. Restore Stream Channels in Bull Trout Spawning and Rearing Habitats** Assess stream channel conditions and develop reach specific management plans to restore channels in undesirable condition. **(**See Objective 1.1). **4. Restore Connectivity in Bull Trout Current and Historic Habitats** Restore connectivity and opportunities for migration by improving instream flows and/or water rights in the North Fork and Upper Malheur watersheds. Evaluate fish passage barriers, establish priorities, and fix barriers in priority order (See Objective 1.3). **5. Evaluate Effectiveness of Restoration Techniques** Evaluate effectiveness of different habitat restoration techniques in restoring channel functions and local bull trout populations in the Malheur Core Area, and provide feedback to land managers.

Goals and Objectives	Strategies
Goal 3 – Reduce Effects of Major Dams on Native Fish Populations Reduce the effects of major dams (migration barriers, poor quality rearing habitat, and entrainment) on native fish populations.	
Objective 3.1 – Evaluate Feasibility for Fish Passage at Major Dams Evaluate feasibility and options for providing fish passage for bull trout and redband trout at dams in the Malheur Subbasin (USFWS Draft Bull Trout Recovery Plan Action #1.2.1 & 1.4.) **Objective 3.2 – Evaluate Operations at Major Dams to Improve Conditions for Bull Trout and Redband Trout** Evaluate feasibility and recommend modifications to water level manipulation, entrainment, and minimum fisheries pool at Agency Valley Dam and Warm Springs Dam.	**1. Determine Feasibility of Fish Passage at Agency Valley Dam.** Further evaluate fish passage at Agency Valley Dam, Beulah Reservoir, to reconnect the Malheur core bull trout populations and other fish species. BOR has completed some studies related to fish passage at this facility, but these studies have not fully evaluated all possible alternatives. **2. Determine feasibility of fish passage at Warm Springs Dam.** Initiate feasibility of fish passage at Warm Springs Dam on the Upper Malheur River to reconnect the Malheur core bull trout populations and other fish species. Little work has been done to date to evaluate fish passage at this facility. **3. Review Reservoir Operations and Provide Recommendations** Evaluate and recommend modifications if needed to water level manipulation, entrainment, and minimum fisheries pool at Agency Valley Dam and Warm Springs Dam. BOR has completed some studies of reservoir operations and reservoir quality for bull trout rearing and overwintering. Further analysis at Beulah and Warm Springs Reservoir is needed to assist in recovery of bull trout in the Malheur River system. **4. Review Flow Releases and Recommend Downstream Flows** Develop recommendations to improve flows during the non-irrigation season below Agency Valley Dam to improve suitability for overwintering habitat for bull trout.

Goals and Objectives	Strategies
Goal 4 – Reduce Effects of Nonnative Fish on Bull Trout and Redband Trout	
Objective 4.1 Reduce Effect of Brook Trout on Bull Trout Prevent and reduce negative effects of brook trout and other nonnative fishes on bull trout. **Objective 4.2 Reduce Effect of Non-native Fish on Redband Trout** Prevent and reduce negative effects of rainbow trout and other nonnative fishes on bull trout.	**1. Determine Integration And Hybridization Extent And Rates** Determine the spatial extent and rates of integration and hybridization in the range of bull trout and redband trout through genetic studies. **2. Evaluate Feasibility of Reducing Non-Native Fish Where They Are Negatively Impacting Bull Trout** Use of barriers, poisoning, selective harvest etc. are all potential control techniques of brook trout that have negative as well as positive effects. All these options need to be evaluated for technical and economic feasibility, and ability to meet the overall objective of restoring bull trout populations. **3. Conduct Demonstration Projects or Pilot Studies on Removal of Nonnative Species** If studies determine feasible options, then the initial step should be to complete a demonstration or pilot project in an isolated stream system to evaluate assumptions and outcomes, and improve control techniques before broader application.
Goal 5 – Develop Redband Trout Protection and Recovery Strategy. Ensure the long-term persistence of self-sustaining, complex interacting groups of redband trout distributed across the species' range.	
Objective 5.1: Determine Status of Redband Trout in the Malheur System. The objective is to fill in data gaps about redband trout in the Malheur River Subbasin identified as part of the aquatic	**1. Genetic Studies** Genetic evaluation of redband trout are needed to determine degree of integration and hybridization with introduced rainbow trout. **2. Data Gap – Spatial and Seasonal Distribution**

Goals and Objectives	Strategies
assessment. Little is known about redband populations, distribution, genetic composition, and degree of hybridization with introduced rainbow trout. **Objective 5.1: Develop Redband Trout Strategy** Develop a redband trout strategy based on more complete information.	Little information is currently known about redband trout distribution, movement, seasonal use of habitat, and the effect on habitat alterations on these habitats. Basic fisheries studies are needed to fill this data gap to provide basic information needed for managing/enhancing this native species. **3. Develop Strategy to Prevent Decline or Enhance Redband Populations** A strategy to manage redband trout for either conservation or increased harvest can be developed once the basic biological studies are completed. The Burns Paiute Tribe can provide assistance to the State in completing these studies.
Goal 6 – Mitigate Tribes and Communities for the Loss of the Anadromous Fish Resource in the Malheur Subbasin.	
Objective 6.1 : Evaluate Mitigation/Substitution Alternatives Evaluate alternatives with the NWPPC and BPA to fully mitigate Tribes (and communities) for loss of anadromous fish to the Malheur River system. **Objective 6.2: Substitution for Anadromous Fish Losses** Implement substitution projects to mitigate the Tribe (and communities) for anadromous fish losses.	**1. Document Extent and Magnitude of Loss Resource to the Tribe** Although historic use of salmon by the Burns Paiute Tribe has been documented, the extent and magnitude of the loss to the Tribe has not been documented to the satisfaction of the Tribe and community stakeholders. An analysis of oral history and historic documents needs to be completed to develop a more definitive assessment as a basis for mitigation. **2. Evaluate and Recommend Substitution Projects** A number of different types of projects have been suggested as substitution for lost resources: Restoring native resident fisheries through habitat enhancement, increasing populations through hatchery production, developing put-and-take fishery at new sites, or taking actions to reintroduce anadromous fish to blocked habitats. These alternatives need to be fully explored to determine the best course of action **3. Acquire Identified Priority Properties** Where possible, acquire management rights to priority properties that can be protected, restored or enhanced to support native ecosystem/watershed function through title acquisition, conservation easements, and/or long-term leases in perpetuity.
Objective 6.3 : Increase Opportunities for Consumptive and Non-consumptive Use of Resident Fisheries. Administer and increase opportunities for consumptive and non-	**1. Property Acquisition for Aquatic Resource Harvest** Where possible, acquire management rights to properties that can be managed for aquatic resource harvest through title acquisition, conservation easements, and/or long-term leases in

Goals and Objectives	Strategies
consumptive use of resident fisheries for native, introduced, wild, and hatchery-reared stocks that are compatible with the continued persistence of native resident fish species and their restoration to near historic abundance (includes intensive fisheries within closed or isolated systems).	perpetuity. **2. Determine Feasibility of Developing a Put and Take Fishery** Where management rights are acquired, determine the feasibility of the development and implementation of a put and take fishery in small reservoirs and ponds.
Objective 6.4. Protect, restore and enhance existing native aquatic resources. Protect, restore, and enhance existing aquatic and terrestrial resources in order to meet the increased demands (i.e., cultural, subsistence, and recreation) on these resources associated with the extirpation of anadromous fisheries. (Note: Acquiring property and managing property for fish and wildlife goals may also achieve one or more of the following objectives: Objective 1.1, restoring stream channel process, Objective 1.2 restoring riparian condition, Objective 1.3, enhancing low flow conditions, Objective 1.4, restoring connectivity, and Objective 1.5, improving water quality.)	**1. Property Acquisition or Easement** Where possible, acquire management rights to priority properties that can be protected, restored or enhanced to support native ecosystem/watershed function through title acquisition, conservation easements, and/or long-term leases in perpetuity. **2. Restore or Enhance Acquired Properties** Where management rights are acquired, identify the current condition and biological potential of the habitat, and then protect or restore and enhance those properties to the extent that their condition is consistent with the Biological Objectives of the 2000 Fish and Wildlife Program. **3. Protect or Restore Habitats through Incentives and Outreach** Create or use existing incentives and outreach programs for private landowners to protect and/or restore habitats to support native ecosystem/watershed functions.
Objective 6.5. Increase Harvest Opportunities Administer and increase harvest opportunities of culturally significant terrestrial species in substitution for the loss of anadromous fish resources.	**1. Property Acquisition for Culturally Significant Terrestrial Resource Harvest** Where possible, acquire management rights to properties that can be managed for culturally significant terrestrial resource harvest through title acquisition, conservation easements, and/or long-term leases in perpetuity
Goal 7 – Complete Watershed Analysis at the Watershed Scale. Complete analysis at finer spatial scales to develop watershed, stream system, and reach specific restoration plans.	
Objective 7.1 : Complete watershed analysis to address data gaps Conduct watershed assessments, such as the Oregon Watershed	**1. Stream Channel Classification and Condition Assessment** Stream channel condition is a controlling factor that influences most other channel and riparian associated functions. Geomorphic assessment of current, historic and potential future condition provides the basis for assessing utility of associated restoration procedures. In addition to basic

Goals and Objectives	Strategies
Assessment Manual*, to fill data gaps identified during the aquatic and terrestrial assessment. * http://www.oweb.state.or.us/publications/wa_manual99.shtml	classification a channel assessment can evaluate the potential for removing/modifying levies, berms, dikes; assessing road encroachment; identifying and assessing confined and relocated channels; and identifying opportunities for developing off-channel habitats. **2. Riparian Area Condition Assessment** Riparian assessments evaluate existing buffer strip width, continuity, and vegetative composition. The assessments can be tailored to forest, cropland, rangeland, or urban environments and evaluation of exotic and noxious plants. **3. Wetland Area Extent and Condition Assessment** Historic and current distribution of wetland areas is a data gap identified during the assessment. Since wetlands are a key habitat component for many wildlife species, an assessment of the current wetland distribution and change from historic would provide a framework for understanding the relative importance of wetland restoration. **4. Culvert Inventory and Prioritization** Providing connectivity to habitats is generally recognized as a fundamental limiting factor that can be readily resolved and enhance fish populations. Culvert inventories should be completed as an initial step to resolving this limiting factor. **5. Fish Screen Needs Survey** During the aquatic assessment and subsequent discussion within the Malheur Coalition, it was evident that the extent and magnitude of screen needs at irrigation diversions has not been evaluated. Fish screening irrigation diversions is a basic infrastructure need (similar to fish passage at culverts) that will help fish populations. **6. Temperature Assessment** Data on temperature conditions is scattered among the agencies (the extent of the data is not known), and has not been compiled or analyzed at the watershed scale to evaluate current water temperature conditions across the subbasin. Consequently, there is considerable disagreement as to the importance of water temperature as a limiting factor. An analysis of existing temperature data, identification of data gaps, and recommendation for monitoring to fill the data gaps is needed. **7. Feasibility of Reintroduction of Native Wildlife Species** The feasibility of reintroducing native wildlife species, such as big horn sheep, sharp-tailed

Goals and Objectives	Strategies
	grouse, and mountain quail, into the Malheur River Subbasin should be further explored. An initial step is to evaluate the potential for these reintroductions in habitats where these introductions are potentially possible.

Table 16. Strategies for Terrestrial Habitats and Wildlife.

Goals and Objectives	Strategies
Goal 8 – Restore Mixed Conifer Forest Habitat Restore mixed conifer forest habitats to provide optimum carrying capacity for native wildlife species.	
Objective 8.1 : Restore forest habitat processes and functions.	**1. Overstory vegetation** Maintain some forests older than 70 years of age for pileated woodpecker. Retain all large-diameter (>53 cm [21 in] d.b.h.) ponderosa pine, cottonwood, Douglas-fir, and western larch snags for pileated woodpecker, preferably in clumps, and provide opportunities for snag recruitment throughout the mixed conifer habitats. As a long-term strategy, conduct mid-scale assessment of species snag use and the dynamics of snags in landscapes and adjust the strategy accordingly. Maintain 60/40 forage to cover ratio for elk summer range. Limit disturbance within areas of habitat. Retain mature stands of ponderosa pine. **2. Understory vegetation** Maintain some forest areas with dense underbrush cover for blue grouse and elk calving areas. Maintain some large contiguous areas of habitat. Limit disturbance within areas of habitat.

Goals and Objectives	Strategies
	3. Fire patterns Use prescribed fire, timber harvest, and thinning to change forest composition and structure to reduce risk of stand-replacing wildfires and shift to maintenance with prescribed low-intensity controlled fires. Use thinning to restore landscapes to a more natural condition. **4. Roads** Close and restore excess roads to reduce fragmentation of habitats by roads. Where natural process areas occur, prioritize road closures and restoration in adjacent areas to increase the interior functional core of habitats. **5. Management** Manage upland habitat through the measurement and evaluation of indicators such as a) soil stability and watershed function, b) distribution of nutrients and energy, and c) recovery mechanisms (i.e. plant demography and vigor). **6. Protection** Provide permanent protection of habitats through acquisition, easements or other methods. Look for opportunities to acquire lands in lower elevation forest and forest-rangeland mosaics to maintain for fish and wildlife habitat. Retain stands of ponderosa pine where old-forest conditions are present, and actively manage to promote their long-term sustainability through the use of prescribed burning and understory thinning.
Goal 9 – Restore Shrub-Steppe Habitat Restore shrub-steppe habitats to provide optimum carrying capacity for native wildlife species.	
Objective 9.1: Restore shrub-steppe habitat processes and functions.	**1. Overstory vegetation** Increase native shrub cover in deer and elk winter and summer range, increase available winter browse forage for pronghorn. Optimize sage grouse breeding, nesting, and winter habitat diversity with regards to density, height, structure, and composition of overstory vegetation. **2. Understory vegetation**

Goals and Objectives	Strategies
	Increase native grass cover and forage in deer and elk winter range, maintain healthy understory populations of forbs for pronghorn, and identify shrub-steppe habitats with remaining native perennial understory vegetation for potential areas for restoration activities. Optimize sage grouse habitat diversity with regards to density, height, structure, and composition of understory vegetation. **3. Soils** Implement agricultural practices that protect soils from erosion. Research biological soil crusts and their effects on soil stability. Research management opportunities for protection and restoration of biological soil crusts. **4. Fire patterns** Identify historic fire patterns and identify areas that may benefit from prescribed burn activities. **5. Restore/Manage Weed and juniper encroachment** Identify juniper encroachment areas that contain remaining shrub-steppe understories as potential areas for restoration/management activities. Research potential for restoration of cheatgrass, medusahead, and other exotic weed invaded/dominated areas. **6. Roads** Identify areas where roads have a negative impact on habitat and evaluate potential road closures or use educational signage to limit damage. **7. Management** Manage upland habitat through the measurement and evaluation of indicators such as a) soil stability and watershed function, b) distribution of nutrients and energy, and c) recovery mechanisms (i.e. plant demography and vigor). **8. Protection** Identify areas of remaining upland shrublands and grasslands where functional integrity is still relatively high and provide permanent protection of habitats through acquisition, easements etc. Actively manage these areas to promote long-term sustainability.
Goal 10 – Restore Mt Mahogany and Bitterbrush	

Goals and Objectives	Strategies
Restore mountain mahogany and bitterbrush habitats to provide optimum carrying capacity for native wildlife species.	
Objective 10.1 : Restore mountain mahogany and bitterbrush habitat processes and functions.	**1. Overstory Habitat** Increase native shrub cover in deer and elk winter range. Manage grazing to allow for mountain mahogany and bitterbrush reproduction. **2. Protection** Identify areas of mountain mahogany and bitterbrush habitats where functional integrity is still relatively high. Actively manage these areas to promote long-term sustainability. Identify and permanently protect functional and critical link habitats and habitats with high function potential through acquisition, easements or other means.
Goal 11 – Restore Open Water Habitats Restore open water habitats to provide optimum carrying capacity for native wildlife species.	
Objective 11.1 : Restore open water habitat processes and functions.	**1. Restoration** For bald eagle, maintain healthy water quality with suitable fish prey, maintain/establish large snags/trees for nesting, maintain expansive open water habitat for bald eagle foraging, maintain/establish nearby perch sites. For river otter, maintain slow-moving pooled areas and a large fish prey base. **2. Protection** Identify areas of remaining quality open water habitats where functional integrity is still relatively high and provide permanent protection of habitats through acquisition, easements etc. Actively manage these areas to promote long-term sustainability.
Goal 12 – Restore Herbaceous Wetlands Restore herbaceous wetland habitats to provide	

Goals and Objectives	Strategies
optimum carrying capacity for native wildlife species.	
Objective 12.1 : Restore herbaceous wetland habitat processes and functions.	**1. Wetland Habitat Mapping** Accurately map historic and current wetland habitats to aid in identification of assessment of loss and gain of habitats. **2. Restoration** To restore native amphibian species: control bullfrog occurrence, maintain minimal non-native predatory fish, maintain/restore high water quality, maintain deeper slow-moving pooled sites for leopard frog. **3. Protection** Identify areas of remaining quality herbaceous wetland habitats where functional integrity is still relatively high and provide permanent protection of habitats through acquisition, easements etc. Actively manage these areas to promote long-term sustainability.
Goal 13 – Restore Riparian Habitats Restore riparian habitats to provide optimum carrying capacity for native wildlife species.	
Objective 13.1 : Restore riparian habitat processes and functions.	**1. Restoration** Increase quality and amount of riparian shrublands and woodlands through restoration of hydrologic flows, vegetation restoration, road management, and control of grazing and recreational activities. Restore habitat by fencing and other proper grazing management strategies. Increase willow density and maintain/restore contiguous riparian corridors for yellow warbler and yellow-breasted chat and elk calving areas. Limit disturbance within habitat. **2. Beaver Management** *(See Objective 1.1, Strategy # 9)* **3. Upland Erosion Management** Incorporate upland vegetative management and erosion control into cropland, rangeland, and

Goals and Objectives	Strategies
	urban management practices. **4. Protection.** Identify areas of remaining riparian habitats where functional integrity is still relatively high and provide permanent protection of habitats through acquisition, easements and other means. Actively manage these areas to promote long-term sustainability.
Goal 14 – Mitigate Wildlife Losses Due to Development of the Federal Columbia River Power System Implement wildlife projects to mitigate for losses due to the hydropower system.	
Objective 14.1: Address habitat losses resulting from development and operation of hydrosystem projects.	**1. Research** Quantify wildlife losses caused by the construction, inundation, and operation of the hydropower projects. **2. Acquisition and Enhancement** Develop and implement habitat acquisition and enhancement projects to fully mitigate for identified losses. Identify and evaluate sites for potential use in mitigation, including opportunities for enhancement and restoration on federal, state, and Tribal lands, and opportunities for cooperative restoration and enhancement efforts with private landowners. **3. Coordinate and Implement Wildlife Mitigation Projects** Coordinate mitigation activities throughout the basin and with fish mitigation and restoration efforts, specifically by coordinating habitat restoration and acquisition with aquatic and terrestrial habitats to promote connectivity of fish and wildlife habitats.. Work with State and Federal agencies as well as neighboring landowners to complete a wildlife mitigation plan to fulfill the mitigation projects and obligations to wildlife. **4. Protect and Maintain Habitats** Protect wildlife habitat through fee title acquisition, conservation easements, lease, or management plans. Maintain existing and created habitat values. Protect, enhance, or restore Habitat Units to address fulfillment of MOA between the Burns Paiute Tribe and Bonneville

Goals and Objectives	Strategies
	Power. **5. Management Planning** Develop management plans that restore degraded habitat to meet specific goals and objectives in accordance with the Operation and Maintenance Guidelines developed by CBFWA for Wildlife Mitigation sites. **6. Monitor** Monitor and evaluate habitat and species responses to mitigation actions.
Objective 14.2: Restore, Enhance and Protect critical wildlife habitat.	**1. Mitigate or Enhance Neo-tropical Migrant Bird Populations.** Maintain or enhance neo-tropical migrant bird habitats relative to current levels within present use areas and identify limiting factors for these populations within the subbasin. Maintain or enhance populations of cavity nesting species relative to current levels within present use areas and identify limiting factors within the subbasin. **2. Mitigate or Enhance Reptile and Amphibian Populations.** Maintain or enhance amphibian and reptile habitats relative to current levels within present use areas and identify limiting factors within the Subbasin. **3. Mitigate or Enhance Invertebrate Populations** Maintain or enhance invertebrate habitats relative to current levels within present use areas and identify limiting factors for these populations within the Subbasin. **4. Mitigate or Enhance Big Game Populations for Cultural and Subsistence Uses** Protect, restore, enhance, and sustain habitats of big game species to support traditional level of cultural and subsistence use, through: a) Developing, prioritizing, and implementing projects and/or research to identify additional big game limiting factors, and b) Monitoring current populations to assess survival, fecundity, sex ratios, and post wintering recruitment. Target species include elk, mule deer, bighorn sheep, and pronghorn. **5. Mitigate Small Game Populations** Protect, restore, enhance, and sustain populations for waterfowl, upland game, and furbearers

Goals and Objectives	Strategies
	under traditional levels of recreation and subsistence use.
Goal 15 – Terrestrial Habitat Mapping Assess and map the condition of habitats within the Malheur subbasin.	
Objective 15.1: Assess and map habitat extent and condition information. Develop a central database for storing habitat information.	**1. Habitat Mapping** Use watershed assessment, BLM riparian functioning condition, and NRCS rangeland health assessment techniques to quantify habitat extents and assess and map habitat condition for identification of areas for management improvements, enhancement, restoration, and protection. **2. Develop a Central Database of Habitat Information.** Collect, assimilate, evaluate, standardize, and enter preexisting and newly collected habitat data into a common database accessible to all resource managers in the subbasin. Identify and address data gaps. **3. Habitat Monitoring** Continue riparian Monitoring & Evaluation at pre-established index sites and establish new sites in additional habitats where appropriate. Coordinate ongoing/future entry of Monitoring & Evaluation data into the central database repository through the interagency team. Use Monitoring & Evaluation results to guide prioritization efforts and/or management strategies.
Goal 16– Evaluate and Address Road Impacts Evaluate and develop strategies to mitigate for the impact of the transportation system on wildlife populations	
Objective 16.1: Identify for improvement, closure, restriction, or decommissioning, existing roads or road networks that are not critical for transportation, recreation and land management activities, but that are negatively impacting wildlife populations and aquatic resources.	**1. Evaluate Transportation System** Evaluate transportation system to identify roads that are the greatest threat to wildlife security, and wildlife travel patterns and those that contribute to fragmentation of prime wildlife habitats. **2. Coordinate Road Closures** Coordinate with aquatic, recreational, and cultural resource experts to make recommendations for road improvement, closure, restriction, or decommissioning that maximize the benefit to both terrestrial and aquatic resources while minimizing impact to the transportation system. Use

Goals and Objectives	Strategies
	any pre-existing data to aid in decision-making process. **3. Monitor Effectiveness** Establish monitoring index sites and compare pre- and post-Monitoring and Evaluation data at index sites to evaluate project effectiveness.
Goal 17– Evaluate and Address Noxious Weeds Assess, prevent, and treat of noxious weeds	
Objective 17.1: Identify noxious weed communities, prevent their introduction, reproduction, and spread, and reduce their density where already established.	**1. Evaluate Noxious Weed Problems in the Subbasin** Use landscape imagery, plant surveys, and existing data to monitor the extent and density of noxious weed populations in the subbasin. **2. Develop and Implement Noxious Weed Control** Develop and evaluate techniques for fighting the spread of noxious weeds. Develop education and awareness programs in noxious weed identification, spread prevention and treatment. Work with agencies/entities actively involved in noxious weed identification, prevention, and eradication.
Goal 18– Restore Native Wildlife Species Evaluate opportunities to restore native wildlife species that have been eliminated or reduced in their historic range. **Objective 18.1: Pursue opportunities to retire domestic sheep allotments so big horn sheep can be reintroduced to historic habitats.** **Objective 18.2. Improve habitat conditions to a condition that can support mountain quail and sharp-tailed grouse populations.** **Objective 18.3. Pursue opportunities to retire grazing**	**1. Retire Allotments to Reintroduce Big Horn Sheep** Disease from domestic sheep are a primary impediment to reintroduction of big horn sheep. Work with land management agencies to retire sheep allotments in the historic habitat for big horn sheep.

Goals and Objectives	Strategies
allotments that would benefit sage grouse, especially that provide lek sites.	

6.4 Prioritization

Introduction

Ecologists generally agree that conserving fish and wildlife species will require protection of high quality habitats and restoration of watershed functions. Kauffman and others (1997) described a process for ecological restoration of western landscapes by using *passive restoration* as the first and most critical step, and then subsequently using *active restoration* once basic watershed processes were in a recovery cycle. This approach was largely in response to the practice of using structural treatments to streams (gabions, streambank protection, adding large wood) to improve fish habitats without treating the reasons for the poor conditions (that is, treating symptoms rather than causes.)

Roni and others (2002) expanded on this concept in discussing stream restoration strategies and techniques. They suggest initial efforts should first focus on protecting areas with intact processes and high-quality habitat, then focus on reconnecting isolated high-quality habitats, such as habitats made inaccessible by culverts or other manmade obstructions. Once the connectivity of habitats within a basin has been restored, efforts should focus on restoring hydrologic, geologic, and riparian processes. Instream habitat enhancement should be employed after restoring natural processes or where short-term improvements in habitat are needed.

Oregon Watershed Enhancement Board (OWEB 2004) recently completed a paper discussing improvement priorities at basin and watershed scales. Like the Northwest Power Council, OWEB faces the issue of how to best respond to grant requests and assure that funded projects are accomplishing overall goals (water quantity, water quality, recovery of ESA-listed fish species). The prioritization framework focuses on five major principles listed briefly below (the principles are not quoted verbatim).

Watershed Restoration Principles (OWEB)

1. Restore watershed connectivity for key fish and wildlife species.
2. Restore watershed processes impacting the aquatic system and wildlife habitat.
3. Restore key habitats and water quality for ESA-listed species.
4. Reduce or eliminate impacts from land use activities.
5. Address the symptoms of disturbance that impact fish and wildlife populations.

Although the approach to prioritizing projects varies among the various entities based on their goals (watershed health, habitats, water quality), there is a common thread that runs through the principles that can conceptually assist in establishing priorities in the Malheur River Subbasin. Specifically, 1) the importance of protecting high-quality habitats, 2) a focus on watershed connectivity, 3) focus on restoring watershed processes and reducing impacts from land uses, and 4) restoring key habitats for ESA-related species, and 5) decreasing the emphasis on treating symptoms in fish and wildlife habitats.

Additional Considerations in Prioritization

In addition to the ecological principles discussed above, there are institutional, technical, and economic constraints to address when prioritizing across the ten-year planning horizon for this plan.

1. As identified in the inventory of existing programs (Appendix B) institutions (primarily agricultural agencies) that deliver technical assistance, funding, and education on land management practices are strained by existing funding levels. More progress would currently be made in restoring watershed health if these farm service agencies had additional resources.

2. Many of the strategies described in the plan, require further evaluation at finer spatial scales to more accurately identify the extent, magnitude, and location of limiting factors that were only evaluated qualitatively in this subbasin plan. Watershed assessments or other fine scale analyses are needed prior to implementing some strategies (e.g., channel restoration). Other strategies can be implemented confidently without needing this additional step.

3. The cost of implementing any strategy described in the strategy tables needs to be more fully explored. Obviously, strategies that can be implemented and projects that can be accomplished at lower cost for similar benefit should be a higher priority. No attempt at cost benefit assessment was completed in this plan.

4. Priorities need to address the land ownership pattern. This plan assessed limiting factors without regard to ownership. The federal land management agencies have regulatory requirements (Clean Water Act, Endangered Species Act, National Environmental Policy Act, etc.) and land management plans in place that already set their management direction. We expect that this plan can best influence work that will be completed by the Coalition partners, the Burns Paiute Tribe and the Malheur Watershed Council, although the federal land management agencies are critical partners in the subbasin.

5. The Coalition partners have different capabilities with respect to implementing strategies. The Malheur Watershed Coalition has traditionally worked most closely with the private land owner and agricultural operators in the subbasin. They will continue to be successful in implementing strategies associated with this stakeholder group; strategies that address riparian improvement on private lands, management practices for water quantity and water quality, and fish and wildlife habitat improvements within the private lands. The Burns Paiute Tribe has been effective at research, monitoring, and evaluation activities; in obtaining and managing properties for restoration/protection of key habitats; and implementing recovery plans, such as the draft Bull Trout Recovery Plan. Each of the Coalition partners, in addition to the State and Federal agencies, has a role in implementing strategies to which they are best suited. This effort needs to occur in

parallel, rather than in a strict step-wise manner that appears to be suggested in some of the conceptual restoration approaches.

A Prioritization Approach for the Malheur Subbasin

Priorities for projects are not static and need to be adjusted on a regular basis. A balance between ecological principles and practical considerations suggests the following as one approach to identify the highest priorities in the subbasin. More important than establishing a static priority at this point in time are the principles and rationale used in developing priorities.

(Note that projects discussed in Goal 6 and Goal 14 as mitigation for loss of fish and wildlife resources associated with the federal Columbia River Power system are not considered for prioritization. Mitigation for loss of natural resources, such as loss of anadromous fish in the subbasin, is an issue that cannot be compared directly to strategies based on protection and restoration. Mitigation is a separate conceptual issue that is best discussed between the Tribe and responsible federal agencies.)

I. Strategies that assist in recovery of the ESA-listed bull trout. These strategies should be implemented in the North Fork and Upper Malheur River watersheds. *(Rationale: Addresses key habitat for ESA-listed species.)*

  - Reconnect habitats by addressing obstructions, such as culverts, within the range of bull trout.
  - Reduce loss of bull trout at irrigation diversions.
  - Protect key bull trout quality spawning and rearing habitat through management actions, property acquisition, or easement.
  - Restore bull trout spawning and rearing habitat that is less than optimal.
  - Address effects of major dams on bull trout.
  - Reduce effects on non-native fish on bull trout.
  - Continue research on bull trout distribution, genetics, and habitat requirements.

II. Strategies that assist in the restoration of the shrub-steppe habitat and prevent ESA listing of wildlife species in this habitat type. *(Rationale: Shrub-steppe habitat is the most extensive wildlife habitat in the subbasin and critical to wildlife species in decline. Preventing further declines will benefit wildlife, but will also prevent the potential regulatory impact on economy and lifestyle.)*

  - Increase native shrub cover in deer and elk winter and summer range, and optimize overstory vegetation for sage grouse.
  - Increase native grass cover in deer and elk winter range, and optimize understory vegetation for sage grouse.

- Implement practices that protect soils.
- Evaluate and treat weed and juniper encroachment.
- Manage upland habitats through measurement and evaluation of ecological indicators.
- Identify areas with high functional integrity and provide protection through management, acquisition, or easement.

III. Restore watershed processes and reduce impacts from land uses for limiting factors that do not require watershed assessments. *(Rationale: For many limiting factors the location and technical procedure is already identified; and no further analysis is needed to assure the project will have a beneficial effect.)*

- Restore riparian buffers where impacts are documented.
- Implement rangeland management practices.
- Implement cropland management practices.
- Implement irrigation conservation practices.
- Consider QHA restoration ranking when prioritizing projects (See Appendix A).

IV. Complete watershed assessments or similar analysis to better assess limiting factors and develop a priority for implementation. *(Rationale: For many limiting factors, this subbasin assessment is not sufficient to identify location, severity, and need. Further step-down analysis is needed at finer spatial scales.)*

- Complete channel classification, identification of channel impacts, and potential for restoration.
- Complete riparian area condition assessment.
- Evaluate wetland area extent and condition.
- Culvert inventory and prioritization (connectivity).
- Assess temperature regimes on a watershed basis.
- Evaluate feasibility of reintroducing native wildlife species.

V. Develop redband trout protection and recovery strategy. *(Rationale: Additional basic research is needed to fully understand basic biology and limiting factors for redband trout in the Malheur River Subbasin. At this point in time, redband are not listed under ESA).*

6.5 Consistency with ESA/CWA Requirements

The Malheur Subbasin Plan was developed to be consistent with and implement provisions of the Endangered Species Act and the Clean Water Act.

Aquatic and terrestrial focal species were selected to include federal ESA species and state listed species including endangered, threatened, and species of special concern (See Section 4.1 for focal aquatic species, and Section 5.1 for focal terrestrial species). All relevant ESA listing and recovery plans have been reviewed for recommendations and suggested actions and where appropriate these actions have been incorporated into strategies for implementation. For example, the Draft Bull Trout Recovery Plan (USFWS 2002) has been used as a basic guidance document, for development of goals and objectives, and as a starting point for development of strategies for recovery of bull trout.

The Clean Water Act has been integrated into this plan by reference to the Snake River TMDL that applies to the mouth of the Malheur River. The Malheur Watershed Council, Malheur County Soil and Water Conservation District, and Malheur Agricultural Experiment Station are implementing a water quality monitoring program in response to the Snake River TMDL and in preparation for a TMDL that will be completed for the Malheur River Subbasin in the future. Strategies incorporated into the plan for habitat restoration (channels and riparian condition relating to sediment and temperature reduction) and for water quality (specifically agricultural BMPs) are designed to reduce pollutants and improve water quality.

In addition to specific content addressing the ESA, a representative of the USFWS, Mr. Keith Paul of the LaGrande office, was an active participant throughout the planning process, and provided us advice on integration of the plan with ESA requirements.

6.6 Research, Monitoring and Evaluation

6.6.1 Overview

The following material outlines the research, monitoring, and evaluation needs currently identified for the Malheur Subbasin. Much of this material follows directly from the aquatic and terrestrial assessments, and the strategies identified in preceding sections of this document. In assembling this material we have incorporated elements of the guidance set forth in the technical guide for subbasin planners (NWPPC, 2001). As described elsewhere, this Management Plan has been developed up through and including the identification of appropriate strategies, but stops short of the development of specific actions to address the identified limiting factors. Consequently, project development will need to incorporate more specific monitoring strategies. Planners are referred to Bisbal (2001), Reid (1994), and Scheeler et al. (2003) for specifics on development of monitoring plans.

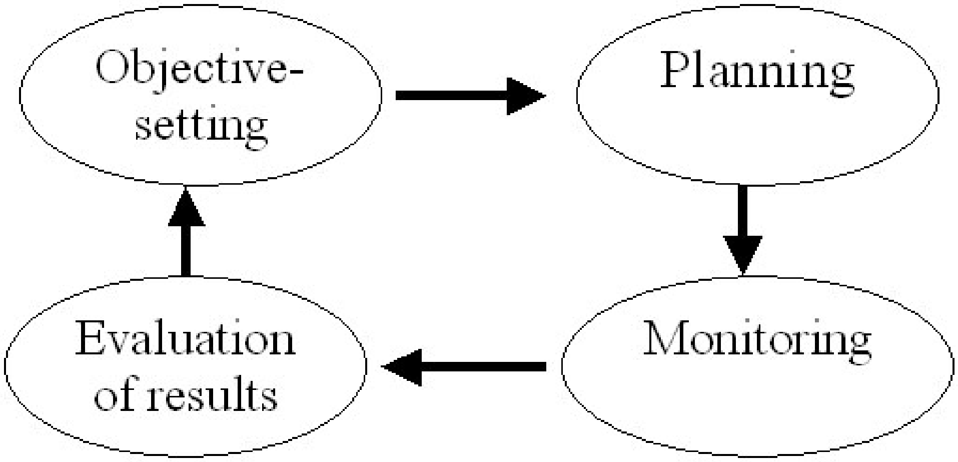
For both the aquatic and terrestrial components we have divided our discussion into two primary categories; 1) Research Needs/Data Gaps and 2) Monitoring and Evaluation needs and existing programs. The research needs and data gaps outline the specific conditions and situations in the subbasin that will require future research studies to help resolve management uncertainties. The monitoring and evaluation section outlines the monitoring approaches that have been identified for the subbasin. Monitoring programs should follow the "tiered" approach identified by the Independent Scientific Review Panel (NWPPC, 2001):

- Tier 1 Trend (Change) Monitoring (generally similar to "implementation monitoring") – Did the agencies, landowners, and managers implement the management guidelines? Implementation monitoring is sometimes viewed as an administrative accounting of actions.

- Tier 2 Statistical Monitoring (generally similar to "effectiveness monitoring") – Did the management guidelines have the expected results? Effectiveness monitoring is viewed as tracking results as a specific outcome of management activities.

- Tier 3 Research Monitoring (generally similar to "validation monitoring") – Are the scientific assumptions underlying the management guidelines correct? Validation monitoring is viewed as testing the scientific basis for the management guidelines, and may entail research.

Evaluation, as envisioned for subbasin planning, is an integral part of the adaptive management cycle, serving as a feedback loop back into any monitoring plan:



Evaluation consists of the interpretation of the information collected through monitoring, assessing the deviation from particular target goals or anticipated results, and recommending modifications to policy or management activities where appropriate. Three elements of evaluation should be recognized (NWPPC, 2001):

- Scientific evaluation: this stage consists of objective and independent scientific interpretation of the strengths and weaknesses of available information.

- Decision-making evaluation: apply this monitoring information to decisions on alternative approaches to fish and wildlife recovery. (1) Who should be responsive to triggers that suggest alternatives are needed? And (2) what is the management response to changes detected in ecological indicators?

- Public evaluation: Develop a review and comment plan with the mechanisms and opportunities for evaluation by the public.

6.6.2 Aquatic Research Needs/Data Gaps

Fine-scale watershed assessments:

The largest impediment to the evaluation of current aquatic conditions within the Malheur Subbasin was the general lack of specific information on current and reference conditions. Consequently, the largest data gap identified is the need to conduct fine-scale watershed assessments within the Subbasin. Assessment should include methodologies identified in the Oregon Watershed Assessment Manual (OWEB, 1999). These assessments should be targeted at increasing our understanding of the aquatic limiting factors identified in the aquatic assessment. Focus should be on the four primary limiting factors: Channel Condition, Riparian Condition, Low Flows, and Obstructions. These assessments will also serve as baseline data for monitoring activities (described below). These assessments should include:

- Channel Classification - Stream channel condition is a controlling factor that influences habitat and riparian functions. Fine scale analysis is needed to identify the current, historic, and potential future distribution of channel types (e.g., Rosgen 1996). This information is needed to more accurately identify current channel conditions and opportunities prior to developing reach specific channel restoration plans. In addition to basic classification a channel assessment can evaluate the potential for removing/ modifying levies, berms, dikes; assessing road encroachment; identifying and assessing confined and relocated channels; and identifying opportunities for developing off-channel habitats.

- Channel Modifications – Analyses should evaluate the feasibility of removing or modifying existing levies, berms, dikes etc. that impede the natural meander pattern. This evaluation can be incorporated into the channel assessment listed above.

- Road Surveys – Analyses should evaluate direct road impacts to streams (i.e., roads located in areas that impinge on stream channels), as well as indirect impacts (i.e., sediment production and delivery to streams). The feasibility of closing, rehabilitating, or relocating problem roads should be included as part of these analyses, and will require coordination with road owners and responsible land managers

- Hydrologic changes – Assessments should include an evaluation of how watershed hydrology has been modified by activities such as wetland/meadow modifications, loss of beaver, and changes in upland vegetation composition (e.g., juniper encroachment). Effects to evaluate include changes to natural water storage pathways and the effects this has on base flows. As part of this evaluation assess the likely effects (both positive and negative) of human-made structures (e.g., stock ponds, irrigation return flow, push up dams) on water storage and release. In addition, an evaluation should be conducted on possible changes in peak flows that have resulted in localized damage to riparian function (e.g., in the lower Cottonwood Creek reach in the Main Malheur watershed).

- Fish habitat condition - Evaluation of locations favorable to establishing off-channel habitats to increase quantity of spawning and rearing habitats, as well as habitat for riparian dependent wildlife.

- Riparian Surveys – Riparian assessments evaluate existing buffer strip width, continuity, and vegetative composition. The assessments can be tailored to forest, cropland, rangeland, or urban environments and evaluation of exotic and noxious plants. Assessments should identify current and historic riparian community type and structure, and identify specific impediments to riparian function (e.g., encroachment by roads, narrow buffers and loss of function associated with cropland, changes in composition and structure associated with range and forest management, etc.). Specific questions include 1) what was the historic distribution of cottonwood gallery forests along the larger mainstem rivers? 2) What is the feasibility of reestablishing historic riparian species?

- Wetland condition – Assessments should identify the current and historic extent of wetlands within the watersheds of the Malheur Subbasin, the functions associated with current and historic wetlands, and an evaluation of how changes to wetlands have affected aquatic and terrestrial focal species.

- Temperature Assessment - Data on temperature conditions is scattered among the agencies (the extent of the data is not known), and has not been compiled or analyzed at the watershed scale to evaluate current water temperature conditions across the subbasin.

Consequently, there is considerable disagreement as to the importance of water temperature as a limiting factor. An analysis of existing temperature data, identification of data gaps, and recommendation for monitoring to fill the data gaps is needed.

Evaluation of barriers:

A subbasin-wide evaluation is needed to evaluate the extent and severity of barriers to the movement of the focal aquatic species. Potential sources of barriers include culverts and other road structures, irrigation diversions and dams, and areas of subsurface flow. Standard protocols should be used for conducting inventories, assessing the barrier (such as the USFS Fish Crossing, http://www.stream.fs.fed.us/fishxing/), and establishment of priorities for fixing the barriers. This evaluation may be conducted in conjunction with the watershed analyses outlined above. This study should build on the ODFW culvert fish passage survey that was conducted for state- and county-owned roads within the Malheur Subbasin (Mirati et al., 1999).

Evaluation of changes in dam operations:

Operations at the major dams in the subbasin have significant impacts on the aquatic focal species. A comprehensive evaluation of dam operations is needed to address the following issues:

- A feasibility study to assess the possibility of fish passage at Agency Valley Dam/Beulah Reservoir, and Warm Springs Dam/Reservoir to reconnect the Malheur core bull trout populations and other fish species.

- Evaluate and recommend modifications if needed to water level manipulation, entrainment, and minimum fisheries pool at Agency Valley Dam/Beulah Reservoir, and Warm Springs Dam/Reservoir to assist in recovery of bull trout in the Malheur River system.

- An evaluation is needed of the feasibility to enhance flows below irrigation dams during the non-irrigation season. In many cases the utilization of channels as irrigation conveyance downstream of dams has resulted in higher low flows than optimum (e.g., North Fork Malheur below Beulah). Conversely, in some areas (e.g., lower Willow Creek) reservoir releases travel through off-channel canals, with little water released directly to the stream channel, and return flow reenters channel far downstream. Improved flows during the non-irrigation season below Agency Valley Dam is particularly important to improve suitability for overwintering habitat for bull trout.

This evaluation should build upon previous work conducted by the Bureau of Reclamation (BOR, 2001). The BOR study evaluated structural alternatives for establishing a conservation pool for bull trout at Beulah Reservoir. Alternatives included adding height to Beulah Dam for additional storage or adding height to Warm Springs Dam and transferring water to Beulah to maintain a pool. Cost estimates are provided.

Evaluation of effects of nonnative fish on bull trout and redband trout

Further genetic studies are needed to determine the spatial extent and rates of integration and hybridization in the range of bull trout and redband trout. Coupled with this is the need to evaluate methods of reducing impacts in areas where non-native fish are determined to be negatively impacting bull trout and rainbow trout. These studies should build on previous work that has been completed within the Subbasin, including:

- The Burns Paiute Tribe, ODFW, and other state and federal agency partners have completed several years of intensive life history studies for bull trout and redband trout (e.g., Gonzalez et al. 1998, Schwabe et al. 2000). These studies have employed radio-telemetry, trapping, spawning surveys, electrofishing methods, and temperature monitoring to document the distribution, abundance, and seasonal migration of bull trout and redband trout in the North and upper Mainstem Malheur River. Fieldwork for these studies was started in 1998.

- In addition, ODFW has provided a seasonal position to assist with the bull trout study and has coordinated annual bull trout spawning ground surveys and survey reports, as well as monitoring stream temperature and flow in the upper NF and upper Malheur River and tributaries annually since 1992.

- The Malheur River was included in two DNA analysis of genetic population structure of Oregon bull trout (Spruell and Allendorf 1997, Leary and Allendorf 1991). Both studies found substantial genetic variation among populations and concluded that preserving the genetic diversity of bull trout will require the continued existence of many populations in the region (Leary and Allendorf 1991).

- A recent research project conducted by Stephanie Gunckel as part of a Master's Thesis, investigated the effect of brook trout on the feeding behavior and diet of bull trout (Gunckel 2000). Feeding behavior, microhabitat use, and agonistic interactions were examined in a controlled in-stream experiment. One of the two study sites was within the Malheur Subbasin, on Meadow Fork of Big Creek. Results provided little evidence of a niche shift for bull trout in the presence of brook trout and suggest that the more aggressive brook trout may potentially displace bull trout.

Comprehensive redband trout evaluation and protection/recovery strategy

A data gap currently exists with respect to the distribution and genetic composition of redband trout, and the degree of hybridization with introduced rainbow trout, in the Malheur River Subbasin. A comprehensive redband trout protection/recovery strategy is needed to ensure the long-term persistence of self-sustaining, complex interacting groups of redband trout across the species' range. Elements of this strategy should include:

- Genetic evaluation of redband trout to determine degree of integration and hybridization with introduced rainbow trout.

- Identification of the spatial and seasonal distribution of redband trout, movement, seasonal use of habitat, and the effect on habitat alterations on the species.

- Development of a strategy to manage redband trout for either conservation or increased harvest.

This evaluation should build on past fish and habitat surveys that have been conducted within the Malheur Subbasin including the following:

- Pribyl and Hosford (1985) - Conducted a comprehensive electro-fishing survey that included most of the North Fork and Upper Malheur River upstream of the reservoirs.
- Buckman et al. (1992) and Bowers et al. (1993) - Summarized population and habitat information on bull trout in the Subbasin.
- ODFW (multiple years) - Conducted aquatic habitat inventories for most of the Mainstem and North Fork of the Malheur River, and the Little Malheur River and tributaries (NWPPC 2000, USFS 2000).
- US Forest Service (USFS) and Bureau of Land management (BLM) - Extensive aquatic monitoring programs within the Subbasin, conducted as part of their ongoing management planning.

Evaluate Mitigation/Substitution Alternatives

Mitigation for the loss of anadromous fish to tribal and non-tribal communities has been identified as an objective of the Malheur Subbasin management plan. However, further evaluation of alternatives is necessary to implement a mitigation strategy. Substitution (either in- or out-of-kind) may be appropriate as part of this evaluation. The evaluation should include the following:

- Documentation of the extent and magnitude of the loss. Although historic use of salmon by the Burns Paiute Tribe has been documented, the extent and magnitude of the loss to the Tribe has not been documented to the satisfaction of the Tribe and community stakeholders. An analysis of oral history and historic documents needs to be completed to develop a more definitive assessment as a basis for mitigation.
- Evaluate and recommend substitution projects. A number of different types of projects have been suggested as substitution for lost resources: Restoring native resident fisheries through habitat enhancement, increasing populations through hatchery production, developing put-and-take fishery at new sites, developing out of-kind (i.e., wildlife or botanical) resources, or taking actions to reintroduce anadromous fish to blocked habitats. These alternatives need to be fully explored to determine the best course of action.

6.6.3 Aquatic Monitoring and Evaluation Programs

The following outlines the aquatic monitoring and evaluation needs identified for the Malheur Subbasin. In each case specific monitoring strategies will need to be developed to answer the following questions:

- Has the action been implemented (**implementation monitoring**)?
- Did the action result in changes (either positive or negative) to the habitat attribute in question, and what was the magnitude of the changes (**effectiveness monitoring**)?

- Was the net result to the aquatic focal species positive, negative, or insignificant, and what was the magnitude of the change (**validation monitoring**)?

- How do we objectively evaluate the quality of the results; how do we apply the monitoring results to management decisions; how do we share the results with the public (**evaluation**)?

In all case the monitoring and evaluation must consider appropriate temporal and spatial time scales, and account for natural variability. For example, a monitoring program to evaluate restoration of riparian function may have a relatively short time frame over which to evaluate implementation (0-3 years), and a longer time frame to evaluate effectiveness and validation (5-50 years). In addition, stochastic events (e.g., flooding) may result in localized setbacks to recovery that is independent of the action.

Restoration of Stream Channel Processes and Conditions: The objective is to achieve both a 1) distribution of channel types, e.g., Rosgen (1996) channel types, as well as 2) a distribution of habitat conditions within those channel types, that are as close as possible to the historic distribution of these two variables within the subbasin. Specific monitoring needs include:

- Periodic watershed- and site-scale evaluations of changes in channel type and characteristics. Including changes associated with both active and passive restoration of lost functions due to levies, berms, dikes, road encroachment, and other channel confinements.

- Effects of upland management strategies designed to reduce erosion on channel condition.

- Effects of programs designed to reduce mechanical streambank damage associated with grazing.

- Effects of restoration developed/implemented to address legacy impacts due to hydraulic and placer mining in the Willow Creek watershed.

- Effects of changes in riparian conditions on channel form and function.

- Effects of changes in channel form associated with management activities that result in beaver dams, and changes in designs of human-made irrigation structures.

- Effects of efforts designed to enhance natural storage pathways (e.g., establishment of beaver dam complexes, restoration of channel/floodplain connectivity) on channel form and function.

- Effects of small-scale human-made water storage (e.g., irrigation structures, flood irrigation) on channel form and function.

Restoration of Riparian Conditions: The objective is to achieve a distribution of riparian communities having 1) a species composition, 2) size, and 3) structure that is appropriate for the channel type and ecoregion, recognizing that the distribution will also vary in time in response to natural disturbance factors. Specific monitoring needs include:

- Periodic watershed- and site-scale evaluations of changes in riparian communities and structure associated with both active and passive restoration of lost functions due to levies, berms, dikes, road encroachment, and past channelization.

- Effects of riparian buffer restoration strategies for cropland, rangeland, and forestland areas.

- Effects of programs designed to eliminate noxious weeds in riparian and wetland areas.

- Periodic watershed- and site-scale evaluations of changes in wetland conditions and functions.

Enhancement of Low Flow Conditions: The objective is to enhance low flow conditions such that they mimic the natural hydrograph to the extent possible, given the limitations posed by agriculturally dependent water use in the region. Specific monitoring needs include:

- Effects of changes in irrigation water management techniques on improved irrigation efficiency, and actual instream benefits realized through the application of these techniques.

- Effects of market-based incentives (e.g., Oregon Water Trust) designed to increase base flows on actual instream benefits.

- Effects of efforts designed to enhance natural storage pathways (e.g., establishment of beaver dam complexes, restoration of channel/floodplain connectivity) on base flows.

- Effects of small-scale human-made water storage (e.g., irrigation structures, flood irrigation) on base flows.

- Effects of constructed wetlands in headwater areas on enhanced base summer flows through diversion and storage of spring runoff.

- Effects of juniper conversion programs on base flows.

- Effects of changes in range and forest land management on upslope hydrologic response and base flows within the shrub-steppe habitat type.

- Effects of changes in dam operation, irrigation conveyance, and return flow collection on base flows.

Restoration of Fish Passage Connectivity: The objective is to eliminate, to the extent possible, human-related obstructions to the movement of the aquatic focal species within the Malheur subbasin (without exposing isolated native populations to possible hybridization with non-native species). Specific monitoring needs include:

- Effects of projects designed to remove barriers to the movement of the focal aquatic species.

- Passage conditions associated with projects designed to remove barriers (e.g., culvert replacement/retrofit, fish screens, infiltration galleries, etc.)

- Effects of changes in irrigation management on barriers posed by low or subsurface flow areas.

- Effects of attempts to provide fish passage at major dams in the subbasin.

- Effects of land acquisition/easement programs on reconnection of disjunct bull trout and redband populations

- Effects of active and/or passive riparian/channel enhancement on reconnection of disjunct bull trout and redband populations

Improvement of Water Quality: The objective is to reduce pollutants to the extent feasible from agricultural activities, urban areas and other sources to meet Oregon water quality standards. Specific monitoring needs include:

- Effects of Malheur Watershed Council Basin Action Plan actions on decreased water pollution associated with agricultural sources.

- Effects of best management practices developed by or compiled by the OSU Malheur Agricultural Experiment Station on decreased pollution levels associated with agricultural and urban activities.

Improve Bull Trout Habitat: The objective is to protect, restore, and maintain suitable habitat conditions for bull trout using strategies that are consistent with the Bull Trout Recovery Plan (USFWS 2002). Specific monitoring needs include:

- Effects of strategies to reduce loss of bull trout at irrigation diversions and related irrigation diversion structures in the North Fork and Upper Malheur watersheds.

- Effects of reach specific plans developed to resolve excessive sediment delivery, channel modifications, and high temperatures in the North Fork and Upper Malheur watersheds.

- Effects of reach specific plans to restore channels in areas of bull trout spawning and rearing habitat.

- Effects of efforts to restore connectivity and opportunities for migration in the North Fork and Upper Malheur watersheds.

- Effects of efforts to reduce the effects of major dams on native fish populations.

Reduced Effects of Nonnative Fish on Bull Trout and Redband Trout: The objective is to reduce the negative effects of brook trout and other nonnative fishes on bull trout and redband trout populations. Specific monitoring needs include:

- Effects of demonstration/pilot projects for controlling populations of non-native fish both on the target populations, and on the populations of bull trout and redband trout.

6.6.4 Terrestrial Habitat Research Needs/Data Gaps

There are many data gaps with respect to terrestrial habitats and focal species status in the Malheur Subbasin. Overall, there is a general lack of specific information on current and reference conditions. Consequently, the largest data gap identified is the need to conduct fine-scale habitat assessments within the Subbasin. Assessment should include methodologies used by ONHP to accurately determine historic vegetation patterns (primarily by researching surveyors records), and condition assessments used by the BLM and NRCS to evaluate riparian and upland health. These assessments should be targeted at increasing our understanding of the limiting factors identified in the terrestrial assessment. These assessments will also serve as baseline data for monitoring activities (described in section 6.6.6). These assessments should include:

Mixed Conifer Forest

1. Identify forests older than 70 years of age for maintenance for pileated woodpecker habitat.
2. Identify clumps of snags for maintenance for pileated woodpecker. Assess species snag use and changes in snag habitat and use this information to adjust strategies.
3. Identify areas of 60/40 forage to cover ratio to maintain for elk summer range.
4. Identify forest areas with dense underbrush cover to maintain for blue grouse.
5. Identify mature, open-grown stands of ponderosa pine to maintain for habitat sustainability.
6. Identify functional forest areas and determine the value of road closure and restoration activities in adjacent areas to develop interior functional core forest habitats.

Mountain Mahogany

1. Identify winter rage areas of elk and mule deer for restoration of dense shrub habitat.
2. Identify mountain mahogany and bitterbrush areas that would benefit from protection from grazing to increase the reproductive capability of these species.

Shrub-Steppe

1. Identify sage grouse home range areas for optimization of these areas for sage grouse habitat.
2. Identify sage grouse lek areas for developing strategies to reduce disturbance.

3. Identify shrub-steppe habitats with intact native understory vegetation for potential areas for restoration activities.

4. Identify California bighorn sheep use areas in mountain and canyon shrub-steppe to develop strategies to reduce disturbance and human use activities.

5. Identify juniper encroachment areas with intact shrub-steppe understories for potential areas for restoration/management activities.

6. Research biological soil crusts and their effects on soil stability. Research management opportunities for protection and restoration of biological soil crusts.

7. Identify high quality functional areas of habitat for protection.

8. Research potential for restoration of cheatgrass invaded areas.

9. Identify areas where roads have a negative impact on habitat and research potential road closures or potential areas for educational signage regarding wildlife values, poaching laws, etc.

Open Water

1. Identify areas for habitat enhancement for bald eagle nesting and foraging.

2. Identify areas for habitat enhancement for river otter.

Herbaceous wetlands

1. Identify areas for bullfrog and non-native fish control and establish methodology to implement and monitor effectiveness for increasing native frog populations.

2. Identify areas with poor water quality.

3. Accurately map historic and current wetland habitats.

Riparian Areas

1. Identify areas with low willow densities for potential for willow restoration plantings.

2. Accurately map historic and current riparian zones.

3. Identify areas with contiguous vegetated corridors and determine potential for protection of these areas.

4. Identify areas that would benefit from limited disturbance.

5. Identify areas with restoration opportunities. These include landowner cooperation with respect to grazing management, areas with potential for passive restoration, and areas with potential for active restoration.

6.6.5 Current Terrestrial Habitat Monitoring and Evaluation Programs

ODFW Elk Telemetry Research

ODFW conducted an elk telemetry project in the North Fork Malheur watershed from 1996 to 1998. The purpose of the study was to learn more about elk movements in the Beulah and South Sumpter wildlife management units. ODFW intended to use the data to manage the population in such a way to reduce damage to agricultural land. In this study elk were captured in 1996 and 1997 and fitted with radio collars. They were then aerially monitored monthly for three years to determine movements and survival (Walt Van Dyke, ODFW, pers. comm. 2004).

Big Game Surveys

ODFW conducts March flights to count elk, deer and bighorn sheep. Counts for pronghorn are conducted in January. Herd counts are conducted in late July. Harvest surveys are also conducted.

Sage Grouse Aerial Surveys

Sage grouse leks were located aerially in portions of the North Fork Malheur River drainage where their habitat exists. These surveys were done from a helicopter from 1993 through 2000 (Walt Van Dyke, ODFW, pers. comm. 2004).

Upland Game Birds

Brood counts are conducted in the summer by local biologists and a harvest survey is conducted out of ODFW Salem headquarters.

Logan Valley Mitigation Site

The Burns Paiute Tribe Department of Fish and Wildlife is conducting a wide range of monitoring and research on the recent acquisition in Logan Valley, including:

- Vegetation monitoring using photo image analysis software
- Watertable study
- Wet/moist meadow vegetation trends
- Rangeland trends
- Wildlife composition surveys and utilization trends
- Neotropical bird surveys

Malheur River Mitigation Site (Jones Ranch)

The Burns Paiute Tribe Department of Fish and Wildlife is conducting a variety of restoration, monitoring and research activities at their recently acquired Malheur River Wildlife Mitigation site (aka Jones Ranch), including:

- Meadow rehabilitation
    - Reseeding/ improved irrigation efficiency
    - Riparian weed control
- Upland Restoration
    - medusahead study
    - livestock exclosures
- Monitoring and evaluation
    - rangeland trends
    - elk distribution/land use
    - Neo-tropical birds surveys
    - Waterfowl utilizations and nesting conditions
    - River channel dynamics and morphology restoration

6.6.6 Terrestrial Habitat Monitoring Needs

The interaction between terrestrial species and their habitats is complex. There are substantial data gaps in the subbasin with regards to terrestrial habitats and focal species populations. Habitat conditions identified through mapping and research will provide a baseline for future monitoring programs.

Development of a specific monitoring plan to address each individual management strategy is recommended. Once areas have by identified for management action or protection, a monitoring plan should be developed to determine the effects of management actions and allow for evaluation of those effects. Adaptive management strategies should be implemented to ensure that the management strategies that have a positive effect on habitats are continued, and the management strategies that negatively effect habitats are discontinued

7 REFERENCES

All references are included in a separate document

8 ATTACHMENTS

Table 17. Agricultural Management Practices used in the Malheur River Subbasin.

The following table displays current water issues and management practices. The management practices that are beneficial in helping solve the problems are marked "X". The appropriateness of any specific practice has to be determined for each site.

Irrigation Induced Erosion	Improve productivity	Irrigation water use efficiency	Erosion control and phosphate losses: Irrigated land	Erosion control and phosphate losses: Non-irrigated land	Groundwater protection	Pesticide losses	Riparian water quality
Laser leveling	X	X	X		X	X	X
Gated pipe	X	X	X		X	X	X
Filter strips			X			X	X
Sediment ponds		X	X			X	X
Mechanical straw mulching	X	X	X		X	X	X
PAM (polyacrylamide)		X	X		X	X	X
Surge irrigation		X	X		X	X	X
Reduced tillage		X	X			X	X
Field slope engineering, furrow design	X	X	X		X	X	X
Nitrate Contamination in Groundwater	Improve productivity	Irrigation water use efficiency	Erosion control and phosphate losses: Irrigated land	Erosion control and phosphate losses: Non-irrigated land	Groundwater protection	Pesticide losses	Riparian water quality

Soil sampling	X		X		X		X
N rates, budgeting based on crop needs and soil test results	X				X		X
N budgeting, credits from N mineralization	X				X		X
N timing	X				X		X
N adjusted using tissue testing	X				X		X
Use of deep rooted rotation "sop up crops"	X				X		X
Irrigation criteria by soil water potential	X	X	X		X	X	X
Nutrient management	X	X	X	X	X		X
Irrigation System Conversion	Improve productivity	Irrigation water use efficiency	Erosion control and phosphate losses: Irrigated land	Erosion control and phosphate losses: Non-irrigated land	Groundwater protection	Pesticide losses	Riparian water quality
Irrigation system redesign	X	X	X		X	X	X
Drip irrigation	X	X	X		X	X	X
Irrigation scheduling	X	X	X		X	X	X
Sediment retention ponds		X	X	X		X	X
Pump back system		X	X			X	X
Buried tail water pipelines	X		X	X		X	X
Dryland Farming	Improve	Irrigation	Erosion	Erosion	Groundwater	Pesticide	Riparian water quality

	productivity	water use efficiency	control and phosphate losses: Irrigated land	control and phosphate losses: Non-irrigated land	protection	losses	
Grass waterways				X		X	X
Chemical application options					X	X	
Reduced tillage				X		X	X
Riparian Management	Improve productivity	Irrigation water use efficiency	Erosion control and phosphate losses: Irrigated land	Erosion control and phosphate losses: Non-irrigated land	Groundwater Protection	Pesticide Losses	Riparian water quality
Grazing management	X			X	X		X
Riparian plantings				X			X
Fish screens							X
Upland Pasture Management	Improve productivity	Irrigation water use efficiency	Erosion control and phosphate losses: Irrigated land	Erosion control and phosphate losses: Non-irrigated land	Groundwater protection	Pesticide losses	Riparian water quality
Forest practices	X			X	X		X
Watering facilities	X			X	X		X
Fencing	X			X	X		X
Planting and reseeding	X			X	X		X
Controlled burns	X			X	X		X
Juniper control	X			X	X		X

Noxious weed control	X			X			X
Urban Areas	Improve productivity	Irrigation water use efficiency	Erosion control and phosphate losses: Irrigated land	Erosion control and phosphate losses: Non-irrigated land	Groundwater protection	Pesticide losses	Riparian water quality
Recycling of chemicals and oils					X	X	X
Nutrient management			X	X	X		X
Runoff management		X	X	X		X	X

Source: Dr. Clinton Shock, OSU, Malheur Agricultural Experiment Station, Ontario, Or. http://www.cropinfo.net/waterq.htm.